Town of Deerfield Multi-Hazard Mitigation Plan

Adopted by the Deerfield Select Board on September 9, 2020
Approved by FEMA on September 29, 2020

Prepared by

Deerfield Hazard Mitigation Committee

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 Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA).

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

October 9, 2020

Samantha C. Phillips, Director
Massachusetts Emergency Management Agency
400 Worcester Road
Framingham, Massachusetts 01702-5399

Dear Director Phillips:

The U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA) Region I Mitigation Division has approved the Town of Deerfield Multi-Hazard Mitigation Plan effective September 29, 2020 through September 28, 2025 in accordance with the planning requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended, the National Flood Insurance Act of 1968, as amended, and Title 44 Code of Federal Regulations (CFR) Part 201.

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

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

Thank you for your continued commitment and dedication to risk reduction demonstrated by preparing and adopting a strategy for reducing future disaster losses. Should you have any questions, please contact Melissa Surette at (617) 956-7559 or Melissa.Surette@fema.dhs.gov.

Sincerely,

Captain W. Russ Webster, USCG (Ret.), CEM
Regional Administrator
FEMA Region I

WRW:ms

cc: Sarah White, State Hazard Mitigation Officer, MEMA
Jeffrey Zukowski, Hazard Mitigation Planner, MEMA
Beth Dubrawski, Hazard Mitigation Contract Specialist, MEMA

Town of Deerfield
Office of the Selectboard
&
Board of Health

Deerfield Municipal Offices
8 Conway Street
South Deerfield, MA 01373
Ph: 413-665-1400
Fax: 413-665-1411

CERTIFICATE OF ADOPTION

A RESOLUTION ADOPTING THE TOWN OF DEERFIELD

MULTI-HAZARD MITIGATION PLAN

WHEREAS, the Town of Deerfield established a Committee to prepare the 2020 Multi-Hazard Mitigation plan; and

WHEREAS, the Town of Deerfield Multi-Hazard Mitigation Plan contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Deerfield, and

WHEREAS, a duly-noticed public meeting was held by the Selectboard on February 26, 2020, and

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

NOW, THEREFORE, BE IT RESOLVED that the Town of Deerfield Selectboard adopts the 2020 Multi-Hazard Mitigation Plan, in accordance with M.G.L. Ch. 40.

ADOPTED AND SIGNED this date September 9, 2020.

Carolyn Shores Ness

Carolyn Shores Ness, Chair

David W. Wolfram

Trevor D. McDaniel

Deerfield Selectboard

ATTEST

Acknowledgements

The Deerfield Select Board extends thanks to the Deerfield Hazard Mitigation Planning Committee as follows:

- Carolyn Shores Ness, Member, Select Board and Board of Health
- Kevin Scarborough, Superintendent, Deerfield Highway Department
- John Paciorek, Jr., Police Chief, Deerfield Police Department
- Tevor D. McDaniel, Chair, Select Board
- Zachary Smith, South County EMS Director
- Robert Walden, Building Inspector
- Diana M. Schindler, Interim Town Administrator
- Richard Calisewski, Health Agent

The Deerfield Select Board offers 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, and to the staff of the Franklin Regional Council of Governments for providing technical assistance to the Town to complete this project.

Franklin Regional Council of Governments

Peggy Sloan, Director of Planning & Development
Kimberly Noake MacPhee, Land Use & Natural Resources Program Manager
Alyssa Larose, Senior Land Use & Natural Resources Planner
Helena Farrell, Land Use & Natural Resources Planner
Allison Gage, Land Use & Natural Resources Planner
Alexander Sylvain, Emergency Preparedness Program Assistant
Ryan Clary, Senior GIS Specialist

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.

Planning efforts, like the one undertaken by the Town of Deerfield, 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.

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 Pre-Disaster Mitigation Program are programs with this requirement.

1.2 HAZARD MITIGATION COMMITTEE

Updating the Town of Deerfield's Hazard Mitigation plan involved a committee comprised of the following members:

- Carolyn Shores Ness, Member, Select Board and Board of Health
- Kevin Scarborough, Superintendent, Deerfield Highway Department
- John Paciorek, Jr., Police Chief, Deerfield Police Department
- Tevor D. McDaniel, Chair, Select Board

- Zachary Smith, South County EMS Director
- Robert Walden, Building Inspector
- Diana M. Schindler, Interim Town Administrator
- Richard Calisewski, Health Agent

The Hazard Mitigation Planning process update for the Town included the following tasks:

- 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

The key product of this Hazard Mitigation Plan Update process is the development of an Action Plan with a Prioritized Implementation Schedule.

Meetings
Meetings of the Hazard Mitigation Committee were held on the dates listed below. Agendas for these meetings are included in Appendix B. All meetings followed Massachusetts Open Meeting Law and were open to the public.

June 26, 2019
Committee discussed and updated the hazard profiles and past events, and began a discussion of hazard identification and risk assessment.

September 17, 2019
Committee discussed Deerfield's Risk to Each Hazard Based on the Location, Extent, Probability, and Severity of Hazards and reviewed the draft Critical Facilities & Infrastructure Map and draft Environmental Resources Map. The Committee discussed a preliminary draft 2020 Multi-Hazard Mitigation Prioritized Action Plan, which included 2018 MVP Action Items as well as 2014 Action Items to be carried forward.

October 2, 2019
Work continued working on the vulnerability assessment and the Committee reviewed existing hazard mitigation strategies and edits to the draft maps.

January 21, 2020
The Committee finalized the vulnerability assessment and hazard prioritization, reviewed remaining sections of the draft plan, revised draft problem statements for each hazard, updated the draft 2020 Prioritized Action Plan, and prepared for the final public meeting.

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

1.3 PARTICIPATION BY STAKEHOLDERS

A variety of stakeholders were provided with an opportunity to be involved in the update of the Deerfield Hazard Mitigation Plan. The different categories of stakeholders that were involved, and the engagement activities that occurred, are described below.

Local and Regional Agencies Involved in Hazard Mitigation Activities
In the Winter of 2018, Deerfield held a Community Resiliency Building workshop as part of the Massachusetts' Municipal Vulnerability Preparedness (MVP) designation program. The workshop was critical to enabling participants to think about and engage across different sectors. Many members of the Deerfield Hazard Mitigation Plan Committee as well as other Town staff, volunteers, residents, and business owners all came together to determine the most threatening hazards to the Town of Deerfield and to agree upon high priorities and actions to address them. The results of the workshop are documented in the Town of Deerfield's *2018 MVP Resiliency Plan*, and were integrated into this Hazard Mitigation Plan update process.

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

- Developing the Sustainable Franklin County Plan, which advocates for sustainable land use throughout the region and consideration of the impact of flooding and other natural hazards on 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, which includes a focus on sustainability and climate resilience, and implementing the Franklin County Transportation Improvement Program to complete transportation improvements in our region.

- 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 Deerfield Hazard Mitigation 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 Deerfield Planning Board is the primary Town agency responsible for regulating development in town. Feedback to the Planning Board was ensured through the participation of a planning board member on the Hazard Mitigation Committee. In addition, the Franklin Regional Council of Governments, as a regional planning authority, works with all agencies that regulate development in Deerfield, including the municipal entities listed above and state agencies, such as the Department of Conservation and Recreation and MassDOT. This regular involvement ensured that during the development of the Deerfield Hazard Mitigation Plan, the operational policies and any mitigation strategies or identified hazards from these entities were incorporated into the Hazard Mitigation Plan.

Participation by the Public, Businesses, and Neighboring Communities

The plan update and public meetings were advertised on the Town website 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 at the Town Offices, at the Tilton Public Library, and on the Town website at www.deerfieldma.us. A public forum was held on February 26, 2020 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 all neighboring communities, 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 February 26 – March 13, 2020 (See Appendix A, Public Participation Process, for copies of public outreach materials and comments received on the draft Plan). Comments were reviewed by the Committee and incorporated into the final plan as appropriate.

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

- 2014 Deerfield Open Space and Recreation Plan
- 2018 Town of Deerfield MVP Resiliency Plan
- 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan
- 2017 Watershed-Based Plan for the Deerfield River Watershed
- 2019 A Framework for Resilience: Responding to Climate Change in the Deerfield River Watershed
- 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 Deerfield is situated in the central region of Franklin County in the Deerfield and Connecticut River watersheds. Two north/south oriented transportation arteries bisect the Town—Interstate 91 to the west and Route 5/10 on the east. The rich alluvial soil of the area contributes to the success of Deerfield's many vegetable and livestock farms. The Town's high quality of life has led to an increase in population over the past 25 years, raising concern over the fate of the farming community as prime agricultural land becomes increasingly desirable for development.

Deerfield was the earliest community settled in Franklin County, with initial European settlement occurring between 1500 and 1620. The Town was incorporated in 1673. In the second half of the 18th century, the Town experienced substantial population increase with the introduction of the railroad. During the Industrial Era, Deerfield's factories were known for manufacturing corn brooms and pocketbooks. Today, Deerfield's largest single employer is Yankee Candle, Inc., which is Massachusetts' second most visited attraction.[1] Manufacturing provides the largest number of jobs in Deerfield, with education (in both public and private institutions) coming in second. The original village—now known as Old Deerfield—has become a popular tourist attraction.

Development is more concentrated in the Center Village Residential District in South Deerfield, which has a higher density of residential housing. That district is largely built out, according to Town officials. There is a diffuse pattern of development in Deerfield's other areas. More recent development patterns show growth occurring along roads outside the village centers in the rural areas of Deerfield.

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-

[1] Deerfield Open Space and Recreation Plan, 2014; p. 3-4.

1999; 2005) so comparisons of land use change over time can't be made using this current data.[2]

However, the 2016 land cover/land use dataset does reveal interesting information about Deerfield that most residents probably already know. For example, most of the *land cover* is forests but the *land use* is primarily residential.

Table 2-1: Deerfield 2016 MassGIS Land Cover and Land Use Data				
Total Acres = 22,098.80				
Land Cover	**Acres**		**Land Use**	**Acres**
Bare Land	292.12		Agriculture	3561.52
Cultivated	2909.21		Commercial	169.73
Deciduous Forest	7830.63		Forest	1753.80
Developed Open Space	1317.45		Industrial	852.40
Evergreen Forest	5426.49		Mixed use, other	999.73
Grassland	705.79		Mixed use, primarily commercial	244.07
Impervious	1154.13		Mixed use, primarily residential	2185.64
Palustrine Aquatic Bed	6.88		Open land	3720.11
Palustrine Emergent Wetland	298.43		Recreation	42.11
Palustrine Forested Wetland	794.59		Residential - multi-family	421.73
Palustrine Scrub/Shrub Wetland	68.55		Residential - other	186.77
Pasture/Hay	744.94		Residential - single family	3110.98
Scrub/Shrub	38.29		Right-of-way	1759.61
Water	511.30		Tax exempt	2449.08
			Unknown	32.76
			Water	608.76

According to the 2016 MassGIS data in Table 2-1, approximately 64 percent of Deerfield's land cover is forest. Approximately 16 percent of the town is classified as agricultural land use, and 27 percent of the town is classified as residential land use. Although the 2005 and 2016 land use data sets cannot be directly compared, the general trend Deerfield is experiencing is an increase in residential development and a decrease in agricultural land. However, according to the Deerfield Housing Production Plan, approximately 50 percent of the Town's agricultural land is permanently protected from development.[3] Approximately 5 percent of the total area in town is comprised of commercial or industrial land uses.

Population Characteristics

According to the 2010 U.S. Census, there are 5,125 residents (an 8% increase since 2000). As of

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

[3] Town of Deerfield Housing Production Plan, 2014-2019

2017, Deerfield's total population is estimated to be 5,049 (a 1.5% decrease since 2010).[4] Although the Town's population has recently decreased, Deerfield was identified as one of the top five towns in Franklin County to have experienced the most population growth between 2000 and 2013, and will likely continue to grow due to its proximity to major employment centers.[5]

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 percent of the statewide median ($62,072 in 2010); or
- 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, the Town of Deerfield does not currently have any environmental justice populations based on race, income, or language proficiency. Almost 95% of the Town's population is White with the next largest racial group is Black at 1.8% of the total population. In terms of income, the annual median household income of Deerfield is well above 65% of the State's annual median household income of $68,563.

Current Development Trends

Bounded by Mount Sugarloaf to the east and by Routes 116 and 5/10 to the south and west, South Deerfield is considered the business and industrial heart of Deerfield, and is one of the major employment centers in Franklin County. The majority of commercial and industrial development is concentrated within the Small Business zoning district in the center of the village, the Expedited Permitting District encompassing the former Oxford Foods site, several Commercial districts along portions of Routes 5/10, two Industrial districts along Routes 5/10, and the Planned Industrial district along the south side of Route 116, at the location of the Deerfield Industrial Park. Unfortunately this area shows early signs of suburban sprawl and if future growth is not laid out and designed creatively, the area could lose its small village character. Recent development in this area, both residential and commercial/industrial, has occurred on land that was once farmland with prime agricultural soils. Continued development of this area without careful planning will result in further degradation of its historically rural nature.

---

[4] U.S. Census Bureau 2013-2017 American Community Survey 5-Year Estimates.

[5] Franklin County Regional Transportation Plan 2016

A Small Business district is also located along Routes 5/10 just south of Old Deerfield, and a Commercial district is designated in East Deerfield, at the confluence of the Connecticut and Deerfield Rivers. It is dominated by a railroad yard and rock quarry operations.

Although the landscapes are mostly permanent, being based on glacial and geomorphic processes, their uses are not. For example, the floodplains of Deerfield have historically been prized for their prime soils and, thus, farming has been a dominant activity there. However, development pressures threaten the continued viability of Deerfield farms. The more fragmented farmland becomes, the more expensive it becomes to farm, based on additional time and fuel costs. In the same way, fragmentation of the landscape affects the viability of forest management operations. When a large forest block is fragmented by a subdivision, the resulting parcels associated with single family homes are often too small to manage individually for forestry purposes. Finally, the most inefficient method of providing municipal services such as police, fire, sewer, water, waste disposal, and plowing is associated with a fragmented landscape where residential development is spread sparsely across the town.

The conversion of forest and agricultural land to building sites for single-family homes is the dominant land use change in Deerfield. Future development patterns in Deerfield may depend on national and regional employment and population trends but also on local conditions that impact development and land use, such as infrastructure and land use controls.

According to information provided by the Deerfield Assessors' and Building Inspector, between 2014 and June 2020, the Town issued sixty-two (62) building permits for new construction. Thirty-eight (38) of these permits were for condominiums under construction for a development in South Deerfield east of North Main Street near Mt. Sugarloaf State Reservation known as the Condominiums at Sugarloaf. FRCOG staff reviewed the addresses of the remaining building permits and most of them were located outside of known hazard areas in or near West Deerfield, South Deerfield and east of Rte. 5/10 in the northern section of Town. FRCOG staff reviewed 2019 aerial photography and the 2016 Land Use/Land Cover data relative to the 100-year floodplain. The number of acres of floodplain and the number of structures are the same as for the 2005 Land Use data although direct comparisons between the two data sets cannot be made due to differences in mapping methods. Franklin County does not have digital floodplain maps. FRCOG's analysis is limited by the lack of digital floodplain maps.

The Town of Deerfield is currently working on a project to update Section 4300 Flood Plain District of the Town's Zoning Bylaws. The Planning Board held a Public Hearing on July 6, 2020 to discuss the draft updates with town residents and stakeholders. The Town continues to work to direct new development away from flood hazard areas and protect valuable agricultural land, which is typically in the floodplain of the Deerfield River and provides flood storage benefits.

National Flood Insurance Program Status

Deerfield is a participating member of the National Flood Insurance Program. Currently there are 28 insurance policies in effect in Deerfield, for a total insurance value of $7,563,500. Eight losses have been paid in Deerfield, for a total losses paid of $96,379, and the Town has one repetitive loss property. On May 1, 2020, after discussions with MEMA and FEMA Region 1 staff, Deerfield filed a signed Information Sharing Access Agreement (ISAA) with FEMA Region 1 to request additional information on the RL property to further inform future mitigation strategies and actions that may be undertaken by the Town. The ISAA must be executed by FEMA Headquarters and then the information will be released to the Town. Once received, Deerfield will update this Plan, as appropriate.

Deerfield's floodplain map is from 1980. In 2018, the Federal Emergency Management Agency (FEMA) initiated a 5-year process to update the floodplain maps for Franklin County towns.

Roads and Highways

Deerfield has a total of approximately 104 miles of roadway within its borders, including the major transportation arteries Interstate 91 and Route 5/10. Interstate 91 connects Deerfield and Franklin County with Vermont and New Hampshire to the north and the larger communities of Northampton, Holyoke and Springfield, Massachusetts to the south.

About 19 percent (20 miles) of Deerfield's roads are gravel. These roads are primarily in the area of Old Deerfield.[6]

Rail

The Pan Am Rail System's Connecticut River Main Line carries between six to ten trains daily. Each train carries up to 100 cars, typically carrying goods such as plastic pellets, fertilizer, steel reinforcement rods and grain. The line runs along the Deerfield River from the Hoosac Tunnel to Greenfield. The East Deerfield Rail Yard is one of only two GRS classification rail yards in New England. A classification yard acts like a post office, splitting up lengths of containers, and rerouting containers into new train lengths based on their final destination. In the future, it may be desirable for the facility to operate as a trans-loading yard for the transfer of cargo from

[6] FRCOG 2017 Road Inventory

train to truck. This would result in increased traffic along Route 5/10 and in Deerfield.[7]

At the 2018 MVP Community Resiliency Building workshop, the East Deerfield Rail Yard was identified as a key vulnerability. The Yard is located along the Connecticut River near the mouth of the Deerfield River, this railyard has hazardous materials subject to flooding impacts.[8]

Public Transportation

Deerfield's public transit is limited. The Town is served by the Franklin Regional Transit Authority (FRTA) and the Pioneer Valley Transit Authority (PVTA). The FRTA has six scheduled weekday trips between Greenfield and South Deerfield. Through UMass transit, the PVTA provides bus service from Amherst through Sunderland to South Deerfield, which travels to and from the university six times daily during the week, five times daily on Saturday, and three times on Sundays.

Public Drinking Water Supply

The water that Deerfield residents drink comes from private wells and springs or public water district supplies. Water district supplies have both groundwater and surface water sources. Groundwater sources are springs and wells while surface water sources include reservoirs and rivers. A well pumps water from underground. The underground water collects in layers of sand and gravel called aquifers. Rain permeating through layers of soil can reach groundwater, which in turn may recharge water within an aquifer.

In the Town of Deerfield, a brief analysis of water supply systems requires a separate discussion of its two main water districts, the South Deerfield Water Supply District and the Deerfield Fire District. Each utilizes a different system of public water sources, aquifers, and each has different issues and concerns. There is one other district in town in East Deerfield. The Town of Greenfield supplies Pan Am Railways with its drinking water supply, which it distributes to approximately ten households. Drinking water for residents, schools and businesses that are not connected to a public drinking water is provided by private wells.

Flooding and other natural disasters have the potential to contaminate both public and private wells. Routine testing of private wells is not required under state regulations but owners can contact the Town's Board of Health for assistance with water testing. Public water supply wells are regulated by the MassDEP and are overseen by certified operators, who routinely test the water for a required list of contaminants and publish Annual Water Quality Reports that are available to the public.

---

[7] Rail information was drawn from the Deerfield Master Plan, pg. 5-27.
[8] Municipal Vulnerability Preparedness for Deerfield: Summary of Findings. Conservation Works, LLC, 2018.

South Deerfield Water Supply District

The South Deerfield Water Supply District (SDWSD) utilizes a water distribution system that withdraws water from two reservoirs connected to each other by way of Roaring Brook. The primary source is a service reservoir located in Whately with a total water volume or capacity of 6.7 million gallons. The secondary reservoir located upstream in Conway has a total storage capacity of 164 million gallons. In comparison, the Roaring Brook Reservoir system has a firm yield of 1.42 million gallons per day. The firm yield is the amount of water that can be utilized on a continuous basis during an extended dry period without adverse hydrological or ecological impacts. The permitted water withdrawal volume is currently 650,000 gallons per day. A system is not considered to be in violation of this permit until it exceeds this amount, plus an additional 100,000 gallon allowable overrun.

To assist the SDWSD in limiting future demand on its water supply systems and to increase the system's climate resiliency, the Town of Deerfield may adopt zoning bylaws that restrict new commercial and industrial development to companies that use less water within the district. The SDWSD may also encourage the adoption of district-wide water conservation practices, such as a fee structure that charges more as usage increases, and other methods.

Deerfield Fire District

The Deerfield Fire District provides water to a stable customer base of primarily residential users with a small amount of agricultural, commercial and industrial services. One hundred percent of the users are metered. The Deerfield Fire District (DFD) provides its customers with water primarily from two sources. The first is the Stillwater Well, with an average daily flow rate of 95,000 gallons per day. The Stillwater well taps into an aquifer straddling the Deerfield River between the bridge and Interstate 91. The Stillwater Springs/Harris Springs are inactive. These sources were closed in July 2003 for failure to pass the microscopic particulate analysis (MPA) and bringing them back on-line would require an expensive water treatment facility, which is not feasible. When these springs were in operation they generated average daily flow rates of 70,000 gallons per day.

The second water source area is located off of Pine Nook Road near Eaglebrook School. The Keats Spring and the new Cistern Spring, with their source the Pocumtuck Range, fill a 210,000 gallon tank reservoir that feeds into the distribution system. The Keats and Cistern Springs produced average daily yield of approximately 41,000 gallons in 2017.[9] The DFD's total water supply system's registered withdrawal is 100,000 gallons per day.

The Wapping well located along Route 5/10 just south of Childs Cross Road is currently inactive

[9] https://www.deerfieldma.us/sites/deerfieldma/files/uploads/od_consumer_confidence_report.pdf

due to road salt contamination, though in the past it was considered as the emergency well. Currently, the Deerfield Fire District can purchase water from the Town of Greenfield in the case of an emergency.

Each well or spring is surrounded by land owned by the water district which is considered to have a high level of protection. The water withdrawal rate rarely exceeds its registered amount, has no contamination problems, and has no apparent concerns with respect to future water demands. Originally, the Deerfield Fire District used the Stillwater Well as their primary drinking water source. Over the years, the district has developed its spring water sources with new pipes and collection boxes. Overall, 35 percent of the DFD's water currently comes from springs, down from 66 percent when the Harris-Stillwater Springs were on line.

The Town needs a town-wide drinking water assessment in order to determine what percentage of the town's population is adequately served by the existing water districts and which ones are not. Once underserved areas have been identified, potential sources of drinking water need to be identified and protected. Many residents on River Road are served by private deep wells that are not potable due to hardness and natural sources of arsenic found in the red rock aquifer that runs north and south in the valley.

Sewer Service

The Town of Deerfield is served by two wastewater treatment plants, one in South Deerfield and one in Old Deerfield, and both were constructed in 1971. Both facilities need repairs and upgrades to maintain their operational capacity as well as to increase their climate resiliency. The plant in Old Deerfield is threatened by fluvial erosion and flood hazards associated with the Deerfield River. An engineering feasibility study is needed to identify climate resilient improvements and associated cost estimates for both plants.

In 2019, Deerfield voters agreed to fund improvements to the South Deerfield Wastewater Treatment Facility, including those required by the MassDEP (replacement of the mechanical system inside an existing secondary clarifier at the plant). Public Works Superintendent Kevin Scarborough previously explained the clarifier is the tank that treated water goes through before making contact with chlorine. It failed in December 2017, when electricity was temporarily disabled by brutally cold temperatures and its metal arm bent after power came back on and tried to move accumulated treated water.[10] Voters agreed to take on the $19M costs of the planning, design, permitting, bidding and construction needed at the 150 Sunderland Road facility. Deerfield has secured a 40-year, approximately $8 million loan (at

[10] https://www.recorder.com/Deerfield-special-ballot-question-election-26377163

2.125 percent interest) and a $2.6 million grant from the U.S. Department of Agriculture. The project's first phase will cost about $11 million.

The issue of wastewater treatment expansion is a difficult one since areas with a high frequency of septic system failures are spread throughout Deerfield, with particular problems in the Mill Village Road area of town. The Weston and Sampson Engineers (WSE) Wastewater Strategic Plan prepared for the Town of Deerfield in 1999 presented a series of alternatives that would attempt to solve the extensive septic failures experienced by residents around Town. The primary cause of the septic problems identified by WSE is an historic high water table in the affected areas. As a result, many people have to pump out their septic tank two or three times per year. The three levels of changes proposed were: sewer line extensions within ½ mile of the existing system, shared Title 5 septic systems for areas outside of the ½ mile buffer, and alternative or conventional on-site systems. Expansion of the sewer line would be expensive, in part because of the necessity for a pumping station. In the meantime, septic failures have been continuing. Further, recent construction of new homes is reported to be affecting the water table for local farmers and homeowners.

Emergency Shelters

Shelters have been established at the Frontier Regional High School, Deerfield Elementary School and the South Deerfield Fire Department. However, the Committee has identified a need to improve coordination between the Town and the private schools such as the Bement School, Deerfield Academy and Eaglebrook. Deerfield also has a practice of setting up cooling shelters at the South County Senior Center and the Tilton Public Library when temperatures reach 96 degrees or higher. The Town participates in the Franklin County Regional Emergency Planning Committee (REPC), which is currently working on regional-based sheltering and evacuation planning.

Natural Resources

Deerfield contains within its boundaries several different landscapes: the foothills of the Berkshires, the floodplains of the Connecticut and Deerfield Rivers, and the North-South running Pocumtuck Range, which reaches a height of nearly 800 feet above sea level on the eastern side of Town. Mount Sugarloaf State Reservation lies to the south of the Pocumtucks. Its two peaks, South and North Sugarloaf, are 652 and 791 feet, respectively. To the west and extending north into Greenfield and west into Conway are foothills of the Berkshire Range. These are split by the Deerfield River and form a gorge. These foothills are mainly forested, with narrow valleys between the hills. Among them are several peaks, including Arthur's Seat, Deerfield's highest point at 960 feet.

Deerfield lies in the watersheds of two rivers: the Deerfield and the Connecticut. The Deerfield River basin includes the northern half of the town west of the Pocumtuck Range, while the Connecticut River basin includes the eastern slopes of the Pocumtuck as well as the southern half of the town. A number of other rivers, streams, and brooks flow through Deerfield before eventually converging with the Connecticut River. According to MassGIS 2016 land cover data, the town has 511 acres of surface water. The most significant of these tributaries is the Mill River which flows through the Town on its way to the Connecticut River. In addition to three major rivers, Deerfield has a significant acreage (1,162 acres) covered by forested and non-forested wetlands, which are essential for promoting water quality and biodiversity of both plant and animal species. These wetlands are fed by nearby brooks and rivers, including Pole Swamp Brook, Clapp Brook, Fuller's Swamp Brook, Hawks Brook, Shingle Brook, and Bloody Brook. Many of these water bodies are popular fishing spots, and the Deerfield and Connecticut Rivers are both supportive of recreational use, although public access to the Connecticut River in Deerfield is limited.

A number of aquifers are known to underlie the Town of Deerfield. These were initially identified in a 1985 report, entitled A Hydrogeologic Investigation of South Deerfield, Massachusetts, produced by the University of Massachusetts. A large, high volume aquifer lies beneath the Interstate 91 corridor, in the floodplain deposits of the Deerfield River. The Deerfield Fire District taps into this aquifer along Stillwater Bridge Road. A shallow unconfined aquifer, known as the "Sugarloaf Street aquifer," lies in the central part of South Deerfield. Bounded on the east by the Pocumtuck Range and on the south and west by Sugarloaf Brook , this aquifer is recharged from the surrounding hills and by infiltrating rainwater along its entire length. The Sugarloaf well field pumped water from this source until it was shut down in 1984 due to excessive ethylene dibromide (EDB) levels. EDB is a chemical found in pesticides commonly used in the cultivation of shade tobacco. Because of potential continued contamination, it is doubtful that the aquifer will provide a satisfactory supply of groundwater without costly treatment.

As previously mentioned, approximately 64 percent of the total land area of the Town of Deerfield is forested, according to MassGIS land use data for 2005. Most of Deerfield's forested areas lie in the eastern and western portions of Town where the Pocumtuck Ridge, North and South Sugarloaf, Arthur's Seat, and Pine Ledge are located. These forests are largely dominated by species such as northern red oak, sugar maple, American beech, wild cherry, white birch and white ash; although eastern hemlock and white pine are also prevalent. Common shrub and herbaceous species that are important food sources for local wildlife are flowering dogwood, choke cherry, high bush and low bush blueberry, mountain laurel, witch hazel, aster, dandelions, goldenrod, sweet fern, cattail, blackberry and raspberry bushes, elderberry, etc.

and water lilies (NHESP; 2001).

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.[11]

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 2010 Deerfield Comprehensive Emergency Management Plan (CEMP) identifies cultural resources in Deerfield, some of which contain historic documents and cultural artifacts (Table 2-2).

Table 2-2: Deerfield Cultural Resources

Resource Name	Resource Location	Resource Type	Materials Contained
Bement School	94 Old Main Street	Historical private school buildings	Historical, cultural
Bloody Brook Monument	North Main Street	Historical monument	Historical
Deerfield Academy	7 Boyden Lane	Historical private school buildings	Historical, cultural
Eaglebrook School	271 Pine Nook Road	Historical private school buildings	Historical, cultural

[11] Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning, State and Local Mitigation Planning How-To Guide, FEMA 386-6 / May 2005.

Table 2-2: Deerfield Cultural Resources			
Resource Name	**Resource Location**	**Resource Type**	**Materials Contained**
Historic Deerfield, Inc.	84B Old Main Street	Historical buildings & sites	Archives, cemetery, library, museums (artifacts)
Magic Wings Butterfly Conservatory	281 Greenfield Road	Conservatory	Live butterflies and plants
Old South Deerfield Town Hall	2 Park Street	Historical/cultural building	Historical/cultural
Pocumtuck Valley Memorial Association and Memorial Hall Museum	8 & 10 Memorial Street; 107 Old Main Street	Historical buildings	Archives, library
Senior Center	67 North Main Street	Historical	Historical, archival
Tilton Library	75 North Main Street	Historical building	Archives, library

The Massachusetts Cultural Resource Information System (MACRIS)[12] lists a total of 115 areas, buildings, burial grounds, objects, and structures of cultural and/or historic significance in Deerfield. Some of these include the Old Deerfield Village Historic District, Deerfield Academy, and the First Church of Deerfield. 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.

[12] http://mhc-macris.net/Results.aspx

2.2 IMPACTS OF CLIMATE CHANGE

Greater variation and extremes in temperature and weather due to climate change has already begun to impact Deerfield, 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 and Deerfield: 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.

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).

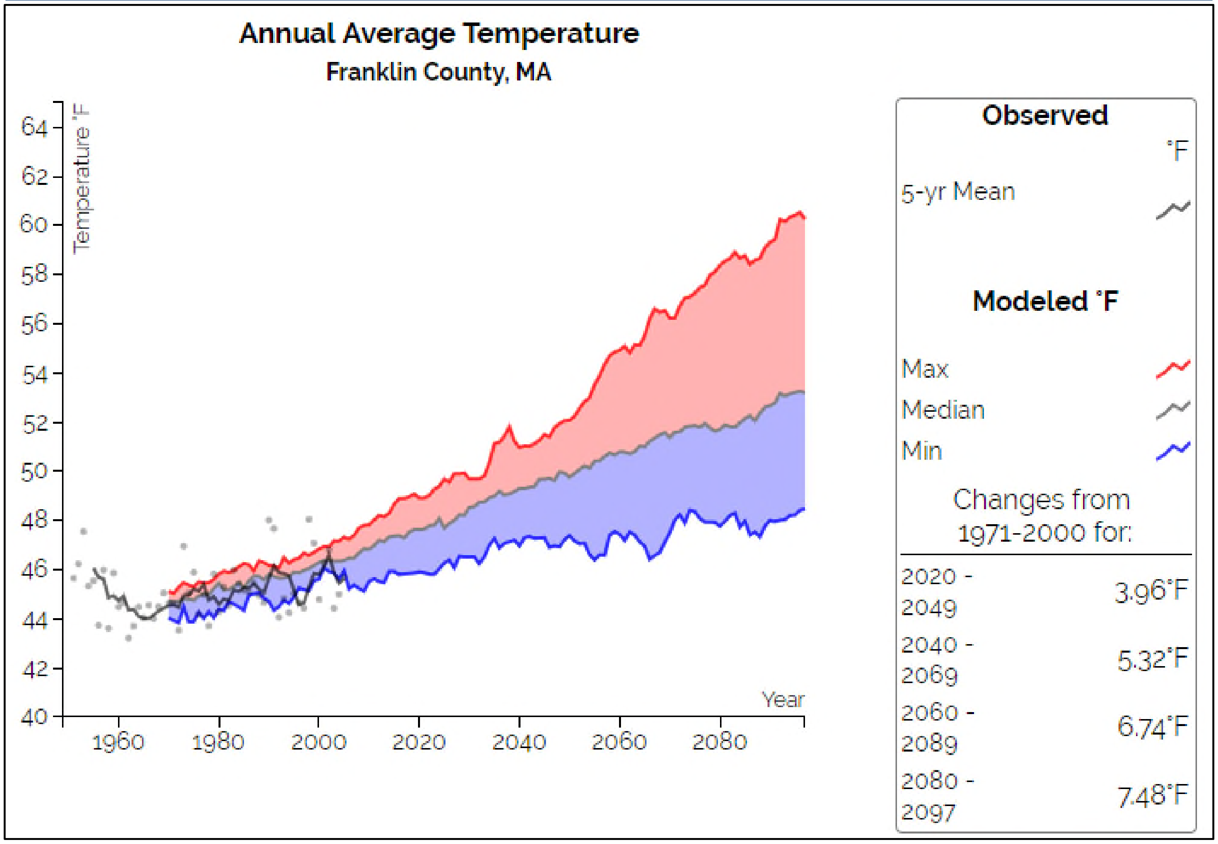
The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (resilient MA, 2018). Figure 2-2 displays the projected increase in annual temperature by mid-century and the end of this century, compared to the observed annual average temperature 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 2-2 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 2-1: 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

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

Figure 2-2: Projected Annual Average Temperature

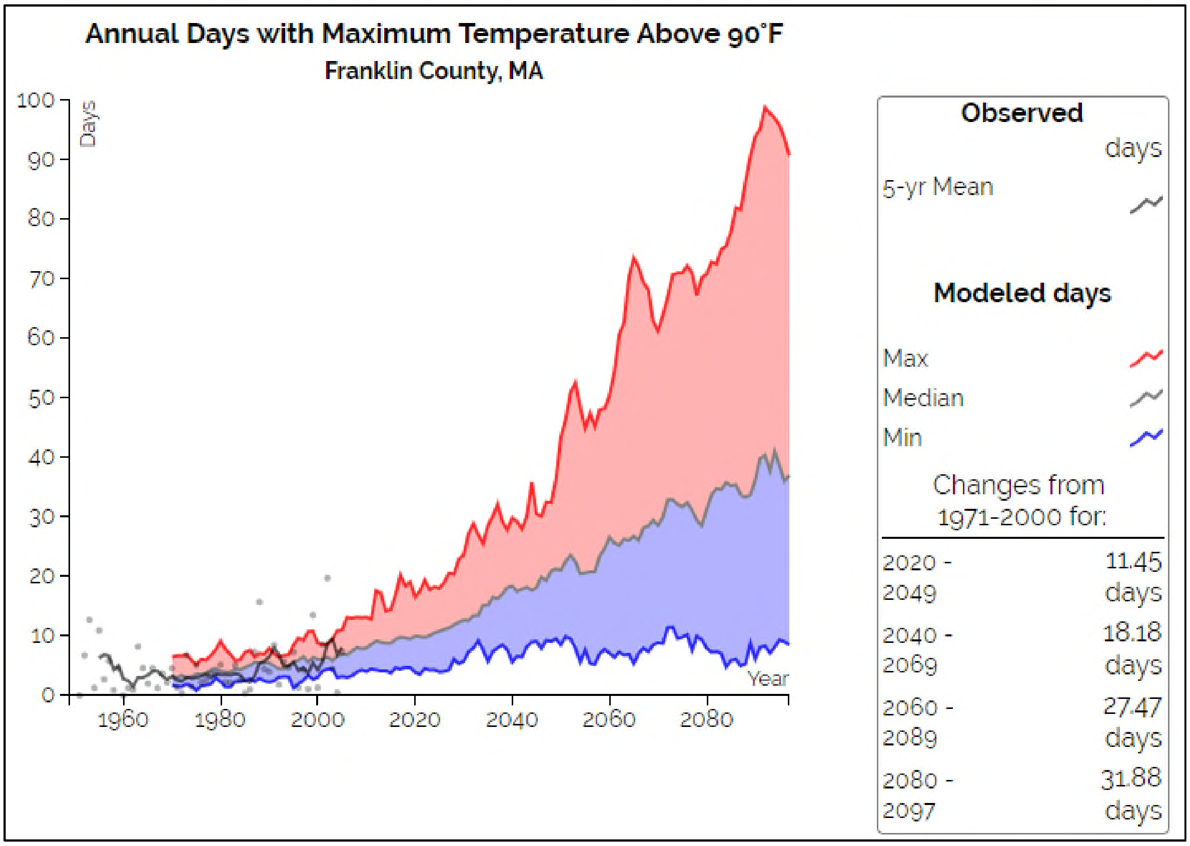


Source: Resilient MA, 2018

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.

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 2-3 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



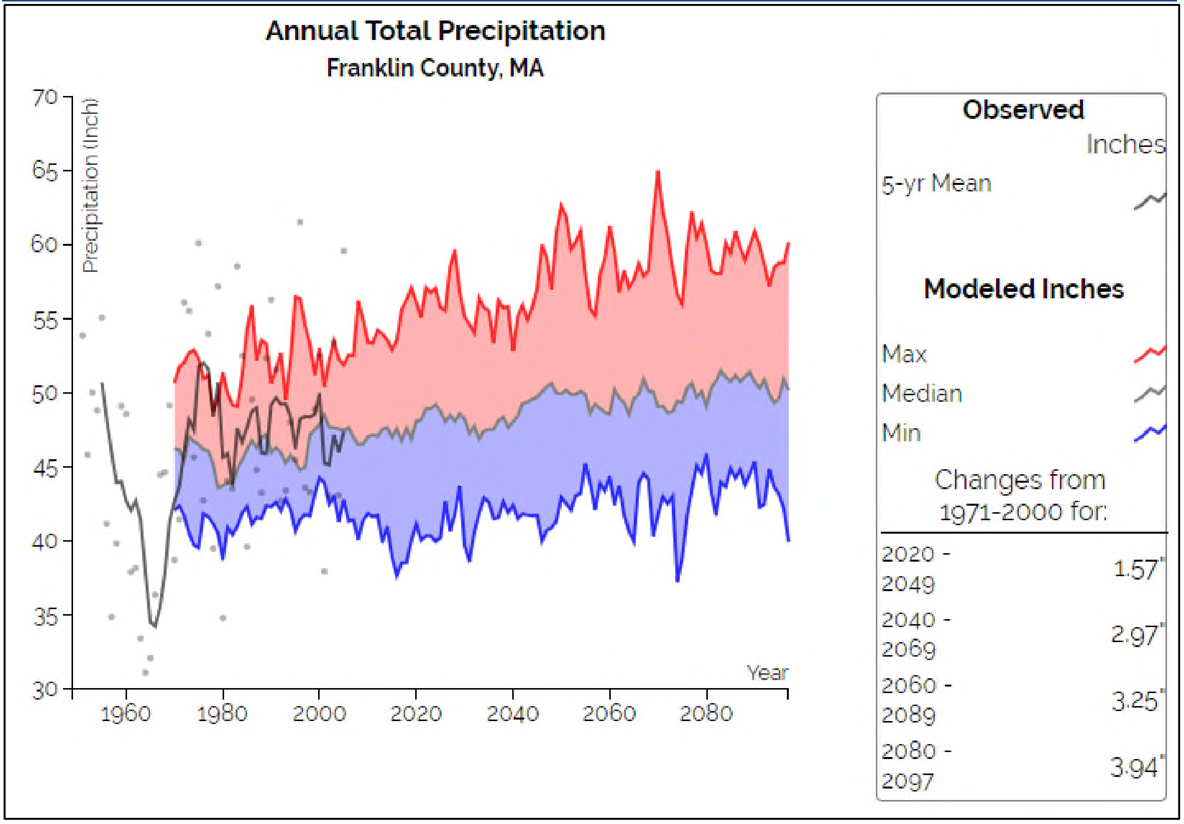
Source: Resilient MA, 2018

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 2-4). 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.[13]

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

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



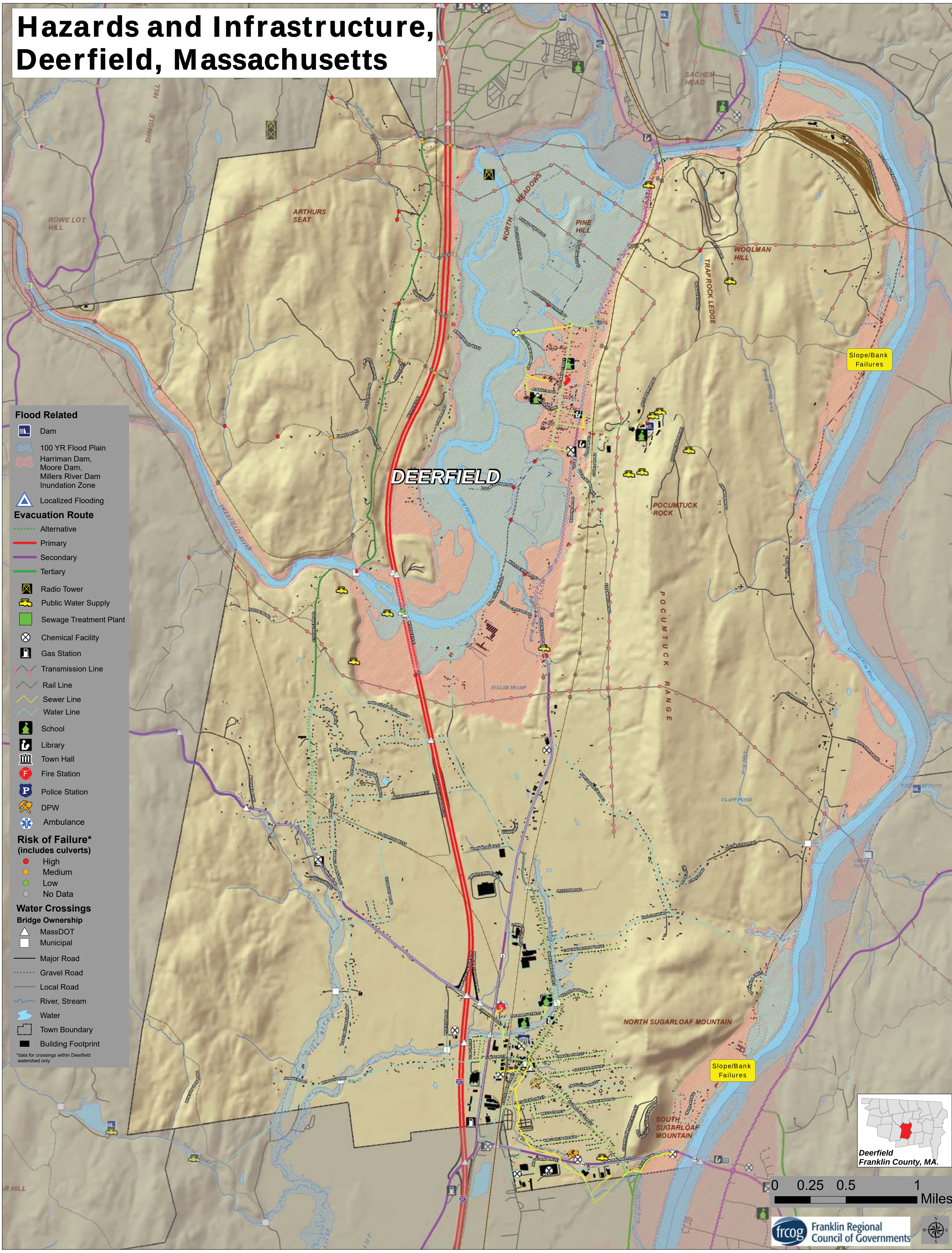
Source: Resilient MA, 2018

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 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.

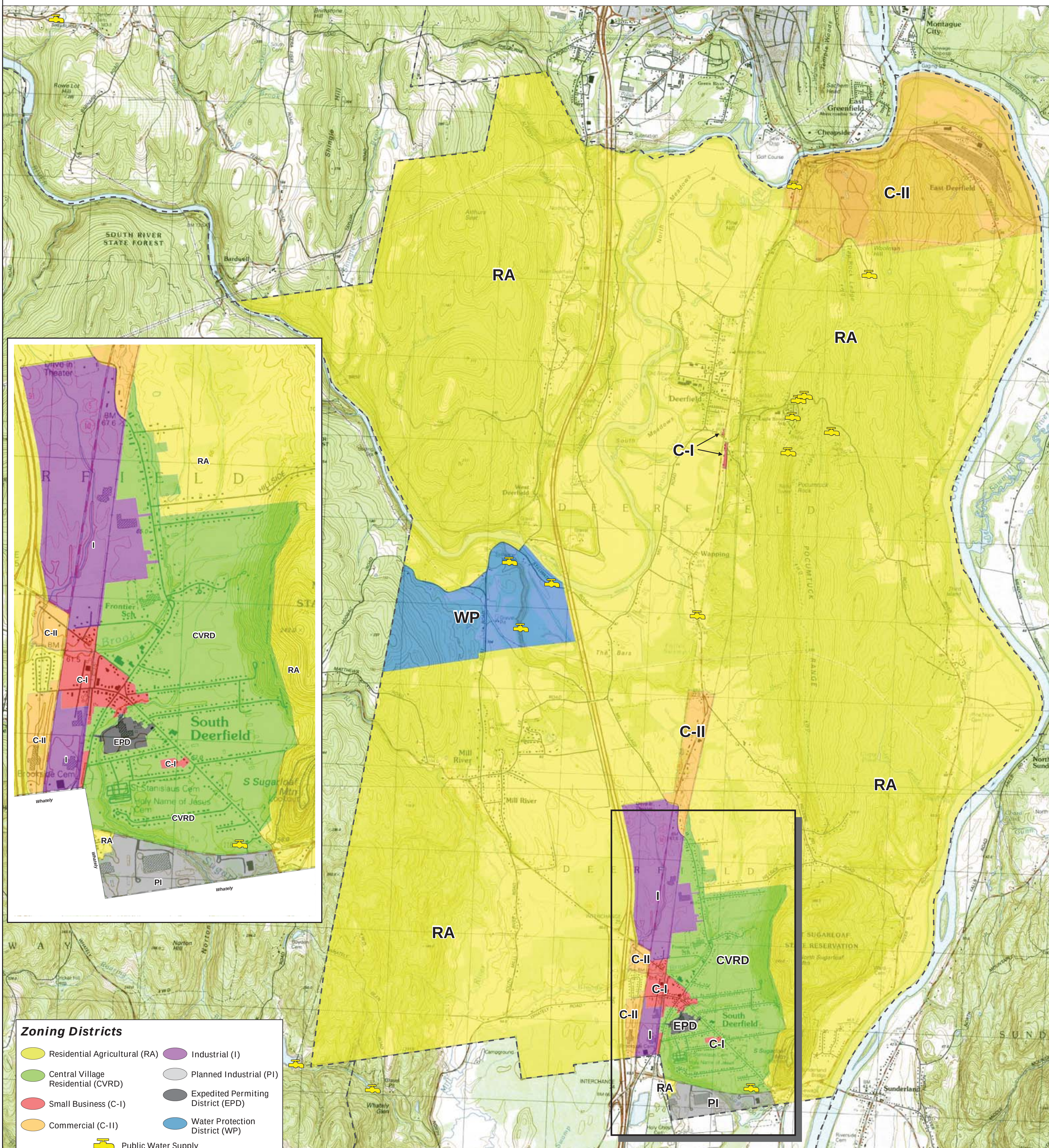
Hazards and Infrastructure, Deerfield, Massachusetts




Environmental Resources,
Deerfield, Massachusetts
DEERFIELD
ARTHURS SEAT
ROWE LOT HILL
SHINGLE HILL
NORTH MEADOWS
PINE HILL
SACHEM HEAD
WOOLMAN HILL
TRAP ROCK LEDGE
POCUMTUCK ROCK
POCUMTUCK RANGE
NORTH SUGARLOAF MOUNTAIN
SOUTH SUGARLOAF MOUNTAIN
CLIFF POND
Flood Related
Dam
100 YR Flood Plain
Harriman Dam Inundation Zone
Localized Flooding
Environmental
Wetland
Slope > 25%
Prime Farmland Soils
Zone II Water Supply Protection Area
Permanently Protected Open Space
Transmission Line
Town Hall
Fire Station
Police Station
Major Road
Gravel Road
Local Road
River, Stream
Water
Town Boundary
Building Footprint
Deerfield
Franklin County, MA.
0
0.25
0.5
1
Miles
frcog
Franklin Regional Council of Governments

Town of Deerfield
Official Zoning Map

October 28, 2013

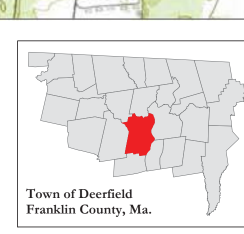


Map composed by FRCOG Planning Department. c:\a_projects\updated_zoning\deerfield\deer_official_April6_2010.mxd

Franklin Regional Council of Governments

0 0.5 1 1.5 Miles

N S E W



Map Sources:

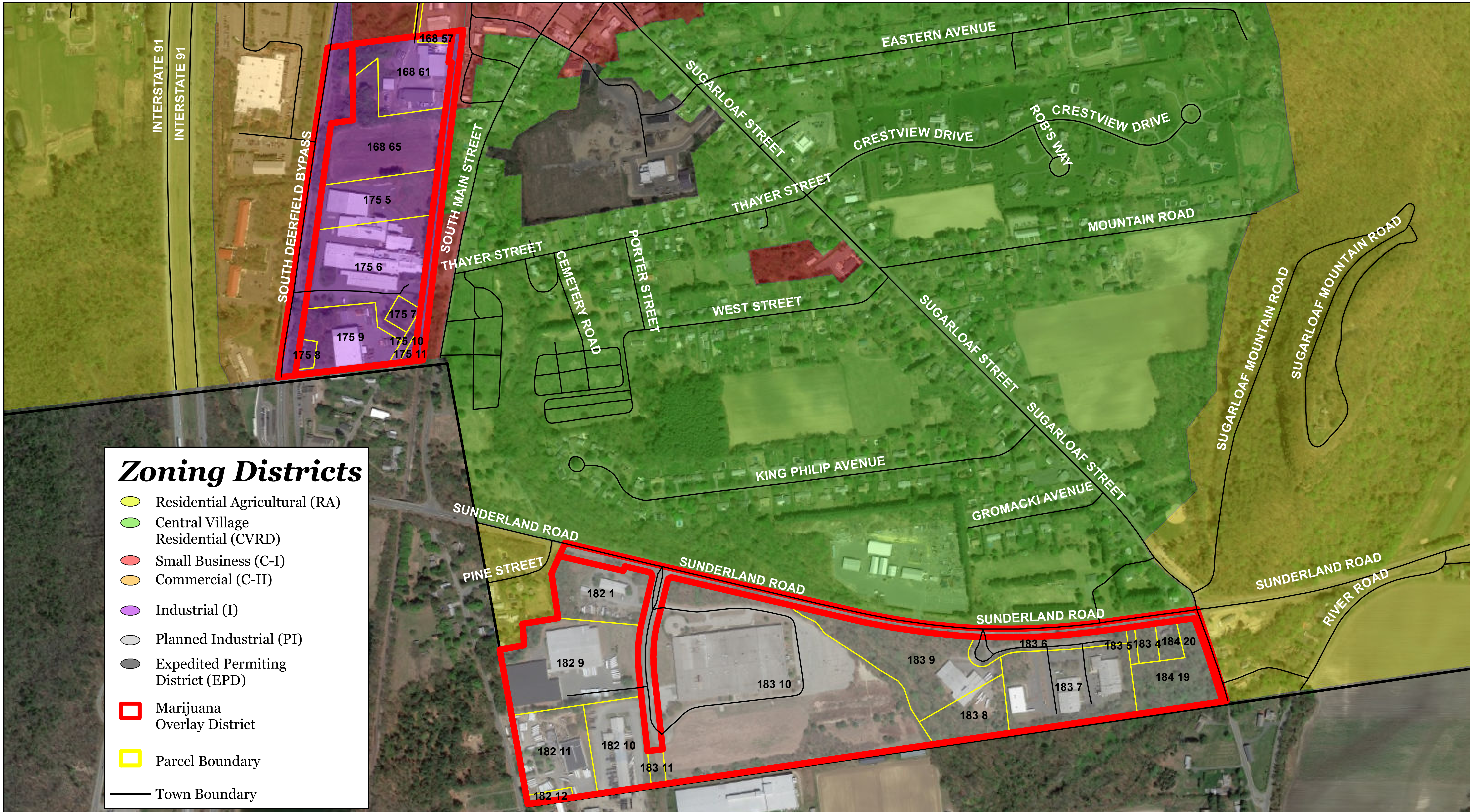
Map produced by The Franklin Regional Council of Governments Planning Department. GIS data sources include the FRCOG Planning Department, the Massachusetts Highway Department and MassGIS. Digital data obtained from MassGIS represent the efforts of the Massachusetts Executive Office of Environmental Affairs and its agencies to record information from the sources cited in the associated documentation. EOEA maintains an ongoing program to record and correct errors in the GIS data that are brought to its attention. EOEA makes no claims as to the reliability of the GIS data or as to the implied validity of any uses of the GIS data. EOEA maintains records regarding all methods used to collect and process these digital data and will provide this information on request. Executive Office of Environmental Affairs, MassGIS EOEA Data Center, 251 Causeway Street, Suite 900, Boston, MA, 617-626-1000.

USGS 7.5 minute series topographic quadrangles scanned to create digital USGS 7.5 minute Arc/Info coverages. The resulting scanned map is projected into NAD83 Massachusetts State Plane meters. Data provided by MassGIS.

Zoning data provided by the Town.

Note: Depicted boundaries are approximate and are intended for planning purposes only. Portions of the source data were obtained from 1:100,000 scale maps, therefore the accuracy of the line work on this map is +/- 100 feet. The boundaries of the town's zoning districts have been snapped to the current Massachusetts Highway Department Road Inventory file. The road inventory file differes than the USGS roads in places therefore inaccuracies may exist when viewing the USGS overlay.

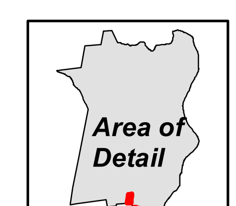
October 28, 2013



Town of Deerfield Marijuana Overlay District

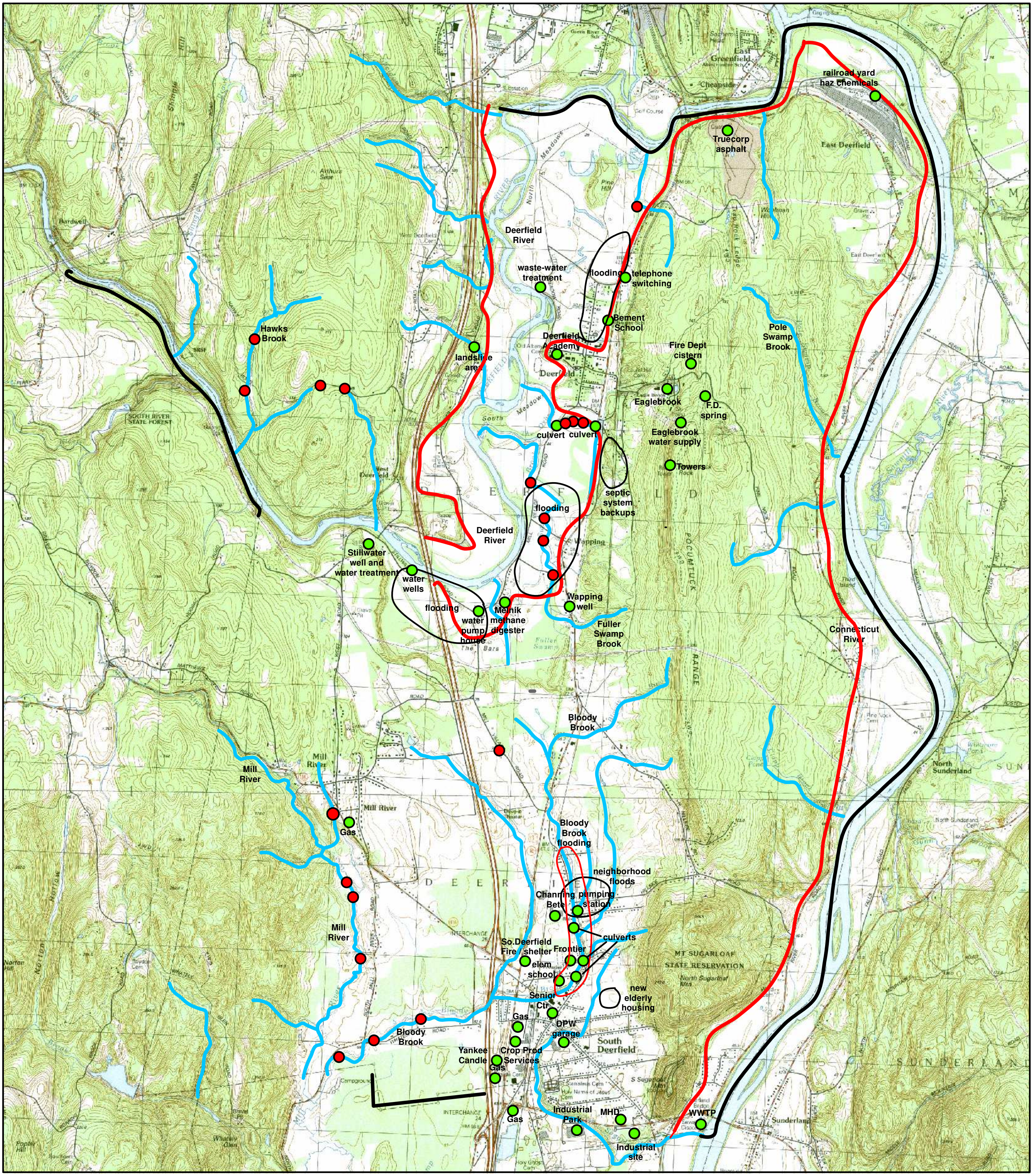
April 30, 2018

0 550 1,100 2,200 Feet



Franklin Regional Council of Governments

Sources: Map produced by the Franklin Regional Council of Governments Planning Department. GIS data sources include MassDOT, MassGIS and FRCOG. Depicted boundaries are approximate and are intended for planning purposes only, not to be used for survey.



Deerfield Community Resilience/Vulnerability Points

- Streams & Rivers
- Approximate 100-year FEMA Flood Plain Boundary
- Facilities & Vulnerability Points
- Beaver dams
- DEP Wetlands

0 1,500 3,000 6,000 9,000 12,000 Feet

N S E W

Ortho Photo from Mass GIS 2014

Conservation Works - January 2018

3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

The following section includes a summary of disasters that have affected or could affect Deerfield. 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 Deerfield. The table below illustrates a comparison between the relevant hazards in the State plan and in Deerfield's plan.

Table 3-1: Comparison of Hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Deerfield Hazard Mitigation Plan, and Deerfield MVP Resiliency Plan

Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	Town of Deerfield Relevance	MVP Resiliency Plan Top Priority Hazard
 Inland Flooding	YES	Flooding/ Dam Failure
 Drought	YES	No
 Landslide	YES	No
 Coastal Flooding	NO	No
 Coastal Erosion	NO	No

Table 3-1: Comparison of Hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Deerfield Hazard Mitigation Plan, and Deerfield MVP Resiliency Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Deerfield Relevance**	**MVP Resiliency Plan Top Priority Hazard**
 Tsunami	NO	No
 Average/Extreme Temperatures	YES	No
 Wildfires	YES	No
 Invasive Species	YES	No
 Hurricanes/Tropical Storms	YES	Hurricanes/ Tropical Storms
 Severe Winter Storm	YES	Severe Winter Storms/ Ice Storms
 Tornadoes	YES	Tornados/Windstorms
 Other Severe Weather	YES	No

Table 3-1: Comparison of Hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Deerfield Hazard Mitigation Plan, and Deerfield MVP Resiliency Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Deerfield Relevance**	**MVP Resiliency Plan Top Priority Hazard**
 Earthquake	YES	No

3.1 NATURAL HAZARD RISK ASSESSMENT METHODOLOGY

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

Hazard Description

The natural hazards identified for Deerfield are: severe winter storms, flooding (including dam failure), hurricanes/tropical storms, severe thunderstorms/tornados/microbursts, earthquakes, landslides, average/extreme temperatures, drought, and wildfire. Many of these hazards result in similar impacts to a community. For example, hurricanes, tornados and severe snowstorms may cause wind-related damage.

Location

Location refers to the geographic areas within the planning area that are affected by the hazard. Some hazards affect the entire planning area universally, while others apply to a specific portion, 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, state-wide, 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

The ranking is qualitative and is based, in part, on local knowledge of past experiences with each type of hazard, review of available data, and the work of the Committee. 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. The highlighted hazards in Table 3-5 were ones identified as priorities in the 2018 Deerfield Community Resilience Building (CRB) workshop. Participants identified four top priority hazards for the town, including:

- tornados and windstorms;
- hurricanes and tropical storms;
- floods and dam failures; and,
- severe winter storm and ice storms.

Table 3-5: Deerfield Hazard Identification and Risk Analysis

Type of Hazard	Location of Occurrence	Probability of Future Events	Impact	Overall Hazard Vulnerability Rating
Severe Winter Storms	Large	Very High	Limited but Critical for ice storms	1
Flooding	Medium	Very High	Critical	1
Tornadoes	Isolated	Moderate	Critical	3
Dam Failure	Medium	Very Low	Catastrophic	3

Table 3-5: Deerfield Hazard Identification and Risk Analysis				
Type of Hazard	**Location of Occurrence**	**Probability of Future Events**	**Impact**	**Overall Hazard Vulnerability Rating**
Hurricanes / Tropical Storms	Large	Moderate	Critical	2
Severe Thunderstorms / Wind / Microbursts	Medium	Very High	Critical	1
Extreme Temperatures	Large	Very High	Critical	1
Earthquakes	Large	Very Low	Catastrophic	3
Landslides	Isolated	High	Limited	2
Drought	Large	Moderate	Critical	2
Wildfires	Medium	Very Low	Minor	3
Invasive Species	Large	Very High	Critical	1

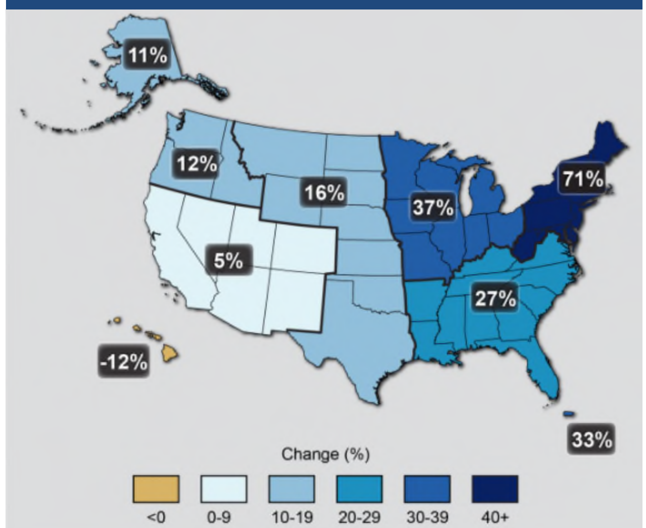
The Committee developed problem statements and/or a list of key issues for each hazard to summarize the vulnerability of Deerfield's structures, systems, populations and other community assets identified as vulnerable to damage and loss from a hazard event. These problem statements were used to identify the Town's greatest vulnerabilities that will be addressed in the mitigation strategy (Section 4).

3.2 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.

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.*

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 resilientMA website contains down-scaled climate data for Franklin County (discussed in Section 2) and for the Deerfield River and Connecticut River Watersheds, which include the Town of Deerfield. Observed annual precipitation over the last several decades (1970-2005) is approximately 47 inches. By 2050, the model predicts that 45 inches per year would be the minimum annual precipitation; the mean (middle value of the model predictions) could be 52 inches/year with a maximum of 66 inches per year. In general, precipitation projections are more uncertain than temperature projections. [14]

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

[14] http://resilientma.org/datagrapher/?c=Temp/basin/pcpn/ANN/Deerfield/

progresses. Figure 3-2 shows potential effects of climate change on flooding from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

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 some areas of Deerfield and across 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 as a result 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, 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 is 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.[15]

---

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

Urban Drainage Flooding

Urban drainage flooding entails floods 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.

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 percent 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 percent 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 Deerfield’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 Deerfield, the 100-year floodplain covers about 2828 acres, or approximately 13% percent of the town, including an estimated 41 acres of developed residential land. Deerfield municipal water supply wells, under districts jurisdiction, are located close to rivers and need flood proofing. Both wastewater treatment plants serving the Town's two villages are located in the 100-year floodplain; the South Deerfield facility on the Connecticut River; and the Old Deerfield facility on the Deerfield River. Dams and flood control measures upstream on both the Deerfield and Connecticut Rivers may provide some level of protection to the town during high flow events. The following areas have been designated by FEMA as floodways in Deerfield:

- Deerfield River;
- Mill River;
- Bloody Brook; and
- Connecticut River.

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.

There are a number of feeder brooks in Deerfield, including Pole Swamp Brook, Clapp Brook, Fuller's Swamp Brook, Hawks Brook, Shingle Brook, and Bloody Brook, which have the potential to cause localized and / or chronic flooding. Key areas of concern include the Deerfield River, Mill River, Bloody Brook, and the Connecticut River.

Bloody Brook[16]

Bloody Brook flows through the center of South Deerfield along North Main Street and flows through numerous undersized culverts along its length, including Kelleher Drive. Flooding is a frequent problem after storm events in many homes along North Main Street. There are a series of under-sized private driveway culverts along North Main Street that create flooding for the homes in this area, notably the culverts at 124 and 130 North Main Street. It will be important to replace these culverts with larger culverts to alleviate this flooding problem and improve flow in Bloody Brook. However, funding for replacement of culverts on private lands may be difficult to come by.

There is a Bloody Brook culvert at the Amtrak rail line near Conway Street, formerly owned by PanAm and now owned by the Commonwealth of Massachusetts, that is also problematic. In previous years, PanAm raised this culvert about 6", resulting in an increase in the static water level in Bloody Brook.

Bloody Brook has long been used as a neighborhood dumping ground for leaves and other debris. The town would like to undertake a geomorphologic study of the brook, and a more comprehensive, neighborhood-wide clean-out of debris and other materials blocking flow in Bloody Brook. Since much of the brook flows through private property, this clean-up may only be possible through a homeowner collective effort of property owners, or through the adoption of a Mosquito Control District. Residents have also suggested increasing the flood storage capacity of Bloody Brook, through increasing stream meanders, stabilizing banks, reducing silt filling and reducing dumping.

Bloody Brook is of concern for chronic flooding due to beaver dams located downstream in Whately that back up into the heavily populated section of South Deerfield. Bloody Brook is also a FEMA-designated floodway in Deerfield.

Ice Jams

The Deerfield River is one of several rivers in Franklin County in which ice jams have occurred with varying frequency. Historically, three ice jam occurrences have been documented on the

[16] Municipal Vulnerability Preparedness for Deerfield: Summary of Findings. Conservation Works, LLC, 2018.

Deerfield River, in 1947, 1957, and 1959. According to the Committee, the Stillwater Bridge has been weakened from ice and debris causing erosion around bridge abutments in recent years. MassDOT has completed emergency repairs and the structure is on the 2023 Transportation Improvement Program (TIP) for a full bridge repair/preservation project.

Town Roads, Bridges and Culverts

Major and ongoing flooding events, especially in the past decade, have caused severe erosion on waterways through the Town. Reduced riverbanks make roads more prone to flooding, which is a concern on Routes 5/10, Mill Village Road, and Stillwater Road. Culvert maintenance and replacements are needed in several locations throughout Deerfield. The Town's 2018 MVP plan identifies culverts at the following locations as high priority for replacement or repair:

- Mill Village Road (south of intersection with Log Plain Road)
- Kelleher Drive (at the North Main Street intersection)
- Route 5 (near Richardson's Candy Kitchen)
- Wapping Road (north of Greenough Crossing Road)
- Broughams Pond Road (west of intersection with Old Ferry Road)
- Captain Lathrop Drive
- Private culverts along North Main Street and Bloody Brook

The Mill Village Road culvert on an unnamed tributary stream to the Deerfield River has been Deerfield's top priority for replacement. This culvert's headwall has partially collapsed, and Town has responded by putting in a temporary relief culvert and closing down one lane of Mill Village Road. This culvert is 15' in diameter and 22' long. In heavy rains, this culvert backs up and floods not only Mill Village Road, but also Route 5.

Deerfield was awarded MVP Action Grant funding in FY18 and FY19 to prepare design and construction documents for a new open bottom culvert on Mill Village Road. This replacement culvert will improve flow and fish/wildlife passage, reduce flooding and protect public safety. It has been designed to promote climate resilience, and sized to reflect increased flood levels with climate change. It meets Massachusetts River and Stream Crossing Standards and is sized to accommodate the 100-year flood event. Typically culverts are designed to accommodate the 25-year design storm, but this capacity was added to compensate for potential future climate change. Construction should be completed in 2020.

Deerfield was recently awarded MVP Action Grant funding (FY2020) to construct an open bottom culvert on Kelleher Drive. Like the Mill Village Road replacement culvert, this one will also be designed to accommodate the 100-year flood event and improve fish/wildlife passage.

Deerfield also has several bridges that are vulnerable to flooding, and under-performing bridges are a focus of replacement and upgrade efforts.

Beaver Dams

Impoundments and landscape changes caused by beavers are occurring in town. Specific areas where beaver activity is known and/or having an impact include the Mill River, Fuller Swamp Brook, Hawks Brook, as well as Bloody Brook, mentioned previously. Regular monitoring of beaver dams and their condition is important for mitigating the risk of downstream flooding in case of failure.

Dam Failure

There are six major upstream dams with the potential to impact Deerfield by dam failure. On the Deerfield River, these include Somerset, Harriman, Sherman, Fife Brook, and Bear Swamp Dam. On the Connecticut River, a dam failure at Moore Dam is a concern because it would likely result in cascading dam failures at the eight additional dams still upstream of the Town.

Based on these locations, flooding has a "Medium" area of occurrence, with 10 to 50% percent 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 percent 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

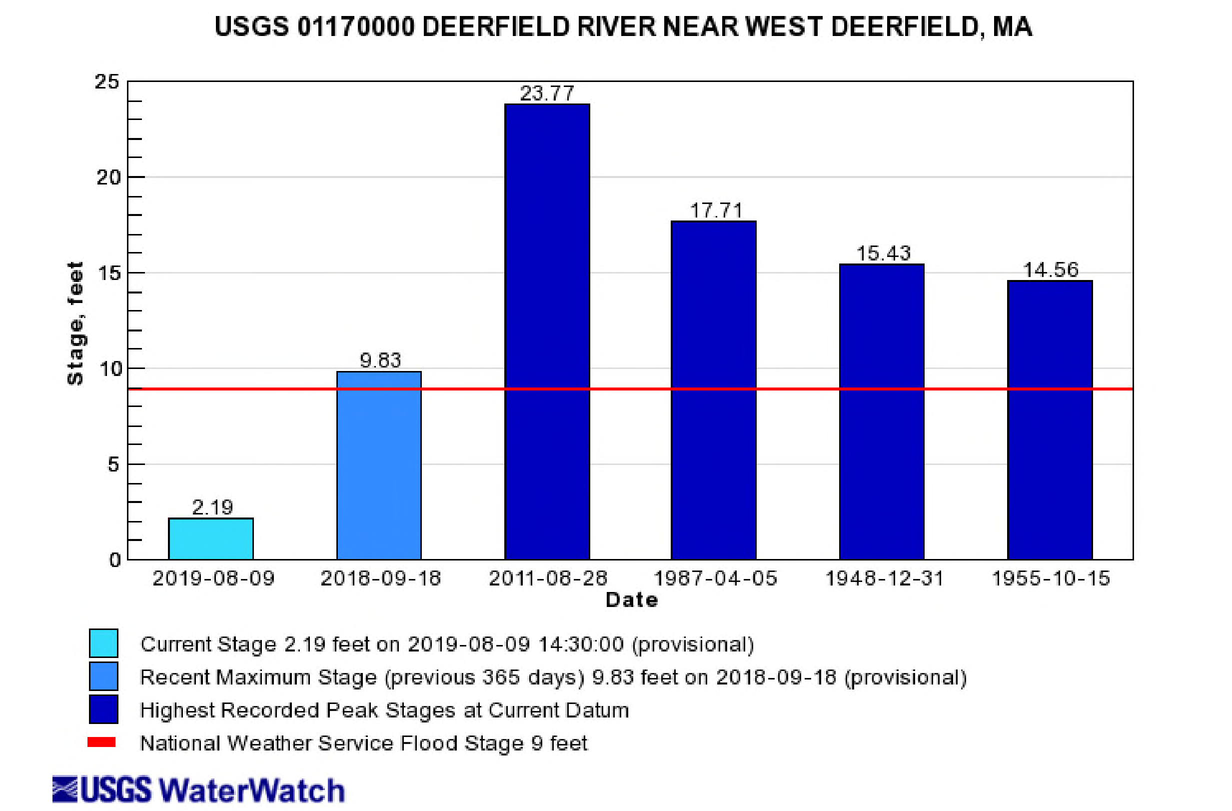
Flash floods are the product of heavy, localized precipitation in a short time period over a given location. Flash flooding events typically occur within minutes or hours after a period of heavy precipitation, after a dam or levee failure, or from a sudden release of water from an ice jam. Most often,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

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 Deerfield River in Deerfield, as well as the highest flow event in the last 365 days.

Figure 3-3: Highest Recorded Flood Events on the Deerfield River Near West Deerfield, MA



Source: USGS WaterWatch https://waterwatch.usgs.gov/?id=wwchart_ftc&site_no=01170000.

The 100-Year Flood

The 100-year flood is the flood that has a 1 percent 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 percent 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 is a convenient tool for assessing 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 percent 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 percent chance of being equaled or exceeded each year. Flood insurance purchases are not required by the Federal Government 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 of hazardous material tanks and the dislodging of hazardous waste containers can occur during floods as well, releasing untreated wastewater or hazardous materials directly into storm sewers, rivers, or the ocean. Flooding can also impact public water supplies and the power grid.

Previous Occurrences

The average annual precipitation for Deerfield and surrounding areas in western Massachusetts is 48 inches. Between 1996 and 2017, 17 flash floods have been reported in Franklin County (Table 3-6), resulting in $3,245,000 in property damages. In Deerfield, on July 23, 2013, heavy rains flooded the parking lots near Deerfield Academy Health Center and inundated several parked cars causing $50,000 in damages. The same storm, which dropped an estimated 3.54” of rain on Deerfield, lifted 2 manholes covers due to water pressure in the storm sewer and flooded a section of Deerfield Street in Greenfield with sewer overflow.[17] Additional heavy rain and flash flood events have impacted Deerfield in recent years, including one on August 13,

[17] Unofficial rainfall totals and storm damage reports, NWS Skywarn, Taunton, MA.

2014, which caused several road closures due to flooding in Deerfield, Greenfield, and Gill, and one on August 11, 2015, in which Greenfield Road was flooded at Old Main Street. No property damages were reported due to those two floods.

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	$0
1998	1	$75,000	$0
2000	1	$0	$0
2003	1	$10,000	$0
2004	1	$10,000	$0
2005	3	$1,235,000	$0
2013	3	$65,000	$0
2014	2	$50,000	$0
2017	1	$0	$0
Total	**17**	**$3,245,000**	**$0**

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

From 1996 to 2018, 44 flood events were reported in Franklin County, resulting in total property damages worth $25,582,000 (Table 3-7). The bulk of these damages ($22,275,000) were from Tropical Storm Irene in August, 2011, which resulted in 274 landslides across the watershed and reportedly caused the most severe erosion of any flood in Massachusetts historical records. The USDA Natural Resources Conservation Service (NRCS) recorded approximately 800 acres of crop loss or damages across the watershed, and almost 2/3 of that (500 acres) was in Deerfield.

Table 3-7: Previous Occurrences of Floods in Franklin County			
Year	**# of Flood Events**	**Annual Property Damage**	**Annual Crop Damage**
1996	7	$0	$0
1998	3	$0	$0
2001	1	$0	$0
2004	1	$0	$0
2005	2	$2,600,000	$0
2007	1	$250,000	$0
2008	3	$38,000	$0

Table 3-7: Previous Occurrences of Floods in Franklin County			
Year	**# of Flood Events**	**Annual Property Damage**	**Annual Crop Damage**
2010	1	$150,000	$0
2011	8	$22,375,000	$0
2012	2	$0	$0
2015	10	$31,000	$0
2017	1	$1,000	$0
2018	4	$137,000	$0
Total	**44**	**$25,582,000**	**$0**

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

Table 3-8 is an inventory of seven flood events with significant impacts to Deerfield. This information was taken from NOAA data that is current through 2018, or provided by the Committee. Event details describe extensive street flooding and impassability, road washouts, and property damage.

Table 3-8: Flooding Events in Deerfield since 1993			
Date	**Location**	**Type**	**Recorded Property Damages**
11/12/1995	Deerfield	Flash Flood	The Deerfield River exceeded flood stage for several hours rising to 28 feet. Flood stage is 25 feet.
6/8/1996	Deerfield	Flash Flood	Heavy rain accompanied thunderstorms in Franklin and Hampden Counties and roads were reported flooded in Erving, Deerfield, and Northfield.
6/13/1996	Deerfield	Flash Flood	Thunderstorms brought torrential rain and gusty winds to several towns in western and central Franklin County. There were many reports of trees and power lines blown down in Ashfield, Deerfield, Greenfield, and Whately.
8/13/2014	Deerfield	Flash Flood	Heavy rain caused several road closures due to flooding in Deerfield, Greenfield, and Gill.
8/11/2015	Deerfield	Flash Flood	Greenfield Road flooded at Old Main Street.
October 2005*	Deerfield	Flood	Lower/Jones Cross Roads
August 2011*	Deerfield	Flood from Tropical Storm Irene	Old Deerfield, Routes 5/10; Mill Village Rd., Stillwater Bridge, Route 91 bridge over Deerfield River; farms along Deerfield River.
8/11/15	Deerfield	Flood	Greenfield Road was flooded at Old Main Street

Source: https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=598442
*Signifies Committee Input

The Town of Deerfield has been severely impacted by major flood events (see Table 3-8).

Chronic flooding is also a problem at a number of feeder brooks in town and occurs most often at Bloody Brook. The two culverts located under Route 5 and Wapping Road also frequently flood, in part due to a partially filled in wetland system that backs up flow through the culverts.


Flooding on Wapping Road in Deerfield. Photo Source: Municpial Vulnerability Prepardness Plan for Deerfield.

Erosion on waterways has lowered riparian buffers and farm fields by approximately 6 feet in some locations, rendering adjacent farmlands, roads, houses and other infrastructure vulnerable to future floods, including Routes 5/10, Mill Village Road, and Stillwater Road. A number of flooding-related problems are affecting municipal infrastructure, including the previously mentioned culvert on Mill Village Road North and the culvert on Broughams Pond Road. The FRCOG completed a risk assessment of culverts and bridges in Deerfield; a complete list of high risk structures are included within the final report published in September 2018.[18]

Probability of Future Events

Based on previous occurrences, the frequency of occurrence of flooding events in Deerfield is "Very High" with a 50 to 100 percent probability in any given year. Flooding frequencies for the various floodplains in Deerfield are defined by FEMA as the following:

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

[18] High Risk Stream Crossings in Deerfield, MA: A Resource for Assessing Risk and Improving Resiliency. Franklin Regional Council of Governments, 2018.

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 Massachusetts may climb from less than 1 day per year to approximately 0.9-1.5 days by 2100. Events which release over one inch during a day could climb to as high as 8-11 days per year by 2100. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure. While the coastal areas in Massachusetts will experience the greatest increase in high-intensity rainfall days, some level of increase will occur in every area of Massachusetts, including Deerfield[19].

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
- 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 could be “Critical” in Deerfield, with more than 25% 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.

[19] ResilientMA: Climate Change Clearing House for the Commonwealth: http://resilientma.org/changes/changes-in-precipitation. Accessed December 13, 2018.

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 Deerfield's total acreage, 2,827 acres lie within the 100-year floodplain. According to 2005 MassGIS Land Use data there are 24 dwellings located in the floodplain (Table 3-9). Using this number and Deerfield's estimated average household size, it is estimated that 57 people, or 1% of Deerfield's total population, reside in the floodplain.

Table 3-9: Estimated Deerfield Population Exposed to a 1 Percent 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
5,049	24	2.37	57	1.1%

Source: 2013-2017 American Community Survey Five-Year Estimates; 2005 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 or not 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 3-10 estimates the number of vulnerable populations and households in Deerfield. 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 Deerfield residents during a flood event.

Table 3-10: Estimated Vulnerable Populations in Deerfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%
Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011

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

Source: U.S. Census American Community Survey 2013-2017 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. Pelican Products, a Plastic fabrication company in the village of South Deerfield, is classified by the State as a Large Quantity Toxic User. The factory is located less than 600ft from Bloody Brook, which is a FEMA-designated floodway in Deerfield and prone to localized flooding. Both of Deerfield's wastewater treatment plants are located within 100-year floodplains. In addition, Interstate 91, Route 5/10, and Pan Am Rail System's Connecticut River Main Line and Freight Main Line travel on either side of the Deerfield River in the north of Town. Meanwhile, the railroads carry between six to ten trains daily, each train typically carrying goods such as plastic pellets, fertilizer, steel reinforcement rods and grain. On the Connecticut River Line an average of two cars per train carry hazardous wastes, while at the Rail Yard and average of between two to five cars per train carry hazardous wastes. Each hour, as many as ten trucks carry hazardous materials through Deerfield on I-91 and/or Route 5/10. Populations living within close proximity to these facilities, roads, railroads, and the East Deerfield Rail Yard are at higher risk of a hazardous material spill. Vulnerability and risk assessment of hazardous material spills in Deerfield are discussed in more detail in the Other Hazards section of this plan.

<u>Health Impacts</u>

The total number of injuries and casualties resulting from typical riverine flooding is generally limited due 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 Deerfield. 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 powerlines, 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 Deerfield 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 percent 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. Nearly five acres of commercial land and more than eight acres of public/institutional land uses lie within the floodplain in Deerfield, accounting for only 0.13 percent of commercial land uses in town and 3.5 percent of public/institutional uses in town. Less than two tenths of an acre of industrial land use is located in the floodplain, accounting for one tenth of a percent of the industrial land in town.

Table 3-11: Acres of Commercial, Industrial, and Public/Institutional Land Use Within the Flood Hazard Area in Deerfield			
Land Use	**Total acres in Town**	**Acres in Flood Hazard Area**	**% of total acres in Flood Hazard Area**
Commercial	3683.54	4.91	0.13%
Industrial	167.23	0.16	.1%
Public/Institutional	232.94	8.09	3.5%

Source: 2005 MassGIS Land Use data.

The total building value (Table 3-12) is presented as a percentage of the replacement value of the building (the assessed value of the structure) based on the class of structure. The percentages vary for certain classes because the replacement cost of the contents is different from institution to business to service. Historic Deerfield falls under the religion/non-profit category, the public and private schools are in the education schools/libraries category, while the wastewater treatment plants are considered a government general service, all of which use 100% as the percentage of building replacement value used to estimate the value of the contents. The estimated combined total building value for all significant structures in Deerfield's flood hazard area is $301,793,280, as shown in Table 3-12.

Table 3-12: Total Building Value in Flood Hazard Area			
Structure	**Building Structure Value**	**Building Contents Value**	**Total Building Value**
Bement School	$7,654,900	$7,654,900	$15,309,800
Deerfield Academy	$101,093,540	$101,093,540	$202,187,080
Frontier Regional School	$18,640,000	$18,640,000	$37,280,000
Historic Deerfield	$19,903,200	$19,903,200	$39,806,400
Old Deerfield Waste Water Treatment Plant	$689,100	$689,100	$1,378,200
South Deerfield Waste Water Treatment Plant	$2,915,900	$2,915,900	$5,831,800
Total	**$150,896,640**	**$150,896,640**	**$301,793,280**

Source: 2011 Assessors data from Deerfield Assessor's Office web page link to the property information database at http://deerfield.patriotproperties.com/default.asp. Building structure values represent the total value of all properties, both developed and undeveloped, that are owned by the named entity, not just those buildings specifically identified as being located within the floodplain.

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 Deerfield 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). Deerfield currently has twenty eight policies in force, eight losses have been paid, and there is one repetitive loss property in town.

On May 1, 2020, after discussions with MEMA and FEMA Region 1 staff, Deerfield filed a signed Information Sharing Access Agreement (ISAA) with FEMA Region 1 to request additional information on the RL property to further inform future mitigation strategies and actions that may be undertaken by the Town. The ISAA must be executed by FEMA Headquarters and then the information will be released to the Town. Once received, Deerfield will update this Plan, as appropriate.

Table 3-13: NFIP Policies, Claims, and Repetitive Loss Statistics for Deerfield

Number of Housing Units (2017 Estimates)	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
2173	28	1.3%	$7,563,500	8	$96,379	1

Source: National Flood Insurance Program (NFIP), FEMA Region I; U.S. Census Bureau 2013-2017 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 impact 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 also 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 impact 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.

Water Infrastructure

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.

Vulnerability Summary

Based on the above analysis, Deerfield has a "High" vulnerability to flooding. The following problem statements summarize Deerfield's areas of greatest concern regarding the flood hazard.

Flood Hazard Problem Statements
• Ice jams have occurred historically on the Deerfield River and present a potential flood risk.
• FEMA floodplain maps are critically important to successful mitigation but are outdated. FEMA is currently updating maps and when the project is complete, the Town will have access to digital floodplain mapping, which will help in the permitting of new construction and floodproofing in areas such as the Bloody Brook watershed, which is impacted by chronic flooding.
• While the chance is low, a catastrophic dam failure at the one of the major hydroelectric dams on the Connecticut or Deerfield Rivers upstream of the Town would result in devastating flooding to many parts of Deerfield. There are six major dams of concern on the Deerfield River, including Harriman Dam, where a failure would result in floodwaters reaching Deerfield in 4 hours. Moore Dam is of concern on the Connecticut River.
• Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning. Evacuations would be needed at Deerfield Academy and Bement School, and roads would be inundated if large upstream dams on the Deerfield River were to fail. Evacuation planning, improved communication, and notification protocols with Great Hydro relating to upstream Deerfield River Dams are of particular concern.
• The Town needs more current and robust evacuation plans and a central communication system on road flooding. Flood-prone roads include Route 5/10, Mill Village Road, and Wapping Road. If Routes 5/10 are closed due to flooding, Deerfield loses an important north-south evacuation route.
• Severe flood events, including TS Irene, as well as ongoing flooding have significantly eroded riverbanks and degraded riparian habitat on the Deerfield River, Connecticut River, and Bloody Brook. Adjacent roads, farms, homes and businesses throughout the Town are more vulnerable to future flooding. Compromised riverbanks are in need of restoration and reinforcement, and flood-prone roadways may need to be raised.

Flood Hazard Problem Statements
• More needs to be done to protect flood storage areas in Deerfield's flood zone. Floodplain zoning needs improvement and land conservation is needed, especially in the north and south meadows of Old Deerfield, along the Deerfield River in west Deerfield, and in farmed areas within the Bloody Brook watershed.
• There is a need to promote farm practices, such as no till agriculture, that limit the risk of phosphorous and nitrogen fertilizer carried by heavy precipitation or flood waters entering the river.
• High risk culverts need to be replaced. Culvert replacements have been prioritized at four locations: Route 5/10, Wapping Road, Broughams Pond Road, and Mill Village Road, and Kelleher Drive
• Silt and flood debris is affecting facilities and drainage ditches in many areas of town, contributing to poor drainage, and providing habitat for mosquitos. During Summer 2019, Massachusetts Department of Public Health detected West Nile Virus positive mosquitoes in Deerfield for the seventh year.
• Stillwater Bridge has been weakened from ice and debris causing erosion around bridge abutments in recent years and is vulnerable to on-going flood damages. Emergency repairs have been made and the bridge is on the 2023 TIP.
• Deerfield's public drinking water and wastewater treatment facilities could benefit from bank stabilization and site armament, and installation and flood proofing of emergency generators. The tank sides should be raised in Old Deerfield; the tanks in South Deerfield are being raised.
• The Stillwater well is located near the Deerfield River and is vulnerable to flooding and fluvial erosion hazards. The pump house needs an emergency generator.
• Beaver activity on Bloody Brook in Whately is causing water to backup and contribute to localized flooding in the village of South Deerfield where residential settlement, municipal buildings, facilities, and infrastructure are located. Other beaver dams and beaver activity in Town need to be identified and evaluated for risk.
• The Deerfield Town Hall is adjacent to Bloody Brook, which is prone to localized flooding.
• Deerfield has in a new Emergency Communications Network (smart911) to deliver Emergency Notification Messages. There is a need to expand this system to include more residents, businesses and more cell numbers.
• New programming is needed to promote and increase household disaster preparedness town wide. Deerfield Operation Neighborhood should be reactivated.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and

Flood Hazard Problem Statements
transient people in town may be difficult to reach in the event of an emergency.
• Vulnerable neighborhoods, including Old Deerfield and Bloody Brook, have a greater need for flood warnings and flood prevention. Old Deerfield village experiences periodic flooding when the Deerfield River overflows.
• Options should be assessed for reconnecting the Deerfield River to its natural floodplain.
• Watershed-scale projects are needed in order to protect blocks of forested land in upstream towns.
• A Fluvial Geomorphic Assessment should be done for the Bloody Brook watershed to identify climate resilient and NBS projects to mitigate flooding and fluvial erosion hazards.
• Options for relocating structures in floodplains that have been subject to repeated flooding should be assessed.

3.3 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 ice storms, nor'easters, heavy snow, blowing 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
- Elderly are affected by extreme weather

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 Deerfield 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 percent 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

Table 3-15: Northeast Snowfall Impact Scale Categories		
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, there have been 80 heavy snow events in Franklin County since 1996, resulting in $15,440,000 in damages; 29 winter storm events since 2002, resulting in $1,170,000 in damages; and two ice storms have resulted in damages of $3,150,000.

In 2018, New England was hit by three Nor'easters within the first two weeks of March. The first was Winter Storm Riley which brought damaging winds, heavy snow and coastal flooding. Then, Winter Storm Quinn dumped heavy snow, taking down more trees and causing additional power outages on top of those caused by Riley. The third Nor'easter, called Winter Storm Skylar, occurred on March 11-13 and brought over a foot of snow in Massachusetts. With severe winter storms occurring soon after each other, there is little time to recover from one storm before needing to brace for the next. Utility companies may have to work for weeks or months to restore power after mounting failures, leaving some customers without power for extended time periods. Snow storage and disposal becomes more challenging and expensive when designated snow storage areas fill up, forcing municipalities to pay for snow removal and hauling.

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. Deerfield did not suffer as devastating a blow from this ice storm as some of its neighboring Franklin County towns at higher elevations and the impact was not widespread throughout. 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 210 winter storms since 1900 that have registered on the RSI scale. Of these, approximately 18 storms resulted in snow falls in all or parts of Franklin County of at least 10 inches. These storms are listed in Table 3-16, in order of their RSI severity.

Table 3-16: High-Impact Snowstorms in Franklin County, 1958 - 2018			
Date	**RSI Value**	**RSI Category**	**RSI Classification**
2/22/1969	34.0	5	Extreme
3/12/1993	22.1	5	Extreme
1/6/1996	21.7	5	Extreme
2/5/1978	18.4	5	Extreme
2/23/2010	17.8	4	Crippling
2/15/2003	14.7	4	Crippling
1/29/1966	12.3	4	Crippling
3/12/2017	10.7	4	Crippling
2/27/1947	10.6	4	Crippling
12/25/1969	10.1	4	Crippling
12/4/2003	9.4	3	Major
2/8/2013	9.2	3	Major
2/2/1961	8.3	3	Major
2/10/1983	7.9	3	Major
2/14/1958	7.9	3	Major
2/12/2007	6.9	3	Major
3/2/1960	6.9	3	Major
1/25/2015	6.2	3	Major

Source: https://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts

Probability of Future Events

Based upon the availability of records for Franklin County, the likelihood that a severe snow storm will hit Deerfield in any given year is “Very High," or a 70 to 100 percent 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 a winter storm would be “Limited,” with more than 10 percent of property in the affected area damaged and complete shutdown of facilities for more than 1 day possible. However, based on past events, the Committee determined that the impact of an ice storm would be “Critical” with more than 25% of property in the affected area damaged.

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 Deerfield 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 Deerfield. 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 Deerfield residents during a severe winter storm event.

Table 3-17: Estimated Vulnerable Populations in Deerfield

Vulnerable Population Category	Number	Percent of Total Population*
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%

Table 3-17: Estimated Vulnerable Populations in Deerfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011

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

Source: U.S. Census American Community Survey 2013-2017 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.[20] 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 Deerfield is exposed to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames rather than building content. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and

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

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 Deerfield 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.[21] 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 in Deerfield

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$535,994,491	$5,359,945	$26,799,725	$53,599,449
Open Space	$0	$0	$0	$0
Commercial	$64,905,895	$649,059	$3,245,295	$6,490,590
Industrial	$76,277,914	$762,779	$3,813,896	$7,627,791
Total	**$677,178,300**	**$6,771,783**	**$33,858,915**	**$67,717,830**

[21] Resilient MA 2018

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

Agriculture

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, Deerfield faces a "High" vulnerability from severe snow storms and ice storms. The following problem statements summarize Deerfield's areas of greatest concern regarding severe winter storms.

Severe Winter Storms / Ice Storms Hazard Problem Statements
• Ice jams have occurred historically on the Deerfield River and present a potential flood risk. Risk of an ice jam may be exacerbated during severe winter storms/ice storms.
• The Town needs a central communication system on road flooding so that residents and emergency responders are not stranded. Flood-prone roads, such as Route 5/10, Mill Village Road, and Stillwater Road, could be affected by heavy precipitation from a severe winter storm or ice storm making them especially hazardous.
• High risk culverts need to be replaced. Culvert replacements have been prioritized at four locations: Route 5/10, Wapping Road, Broughams Pond Road, and Mill Village Road, and Kelleher Drive.
• Strategies for safeguarding power lines and utilities infrastructure on Route 5/10 and Old Main Street need to be identified and evaluated.
• Stillwater Bridge has been weakened from ice and debris causing erosion around bridge abutments in recent years and may be vulnerable to impacts from severe winter storms or ice storms. Emergency repairs have been done and the structure is on the 2023 TIP.

Severe Winter Storms / Ice Storms Hazard Problem Statements
• All of Deerfield's public drinking water supply and wastewater treatment facilities should be equipped with emergency generators in case of power outages.
• Although the Town has a new smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.
• Improved planning and coordination is needed to assess the potential for schools in Deerfield, including Bement, Eaglebrook and Deerfield Academy, to serve as shelters and emergency supplies stockpile locations in emergency situations.

3.4 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 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

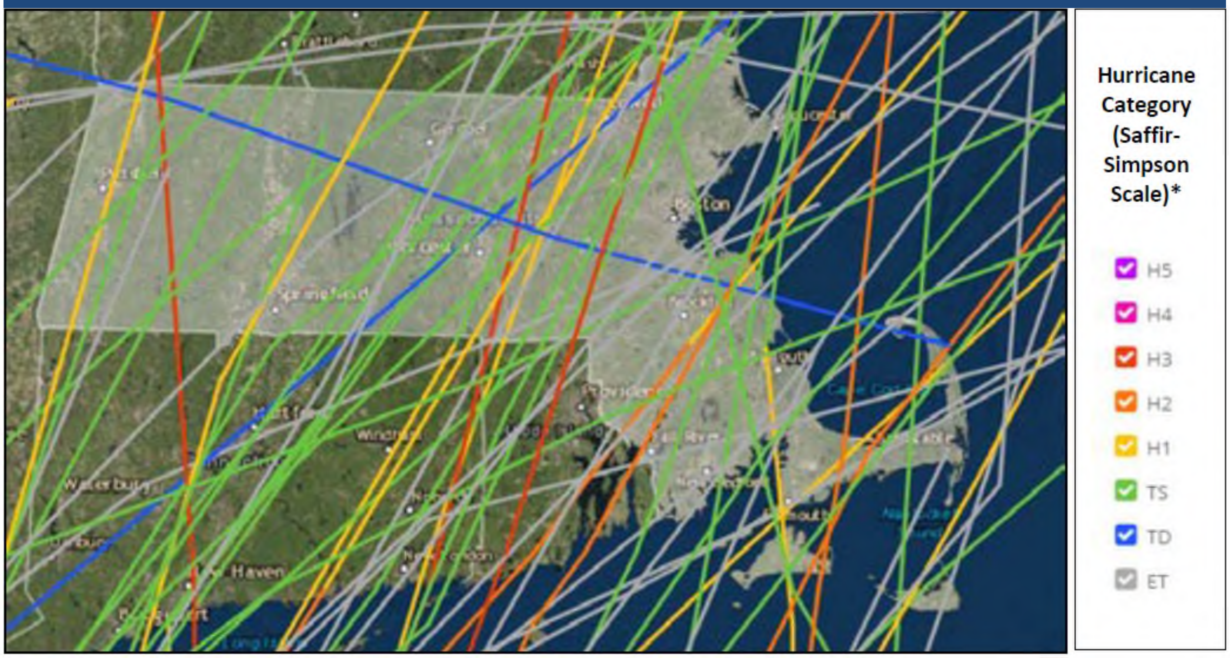
A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as a tropical storm versus a hurricane). Tropical storms strengthen when water evaporated 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 Deerfield is at risk from hurricanes and tropical storms, with a "Large" location of occurrence with over 50 percent 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.

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



Source: NOAA, n.d. * TS=Tropical Storm, TD=Tropical Depression

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 2017. According to this resource, over the time frame tracked, 63 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.

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, 63 hurricane or tropical storm events have occurred in the vicinity of Massachusetts between 1842 and 2016. The Commonwealth was impacted by tropical storms Jose and Phillipe in 2017. Therefore, there is an average of one storm every other 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. No hurricane has tracked directly through the Town of Deerfield.

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.[22]

Deerfield'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, Deerfield has a "Moderate" probability, or a 2% to 25% chance, of experiencing a hurricane or tropical storm event in a given year.

Impact

The Vulnerability Assessment revealed an occurrence could critically impact the Town, with potential multiple injuries to citizens possible and with a potential of more than 25% 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

<u>Vulnerable Populations</u>

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 Deerfield. Individuals and households may fall into multiple categories, so the numbers should not be

---

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

added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Deerfield residents during a hurricane or tropical storm event.

Table 3-20: Estimated Vulnerable Populations in Deerfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%
Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

<u>Health Impacts</u>

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.

<u>Economic Impacts</u>

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.[23]

Infrastructure

Hurricanes and tropical storms could critically impact the Town, with a potential of more than 25% 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.

Table 3-21: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$535,994,491	$5,359,945	$26,799,725	$53,599,449
Open Space	$0	$0	$0	$0
Commercial	$64,905,895	$649,059	$3,245,295	$6,490,590
Industrial	$76,277,914	$762,779	$3,813,896	$7,627,791
Total	**$677,178,300**	**$6,771,783**	**$33,858,915**	**$67,717,830**

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

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

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

patients.

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.[24]

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 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-

[24] Resilient MA 2018.

term population impacts on species in the area.

Vulnerability Summary

Based on the above analysis, Deerfield faces a "Medium" vulnerability from hurricanes and tropical storms. While historically there have been no Hurricane events in Deerfield, the Vulnerability Assessment revealed an occurrence could critically impact the Town, with potential multiple injuries to citizens possible and with a potential of more than 25% of property in affected area damaged or destroyed. The following problem statements summarize Deerfield's greatest areas of concern regarding hurricanes and tropical storms.

Hurricane/Tropical Storm Problem Statements
• FEMA floodplain maps are critically important to successful mitigation but are outdated. FEMA is currently updating maps and when the project is complete, the Town will have access to digital floodplain mapping, which will help in the permitting of new construction and floodproofing in areas such as the Bloody Brook watershed, which is impacted by chronic flooding.
• While the chance is low, a catastrophic dam failure at the one of the major hydroelectric dams on the Connecticut or Deerfield Rivers upstream of the Town would result in devastating flooding to many parts of Deerfield. There are six major dams of concern on the Deerfield River, including Harriman Dam, where a failure would result in floodwaters reaching Deerfield in 4 hours. Moore Dam is of concern on the Connecticut River.
• Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning. Evacuations would be needed at Deerfield Academy and Bement School, and roads would be inundated if large upstream dams on the Deerfield River were to fail. Evacuation planning, improved communication, and notification protocols with Great Hydro relating to upstream Deerfield River Dams are of particular concern.
• The Town needs more current and robust evacuation plans and a central communication system on road flooding. Flood-prone roads include Route 5/10, Mill Village Road, and Wapping Road. If Routes 5/10 are closed due to flooding, Deerfield loses an important north-south evacuation route.
• Severe flood events, including flooding from TS Irene, as well as ongoing flooding have significantly eroded riverbanks and degraded riparian habitat on the Deerfield River, Connecticut River, and Bloody Brook. Adjacent roads, farms, homes and businesses throughout the Town are more vulnerable to future flooding. Compromised riverbanks are in need of restoration and reinforcement, flood-prone roadways need to be raised.

Hurricane/Tropical Storm Problem Statements
• There is a need to restrict vehicles from driving to the Deerfield river and eroding riverbanks.
• More needs to be done to protect flood storage areas in Deerfield’s flood zone. Floodplain zoning needs improvement and land conservation is needed, especially in the north and south meadows of Old Deerfield, along the Deerfield River in west Deerfield, and in farmed areas within the Bloody Brook watershed.
• There is a need to promote farm practices, such as no till agriculture, that limit the risk of phosphorous and nitrogen fertilizer runoff carried by heavy precipitation into the river.
• There is a small, unnamed, privately owned dam in Town that needs removal.
• High risk culverts need to be replaced. Culvert replacements have been prioritized at four locations: Route 5&10, Wapping Road, Broughams Pond Road, and Mill Village Road.
• Silt and flood debris is affecting facilities and drainage ditches in many areas of town, contributing to poor drainage, and providing habitat for mosquitos. During Summer 2019, Massachusetts Department of Public Health has detected West Nile Virus positive mosquitoes in Deerfield for the seventh year.
• Strategies for safeguarding power lines and utilities infrastructure on Route 5/10 and Old Main Street need to be identified and evaluated.
• Stillwater Bridge has been weakened from ice and debris causing erosion around bridge abutments in recent years and is vulnerable to on-going flood damages. Emergency repairs have been made and the bridge is on the 2023 TIP.
• Deerfield’s public drinking water and wastewater treatment facilities could benefit from bank stabilization and site armament, and installation and flood proofing of emergency generators. The tank sides should be raised in Old Deerfield; the tanks in South Deerfield are being raised.
• The Stillwater well is located near the Deerfield River and is vulnerable to flooding and fluvial erosion hazards. The pump house needs an emergency generator.
• Beaver activity on Bloody Brook in Whately is causing water to backup and contribute to localized flooding in the village of South Deerfield where residential settlement, municipal buildings, facilities, and infrastructure are located. Other beaver dams and beaver activity in Town need to be identified and evaluated for risk.
• The Deerfield Town Hall is adjacent to Bloody Brook, which is prone to localized flooding.
• Deerfield has in a new Emergency Communications Network (smart911) to deliver Emergency Notification Messages. There is a need to expand this system to include more residents, businesses and more cell numbers.

Hurricane/Tropical Storm Problem Statements
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.
• Vulnerable neighborhoods, including Old Deerfield and Bloody Brook, and elderly housing have a greater need for flood warnings and flood prevention. Old Deerfield village experiences periodic flooding when the Deerfield River overflows.
• Improved planning and coordination is needed to assess the potential for schools in Deerfield, including Bement, Eaglebrook and Deerfield Academy to serve as shelters and emergency supplies stock points in emergency situations.
• Options for relocating structures in floodplains that have been subject to repeated flooding should be assessed.

3.5 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.[25]

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

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

across large areas is known as a "derecho." These occasionally occur in Massachusetts. Winds exceeding 100 mph have been measured from downbursts in Massachusetts.

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

The entire town of Deerfield is 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.

Deerfield 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

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

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).

Previous Occurrences

Since 1996, a total of 13 high wind events occurred in Franklin County (Table 3-22), causing a total of $288,000 in property damages. 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	2	$0	$0
1999	1	$0	$0
2003	2	$130,000	$0
2004	1	$30,000	$0
2005	1	$10,000	$0
2006	3	$68,000	$0
2011	1	$15,000	$0
2013	2	$35,000	$0
Total	**13**	**$288,000**	**$0**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

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. Deerfield has experienced fifteen thunderstorm wind events since 1994 (Table 3-23). These storms resulted in downed trees and wires and caused $144,000 in property damage.

Table 3-23: Thunderstorm Wind Events in Deerfield				
Year	**# of Thunderstorm Wind Events**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
2007	1	$0	$0	Trees were downed on Graves Road.
2010	1	$20,000	$0	Multiple trees were downed by thunderstorm winds.
2011	2	$20,000	$0	Trees were downed on Route 116, Route 5, and Hillside Road.
2012	1	$5,000	$0	A tree and wires on Lower Road were downed by thunderstorm winds.
2013	2	$20,000	$0	Two trees were downed in South Deerfield by thunderstorm winds. In the second event, trees and wires on Mill Village Road and Greenfield Road were downed.

Table 3-23: Thunderstorm Wind Events in Deerfield				
Year	**# of Thunderstorm Wind Events**	**Annual Property Damage**	**Annual Crop Damage**	**Event Description**
2015	4	$50,000	$0	Trees and wires were downed by thunderstorm winds. In one event Tree damage was observed on Hillside Road near the intersection of River Road and north of the Mount Sugarloaf State Reservation. Several tall pine trees were snapped off at the top and other large trees fell, taking down power lines. A gazebo was blown off its foundation in the backyard of a house.
2016	1	$5,000	$0	A tree was downed onto wires on Stillwater Road.
2017	2	$9,000	$0	Tree and wires down across Upper Road in Deerfield. Tree and wires down across Old Main Street. Multiple trees were reported down on wires on River Road in Deerfield.

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

Secondary hazards of thunderstorms and severe weather include lightning and hail. In Franklin County, 22 lightning events since 1997 caused a total of $835,500 in property damages (Table 3-24).

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
Total	**22**	**$835,500**	**$0**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

A total of 42 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
Total	**42**	**$5,000**	**$50,000**

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

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% - 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 Deerfield 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 Deerfield can experience the effect and impact from severe thunderstorms, microbursts, and hail. The magnitude of impact of a severe thunderstorm event is likely "Critical," with more than 25% of property in the affected area damaged or destroyed.

Vulnerability

Society

The entire population of Deerfield 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.

<u>Vulnerable Populations</u>

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 Deerfield. 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 Deerfield residents during a severe weather event.

Table 3-26: Estimated Vulnerable Populations in Deerfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%

Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011

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

Source: U.S. Census American Community Survey 2013-2017 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.[26] 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>

Wind storms 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

---

[26] 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

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.

Infrastructure

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,[27] 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. Deerfield 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.

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

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 3-27: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$535,994,491	$5,359,945	$26,799,725	$53,599,449
Open Space	$0	$0	$0	$0
Commercial	$64,905,895	$649,059	$3,245,295	$6,490,590
Industrial	$76,277,914	$762,779	$3,813,896	$7,627,791
Total	**$677,178,300**	**$6,771,783**	**$33,858,915**	**$67,717,830**

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.

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 impact 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 impact 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

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 as well as 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, Deerfield 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 Deerfield. 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. The following problem statements summarize Deerfield’s areas of greatest concern regarding severe thunderstorms and wind events.

Thunderstorms/Wind/Microbursts Hazard Problem Statements
• Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning.
• Strategies for safeguarding power lines and utilities infrastructure on Route 5/10 and Old Main Street need to be identified and evaluated. A tree management plan is needed along power lines.
• Town wells need emergency generators in case of power outages.
• Although the Town has a smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.
• Improved planning and coordination is needed to assess the potential for schools in Deerfield, including Bement, Eaglebrook and Deerfield Academy to serve as shelters and emergency supplies stock points in emergency situations.

3.6 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.

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

Hazard Description

A tornado is a narrow, violently rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The observable aspect of a tornado is the rotating column of water droplets, with dust and debris caught in the column. Tornadoes are the most violent of all atmospheric storms.

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.

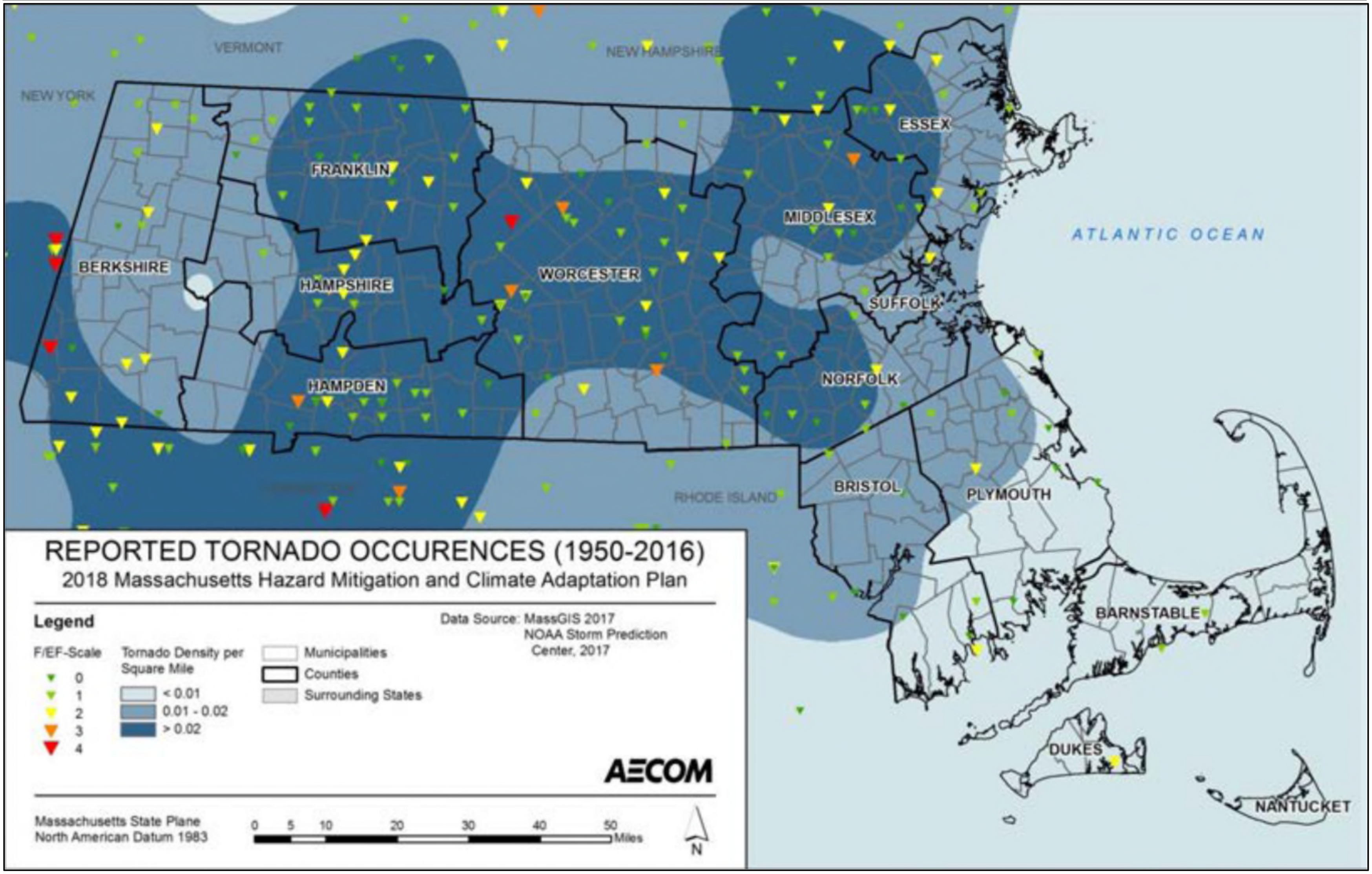
Location

Figure 3-10 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 Deerfield and much of Franklin County. Tornadoes are rated as having an Area of Occurrence of “Isloated.” If a tornado were to occur in Deerfield, it could impact 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 3-11 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. Trees were downed on Route 116 and Hillside Road. $15,000 in property damages was reported for Deerfield.

Since the 1950s, there have been over twenty tornadoes in Franklin County. In the last two decades, five tornadoes have been reported in Franklin County, in the towns of Heath, Charlemont, Wendell, New Salem, and Conway (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

Table 3-28: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
				50 to 100 yards. The tornado path ended in the Copeland Hills section of 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.

Source: NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/

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. Based on past occurrences, there is a “Low” probability (a 1-2% chance) 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 Deerfield, 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 25% of property in the affected area damaged or destroyed.

Vulnerability

Society

The entire town of Deerfield 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 1,006 housing units in Deerfield, or 46% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. Table 3-29 estimates the number of vulnerable populations and households in Deerfield. 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 Deerfield residents during a tornado event.

Table 3-29: Estimated Vulnerable Populations in Deerfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%
Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011

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

Source: U.S. Census American Community Survey 2013-2017 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 Deerfield 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 in Deerfield

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$535,994,491	$5,359,945	$26,799,725	$53,599,449
Open Space	$0	$0	$0	$0
Commercial	$64,905,895	$649,059	$3,245,295	$6,490,590
Industrial	$76,277,914	$762,779	$3,813,896	$7,627,791
Total	**$677,178,300**	**$6,771,783**	**$33,858,915**	**$67,717,830**

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 tornadoes.

Energy

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

Public Safety

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.

Transportation

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, Deerfield has a "Low" vulnerability to tornadoes. Tornadoes are not common occurrences in Deerfield, 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. The following problem statements summarize Deerfield's areas of greatest concern regarding tornadoes.

Tornado Hazard Problem Statements
• The Town needs more current and robust evacuation plans. Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning.
• Strategies for safeguarding power lines and utilities infrastructure on Route 5/10 and Old Main Street need to be identified and evaluated. Tree management is needed along power lines.
• Town wells need emergency generators in case of power outages.
• Although the Town has a smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.
• Improved planning and coordination is needed to assess the potential for schools in Deerfield, including Bement, Eaglebrook and Deerfield Academy to serve as shelters and emergency supplies stock points in emergency situations.

3.7 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.[28] Another study found that the frequency of lightning strikes—an occasional cause of wildfires—could increase by approximately 12 percent for every degree Celsius of warming.[29] 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

[28] 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

[29] 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

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 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.[30]

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.

---

[30] "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*.

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.

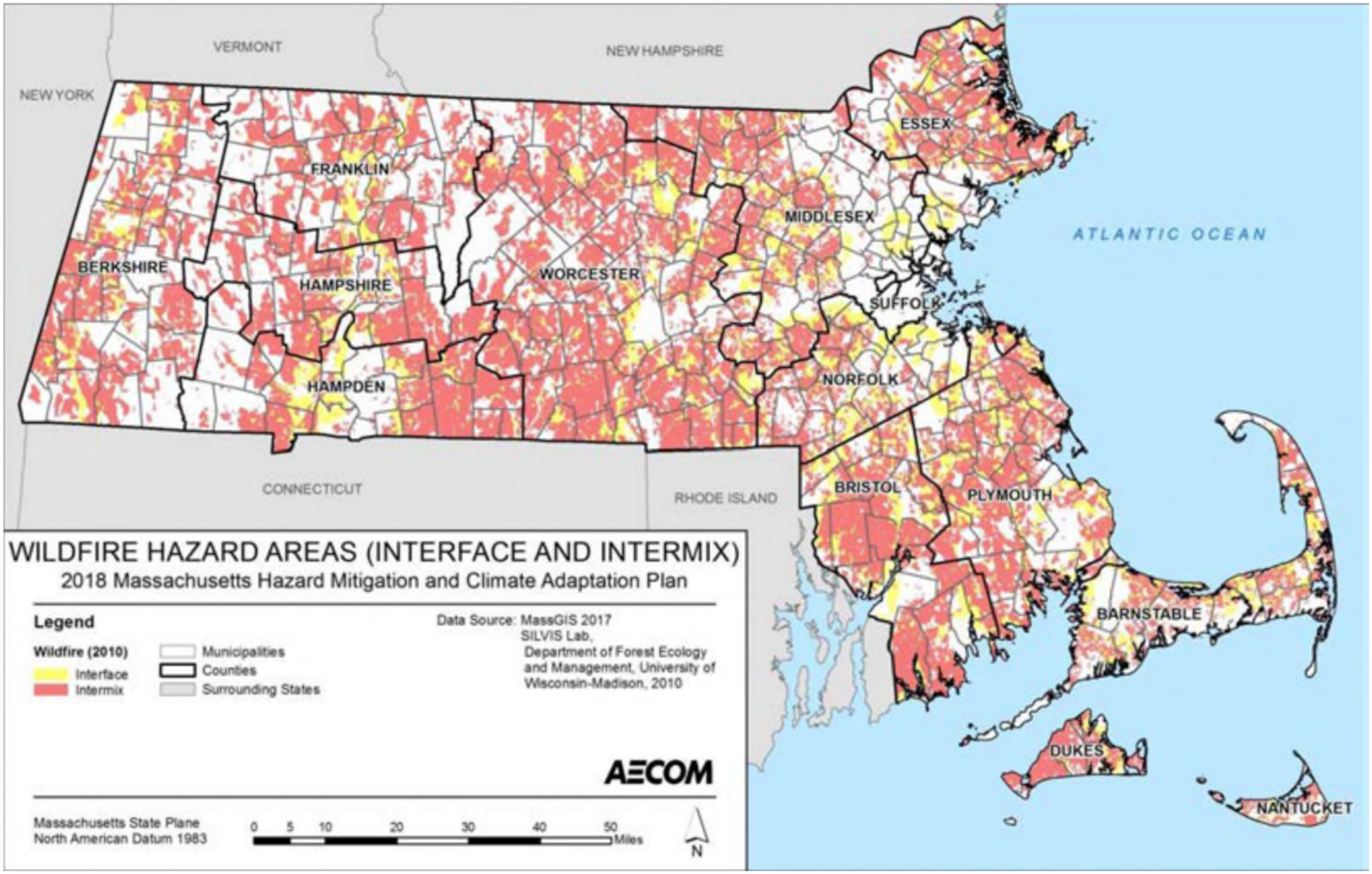
Location

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 percent vegetation and has a housing density greater than one house per 16 hectares (approximately 6.5 acres). Interface communities are defined as those in the vicinity of contiguous vegetation, with more than one house per 40 acres and less than 50 percent vegetation, and within 1.5 miles of an area of more than 500 hectares (approximately 202 acres) that is more than 75 percent vegetated. 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. Deerfield 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. Deerfield mostly falls within the "High" wildfire risk area. The entire town of Deerfield, which is approximately 64% forested, is at risk for wildfire.

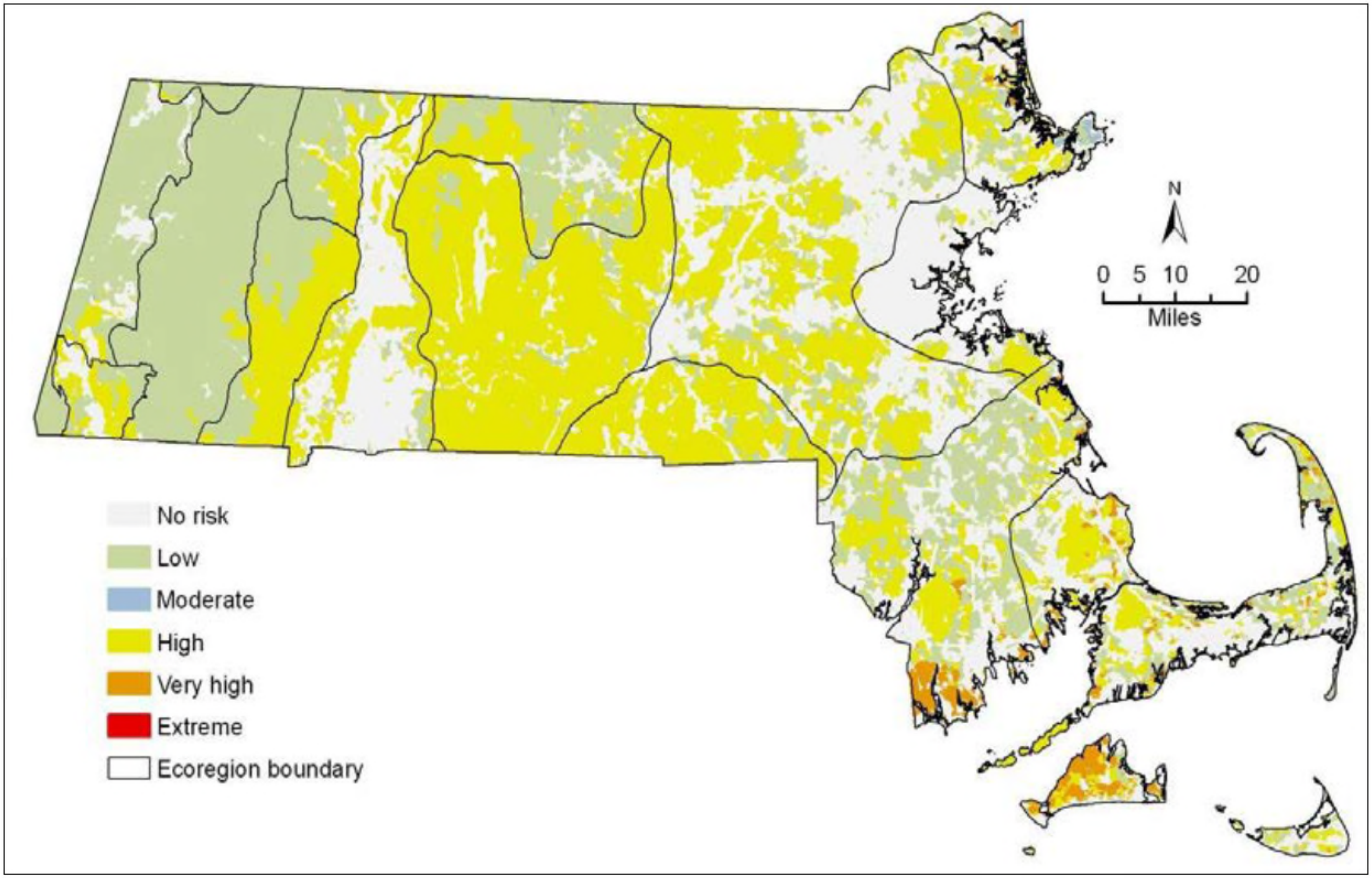
Early detection of wildfires is a key part of the Bureau's overall effort. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols 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



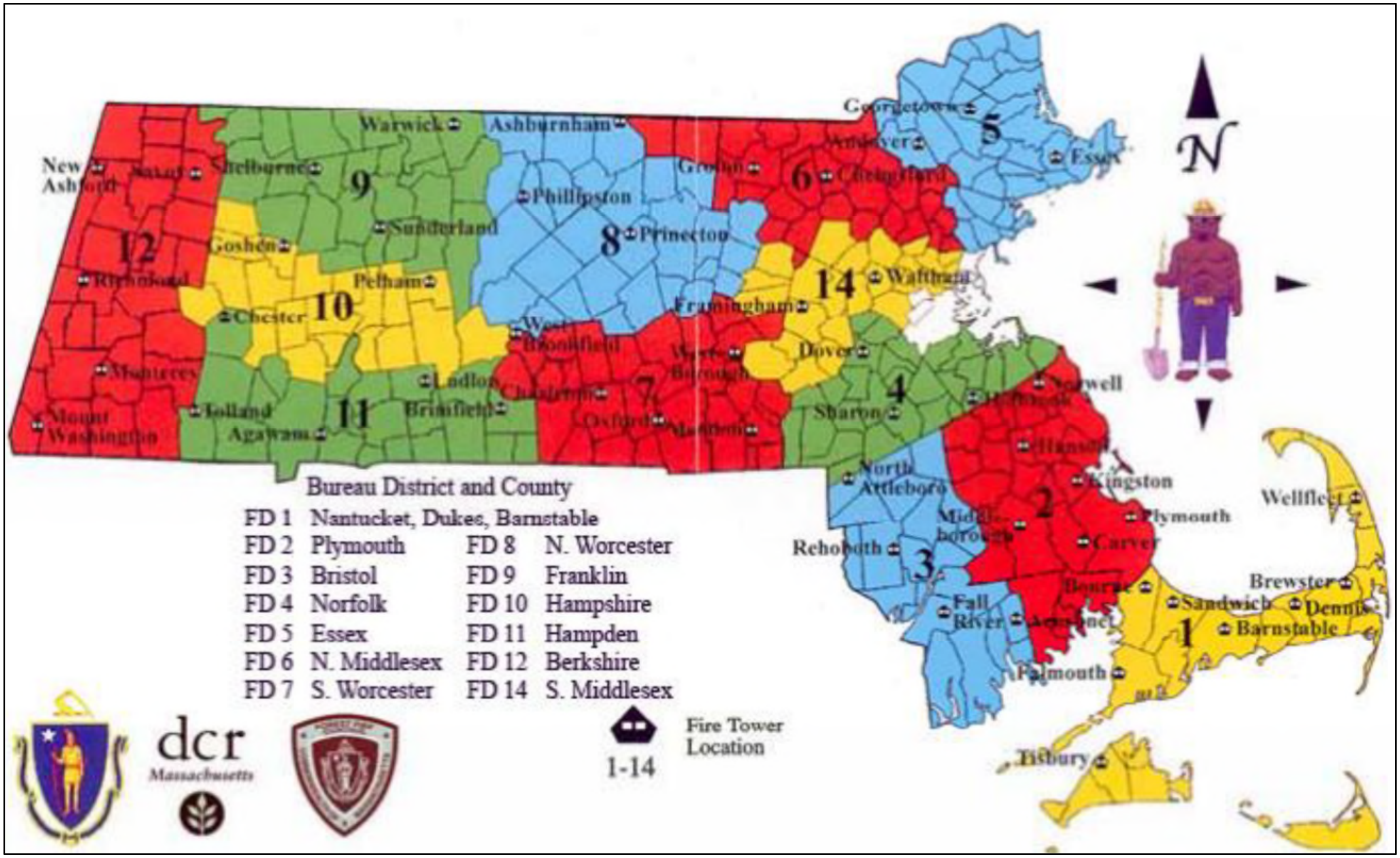
Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

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.[31]

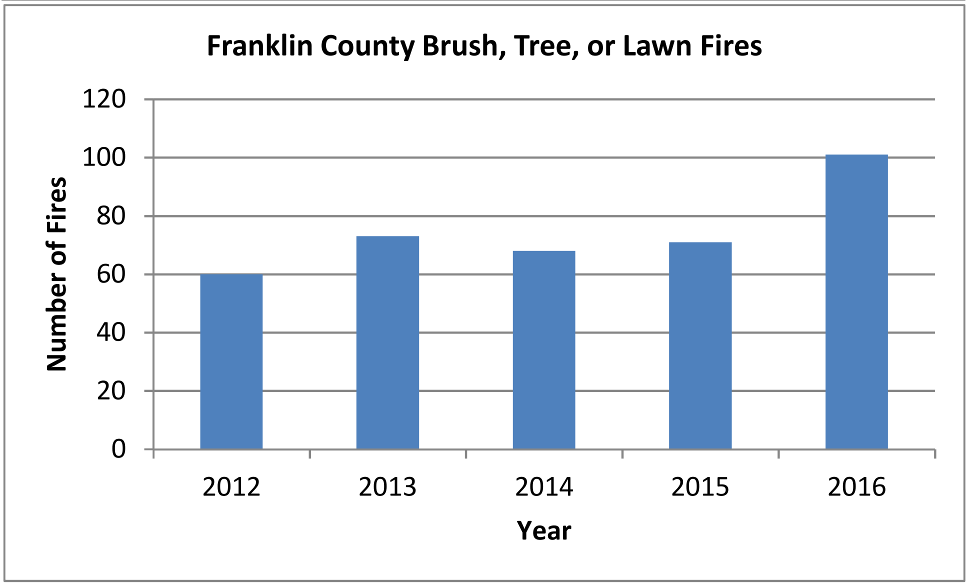
If a fire breaks out and spreads rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in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

Previous Occurrences

In the last five years (2012 – 2016) Franklin County has averaged 75 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.

[31] 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 - 2016



Source: Massachusetts Fire Incident Reporting System County Profiles.

While wildfires have not been a significant problem in Deerfield there is always a possibility that changing land use patterns and weather conditions will increase a community's vulnerability. For example, drought conditions can make forests and other open, vegetated areas more vulnerable to ignition. While moderate drought conditions were experienced in the western half of the state in July 2011, they were back to normal by October. Historically, drought has not been a problem in the Town of Deerfield. Once the fire starts, it will burn hotter and be harder to extinguish. Soils and root systems starved for moisture are also vulnerable to fire. Residential growth in rural, forested areas increases the total area that is vulnerable to fire and places homes and neighborhoods closer to areas where wildfires are more likely to occur.

Lightning can also be a cause of wildfires, brush fires, and structural fires. In June of 2005 severe thunderstorms accompanied by lightning affected portions of western Massachusetts, northeast Massachusetts, and southwest New Hampshire. During the storm, lightning struck the basement of a ranch style house in Deerfield, causing $50,000 of structural damage to the house.

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, based on the frequency of past occurrences, Deerfield has a "Very Low" probability (less than a 1% chance) that it will experience a wildfire in a given year.

Impact

Unfragmented and heavily forested areas of Deerfield 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 Deerfield from a wildfire is to the natural environment, which faces a "Minor" impact from wildfires, with limited 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.

<u>Vulnerable Populations</u>

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 Deerfield. 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 Deerfield residents during a wildfire event.

Table 3-31: Estimated Vulnerable Populations in Deerfield		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%
Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 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 (CO2), 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 in Deerfield				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$535,994,491	$5,359,945	$26,799,725	$53,599,449
Open Space	$0	$0	$0	$0
Commercial	$64,905,895	$649,059	$3,245,295	$6,490,590
Industrial	$76,277,914	$762,779	$3,813,896	$7,627,791
Total	**$677,178,300**	**$6,771,783**	**$33,858,915**	**$67,717,830**

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 to 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, Deerfield faces a “Low” vulnerability from wildfire and brushfires. While wildfires have caused minimal damage, injury and loss of life to date in Deerfield, 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 Deerfield 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. The following problem statements summarize the areas of greatest concern to Deerfield regarding wildfires.

Wildfire Hazard Problem Statements
• The Town needs more current and robust evacuation plans. Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning.
• Strategies for safeguarding power lines and utilities infrastructure on Route 5/10 and Old Main Street need to be identified and evaluated. Tree management is needed along power lines.
• Town wells need emergency generators in case of power outages.
• Although the Town has a smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.
• Improved planning and coordination is needed to assess the potential for schools in Deerfield, including Bement, Eaglebrook and Deerfield Academy to serve as shelters and emergency supplies stock points in emergency situations.

3.8 EARTHQUAKES

Potential Impacts of Climate Change

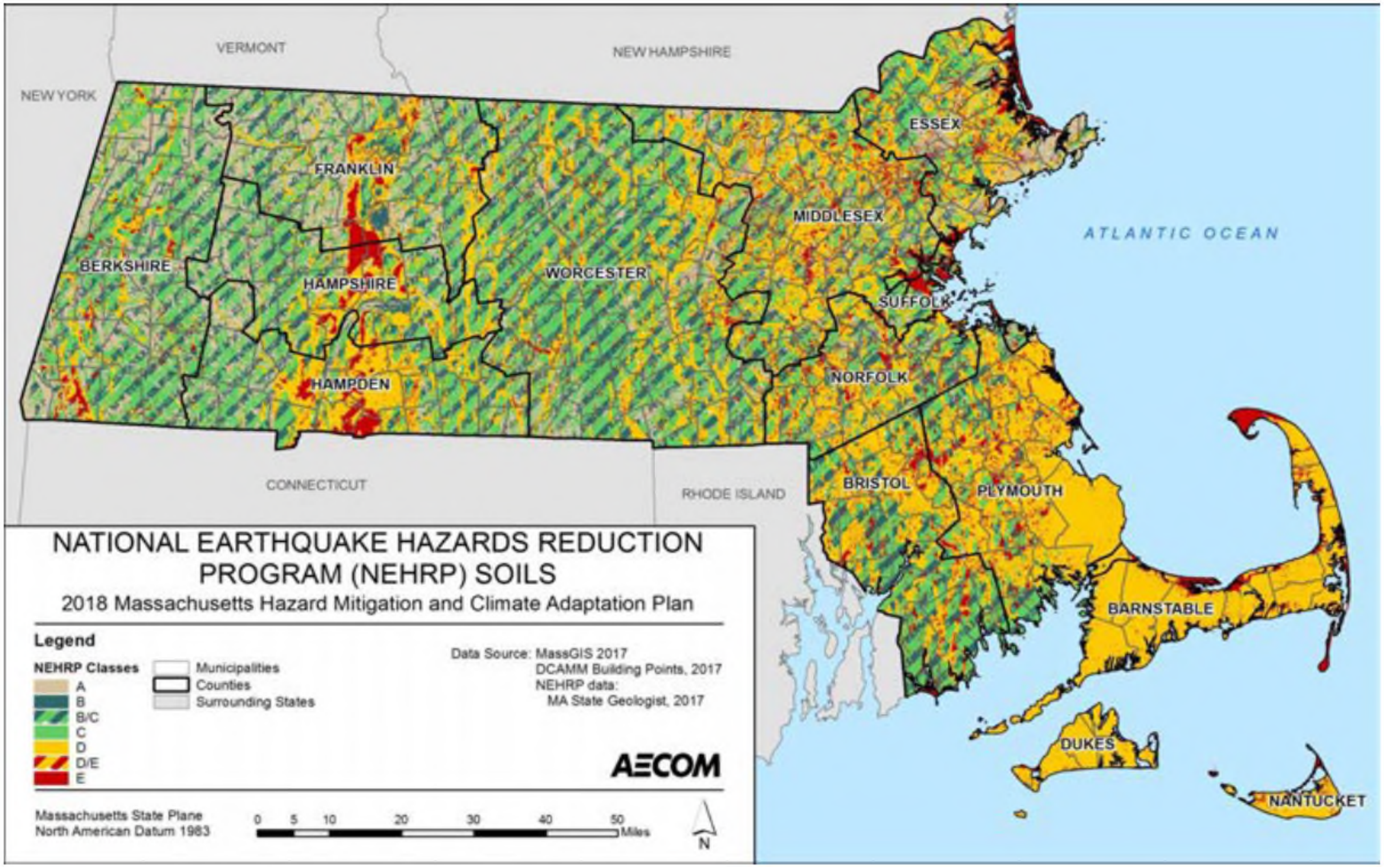
The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the earthquake hazard in Massachusetts.

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.[32]

Because of the regional nature of the hazard, the entire town is susceptible to earthquakes, and the location of occurrence would be "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

[32] 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

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 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 percent 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 percent 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

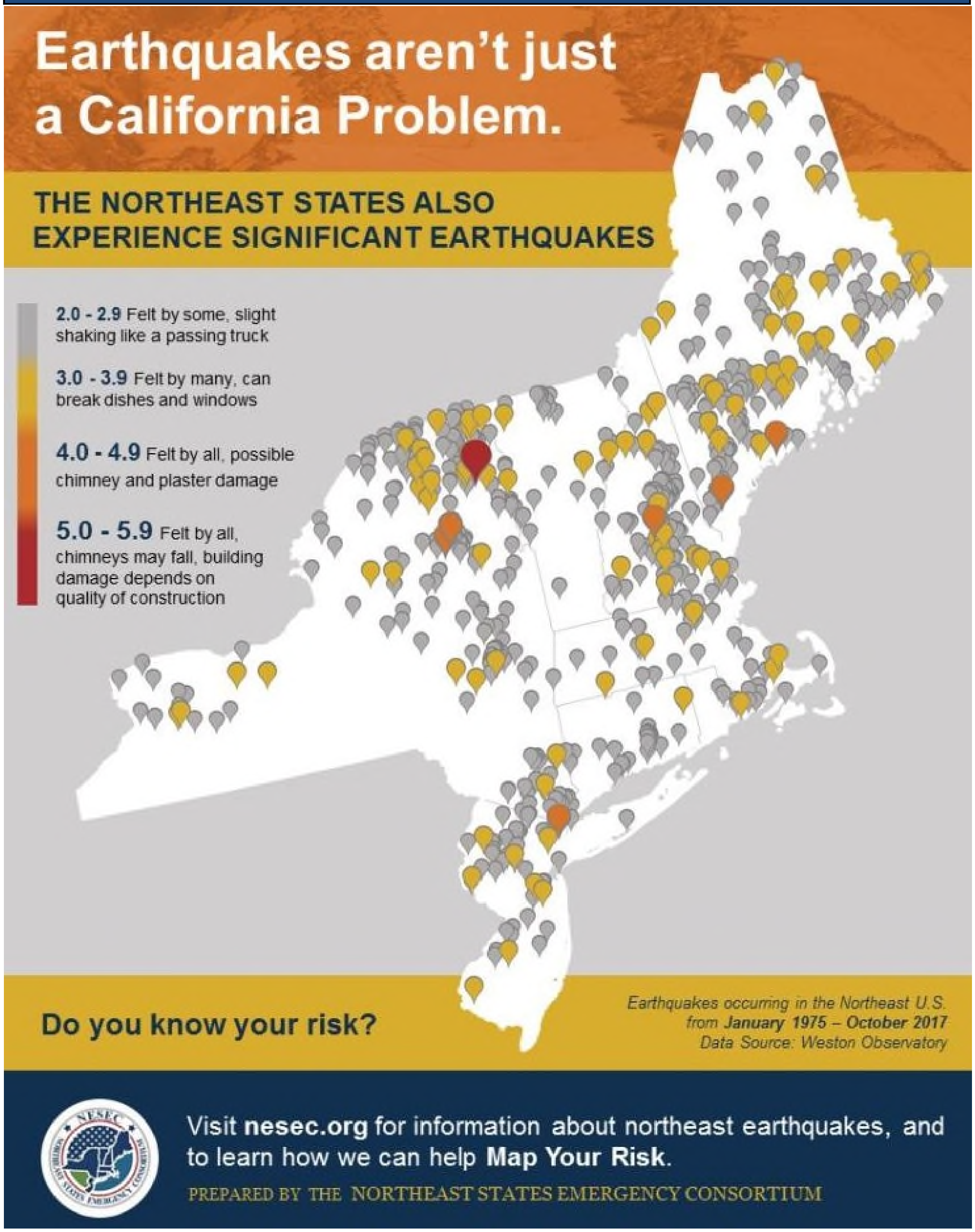
Table 3-34: Modified Mercalli Intensity Scale for and Effects			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
I	Instrumental	Detected only on seismographs.	
II	Feeble	Some people feel it.	< 4.2
III	Slight	Felt by people resting; like a truck rumbling by.	
IV	Moderate	Felt by people walking.	
V	Slightly Strong	Sleepers awake; church bells ring.	< 4.8
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 3-18). 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 the Town of Deerfield are shown in Figure 3-18. There is no record of any damage to the Town of Deerfield 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 percent to 15 percent. This probability rises to about 41 percent to 56 percent 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, Deerfield has "Very Low" probability, or less than 1% 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.

Deerfield faces potentially “Catastrophic” impacts from earthquakes, with more than 50% of property damaged in the affected area.

Vulnerability

Society

The entire population of Deerfield 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 (17% of Deerfield’s population) and those living below the poverty level (20% of Deerfield’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 1,006 housing units in Deerfield, or 46% of all housing units in town, were built prior to the 1970s.

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes. As mentioned previously, there are many dams on the Deerfield and Connecticut Rivers directly upstream of Deerfield. In the rare event that a compromise of any of these facility’s dam should occur, residents would have to evacuate their homes. There is also a small, unnamed privately owned dam that needs removal in town. Dam failure at Moore and Harriman Dams was identified by Town officials as a specific area of concern during the town’s Municipal Vulnerability Preparedness Community Building Workshop in 2018, and discussed in more detail in the Dam Failure section.

Health Impacts

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.

Economic Impacts

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 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 Deerfield 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 in Deerfield

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$535,994,491	$5,359,945	$26,799,725	$53,599,449
Open Space	$0	$0	$0	$0
Commercial	$64,905,895	$649,059	$3,245,295	$6,490,590
Industrial	$76,277,914	$762,779	$3,813,896	$7,627,791
Total	**$677,178,300**	**$6,771,783**	**$33,858,915**	**$67,717,830**

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, Deerfield has a "Low" vulnerability to earthquakes. The following problem statements summarize Deerfield’s areas of greatest concern regarding earthquakes.

Earthquake Hazard Problem Statements
• 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 1,006 housing units in Deerfield, or 46% of all housing units in town, were built prior to the 1970s.
• The Town needs more current and robust evacuation plans. Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning.
• Strategies for safeguarding power lines and utilities infrastructure on Route 5/10 and Old Main Street need to be identified and evaluated. A tree management program is needed along power lines.
• Town wells need emergency generators in case of power outages.
• Although the Town has a new smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.

Earthquake Hazard Problem Statements
• Improved planning and coordination is needed to assess the potential for schools in Deerfield, including Bement, Eaglebrook and Deerfield Academy to serve as shelters and emergency supplies stock points in emergency situations.

3.9 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.

Dams and reservoirs licensed and subject to inspection by 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. FERC requires that an Emergency Action Plan (EAP) be created and updated annually for licensing of hydropower facilities. The primary purpose of an EAP is to "provide operating and mobilization and notification procedures to be followed in the case of an emergency" such as a sudden release of water caused by a natural disaster or accident.

Location

Dams of concern to the Town of Deerfield include five dams on the Deerfield River formerly owned by USGen New England Inc. that were sold when its parent company, National Energy and Gas Transmission, Inc. (NEGT) went bankrupt in 2005. The dams were sold again in 2017 to Great River Hydro LLC, an affiliate of ArcLight Capital Partners. There are 10 hydroelectric dams along the 73-mile length of the Deerfield River as it flows through Vermont and Massachusetts. Of particular note are the projects on the Deerfield River owned by Great River Hydro LLC (Somerset Dam, Harriman Dam, and Sherman Dam) and Brookfield Renewable Power (Fife Brook Dam and Bear Swamp Upper Reservoir) and licensed by the FERC. All of these dams are classified as High Hazard Dams. The Emergency Action Plans for these projects include a series of inundation maps for each dam which illustrate potential flooding conditions for downstream areas including portions of Deerfield and adjacent to the Deerfield and Connecticut Rivers.[33] The remaining five dams on the Deerfield River are classified as Low Hazard Dams. A catastrophic failure of any one of the High Hazard dams would likely result in the cascading failure of all the downstream dams (both High and Low Hazard dams), resulting in widespread flooding of downstream areas in a matter of hours.

The Harriman Dam holds back the Harriman Reservoir. Located on the Deerfield River near Whitingham, VT, the drainage basin of the dam is roughly 25.3 miles long with a basin width of 13 miles. The development structures were completed in 1924 and consist of an earth embankment of the semihydraulic fill type, a morning glory spillway, a concrete lined rock tunnel from a concrete intake tower upstream of the dam, and a power house connected to the surge tank.

Deerfield's 2014 Multi-Hazard Mitigation Plan reported ten locations where beaver activity was known to be having a significant impact on the landscape. These included dams on Bloody Brook downstream in Whately which back the entire brook up into Deerfield, causing problems

---

[33] "Emergency Action Plans for the Deerfield River FERC Licensed Projects Nos. 2323 and 2669," prepared for US GEN New England, Inc., by Kleinschmidt Energy and Water Resource Consultants, November 2003.

that would require cooperative agreements between the two towns to mitigate. Additional dams were identified at the following locations in Town:

- 2 dams on Hawks Road
- 1 on Broughton Pond Road
- 2 on Childs Cross Road
- 1 on Mill Village Road
- 1 on Wells Cross Road
- 1 on Stockbridge Road
- 2 on Whately Road

Overall, the Committee identified the possible extent of flooding due to beaver dams as small. The Committee identified some sites where beaver dams are having an notable impact on the landscape.

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.

Inundation maps for the Harriman Dam extend from the dam downstream to Holyoke, roughly 86 miles away. Under sunny conditions (with no additional precipitation added to released water), water from a catastrophic failure of the Harriman Dam would reach the I-91 bridge (60.9 miles from origin) over the Deerfield River in 3.5 hours. In four hours, it will reach Deerfield (63.5 miles from origin). It will reach the Route 5 Bridge (67.6 miles from origin) in 4.6 hours and the confluence of the Deerfield and Connecticut Rivers (68.9 miles from origin) in 5 hours. As the flood joins with the Connecticut River it is expected to significantly increase in magnitude and velocity.

Deerfield Academy and the Bement School, both located in Historic Deerfield would be within several hundred feet of the flooded areas and would need to be evacuated. Roadways in Historic Deerfield that would be expected to become inundated by the flood include Route 5/10 (Greenfield Road), Old Main Street, and Broughman's Pond Road. Other roads in the Town of Deerfield that would be expected to become inundated include Route 116 (Sunderland Road), River Road; McClelland Farm Road, Wapping Road and Mill Village Road.

In 2010 the Franklin Regional Council of Governments (FRCOG) and the University of Massachusetts Transportation Center (UMTC) prepared a study that examined the impact of a Harriman Dam failure on the transportation network in the towns within the inundation zone as well as the county. Building upon this exercise, the FRCOG developed town-specific recommendations in the event of flooding caused by failure of the Harriman Dam. An analysis was conducted for each of the Towns located along the path of the flood including identification of critical facilities located within Town boundaries. The recommendations are intended to be used as a starting point for the development of specific emergency plans in each Town. Recommendations for Deerfield include the immediate evacuation of schools located in Historic Deerfield; evacuation to nearby MassCare shelters at Frontier Regional High School and Yankee Candle Company prior to the expected inundation and closure of Route 5/10; and use of Eaglebrook School as an alternate evacuation point.

Under "Probable Maximum Flood" (PMF) conditions, the worst-case scenario, floodwaters from a catastrophic failure of the Sherman Dam would reach the Route 5 Bridge in 3.2 hours. Both "Sunny Day" and PMF conditions are presented on the inundation maps for the five TransCanada New England High Hazard Dams.

Of additional concern is the Moore Dam, also owned by TransCanada and located on the Connecticut River in the towns of Littleton, New Hampshire, and Waterford, Vermont, approximately 166 miles upstream from the Turners Falls Dam. According to the Emergency Action Plan, flooding caused by a failure of the dam would reach Deerfield within 25 hours under Probable Maximum Flood (PMF) conditions. Flood waters would inundate a large area along the Deerfield River between Interstate 91 and Routes 5/10 (Greenfield Road) from the Town Line in the north to below the intersection of Mill Village and Stillwater Roads in the south where there are power transmission lines crossing Fuller Swamp. Along the western side of the Connecticut River the area of inundation would extend along McLelland Farm Road, and the full length of River Road (except in the Whitmore Ferry Road area), to the Whately Town Line just south of the intersection with Route 116 (Sunderland Road).

The remaining TransCanada dams on the Deerfield River are classified as Low Hazard Dams; therefore, no Emergency Action Plan or inundation mapping are required by FERC. Consultants hired by TransCanada examined a "Sunny Day" failure scenario for these dams to determine the downstream flooding hazard potential. Next, the incremental impact was determined for a dam failure that occurred at a flow equivalent to the 100-year frequency flood. For these two scenarios, the study indicates that the additional flooding above the 100-year flood stage was insignificant and therefore these projects do not present a significant hazard to life and property. However, the cascading failure of one or more of these dams that would occur if one of the High Hazard dams failed would result in the catastrophic flooding shown on the inundation maps in the EAP.

Massachusetts Emergency Management Agency (MEMA) identifies one dam in Deerfield. The dam was last inspected in 2000 and is classified by MEMA as a Significant Hazard Potential dam. The dam is owned by Eaglebrook School. The South Deerfield Water District owns two dams in Whately, the Upper and Lower Dams, that bring water to the Whately filtration plant. While these dams are not located in Deerfield, a breach or dam failure could cause inundation downstream that would affect Deerfield residents.

The 100-year flood plain covers about 13 percent, or roughly 2,828 acres of the Town, including an estimated 41 acres of developed residential land. An inundation area due to dam failure would cover substantially more acreage. Emergency responders should review inundation areas in the Emergency Action Plans and the findings and recommendations from the 2010 Harriman Dam study and Town Recommendations and identify possible evacuation routes, since significant portions of Deerfield, including sections of Route 5/10 may be flooded.

There are critical facilities in Deerfield located either within the 100-year floodplain, in a dam inundation area, or in areas prone to localized flooding. These include several of the town's identified shelters (including the Frontier Regional School), the Old Deerfield Fire Station, the South Deerfield and Old Deerfield Wastewater Treatment Plants, an electrical switching station near Old Ferry Road, South Deerfield Village Center, Historic Deerfield, Deerfield Academy, Bement School, and several bridges, all of which have the potential to be inundated by flood waters.

Flooding from a dam failure at Harriman and Moore Dams was identified as a key area of concern during the 2018 Municipal Vulnerability Preparedness Community Building workshop in Deerfield.

Previous Occurrences

To date, there have been no known dam or levee failures in Deerfield.

Probability of Future Events

Currently the frequency of dam failures is "Very Low" with a less than 1 percent 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 in Deerfield is likely to have a catastrophic impact, with multiple deaths and injuries possible, more than 50% of property in the affected area damaged or destroyed, and a possible complete shutdown of facilities for 30 days or more.

Vulnerability
Dam failures, while rare, can destroy roads, structures, facilities, utilities, and impact the population of Deerfield. Existing and future mitigation efforts should continue to be developed and employed that will enable Deerfield 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

Vulnerable Populations
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, including 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.

Economic Impacts
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.[34]

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

[34] *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

Deerfield. There are critical facilities in Deerfield located either within the 100-year floodplain, in a dam inundation area, or in areas prone to localized flooding. These include several of the town's identified shelters (including the Frontier Regional School), the Old Deerfield Fire Station, the South Deerfield and Old Deerfield Wastewater Treatment Plants, an electrical switching station near Old Ferry Road, South Deerfield Village Center, Historic Deerfield, Deerfield Academy, Bement School, and several bridges, all of which have the potential to be inundated by flood waters. In total, the structures and building contents are valued at $9,381,800. It is evident that catastrophic flooding would cause significant economic, financial and environmental damage.

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
- Degradation to wetlands
- Loss of topsoil or vegetative cover
- Loss of indigenous plants or animals[35]

The 2018 Deerfield MVP report identified that existing erosion problems and riparian buffer damages on the Deerfield River, Connecticut River, Mill River and their tributaries from recent and historic flood events have rendered these waterways extremely vulnerable to the ongoing, harmful impacts of smaller dam failures or planned releases.

Vulnerability Summary

There are several High Hazard Dams on the Deerfield and Connecticut Rivers, which could cause catastrophic impact in the event of a dam failure. Due to the Town's current dam inspection

---

[35] *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

schedule and the current EAPs and inundation mapping for all High Hazard dams plus the lead time for evacuation if dams on the Deerfield or Connecticut River were to fail, the Committee determined that the Town has a "Low" vulnerability from dam or levee failure.

Dam Failure Hazard Problem Statements
• While the chance is low, a catastrophic dam failure at the one of the major hydroelectric dams on the Connecticut or Deerfield Rivers upstream of the Town would result in devastating flooding to many parts of Deerfield. There are six major dams of concern on the Deerfield River, including Harriman Dam, where a failure would result in floodwaters reaching Deerfield in 4 hours. Moore Dam is of concern on the Connecticut River.
• Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning. Evacuations would be needed at Deerfield Academy and Bement School, and roads would be inundated if large upstream dams on the Deerfield River were to fail. Evacuation planning, improved communication, and notification protocols with Great Hydro relating to upstream Deerfield River Dams are of particular concern.
• The Town needs more current and robust evacuation plans and a central communication system on road flooding. Flood-prone roads include Route 5/10, Mill Village Road, and Wapping Road. If Routes 5/10 are closed due to flooding, Deerfield loses an important north-south evacuation route.
• More needs to be done to protect flood storage areas in Deerfield's flood zone. Floodplain zoning needs improvement and land conservation is needed, especially in the north and south meadows of Old Deerfield, along the Deerfield River in west Deerfield, and in farmed areas within the Bloody Brook watershed.
• There is a need to promote farm practices, such as no till agriculture, that limit the risk of phosphorous and nitrogen fertilizer carried by heavy precipitation or flood waters entering the river.
• There is a small, unnamed, privately owned dam in Town that needs removal. Discussed during 2018 MVP Workshop.
• Beaver activity on Bloody Brook in Whately is causing water to backup and contribute to localized flooding in the village of South Deerfield where residential settlement, municipal buildings, facilities, and infrastructure are located. Other beaver dams and beaver activity in Town need to be identified and evaluated for risk.
• Although the Town has a new smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.

Dam Failure Hazard Problem Statements
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.

3.10 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.

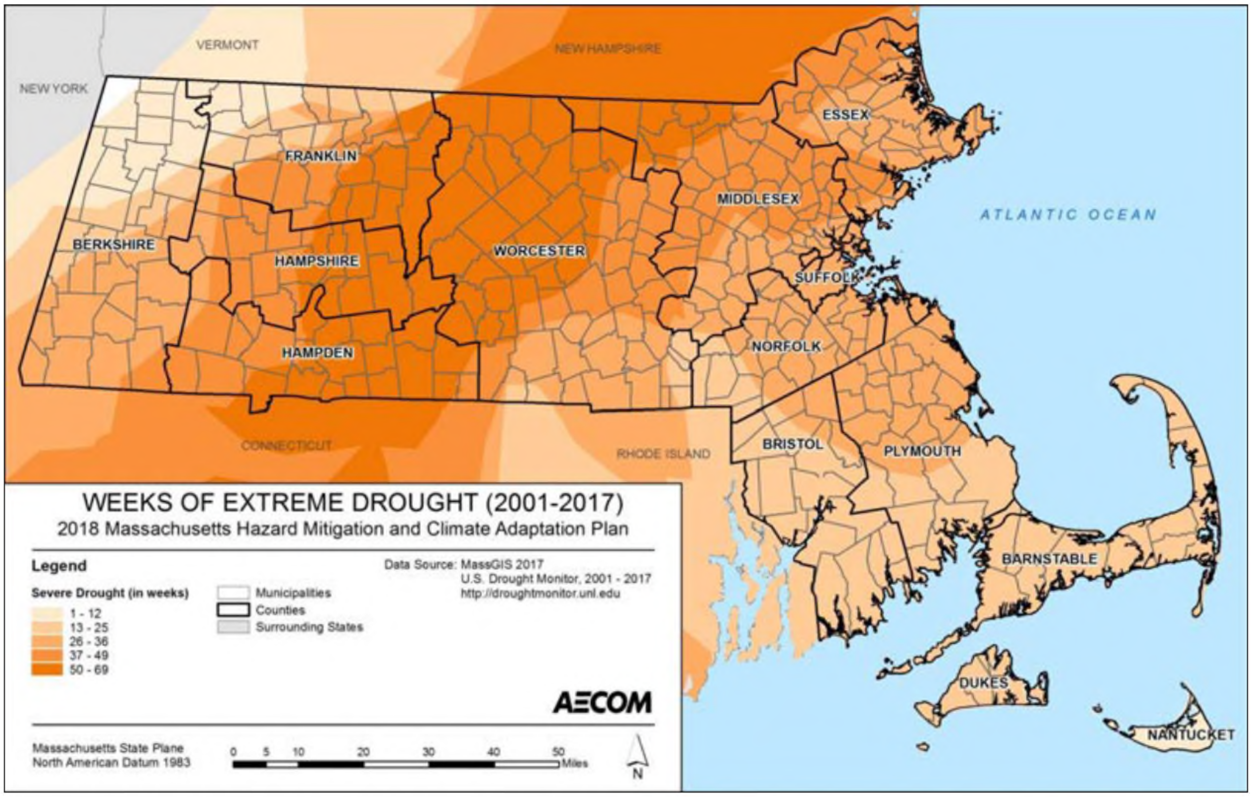
Highly urbanized areas with traditional stormwater drainage systems tend to result in higher peak flood levels during rainfall events and rapid decline of groundwater levels during periods of low precipitation. Thus, the hydrology in these areas becomes more extreme during floods and droughts.[36] The 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.

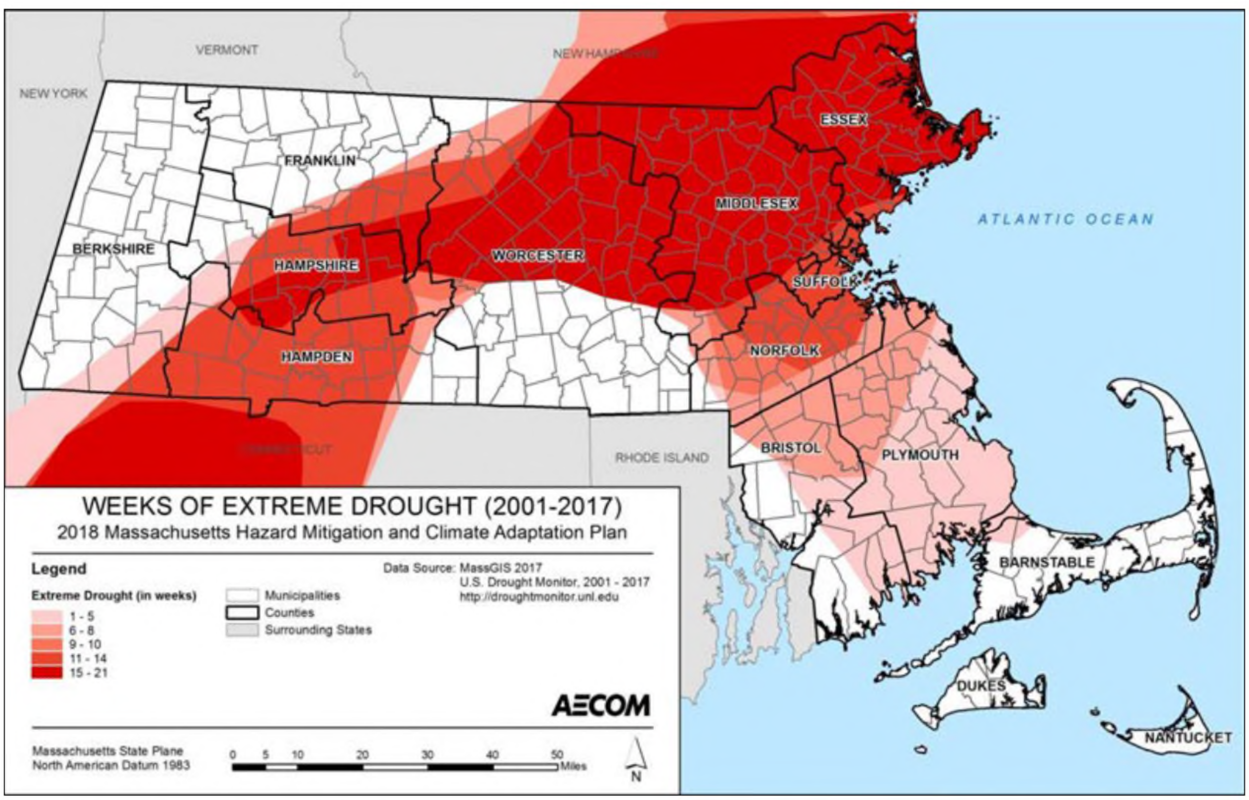
Location

Deerfield 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 percent of total land area affected.

[36] 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, as presented in the *2018 Massachusetts 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. The majority of residents in Deerfield rely on the public water supply, which draws from both groundwater and surface water resources. The remaining residents depend on private wells for water. 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 as shown below.

Table 3-37: 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

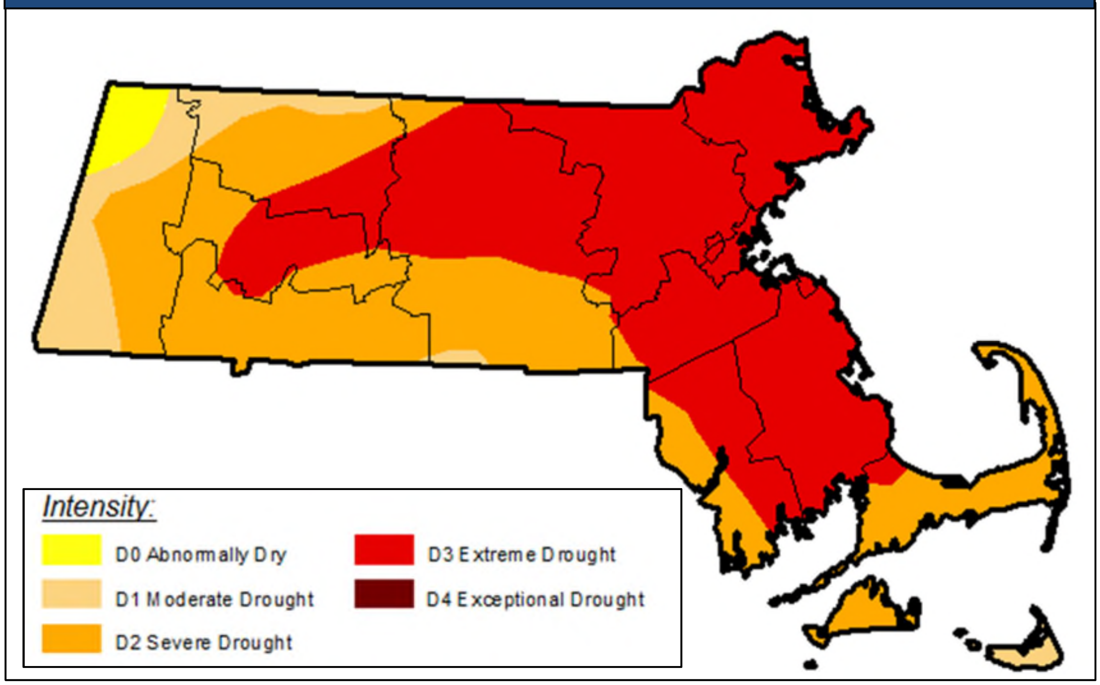
Previous Occurrences

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).[37] 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 Deerfield, drought has a "Moderate" probability of future occurrence, or between a 2% and 25% chance of occurring in

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

any given year.

Impact

Due to the water richness of western Massachusetts, Deerfield is unlikely to be adversely affected by anything other than a major, extended drought. The major impact to residents 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. Firefighting capabilities could be compromised in a drought if aquifers, fire ponds, or rivers used for pumping water are low. Drought may increase the 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 25% of the property in the affected area damaged or destroyed.

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 Deerfield 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 and reduce local firefighting capabilities. Public water supplies (PWS) provide water for both of these services and may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The Massachusetts Department of Environmental Protection (DEP) requires all PWS to maintain an emergency preparedness plan. The Deerfield Water Department serves residents in the north end of town, and has two interconnections with South Deerfield and Greenfield as an emergency back-up water supply. However, residents served by private wells may be vulnerable to drought.

<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 snowpacks 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:[38]

- 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
- 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 Deerfield's environment as well as economic damage related to the loss of valuable natural resources.

Vulnerability Summary

Based on the above assessment, Deerfield has a vulnerability of "Medium" from 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. The following problem statements summarize Deerfield's areas of greatest concern regarding droughts.

[38] 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.

Drought Hazard Problem Statements
• The Town needs a town-wide drinking water assessment in order to determine what percentage of the town's population is adequately served by the existing water districts and which ones are not. Once underserved areas have been identified, potential sources of drinking water need to be identified and protected. Many residents on River Road are served by private deep wells that are not potable due to hardness and natural sources of arsenic found in the red rock aquifer that runs north and south in the valley. Shallow private wells could run dry during a drought.
• Deerfield's forests make up approximately 60% of the town and are vulnerable to drought, which could also increase the risk to other hazards including wildfire and pests.
• A drought could compromise firefighting efforts, particularly because there are no hydrants outside of downtown and fireponds are heavily relied on.
• Although the Town has a new smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.

3.11 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.[39] This precipitation can cause slopes to become saturated.

[39] 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

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

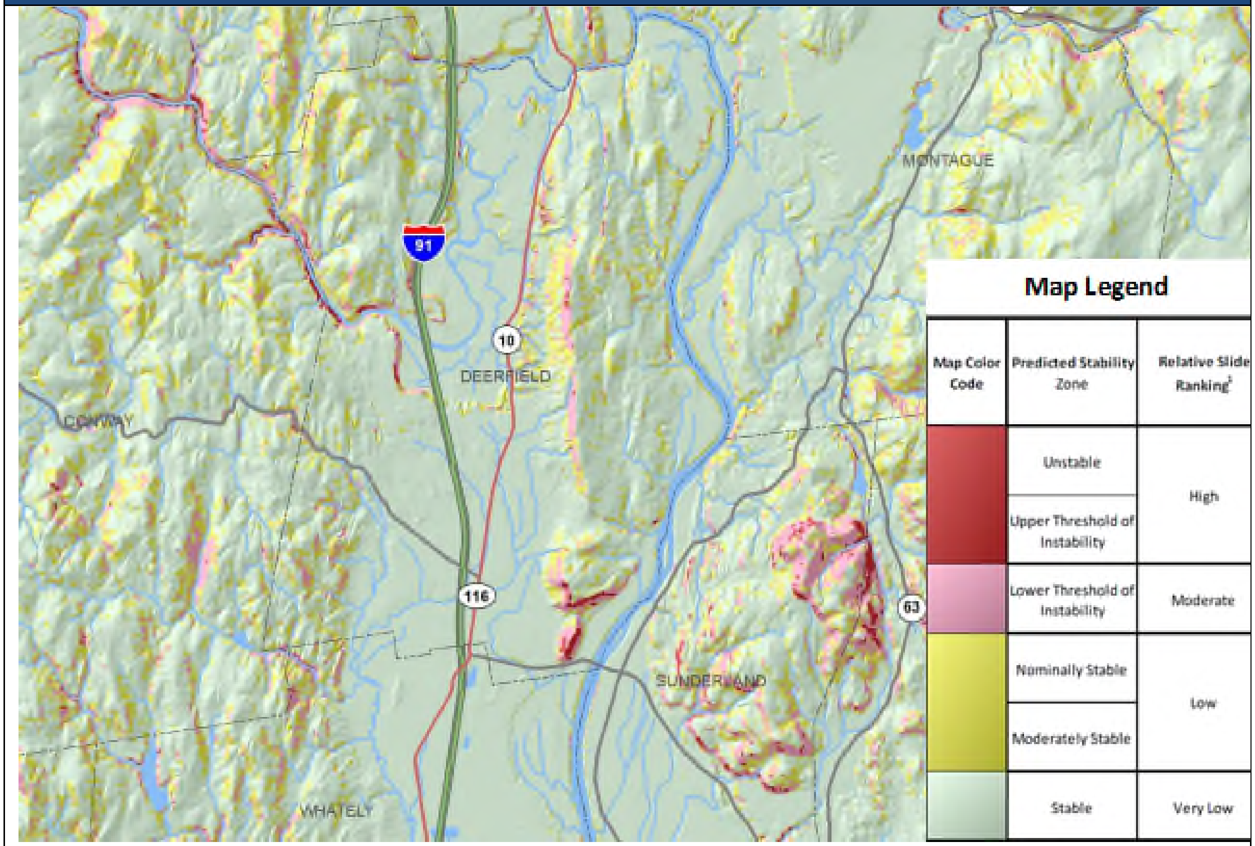
Landslides are created by human activities as well, including deforestation, cultivation and construction, which destabilize already fragile slopes. Some human activities that could cause landslides include:

- 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.

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



Source: Massachusetts Geologic Survey and UMass Amherst, 2013

Deerfield has areas in town with high and moderate landslide rankings. These areas are shown in Figure 3-23 and are mostly located within the Mount Sugarloaf State Reservation and along the Deerfield River. In general, due to the topography and soils in town, Deerfield has a smaller amount of unstable soils than many surrounding towns. The Committee therefore determined that landslides have an "Isolated" area of occurrence, with less than 10% of the Town affected.

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 Deerfield 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

According to WWLP News, early in the morning on March 7 of 2011, torrential rains swept away a piece of cemetery into the backyards of homes and nearby streets in Greenfield, MA. The landslide sent silt, mud, and debris down from the Green River Cemetery into homes on nearby Meridian Street. Residents did not hear a thing. A passerby called 911 and alerted authorities that part of the Green River Cemetery had slid down onto Meridian Street. Residents of three homes were evacuated. This area of Greenfield has been in the news before due to other landslides.

According to the Greenfield Recorder, state geologists estimated that about 1,500 to 3,000 cubic yards of mud and debris came down into the yards but that no graves were involved. Three inches of rain in Greenfield over a day and a half contributed to the disaster that caused thousands of dollars worth of damage. The company called in to divert water away from homes below and help clear their yards of some of the mud found that a drainage system that had been installed in 1986 was plugged and buried by the mudslide. The drainage system was cleaned out and was found to be in good shape and should handle any future rains adequately. The Town indicated that it is the responsibility of the Cemetery board to make sure the system is evaluated and cleared of any silt accumulation on a regular basis.


The aftermath of the mudslide from the Green River Cemetery included cleanup on a nearby street and bridge.

The Committee reports that there was a significant mudslide that occurred on River Road in Deerfield following removal of a 12-foot-high beaver dam on Clapp Pond in late 2004, causing erosion along Clapp Brook that had an impact on the septic systems for four homes nearby. In addition, in November 2011, Routes 5/10 had to be closed to clear a blocked culvert that was the result of a slow-moving landslide and was causing significant flooding.[40]

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 Deerfield. There is a "High" probability, or a 25-50% chance, of a landslide happening 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 Deerfield would be "Limited" depending on where it occurs. More than 10% of property in the affected area could be damaged or destroyed.

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 Deerfield, many residents may be vulnerable to landslides due to the fact that many homes are built on property below steep slopes, and also because Deerfield has limited alternative routes for accessing homes if Route 5/10 were blocked by a 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

[40] The Greenfield Recorder, November 26, 2011.

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.

<u>Public Health</u>

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.

<u>Public Safety</u>

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.

<u>Transportation</u>

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, Deerfield has a hazard index rating of "Medium" for landslides. The following problem statements summarize Deerfield's areas of greatest concern regarding landslides.

Landslide Hazard Problem Statements
• The steep slopes above Route 5/10 and Wapping Road are vulnerable to landslides, as identified on the Slope Stability Map. Structures and roads in these areas are at risk of damage.
• Deerfield's dependence on Route 5/10 as a primary transportation route places residents and emergency responders at risk if the road were impacted by a landslide.
• Although the Town has a new smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Vulnerable populations, including elderly and disabled residents are more vulnerable in the event of an emergency due to lessened mobility or medical needs. Homeless and transient people in town may be difficult to reach in the event of an emergency.

3.12 EXTREME TEMPERATURES

Potential Impacts of Climate Change

Beyond the overall warming trend associated with global warming and climate change, Deerfield 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.[41]

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

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

Greenfield data as a proxy) are provided in Table 3-38.

Table 3-38: Annual Average High and Low Temperatures (Greenfield)		
	July (Hottest Month)	January (Coldest Month)
Average High (°F)	81°	33°
Average Low (°F)	57°	12°

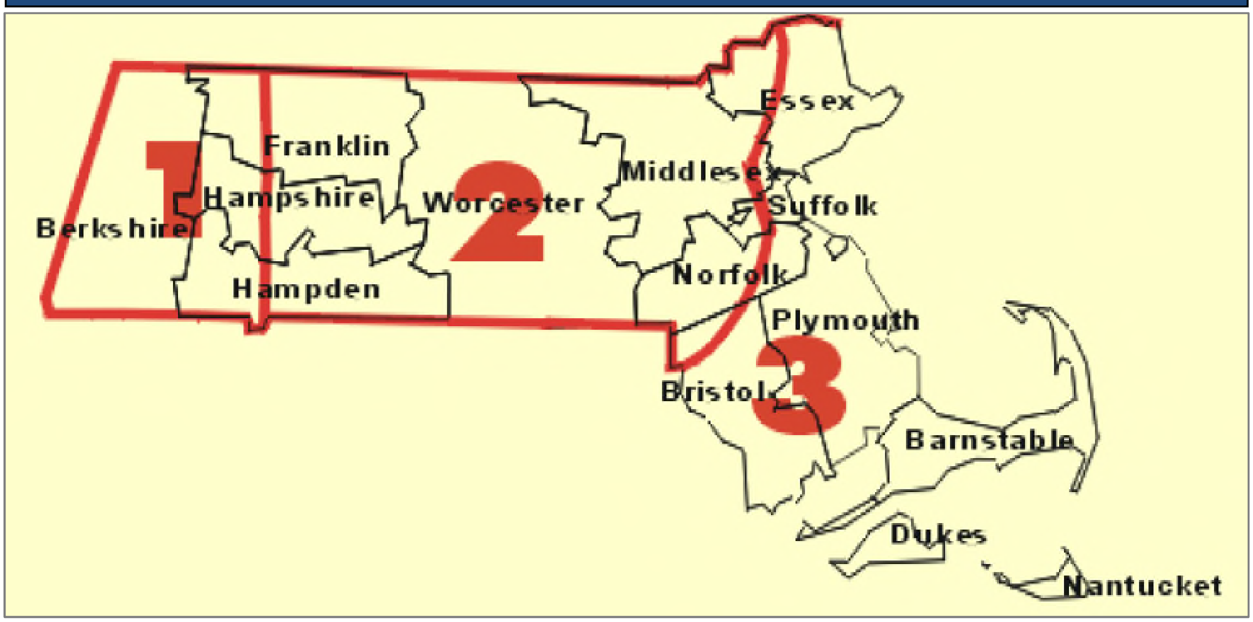
Note: Average temperatures are for the years 1981-2010.

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). Deerfield falls within the Central climate division.

Figure 3-25: Climate Divisions in Massachusetts



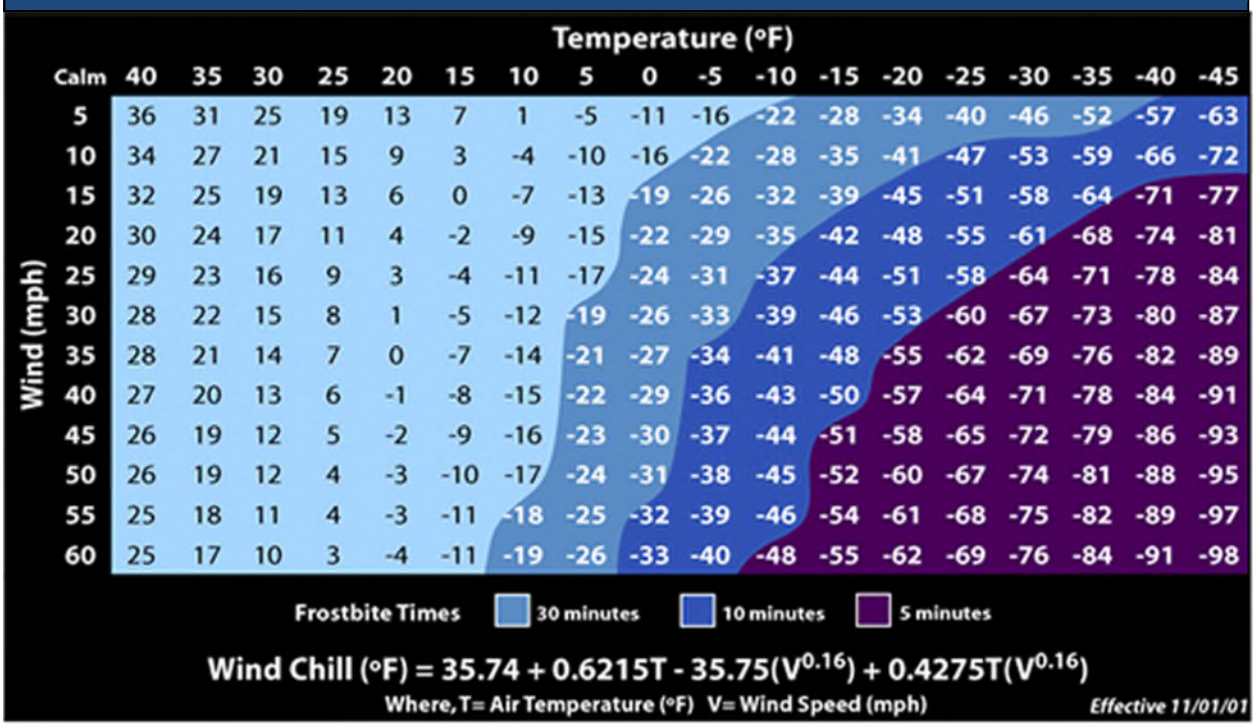
Source: NOAA, as presented in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, September 2018

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.

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

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

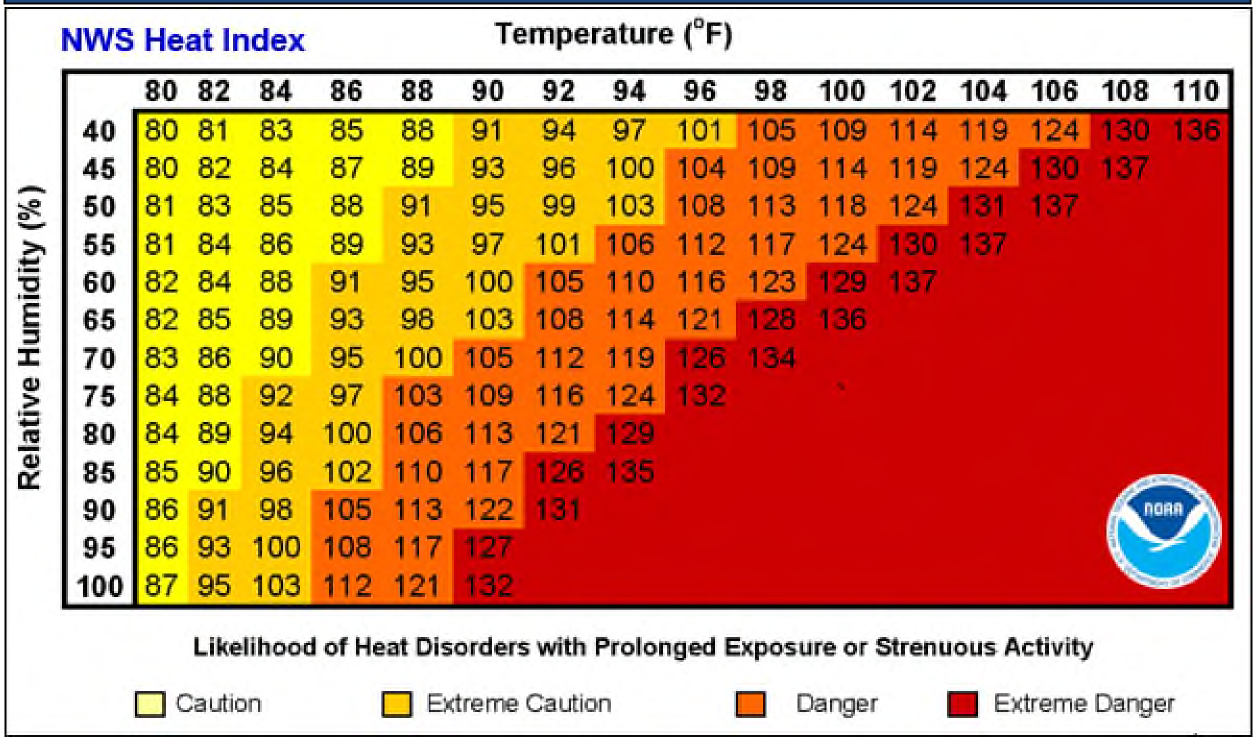
Where, T= Air Temperature (°F) V= Wind Speed (mph)

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

Source: National Weather Service: https://www.weather.gov/safety/heat-index

Previous Occurrences

Since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. Information on severe cold weather events in Deerfield and Franklin County was not available prior to 2015. However, detail on recent extreme events is provided below.

In February 2015, a series of snowstorms piled nearly 60 inches on the city of Boston in 3 weeks and caused recurrent blizzards across eastern Massachusetts. While Deerfield and western Massachusetts was not impacted as much from the snow, temperature gauges across the Commonwealth measured extreme cold, with wind chills as low as -31°F. Wind chills as low as 28 below zero were recorded at the Orange Municipal Airport.

In February 2016, one cold weather event broke records throughout the state. Arctic high pressure brought strong northwest winds and extremely cold wind chills to southern New England. Wind chills as low as 38 below zero were reported in Orange.

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 Deerfield or Franklin County prior to 2018.

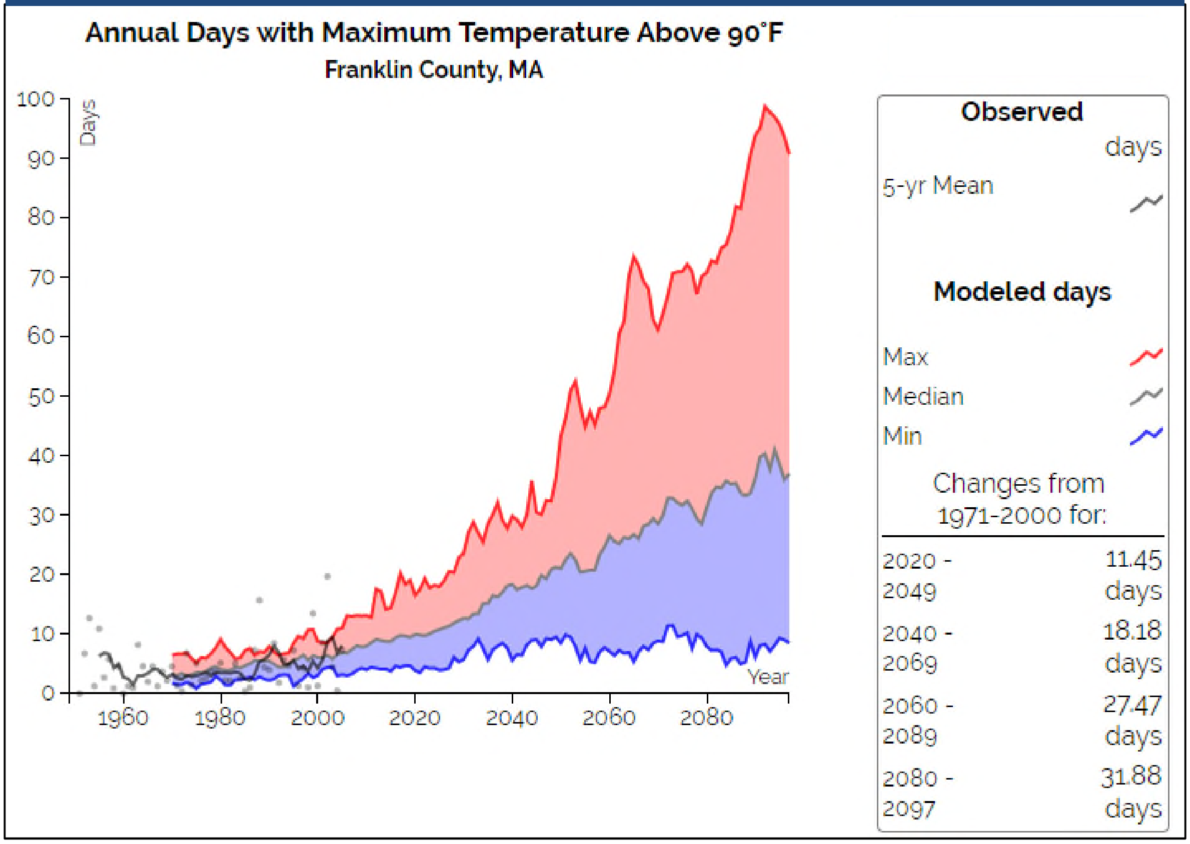
In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit Massachusetts and the East Coast. In July 2013, a long period of hot and humid weather occurred throughout New England. 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: resilient MA, 2018.

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.

Vulnerability

The entire town of Deerfield is vulnerable to extreme temperatures.

Society

Vulnerable Populations

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 3-39 estimates the number of vulnerable populations and households in Deerfield. 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 Deerfield residents during an extreme temperature event.

Table 3-39: Estimated Vulnerable Populations in Deerfield

Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%
Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011

Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 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 percentile (hot: 85-86°F), 90th percentile (very hot: 87-89°F) and 95th percentile (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 percentages of African American residents and elderly residents on days exceeding the 85th percentile.[42] A 2013 study of heart disease patients in Worcester, MA, found that extreme heat (high temperature greater than the 95th percentile) in the 2 days before a heart attack resulted in an estimated 44 percent increase in mortality. Living in poverty appeared to increase this effect.[43] 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 percent rise in the mortality rate due to an increase in the number and intensity of heat events.[44]

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 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

[42] 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

[43] 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.

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

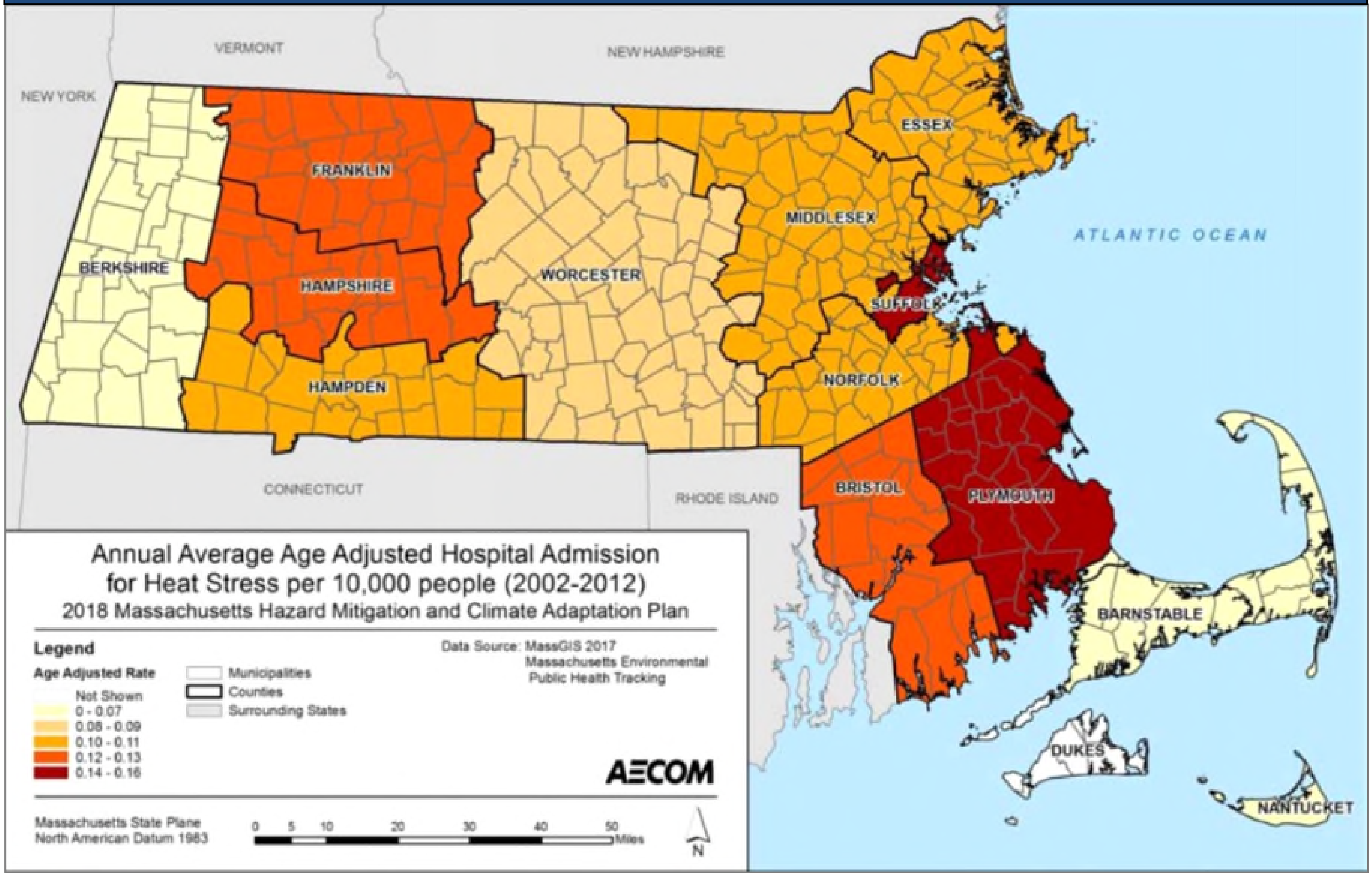
continent. Poor air quality can negatively affect respiratory and cardiovascular systems, and can exacerbate asthma and trigger heart attacks.

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 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.

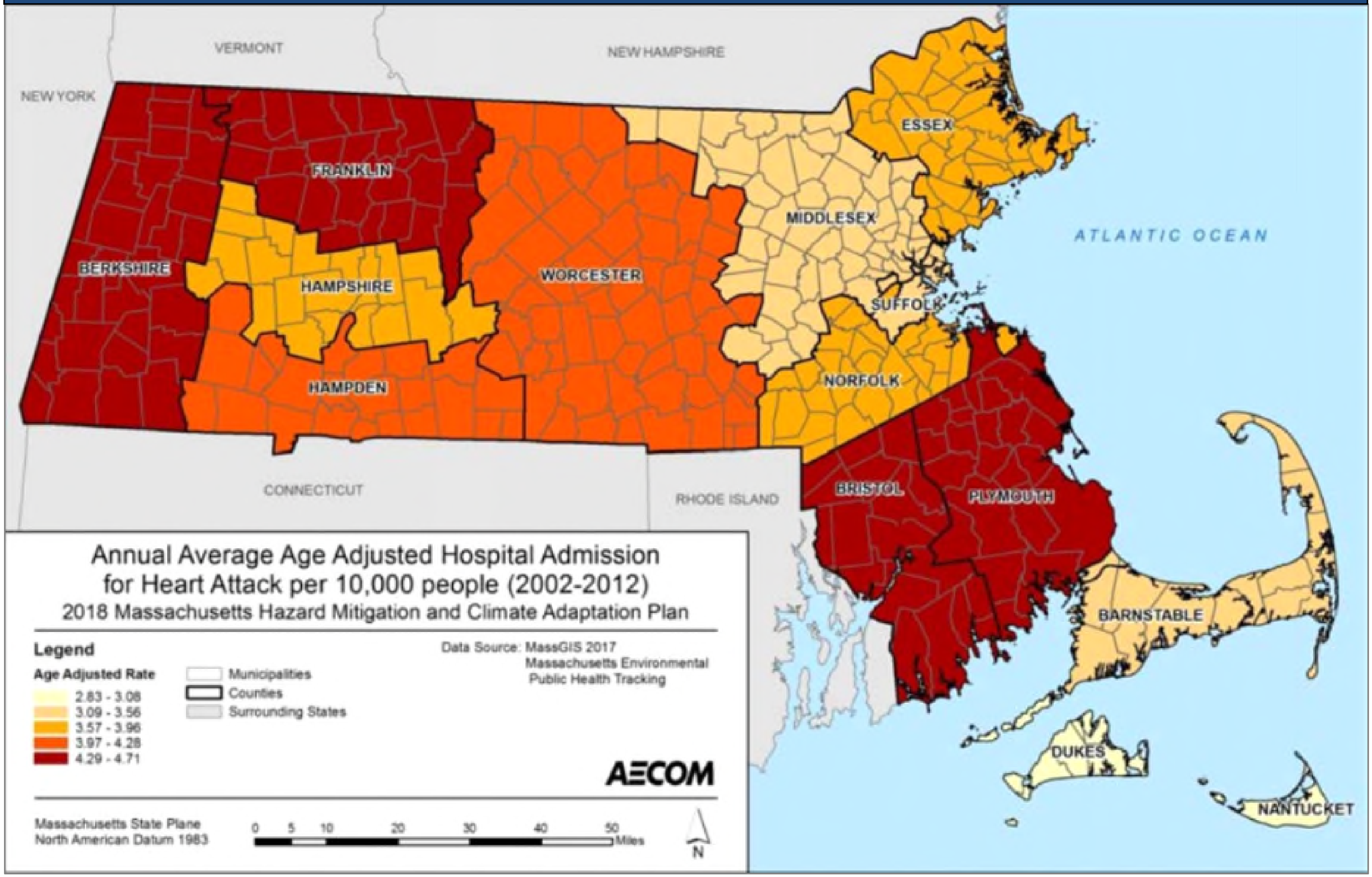
Cold-weather events can also have significant health impacts. The most immediate of these impacts are cold-related injuries, such as frostbite and hypothermia, which can become fatal if exposure to cold temperatures is prolonged. Similar to the impacts of hot weather that have already been described, 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



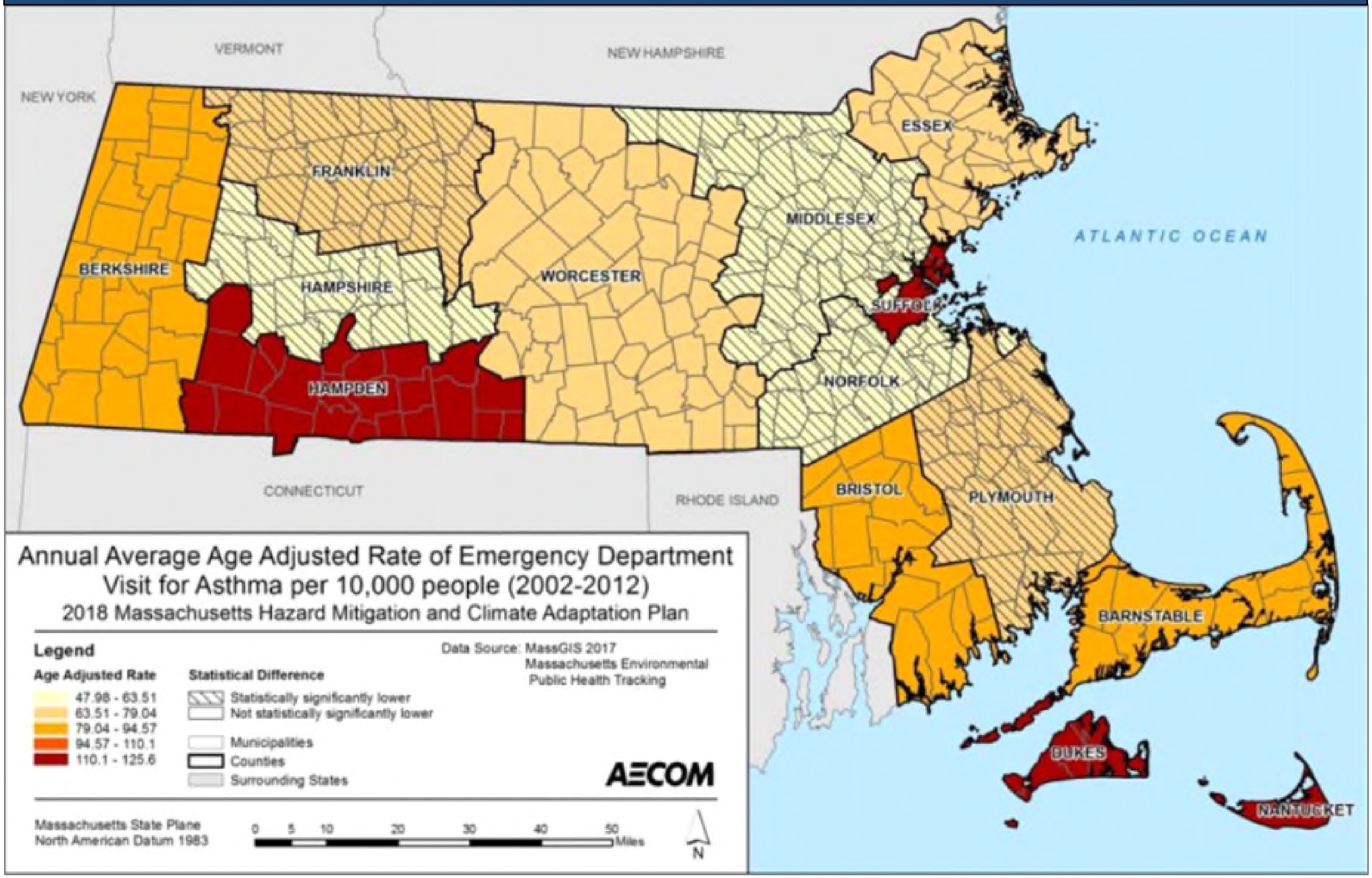
Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

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 grows.

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.[45]

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 percent of this consumption may be attributable to climate change.[46] 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 percentage 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.[47] 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.[48]

---

[45] Resilient MA: http://resilientma.org/sectors/agriculture. Accessed March 4, 2019.
[46] Massachusetts Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee (EOEEA). 2011. Massachusetts Climate Change Adaptation Report.
[47] 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
[48] Resilient MA: http://resilientma.org/sectors/transportation. Accessed March 4, 2019.

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.

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.[49] 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.[50] 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.

---

[49] Massachusetts Department of Transportation (MassDOT). 2017. Assessment of Extreme Temperature Impacts on MassDOT Assets

[50] Resilient MA: http://resilientma.org/sectors/water-resources. Accessed March 4, 2019.

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.[51] 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 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.[52] 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

[51] 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.

[52] 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

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.[53] 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 wooly 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 insect pests, which cause damage to forests.[54] As temperature increases, the length of the growing season will also increase.

Vulnerability Summary

Based on the above assessment, Deerfield has a "High" vulnerability to extreme temperatures. The following problem statements summarize Deerfield's areas of greatest concern regarding extreme temperatures.

Extreme Temperature Hazard Problem Statements
• A better understanding is needed of the impact that extreme temperatures will have on Deerfield's natural resources, including rivers, farmland, and forest that support vital economies for the Town and the region.
• Deerfield should assess its need for and availability of locations for cooling centers. Determine access barriers, equipment (AC with backup generators, etc.).
• Accessing heating and cooling centers may be difficult for vulnerable populations who are most in need during extreme temperatures, including elderly residents, disabled

[53] 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

[54] 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.

Extreme Temperature Hazard Problem Statements
residents and those with medical conditions.
• Although the Town has a new smart911 Warning System, there is a need to expand the system and increase subscription among residents and businesses.
• New programming is needed to promote and increase household disaster preparedness town wide.
• Homeless and transient people in town may be difficult to reach in the event of an emergency.

3.13 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. Another way in which climate change may increase the frequency of natural species threat is through the possibility of climate refugees. As 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 wooly 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.[55]

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

[55] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 4, 2019.

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 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.[56]

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

[56] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 4, 2019.

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, 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.[57]

Location

The damage rendered by invasive species is significant. The massive scope of this hazard means that the entire Town of Deerfield 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).

[57] https://masswoods.org/outsmart. Accessed March 5, 2019.

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 (such as the gypsy moth) are nearly 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 3-40. The table also includes details on the nature of the ecological and economic challenges presented by each species as well as information on where the species has been detected in Massachusetts. Twenty-five of the invasive species on the list have been observed in Deerfield since 2010.

Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Deerfield**
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.	Y
Alliaria petiolata (Bieb.) Cavara & Grande (**Garlic mustard**)	A biennial herb occurring 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 occurring 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 occurring in all regions of the state in aquatic habitats. Common in the aquarium trade; chokes waterways.	N
Celastrus orbiculatus Thunb. (**Oriental bittersweet; Asian or Asiatic bittersweet**)	A perennial vine occurring 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.	N
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

Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Deerfield**
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.	Y
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.	N
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.	N
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
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	Y

Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Deerfield**
	cultivation; overtakes wetlands; high seed production and longevity.	
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.	Y
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.	Y
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.	Y
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	Y

Table 3-40: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Deerfield**
	woodlands; an ephemeral that outcompetes native spring wildflowers.	
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 Franklin County Flora Group, 2019.

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 Deerfield (Table 3-41). One invasive species, the Zebra mussel, was first documented in Massachusetts in Laurel Lake in Berkshire County 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 3-41: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
Terrestrial Species	
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.
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.
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.
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.
Anoplophora glabripennis (**Asian long-horned beetle**)	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.

Table 3-41: Invasive Animal and Fungi Species in Massachusetts	
Species (Common Name)	**Notes on Occurrence and Impact**
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.
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 Deerfield Committee agreed that the probability of future events is “Very High” (50%-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.

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 wooly 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.

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.[58]

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.

Vulnerability

Because plant and animal life is so abundant in Deerfield, 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.

---

[58] This section excerpted from the MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

Vulnerable Populations

Invasive species rarely result in direct impacts on humans, but sensitive people may be vulnerable to 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 albopictus). 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.[59]

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 Deerfield for their economic success. This includes all individuals working in forestry and agriculture-related fields, as well as those whose

[59] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 5, 2019.

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 Deerfield 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 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.

Agriculture

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.

Public Health

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.

Transportation

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.

Water Infrastructure

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
Deerfield is 64% 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.[60]

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

[60] 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

- Diminished property values
- Local and complete extinction of rare and endangered species

Vulnerability Summary

Overall Deerfield faces a "High" vulnerability to invasive species. Impacts from invasive species have the potential to dramatically alter Deerfield's forests and other natural landscapes. The following problem statements summarize Deerfield's areas of greatest concern regarding invasive species.

Invasive Species Hazard Problem Statements
• Changing climate has resulted in fewer days below freezing, a trend that will progress over the next century. Fewer days below freezing and deep frosts occurring later in the season are some of the contributing factors that has resulted in a climate more suitable for invasive insects and other pests that can carry non-native diseases.
• Invasive species exacerbate stormwater flooding and erosion issues by dominating streambanks and altering the stability of river corridors. There are some areas in Deerfield that have unstable riverbanks due to invasive species crowding out native vegetation.
• Residents may not be familiar with how to deal with or prevent vector-borne diseases spread by insects drawn to Town by warmer temperatures.
• Education and outreach is needed to increase local awareness around invasive species and equip residents with appropriate control measure.

3.14 OTHER HAZARDS

In addition to the hazards identified above, the Committee 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 Deerfield, the Committee determined that coastal hazards, coastal erosion, sea level rise, and tsunamis are not relevant to Deerfield and therefore were determined not to be a threat. Manmade hazards are not addressed in the State plan, but were addressed in the 2014 Deerfield Multi-Hazard Mitigation Plan, and are considered a risk to the Town.

This plan does not address all manmade hazards that could affect Deerfield. A complete hazards vulnerability analysis was not within the scope of this update. For the purposes of the 2020 plan, the Committee discussed and updated the information from the 2014 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 2020 plan is an evaluation of cyber-security, which has become a threat of greater concern in recent years, and a section on vector-borne disease.

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, use and disposal of hazardous materials.

Hazardous materials in various forms can cause death, serious injury, short and long-term 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, corrosives, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in facilities.

Location and Extent

A release may occur at a fixed facility or in transit. Communities with a large industrial base, like Deerfield, 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.

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.

The major trucking corridors in Franklin County are Interstate 91, running north/south, and Route 2, running east/west. These two highways also represent the busiest travel corridors in the region for non-commercial traffic. 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.

According to the Franklin County Hazardous Material Emergency Plan,[61] approximately 13 trucks per hour traveling through the region contain hazardous materials (Table 3-42). Most of these vehicles are on Interstate 91, which passes through Deerfield. However, approximately two vehicles per hour travel along Route 2 and up to one truck per hour may be carrying hazardous materials along Routes 5/10, which crosses through Deerfield. In addition, the HMEP notes that all roads in the county likely have vehicles carrying hazardous materials at varying intervals.

[61] Franklin County Regional Emergency Planning Committee, Franklin County Hazardous Material Emergency Plan and Maps, 2006. Based on a one-time survey conducted in 2003.

Table 3-42: Estimated evels 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 major roadways *(Routes 5/10, 63, 47, 116,202, 8A, 78, 122, 142, and 2A)*	1 or 0

The hazardous materials regularly carried on these trucks passing through Deerfield include:

- Gasoline
- Fuel oil
- Kerosene
- Liquefied petroleum gas
- Propane
- Sodium aluminate
- Sulfuric acid
- NOS liquids 3082

Two to three trains per day travel on the Pan Am Systems Connecticut River Line which runs through Deerfield and 10-15 trains pass through the East Deerfield Rail Yard each day (Table 3-43). On the Connecticut River Line an average of two cars per train carry hazardous wastes, while at the Rail Yard and average of between two to five cars per train carry hazardous wastes. While there have been upgrades in the track systems in recent years and changes in switching processes, a Pan Am Railways representative reports that this has increased the speed with which trains move through Franklin County, but has not had a significant impact on the number of trains passing through.

The hazardous materials regularly carried on these trains passing through Deerfield include:

- Sulfuric acid
- Liquified petroleum gas
- Hydrochloric acid
- Chlorine
- Caustic soda
- Methanol
- Sodium chloride

Table 3-43: 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 Waste**
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

<u>Industrial Accidents – East Deerfield Rail Yard</u>[62]

The East Deerfield Rail Yard has been the source of numerous releases of hazardous materials over the years. The railyard is located at 246 Railroad Avenue in a commercial/ residential section of East Deerfield. The property is approximately 129 acres, and is bound to the north and east by open land and the Connecticut River, to the south by East Deerfield Road, and to the west by the Deerfield River. The southwest border of the railroad yard has residences along River Road. Prior to its current use, the site was either undeveloped or used as farmland. The property has been a railyard since the late 1800s. The Commonwealth currently owns the property and it is managed by the Massachusetts Executive Office of Transportation. The property is leased long-term to Pan Am Railways, who owns and operates the tracks and buildings on the site. It has 35 rail lines as well as numerous work buildings, including an engine house. Pan Am owns the land immediately surrounding the site.

Pan Am services locomotives, fuels and sands locomotives, and operates a rail switching yard and layover facility for its freight train operation. Some of the maintenance activities undertaken on the site produce process wastewater, including changing oil in locomotives, cleaning the locomotives, and fueling the locomotives. As a result, the site is subject to a permit for storm water management under the National Pollutant Discharge Elimination System (NPDES) overseen by the U.S. Environmental Protection Agency (Permit #MA0000272).

There are six outfalls that are numbered sequentially from the west-side of the facility to the east-side as Outfalls 001, 002, 003, 004, 005 and 006. Each of these outfalls discharge along the northern side of the rail facility into a wetland or stream that leads to the Connecticut River.

[62] Lynn Rose, Pollution Prevention and EHS Consultant, and resident of Deerfield, provided detailed comments to the FRCOG on the draft update of this section.

The Town sought to have the NPDES permit revised for over a decade. EPA had allowed an "administrative continuance" of the original permit under which Pan Am exceeded both the volume and types and amounts of contaminants. The Town worked with the Connecticut River Watershed Council (CRWC), who also worked with the Western New England University, School of Law, to ensure that the NPDES permit was adequate. Due to issues with the revised permit, CRWC worked with the Western New England College of Law to appeal the revised permit to EPA. CRWC won the appeal and the NPDES permit was revised again. CRWC and the Town also appealed the initial Stormwater Pollution Prevention Plans (SWPPP) submitted by Pan Am, and Pan Am was required to revise it.

The groundwater flows from the railyard northeasterly in the direction of the Connecticut River and it is located within two major watersheds. The depth to the very shallow water table is 3 to 12 feet below ground surface. The site is underlain by a Potentially Productive Medium Yield Aquifer. The section of this aquifer directly under the railyard is exempt from drinking water standards due to its industrial designation. There is a section of this aquifer that is located beyond the railyard boundaries and is subject to the drinking water regulations, and has been contaminated by chlorinated solvents from the railyard. This contamination is one of the release sites listed below.

There is a perennial stream located within 540 feet north of one of the hazardous release sites with an associated wetland buffer zone. There are also two perennial streams that run from the Pocumtuk Ridge, under River Road (on the southwest border of the site) and under the railyard site and discharge at the far side of the railyard. The pathway and conduit of these streams under the railyard are not completely known. Flows have been identified at the stormwater outfalls at the eastern end of the site during non-storm events, and we suspect that the source is either groundwater infiltration or possibly from one of these perennial streams. The concerns about these streams is there potential as a pollutant pathway for the contaminated soils at the site. Contaminated sites are located within the railyard area within 500 feet of protected and recreational open space.

The entire railyard is located on floodplain deposits of the Connecticut River on a meander point bar. It is located about 15 to 20 feet above the Connecticut River. It is located right below the confluence of the Deerfield and Connecticut Rivers. There has been a significant amount of fill from coal ash used at the site (which is exempted from background mercury concentrations due to an EPA designation under the Final CCR Disposal Rule as "beneficial use" and the Massachusetts Contingency Plan (MCP) identifies Historic Fill as a type of "Anthropogenic Background" that does not require remediation).

The site's soils include:[63]

- Hb - Hadley very fine sandy loam 133 - Well drained, Subject to infrequent flooding, Rated severe for septic tank, sewage effluent disposal
- Mu - Muck 142 - Very poorly drained, Not suitable for engineering purposes, Have very severe limitations for urban use
- Af - Agawam fine sandy loam 112 - Well drained
- Lk- Limerik silt loam 137 - Poorly drained, Subject to flooding, High water table at or near surface for 7 or more months of the year, Rated severe for septic tank, sewage effluent disposal
- Ww - Winooski fine sandy loam 160- Moderately drained, Subject to flooding, Rated severe for septic tank, sewage effluent disposal

Because much of the site's soils are moderately to well drained, and in some locations, just a few feet to groundwater, the Town is concerned that any contamination in the soil can easily migrate into the groundwater.

Due to the numerous historic and ongoing releases of hazardous materials at the railyard, the site has been subject to the regulations set forth in M.G.L. Chapter 21E and the Massachusetts Contingency Plan (MCP; 310 CMR 40.1403), which are the state's hazardous waste site clean-up regulations. The MCP governs the site assessment, remedial response actions, and public involvement process of hazardous waste sites.

Pan Am, as the operator at the site, was required to retain a Licensed Site Professional (LSP) to oversee and approve assessment and remedial activities conducted at the Site. An LSP is an environmental scientist or engineer experienced in the assessment and cleanup of releases of oil and/ or hazardous materials (OHM) to the environment. LSPs are licensed by the Massachusetts Department of Environmental Protection (MassDEP) to ensure responsible party compliance with the MCP. The LSP's role is to ensure that actions taken to address releases of OHM at a site comply with the requirements of the MCP and protect human health, safety, public welfare, and the environment.

MassDEP retains the authority to ensure that both technical and public involvement activities are conducted in accordance with state law and regulations. The town is working closely with the MassDEP to ensure Pan Am's compliance with the MCP. Due to cutbacks at MassDEP over the last two decades, many MCP sites such as this one are considered privatized cleanups that

[63] Soil Survey, Western MA, USDA 1967.

must be conducted under the responsible party's LSP. Since the town has working very closely with the MassDEP to ensure Pan Am's compliance with the MCP, MassDEP has been more involved with these sites in the past decade than other sites with similar MCP designations. Due to further cuts, MassDEP has only been able to conduct audits of Pan Am's efforts. The most recent audit was conducted within the last six months. These audits consistently find lapses in compliance with required MCP activities.

The Town of Deerfield has a Hazardous Waste Coordinator, who initiated the investigation into the issues at the railyard and has been overseeing Pan Am's compliance with the MCP for over two decades. She has written grants as well as working with the Town to fund an LSP on behalf of the town. She has overseen both the consultant's work and Pan Am's compliance with MCP requirements. She initiated the Public Information Process at the railyard for oversight of the MCP process at all of the hazardous waste sites. This process enables the Town to evaluate and comment on all of Pan Am's plans for investigation and clean-up of each site and has been instrumental with enabling the Town to have an active role in ensuring compliance. Pan Am has had to provide the Town with fact sheets, draft documents for comment, and to hold public hearings to explain site activities and solicit comments from residents and public officials.

In accordance with the MCP, the Chief Municipal Officer and the Board of Health are notified by Pan Am of the following activities are conducted:

- The purpose, nature and expected duration of any field work related to the investigation phases of the MCP and the implementation of Phase IV remedial activities;
- The use of respirators and other personal protective equipment (PPE) required under Level A, B or C as defined in the site specific Health and Safety Plan (HASP); and
- Sampling of any drinking water supply wells, indoor air or surface soils at any residential property at, adjacent to or down gradient from the Site.

Additionally, the Chief Municipal Officer and Board of Health are notified of the implementation of any Release Abatement Measure (RAM), including information about the purpose, nature and expected duration of the RAM. The Chief Municipal Officer and Board of Health will also be notified by Pan Am of the status of the availability of any closure determinations (Temporary Solution, Permanent Solution without Conditions, and Permanent Solution with Conditions).   If issues of public safety are involved, the Deerfield Fire and Police Departments will be notified of any threat to public safety prior to the implementation of remedial actions, unless prior notification is impracticable. The MCP requires community notification of major planning and implementation milestones at disposal sites.

Summary of Contaminated Sites at the Railyard

The site has hazardous waste sites from both current releases of hazardous waste and historical incidents. The pattern that has emerged during the investigation of current releases is the identification and related assessment of historical contamination. It is important to note the frequency and number of releases at the site as well at how long it takes to address the contamination. Also, there are a number of older, closed sites not listed here.

Key: the following sites are evaluated and addressed using the following phases:

- Phase I: Initial Site Investigation - initial investigation activities to evaluate a release.
- Phase II: Comprehensive Site Assessment - investigation to evaluate extent, source, and risks associated with contamination to determine need for remedial actions at the site.
- Phase III: Remedial Action Plan – evaluation of clean-up options.
- Phase IV: Remedy Implementation Plan – implementation of selected clean-up option.
- Phase V: Remedial Operation Maintenance or Monitoring – of an implemented clean-up option.
- Temporary Solution, Permanent Solution without Conditions, and Permanent Solution with Conditions – close out the site based on completion of environmental work.
- Immediate Response Action (IRA) – clean-up required whenever a sudden release of hazardous material, or other time-critical situation, is encountered.
- Release Abatement Measures (RAM) - further clean-up prior to Phase IV if they need to clean-up to prevent a release during release.

Since the last update of Deerfield's Hazard Mitigation Plan, no releases have been reported to the Waste Site & Reportable Releases database maintained by the Massachusetts Office of Energy & Environmental Affairs. Updates to releases covered in the last plan are summarized in the following sections.

Older Sites that Continue to be Addressed:[64]

1. **SITE # 1-16603** - *Lake Asphalt* - This property was previously leased from Pan Am for use as an asphalt plant and then abandoned for more than 20 years. It is located right on River Road, along the southwestern boundary of the railyard across from several residences. Pan

[64] https://eeaonline.eea.state.ma.us/portal#!/search/wastesite
http://eeaonline.eea.state.ma.us/DEP/wsc_viewer/main.aspx
ERM East Deerfield Railyard project site:
https://eastdeerfieldrailyard.erm.com/home.cfm?CFID=18411&CFTOKEN=98305758&dest=main&loc=pg-s-02&pg=jqpg9

Am removed 4 buildings, 18 above ground storage tanks, 1 vault and approximately 60 drums. Contaminants found included asbestos, PCBs, petroleum products and lead.

Although they removed some of the contaminants from the site, MassDEP audited the site and based on the audit findings and the discovery of a private drinking water well across the street from the site, they required Pan Am to revise their Phase II. MassDEP considers the site to be a potential drinking water source area due to the location of the private well, which requires a higher standard of investigation and clean-up than the railyard. They required Pan Am to add additional groundwater monitoring wells, and further test soils for asbestos, lead, petroleum by-products and other contamination.

In order to address asbestos-impacted soil on site, a soil cover system was developed by Environmental Resources Management (ERM). The system involved placing 20 inches of high-organic content clean soil on the impacted area and planting upland habitat seed mix on the soil cover. The resulting vegetation will help to promote proper drainage, minimize erosion of the cover system, and prevent waste from further contaminating the area. Results from the annual inspection of the system in August 2019 concluded that vegetation coverage exceeded 75% of the total soil cover area, indicating that the soil cover has remained stable. Per the Post-Temporary Solution Status report submitted by Pan Am Railways in October 2019, the site will continue to be monitored via groundwater sampling through Summer 2020. A final Permanent Solution will be submitted in the Fall 2020, pending the continued success of remediation activities.[65]

Note that this site was recently under serious consideration and planning for installation of a solar farm.

2. **SITE # 1-12430** – A total of seven release conditions, including the main release number, which were originally investigated separately were linked together under this tracking number to enable Pan Am to streamline the investigation and clean-up of so many sites. Sites include:
    a. **SITE # 1-12430** – *Historical release of petroleum to soil* near fueling island identified during another investigation.
    b. **SITE 1-12430 Addendum** - *Chlorinated Solvents* - – This site was investigated based on a request from the Town due to the known historical extensive use of chlorinated solvents at the site. This solvent contamination was found in groundwater in an area that was exempt from the drinking water regulations due to the industrial use of the site, as well as an having migrated out of the exempt area into an area that is not exempt and is regulated under the drinking water regulations.

       Based on Town monitoring, concerns and an audit, MassDEP sent a notice on noncompliance to Pan Am 10/9/09 to require them to conduct additional investigation activities to define the source and extent of the contamination. A

[65] Post-Temporary Solution Status Report for the Former Lake Asphalt Site, East Deerfield Massachusetts. Pan Am Railways and Environmental Resources Management, October 2019.

public involvement plan meeting was held 11/30/10 at Town Hall on the Phase II *addendum* report which described the results of additional investigation activities to *actually* define the nature and extent of petroleum impacts from the four identified sources of release and evaluate risks posed by petroleum and chlorinated solvent impacts in soil and groundwater to human health and the environment. MassDEP sent Pan Am another notice of noncompliance on 2/24/11 to conduct additional investigation.

c. **SITE # 1-17432** - *Release of 20 gallons of fuel from a train* during transfer of the locomotive between tracks 4/09. The release occurred at each of 3 adjacent switches.

d. **SITE # 1-12501** - *Releases of diesel* from an underground storage tank 8/98.

e. **SITE # 1-13006** - *Former fueling island generating petroleum contamination* floating on the groundwater 7/99.

f. **SITE # 1-18115 –** *Fuel Island 100-gallon Diesel Spill (2/11).* An Immediate Response Action was completed on 2/17/12.

g. **SITE # 1-18128 –** *Identified Petroleum Contamination in Groundwater Exceeding Reportable Concentrations.* As part of an investigation for another release, Pan Am identified that the amount of contamination found in the newly installed (11/10) monitoring wells MW-26S and MW-26D exceeded acceptable reportable concentrations. MassDEP deemed the contamination be a "reportable release", designated this contamination as a new release condition (waste site), and is requiring them to evaluate the competence and possible leaks of current and past underground storage tanks and the oil/water separator connected to the current on-site wastewater treatment plant.

h. **SITE # 1-19466** – *Release of 20* gallons of engine oil leaked from a train due to a drain plug on an oil filter being left open (7/22/2014).

i. **SITE # 1-17125 –** *Release of 100 gallons of diesel from* a *100,000 gallon aboveground storage tank (AST)* 8/08. This site was complicated by the fact that in addition to removing old contamination, and decommissioning and replacing this AST with a new tank farm, there was a threat of release from the tank. In 9/10 they found holes in the AST shell and in 12/10, they found holes in the tank floor. Although Pan Am attributed the presence of contamination in the soils and groundwater underneath the tank to the release in 2008, MassDEP proposed that their secondary containment was not adequate and that there was an ongoing condition of "substantial release migration".[66]

   The Town, MassDEP and the State Fire Marshal's Office were involved in this process. MassDEP issued an order 9/10 to take the AST out of service. When they

---

66 https://eastdeerfieldrailyard.erm.com/DocDisplay.cfm?CFID=18411&CFTOKEN=98305758e&extdoc=Fact_Sheet_1-17125.pdf&&CFTREEITEMKEY=

did, they found that the tank had been leaking undetected underneath. The new tank farm was scheduled to come on-line spring 2011.

Combined Sites RTN 1-2430 - A Phase IV Completion Statement and Phase IV Final Inspection report for RTN 1-2430 (combined sites) was submitted in September 2015, which summarized remediation activities for all petroleum-impacted soils. According to the Remedy Operation Status (ROS) Submittal by Pan Am Railways in September 2019, groundwater-monitoring data show that concentrations of EPH, VPH, and CVOCs are generally decreasing. Quarterly groundwater monitoring will be conducted through 2019, and then semiannually beginning in 2020 to ensure that the excavation of soils was effective.

Closed Out Sites:

1. **SITE # 1-12219** – *release of 1,000 gallons of lube oil.* Approximately 700 gallons were contained in the spill containment system, and 300 gallons spilled in the soil.
2. **SITE # 1-18124** – *Release of Hydraulic Fluid at the Work Equipment Building.* Approximately 5 gallons of oil spilled during a snowstorm. Unseasonably warm weather caused snowmelt, which carried the oil spill to the fire pond (2/11).
3. **SITE # 1-17029** – *Release of 250 to 500 gallons* of fuel during from a fuel tank during an incident (6/08).
4. **SITE # 1-15823** – *Release of 750 gallons* of fuel during from a train during an incident in 7/05.
5. **SITE #1-18888** – *Release of 50-70 gallons of diesel fuel* from a 2,000 gallon AST when it was crushed for scrap metal (10/12).
6. **SITE # 1-17606** – *100 gallon diesel spill* from an overfill of a locomotive (10/09). Approximately ½ of the diesel was contained in the fueling area containment system and processed in the site's wastewater treatment plant. The other ½ of the diesel contaminated the soil, which was excavated in 2010.
7. Site # 1-20290 - *Release of approximately 35 gallons of hydraulic oil* to a concrete pad in the railyard from repositioning a swing loader on June 27, 2017. The concrete pad where the release occurred is located within the center portion of the rail yard approximately 50 feet west of the roundhouse. Pan Am completed an Immediate Response Action Completion Report and Permanent Solution Statement with No Conditions.
8. Site #: 1-20466 - 14 February 2018, *a release of an unknown quantity of what is believed to be engine oil* was discovered along the Pan Am "Deerfield Loop" right of way. Pan Am submitted an Immediate Response Action Completion Report and Permanent Solution Statement With No Conditions in April 2018.

9. Site # 1-20740 - *a release of approximately 20 gallons of engine oil* onto the ground surface and track ballast area along track 5, near the Engine House building, due to equipment failure of a hose on December 19, 2018. Pan Am completed Immediate Response Actions (IRA): deployment of absorbents; excavation and proper disposal of up to 50 cubic yards of contaminated ballast and soil; and completion of assessment activities.

   On 14 February 2019, Pan Am submitted an IRA Plan which included an Imminent Hazard Evaluation pursuant to the MCP, 310 CMR 40.0321. Based on the completion of response actions under the IRA, Pan Am concluded that an Imminent Hazard does not exist under current site conditions.

Industrial Accidents – Other 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 which involve toxic chemicals.[67]

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. Table 3-44 lists these facilities located in Deerfield.

[67] https://www.epa.gov/enviro/tri-overview

Table 3-44: Toxics Release Inventory (TRI)	
Facility Name	**Facility Location**
Deefield Urethane Inc.	South Deerfield
Disston Co.	South Deerfield
Hardigg Industries, Inc. (now Pelican Products)	South Deerfield
Pliant Corp	South Deerfield

Source: TRI Search Results. EnviroFacts USPA. http://envior.epa.gov/enviro/ Accessed 1/6/2020.

Table 3-45 lists the hazardous facilities in Deerfield identified in the Town's Comprehensive Emergency Management (CEM) Plan, the Franklin County Regional Emergency Planning Committee (REPC) 2018 List of Tier II Facilities, and others added following Committee input. 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).

Table 3-45: Hazardous Facilities in Deerfield	
Hazardous Facility	**Location**
Bement School	94 Main Street
Comcast – Deerfield Headend	271 Greenfield Road – Rt.5
Crop Productions	25 Elm Street
Deerfield Academy	7 Boyden Lane
Deerfield Elementary School	21 Pleasant Street
Deerfield DPW	5 Jewett Avenue
Eaglebrook School	271 Pine Nook Road
Frontier Regional High School	113 North Main Street
Goulet Trucking	20 Industrial Drive West
Grybko's Garage	185 North Main Street
Henry C. Kocot & Sons, Inc.	126 Whately Road
Old Deerfield Waste Water Treatment Plant	82 Old Main St.
Pan Am Railways East Deerfield Rail Yard	200 McClelland Farm Road
Pelican Products (former Hardigg Industries)	147 North Main Street
Pocumtuck Valley Memorial Association	8 Memorial Street
Sokoloski's Landscaping	208 North Main Street
South Deerfield Waste Water Treatment Plant	150 Sunderland Road
Trew Corporation/Allstate Asphalt	901 River Road
Yankee Candle Co.	9 Greenfield Road

Source: 2018 Franklin County REPC List of Tier II Facilities

Pesticides (herbicides, insecticides, fungicides)

The University of Massachusetts owns several parcels of land on River Road, immediately across the street from the Connecticut River. At least one of the sites is used for livestock and one is used for turf research.

In a Deerfield Selectman's Meeting at the Deerfield Town Offices on 1/23/19, which had been requested by the Town in response to resident concerns about the turf research site, UMass provided some very limited basic background of their use of this property. UMass conducts turf grass evaluation trials on 1,200 research plots. They use pesticides on up to 70 small sites in a year. Their regulatory compliance regarding chemical use and hazardous waste includes the following:

- UMass compliance with MA Department of Agricultural Resources (MDAR) regulations:
    - Posting of Pesticide Application Notifications - They only provide to on-site students and staff. They do not believe that they are required to provide any other notifications.
    - Pesticide Applicators - They are licensed by MDAR and provide "Records of Applications" to MDAR who has full knowledge of what pesticides are used on site.
- UMass compliance with EPA Worker Protection Standard (WPS)
    - Notification - requires employers to inform agricultural workers and pesticide handlers about pesticide safety, provide protections from potential exposure to pesticides, and mitigate exposures that do occur. *Please note that residents would like to be notified due to drift concerns.*
    - Restricted-Entry Interval (REI) - the time immediately after a pesticide application when entry into the treated area is restricted. Some pesticides have one REI, such as 12 hours, for all crops and uses. Other pesticides have different REIs depending on the crop, method of application, or the post-application activity to be performed. When two or more pesticides are applied at the same time and have different REIs, the longer REI must be followed.
- MassDEP – hazardous waste generator requirements and Hazardous Waste Accumulation:
    - Based on the MassDEP database of Hazardous Waste Generators, only one current Hazardous Waste Generator Identification Number is listed for a "very small generator" of hazardous waste under the generator number MV4136653592, for the address; University of Massachusetts Dairy Farm, 91 River Rd, Deerfield, Ma 01342, 413-545-2682. This address appears to be a separate parcel further north on River Road.

Based on the information provided by UMass at the meeting, it was unclear to residents whether UMass is aware of all the chemicals used on-site, including locations, containment, security, application frequencies and quantities. Without this information as well as any site plan information for managing these various sites, it would be impossible to evaluate any potential impacts for the following:

- Planning hazard mitigation measures/systems for incident response (are there any types or quantities of chemicals requiring notification to the Fire Department or MassDEP under EBCRA (the Community Right to Know)?
- Implementing exposure controls to abutters, if warranted, including notification procedures.
- Identifying opportunities for toxics reduction and pollution prevention of drinking water sources and the Connecticut River, etc.
- Information needed based on the location of property, potentially in a regulated floodplain (100 year floodplain) and/or within the mapped inundation area of a catastrophic dam failure on the Connecticut River:
    - The site needs to be included in the updated hazard mitigation plan. UMass needs to provide the Deerfield Fire Department and EMD with a list of chemicals on site, their emergency response plans, etc.
    - Containment of chemicals is required if the site is located in a documented flood zone. This needs to be determined on two fronts: is the site in the 100-year flood plain? Does the dam failure inundation area trigger this requirement?

Also worth consideration is that 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. And 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, including Savage's Sod Farm, Ciesluk Farm, J.M. Pasiecnik Farms, Melnik Farm, Williams Farm, Yazwinski Farm, Clarkdale Farm, Atlas Farm (organic, but uses some approved chemicals), Tatro Farm and among others.

Hazardous facilities located outside of Town boundaries can potentially impact the Town as well. The Vermont Yankee nuclear power plant is located on the Connecticut River in Vernon, Vermont, near the Vermont/Massachusetts border and approximately 33 miles from Deerfield. 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.[68]

On August 27, 2013, Entergy, then-owner of Vermont Yankee, announced that Vermont Yankee would cease operations at the end of 2014 for economic reasons. Vermont Yankee officially disconnected from the grid on December 29, 2014. The reactor was manually shut down without incident. Transfer of all Vermont Yankee spent fuel from the reactor to the spent fuel pool was completed on January 12, 2015. The transfer of all Vermont Yankee spent fuel to dry cask storage was completed on August 1, 2018. On December 6, 2018, the Vermont Public Utilities Commission (PUC) approved Entergy's sale of Vermont Yankee to subsidiaries of NorthStar Group Services, Inc., as a means of completing the decommissioning and site restoration on an accelerated schedule.[69]

The Yankee Atomic Electric Company (YAEC) stores spent nuclear fuel from the former Yankee Rowe nuclear facility, which operated for over three decades as a power generating facility until 1992. The plant was disassembled and officially decommissioned in 2007. However spent fuel from the plant's operation is still stored on site adjacent to the Sherman Reservoir on the Deerfield River, upstream from Deerfield. The fuel is stored in Nuclear Regulatory Commission – approved dry canisters and casks made of steel and concrete, which are placed on a concrete pad on the site. The stored fuel is monitored 24 hours a day. The fuel storage site is within the inundation zone for the Harriman Dam, which is located approximately 6.5 miles upstream from the site. According to the YAEC's website, the type of container that the fuel is stored in has been tested to withstand submersion under 50 feet of water for 8 hours, among other safety tests.[70]

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. Town officials should stay abreast of proper evacuation procedures in the event of an accident at the Vermont Yankee or Yankee Rowe facilities.

Cyber Threats

A failure of networked computer systems could result in the interruption or disruption of Town

[68] Vermont Department of Health. http://healthvermont.gov/enviro/rad/vt_yankee.aspx
[69] Vermont Department of Public Service: https://publicservice.vermont.gov/content/nuclear_decommissioning_citizens_advisory_panel_ndcap/history. Accessed July 6, 2019.
[70] Yankee Atomic Electric Company. http://www.yankeerowe.com/fuel_transportation.html.

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.

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. [71] These threats are not only external; many acts of cyber-crime happened from current or former employees who were given network access legitimately.

---

[71] NYC Hazard Mitigation, Cyber Threats, https://nychazardmitigation.com/hazard-specific/cyber-threats/what-is-the-hazard/

For Deerfield, 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.

Social Engineering:

Social engineering involves obtaining confidential information from individuals through deceptive means by mail, email, over the phone, and increasingly through text messages.[72] 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 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 sophisticate 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

[72] Cybersecurity Precautions, MA Executive Office of Technology Services & Security, 2017

Executive Office of Technology Services and Security (EOTSS)[73] 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.

Manmade hazards were assessed at the local level for the first time in the 2014 Multi-Hazard Mitigation Plan. The 2020 Plan adds to this work but is still just a preliminary assessment of Deerfield's vulnerability to these hazards. The potential for these types of manmade hazards to impact the Town, its critical infrastructure and its residents is Medium to High.

Manmade Hazard Problem Statements
• Deerfield is vulnerable to a spill of hazardous materials and/or hazardous waste transported on Interstate 91, Route 5/10, Route 2, or on the rail lines through town.
• Deerfield is vulnerable to a spill of hazardous materials and/or hazardous waste at one of several facilities in town that use and store hazardous materials. These facilities and/or hazardous materials storage may be in the 100-year floodplain and the inundation area identified by the USGS Flood Inundation Mapper Tool.
• Cyber-attacks on local government is a growing threat. Keeping up with current best practices in cyber security can be challenging for communities.
• Deerfield Railyard site clean-up is an ongoing activity that the Town should continue to be involved in monitoring and commenting on reports, remedial plans, etc. Much of the site's soils are moderately to well drained, and in some locations, just a few feet to groundwater. The Town is concerned that any contamination in the soil can easily migrate into the groundwater.
• The Town needs to continue their dialog with UMass and follow-up is needed regarding all the chemicals used on-site at the UMass livestock and turf farm facility, including locations, containment, security, application frequencies and quantities. Without this information, as well as any site plan information for managing these various sites, it is not possible to evaluate incident response needs/vulnerabilities, the potential impacts on abutters, and potential impacts on natural resource impacts. It needs to be determined whether the facility is in the 100-year floodplain.

[73] https://www.mass.gov/cybersecurity

VECTOR-BORNE DISEASES[74]

Hazard Profile

The Town of Deerfield 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 and an increase in mortality.

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

---

[74] 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. BRPC shared this text with Carolyn Shores Ness, Board of Health and Select Board member for the Town of Deerfield. Deerfield requested that this section be added to their 2020 Multi-Hazard Mitigation Plan. FRCOG updated available statistics for Massachusetts using information from MA DPH's website and for Franklin County (FRCOG Public Health Nurse and MAVEN).

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.

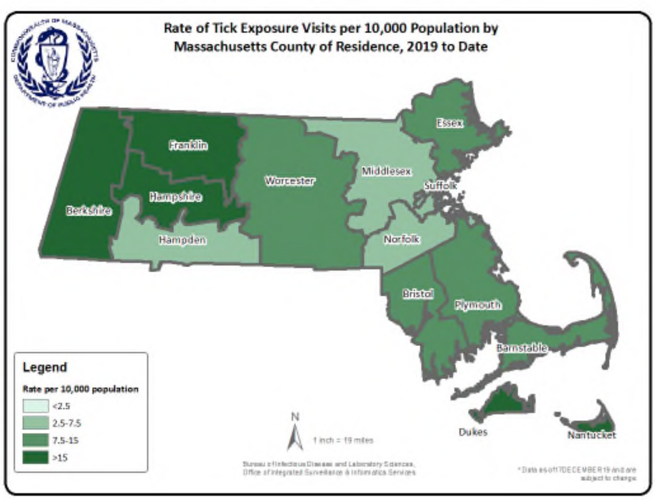
Location

The entire Town of Deerfield 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.

Extent[75]

<u>Tick-borne Illness</u>
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.

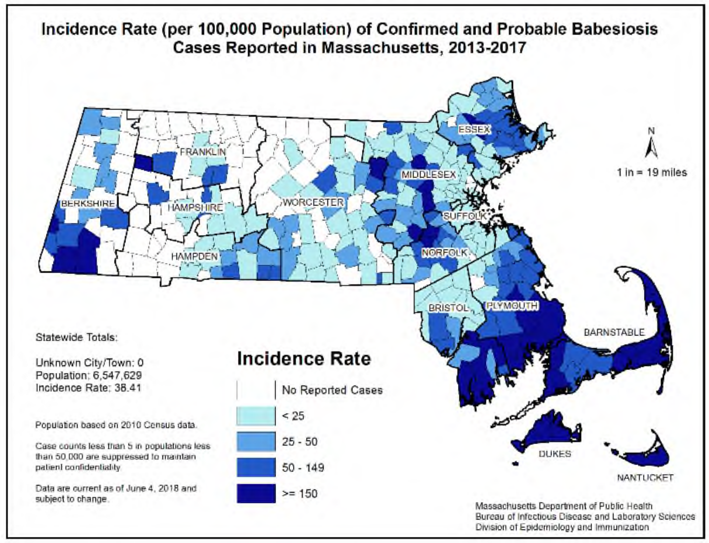
The map below shows the rate, per 10,000 total population, of ED visits by patients who had a visit related to a tick exposure, by Massachusetts county of residence, 2019 to date. Although there are differences in the rate of patient visits, this shows that people are exposed to ticks throughout all of Massachusetts and should take recommended steps to reduce the chance of being bitten.[76]



The following information was downloaded from the website of the Massachusetts Department of Public Health.[77]

[75] https://www.mass.gov/lists/tick-borne-disease-surveillance-summaries-and-data#monthly-tick-report-page- accessed March 19, 2020.
[76] https://www.mass.gov/info-details/monthly-tick-report-november-2019 accessed March 19, 2020.
[77] https://www.mass.gov/lists/tick-borne-disease-surveillance-summaries-and-data#lyme-disease-surveillance-data- accessed March 19, 2020.

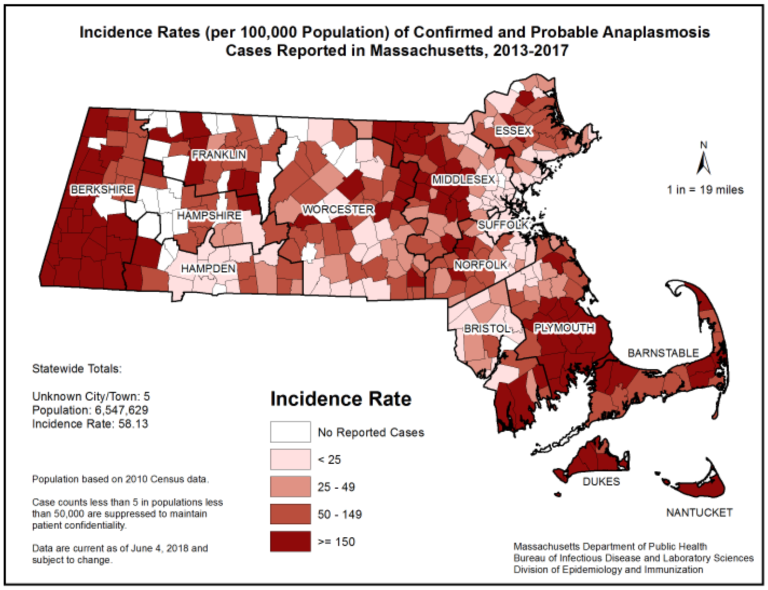
Babesiosis:



- 590 confirmed and probable cases of Babesiosis were reported in Massachusetts in 2017, a 13% increase from 2016. Overall, 1,677 suspect cases of Babesiosis were investigated.
- **2 confirmed cases in Franklin County**.
- Statewide, Babesiosis incidence increased from 7.9 to 9.0 cases per 100,000 residents. The incidence in Berkshire, Dukes, Hampden, Hampshire, Norfolk, Plymouth, Suffolk, and Worcester counties increased slightly. Counties with the highest incidence continued to be Barnstable, Dukes, and Nantucket.
- The majority of cases occurred in June, July and August, with only 35% of cases reporting awareness of a recent tick bite.
- People aged 60 years and older continue to be at greatest risk for clinical disease (59% of all patients identified with Babesiosis were 60 years or older) and 66% of all cases were male.
- 1,209 confirmed and probable cases of HGA were reported in Massachusetts in 2017, a 38% increase over 2016. Overall 2,473 suspect cases of HGA were investigated.

Human Granulocytic Anaplasmosis (HGA)

- Statewide, HGA incidence increased from 13.3 to 18.4 cases per 100,000 residents. The counties with the highest incidence are Barnstable, Berkshire, Dukes, **Franklin**, Nantucket and Plymouth. Berkshire County had the greatest change in incidence, from 66.3 to 133.4 cases per 100,000 residents.
- **27 confirmed cases in Franklin County**.



- The majority of cases occurred in May, June, and July, with only 45% of cases reporting awareness of a recent tick bite.
- People aged 60 years and over continue to be at greatest risk for clinical disease (56% of patients identified with HGA were 60 or over) and 64% of all cases were male.
- Nearly one out of three patients with HGA (29%) was hospitalized. The symptoms most commonly reported included fever (93%), malaise (72%), and muscle aches and pain (63%). There were three fatalities.

Lyme disease:

- 3,830 confirmed Lyme disease cases, and 1,770 probable cases, were reported in Massachusetts in 2014, which is a decrease of 1% from the number of confirmed and probable cases reported in 2013
- **50 confirmed cases in Franklin County in 2014**.
- The highest incidence rates were among children aged 5-9 years and adults aged 65-74 years.
- The majority of cases had onsets in June, July, and August.
- 66% of confirmed cases had a reported erythema migrans (“bulls-eye”) rash.

The Franklin Regional Council of Governments’ Cooperative Public Health Services (CPHS) Public Health Nurse supplied the following information for reported cases of vector-borne illnesses in 2019:[78]

- Lyme 92 suspect (**12 were Deerfield**) in 2019
  - In 2018, 76 suspect Lyme

[78] 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.

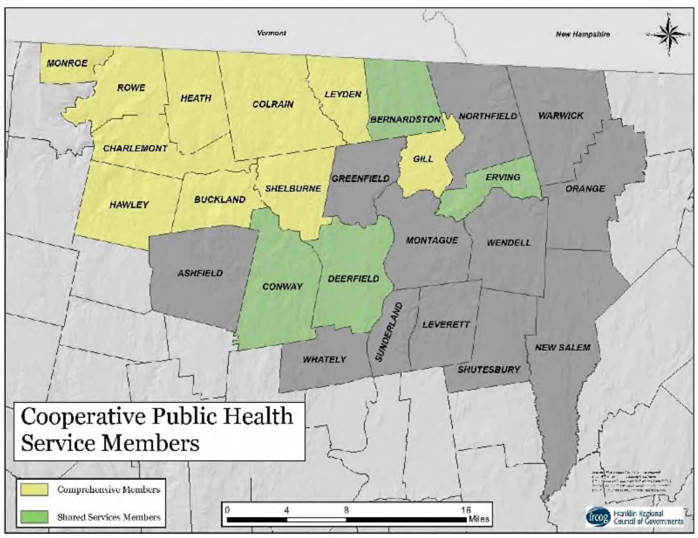
- In 2017, 86 suspect Lyme

- Babesiosis 1 (5 were reported but 4 were revoked-determined not to be Babesiosis)

- HGA Human Granulocytic Anaplasmosis (37 total reported, 11 confirmed, 14 suspect, 1 probable and 10 revoked)

- Erlichiosis 1 (6 reported: 1 probable, 5 revoked)

- No other tick-borne illnesses reported in 2019.



<u>Mosquito-borne Illnesses[79]</u>

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.[80]

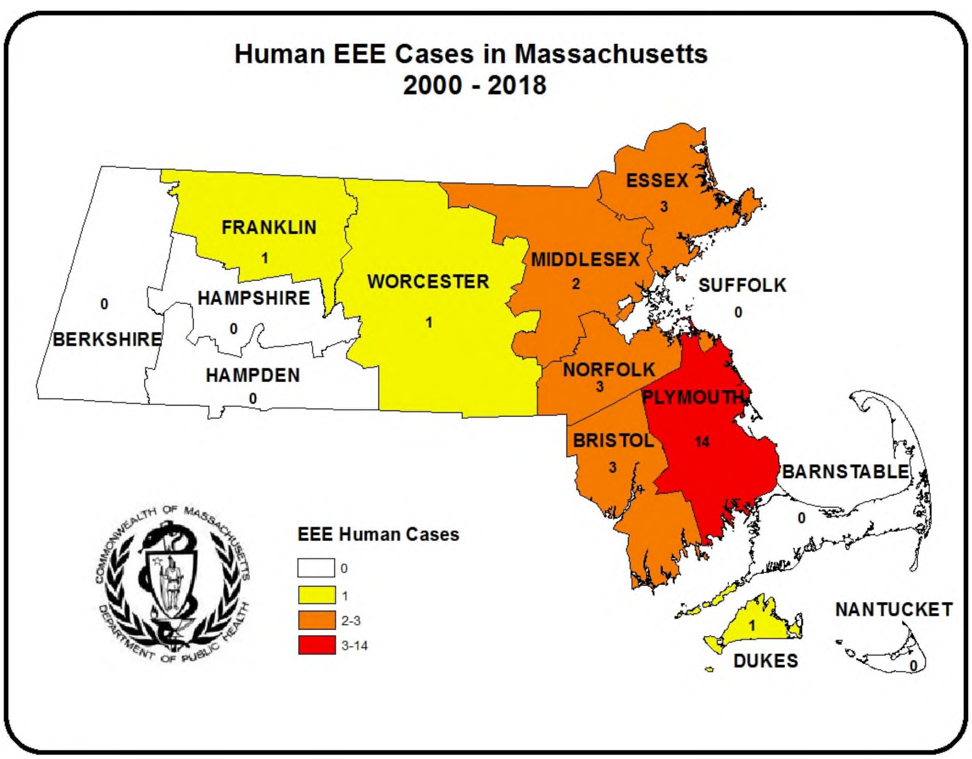
EEE has a 30-50% mortality and lifelong neurological disability among many survivors. The first

[79] https://www.mass.gov/mosquito-borne-diseases accessed March 20, 2020.
[80] https://www.mass.gov/guides/eee-in-massachusetts accessed March 20, 2020

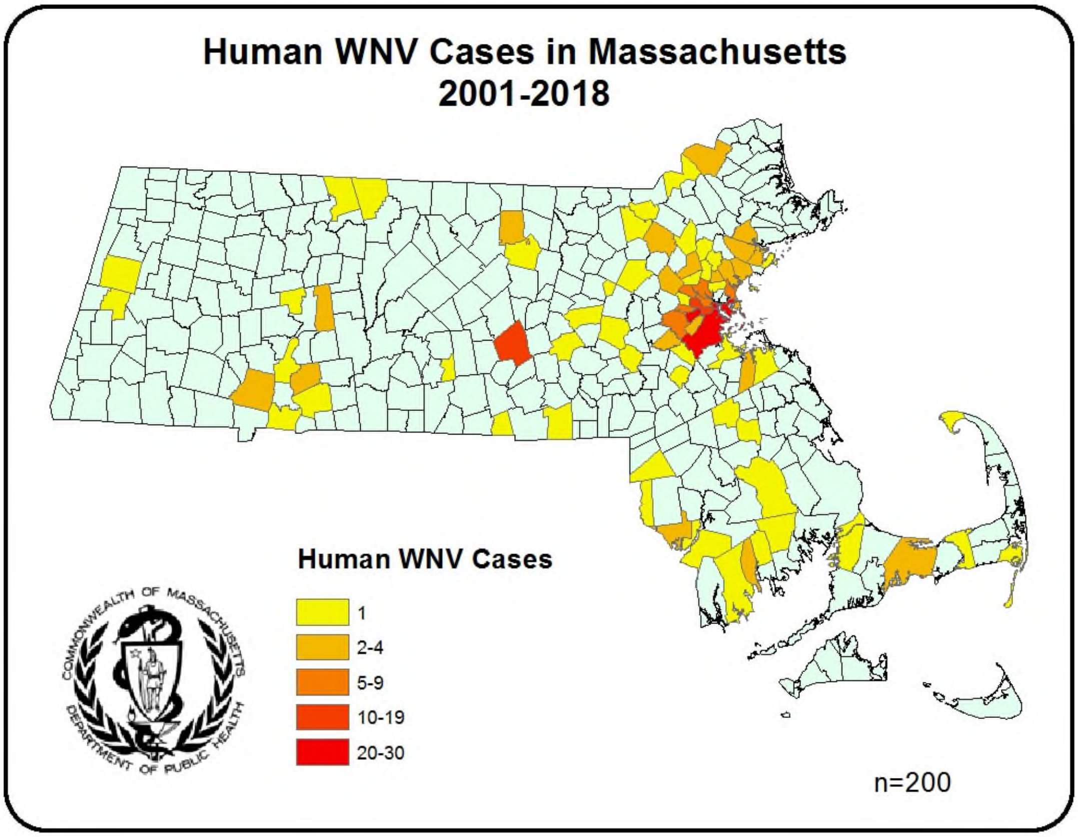
symptoms of EEE are fever (often 103º to106ºF), stiff neck, headache, and lack of energy. These symptoms show up three to ten days after a bite from an infected mosquito. Inflammation and swelling of the brain, called encephalitis, is the most dangerous and frequent serious complication. The disease 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.

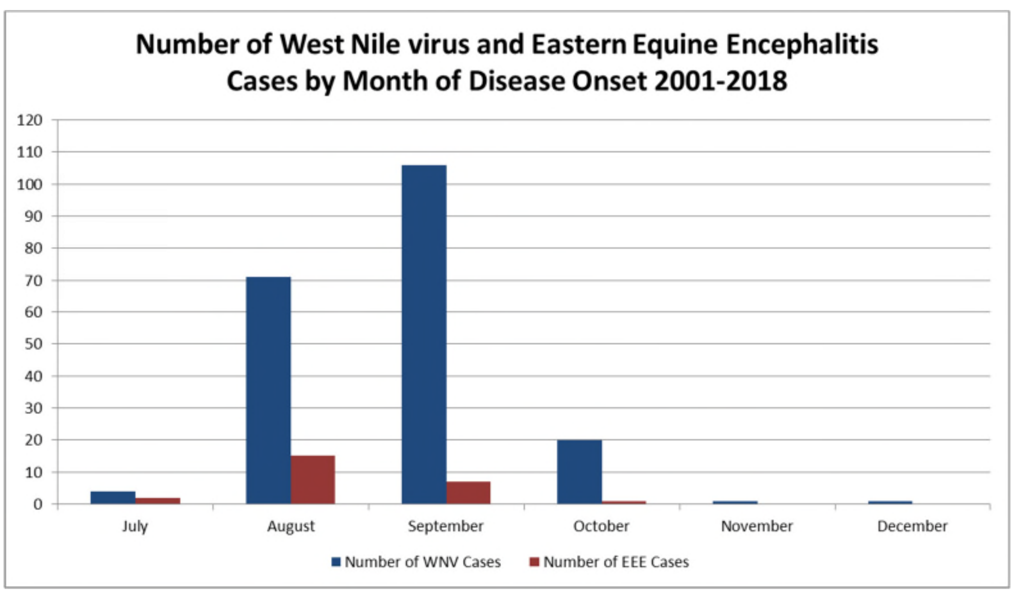
Historically, clusters of human cases have occurred over a period of two to three years, with a variable number of years between clusters. In the years between these case clusters or outbreaks, isolated cases can and do occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39, 1955-56, 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 2019 Arbovirus Surveillance and Response Plan.[81]



[81] https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data accessed March 20, 2020. Narrative copied from p. 1 of the report. Figures from pp. 24-26.





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.[82]

The number of EEE and WNV cases in Massachusetts in 2019 is shown below.[83]

2019 Arbovirus results summary

	Mosquito samples positive	Animals positive	Humans positive
WNV	87	0	3
EEE	428	9	12

LAST UPDATED: November 14, 2019

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

[82] https://www.mass.gov/lists/arbovirus-surveillance-plan-and-historical-data accessed March 20, 2020. pp.3-4.
[83] https://www.mass.gov/info-details/massachusetts-arbovirus-update accessed March 20, 2020.

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. 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 practioners about current and new vector-borne illnesses so treatment can be expedited. Towns should implement educational programs for residents and visitors for bite-prevention and detection.

Vector-borne Disease Problem Statements
• Climate change will increase the number of disease carrying vectors (ticks and mosquitoes) and increase demands on our public health system for symptom management and care for infected people.
• More and consistent outreach and education is needed to increase prevention and diagnosis of vector-borne diseases. The Massachusetts DPH website contains many good education and outreach materials as does the Franklin Regional Council of Governments' Cooperative Public Health Service program.
• Participating in mosquito control districts will reduce hazards and protect public health. Deerfield is a member of the newly formed Pioneer Valley Mosquito Control District.
• Vector-borne disease can have a significant negative impact on public health and the local and regional outdoor recreation economy.
• Vector management strategies should strive to be protective of public health and, when feasible, use effective alternatives that are cost-effective and have minimum impacts on the natural environment.


PREVENT
LYME
DISEASE!
• WEAR DEET REPELLENT
• CHECK FOR TICKS DAILY
• SHOWER SOON AFTER
BEING OUTDOORS
• TUCK PANTS INTO SOCKS
• CALL YOUR DOCTOR IF
YOU ARE BITTEN
Brought to you by your Board
of Health and the Cooperative
Public Health Service
A program of the Franklin Regional
Council of Governments
Public Health
frcog

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 Deerfield Multi-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.

Deerfield has most of the no cost or low cost hazard mitigation capabilities in place. 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. Deerfield has appropriate staff dedicated to hazard mitigation-related work for a community its size, including a Town Administrator, Emergency Management Director, a professionally run Highway Department, and a Tree Warden. Deerfield is a member of the Franklin County Inspection Service, which provides Building, Plumbing, and Electrical permitting and inspections in town. In addition to Town staff, Deerfield has an experienced Planning Board which reviews all proposed developments and assures that buildings are built to the current zoning requirements.

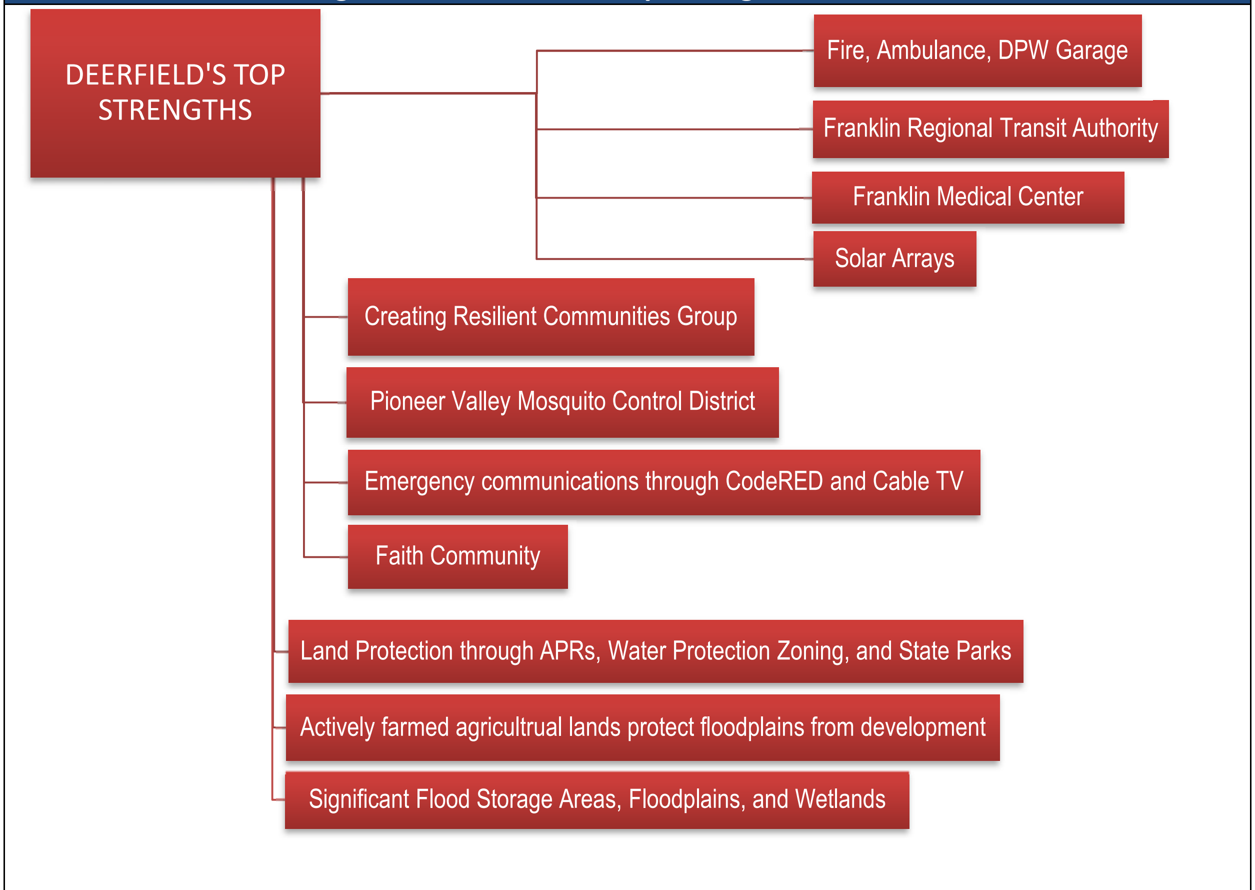
Deerfield has some recommended plans in place, including a Master Plan and a recently updated Open Space and Recreation Plan. The Master Plan needs to be updated and should be supplemented by a Capitol Improvements Plan. The Town also has very committed and dedicated volunteers who serve on Boards and Committees and in Volunteer positions. The Town collaborates closely with surrounding communities and is party to Mutual Aid agreements through MEMA. Deerfield is also a member community of the Franklin Regional Council of Governments, and participates in the Franklin County Regional Emergency Planning Committee (REPC).

Deerfield's Top Strengths and Assets

All Hazards

Participants at the Deerfield MVP Community Resilience Building workshop expressed pride that people who have lived in both towns for a long time are accustomed to weathering storms, "sheltering in place," and helping out neighbors. Many families know each other and know the first responders and Town staff who help run the Towns. Participants cited several strengths and assets that help keep their communities resilient in the face of climate change and other challenges. They include:

Figure 4-1: Deerfield's Top Strengths From MVP



- Sugarloaf State Park and Connecticut River Greenway State Park - These parks protect Connecticut River floodplain lands and other environmentally sensitive areas.
- Deerfield Water Protection Zoning District - This overlay zone protects land in the reservoir watershed from development.
- Agricultural Preservation Restrictions - APRs are important land protection tools that permanently protect farmland in floodplains from development. This tool needs to be used more expansively, particularly along the Deerfield River in Old Deerfield and West Deerfield;
- Creating Resilient Communities Group - This committee helps to coordinate the efforts of 20 communities along the Deerfield River using a watershed-based approach to protect flood storage areas, particularly along tributaries like the North and South Rivers.
- Solar Arrays - Locally generated solar power mitigates greenhouse gas emissions by providing renewable energy.
- UMass Farm - This farm helps protect the Connecticut River floodplain from development.
- Fuller Swamp - This wetland area serves as an important flood storage area.

- Franklin Medical Center - Located in Greenfield, this medical center should be used to establish a center for special medical needs and could promote better communication between town Fire Departments and emergency medical services.
- Franklin Regional Transit Authority - Also located in Greenfield, this public transit agency is an asset for evacuation.
- Emergency Shelters -Shelter sites are an asset in storm events, and are established at Frontier Regional High School, Deerfield Elementary School and South Deerfield Fire Department.
- Flood Storage Areas - There are substantial natural flood storage areas along the Deerfield River, including farmlands, Deerfield Academy playing fields, and floodplain areas in upstream communities. There is a need for an multi-community effort to protect these areas, through agreements with neighboring communities, and use of tools like APR and NRCS farmer floodplain agreements and payments.
- Member of the newly formed Pioneer Valley Mosquito Control District - This regional initiative to reduce
  mosquitoes and habitat can also provide joint benefits of improving flood drainage in swampy areas.
- Smart911 - Deerfield has in place a contract with the Emergency Communications Network to deliver Emergency Notification Messages through the smart911 high-speed notification system, which provides town officials with the ability to quickly deliver messages to targeted areas of town or town-wide about emergencies, including weather events. There is a need to expand this system to include more residents and more cell numbers.
- Frontier Community Access Television (Cable TV) - Another asset in delivering messages about weather events.
- Faith Community - Can be a helpful partner in providing shelters or other support in weather disasters.
- Fire, Ambulance, DPW Garage: These can provide emergency shelter and support emergency communications.

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 Deerfield. 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 Deerfield 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. The Town has requested assistance from FRCOG to evaluate culverts at road-stream crossings to prioritize upgrades.

Severe Snowstorms / Ice 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 could pertain to severe winter storms, summarized in Table 4-1.

Severe snowstorms or ice storms can often result in a small or widespread loss of electrical service.

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 Deerfield 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

Sixty-four percent of Deerfield is forested, including over 1,000 acres of state park in the Connecticut River Greenway and Sugarloaf State Parks. 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.

The Deerfield Fire Department has several ongoing educational programs to educate residents on fire safety, including fire drills in the school and a homeowner education program. The Deerfield Fire Department is actively involved in teaching fire safety during Fire Prevention Week. Burn permits for the Town of Deerfield are issued by Shelburne Control. 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 Deerfield 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 an extremely 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 - even in spite of more precipitation and heavier rainfall events.[84] The primary mitigation strategy currently in place is regulating uses within the aquifer recharge area of the public water supply well. Deerfield's Groundwater Protection District requires any development that renders impervious more than 15% or 2,500 square feet of any lot, whichever is greater, to provide a system for groundwater recharge which does not degrade groundwater quality. Deerfield also requires environmental controls for any project requiring a

---

[84] MassWildlife Climate Action Tool: https://climateactiontool.org/content/drought. Accessed March 8, 2019.

Special Permit. Deerfield could also consider promoting or requiring drought and heat-tolerant grass, plants and trees in new development, to limit the amount of irrigation needed.

The Deerfield Water Department serves residents in the north end of town, and has two interconnections with South Deerfield and Greenfield as an emergency back-up water supply.

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.[85]

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 their own van to transport the elderly in the event of a hazard or emergency. Deerfield has a practice of setting up cooling shelters when temperatures reach 96 degrees or higher. Cool water and comfortable seating will be made available to the public at the South County Senior Center and the Tilton Public Library. In most cases these two locations will serve as the Town's designated cooling shelters, but any official announcements will be posted on the entrances to the buildings and the Town's website. The Town's Cooling Center Policy states that the Senior Center is meant to be used by older residents, while the Library is designed to be used by people of all ages.

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.

---

[85] 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

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 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.[86]

In addition, Deerfield can require only native, non-invasive species be used in new development and redevelopment.

All Hazards

Shelters have been established at the Frontier Regional High School, Deerfield Elementary School and the South Deerfield Fire Department, however the Committee has identified a need to improve coordination between the Town and the private schools such as the Bement School, Deerfield Academy and Eaglebrook. 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). The Franklin County REPC is now working on operationalizing the plan by creating Shelter Management Teams and cost sharing agreements between towns. Deerfield officials can participate in this process to ensure its residents have clear guidance on where to shelter during an emergency.

Primary and secondary evacuation routes are shown on the Critical Infrastructure map for Deerfield. Interstate 91 and Route 5/10 are heavily traveled highways, and accidents on these roads can cut off the Town from nearby hospitals and other communities. Deerfield's reliance on I-91 and Route 5/10 as a means of connectivity between its two villages and neighboring towns was highlighted at the MVP Community Resilience Building workshop as a primary vulnerability for the Town.

A regional disaster debris management plan was created for Franklin County in 2015. The Franklin County REPC is currently working to verify the sites identified in the plan and complete agreements between towns for use of the regional sites. Towns may need to identify a site in their own town if regional agreements cannot be made.

Existing Mitigation Capabilities

The Town of Deerfield had numerous policies, plans, practices, programs and regulations in

[86] MassWildlife Climate Action Tool: https://climateactiontool.org/content/maintain-or-restore-soil-quality-limit-recreational-impacts. Accessed March 8, 2019.

place, prior to the creation of this plan, that were created to mitigate the impact of natural hazards in the Town. These various initiatives are summarized, described and assessed on the following pages and have been evaluated in the "Effectiveness" column.

Table 4-1: Existing Mitigation Capabilities

Strategy	Capability Type	Description	Hazards Mitigated	Effectiveness / Improvements
Floodplain Overlay District	Regulation – Zoning bylaw	Overlay district to control development in the 100-year floodplain.	Flooding	Effective. Deerfield updated the floodplain zoning district bylaw in June 2019 in order to discourage and limit development within the floodplain. A Special Permit must be obtained in order to erect, construct, substantially improve, reconstruct a structure within the floodplain.
Alternative Procedures Plan	Regulation – Subdivision Rules and Regulations	Provides qualified subdividers an option to develop a parcel of land under less stringent requirements. The APP procedure includes the following flooding considerations: reducing cut and fill; and providing buffer zones of indigenous vegetation along lot lines and public ways.	Flooding	Effective for mitigating the potential for localized flooding by preserving open space in the watershed, reducing impervious surfaces and regulating stormwater runoff.
Definitive Plan	Regulation – Subdivision Rules and Regulations	Requires a Definitive Plan for new subdivisions, including the location of swamps, floodplain areas, water bodies and watercourses, including depth of water and direction of flow within or adjacent to the proposed subdivision; proposed storm drainage of land, description of any areas subject to ponding or flooding, existing or proposed flood control or wetland easements.	Flooding	Effective for controlling impacts from stormwater runoff, and effective for mitigating or preventing localized flooding of roads and other infrastructure. Deerfield should consider "Consider creating a 'Purpose Section' to the Subdivision Regulations, which would include flood prevention and mitigation as one of the goals."
Accompanying Statements and Data	Regulation – Subdivision Rules and Regulations	Requires the inclusion of: • Identify existing zoning, including easements, covenants and restrictions applying to the area. • Drainage calculations prepared by the applicant's engineer, including design criteria, drainage area and other information sufficient for the	Flooding	Effective for controlling impacts from stormwater runoff.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		Board to verify the size of any proposed drain, swale, drainfield, culvert, bridge or catchbasin. This information must include a description of any areas subject to ponding or flooding existing or proposed flood control or wetland easements, estimated increase of peak runoff caused by altered surface conditions, and methods to be used to return water to the soils.		
Development Impact Statement	Regulation – Subdivision Rules and Regulations	A Development Impact Statement shall be submitted for any subdivision creating frontage potentially allowing twenty (20) or more lots. The DIS must describe: the location, extent and type of existing water and wetlands, any areas subject to flooding or ponding; any proposed alterations of riverbanks, marshes or seasonal wet areas; any existing or proposed flood control or wetland easements; estimated increase of peak run-off caused by altered surface conditions and methods to be used to return water to the soils; and the developmental impact upon surface water and groundwater quality and indicate any mitigating measures to be taken to reduce impact.	Flooding	Effective.
Performance Guaranty	Regulation – Subdivision Rules and Regulations	Performance guarantee ensures that developers cover the cost of construction and improvements for projects.	Flooding	Effective for controlling impacts from stormwater runoff. Effective for mitigating or preventing localized flooding of roads and other infrastructure. Consider creating a "Purpose Section" to the Subdivision Regulations, which would include flood prevention and mitigation as one of the goals.
Design Guidelines, Wetlands	Regulation – Subdivision Rules and Regulations	All subdivisions shall be designed to reduce, to the extent possible, flood damage.	Flooding	Effective for controlling impacts from stormwater runoff.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Protection, Stormwater Management, Floodplain District		The Board may condition its approval of a Definitive Plan upon the issuance of an "Order of Conditions" by the Conservation Commission of the Town, pursuant to the Wetlands Protection Act, G.L. c. 131, s. 40. Storm drains, culverts, swales, detention basins, and related facilities shall be designed to permit the unimpeded flow of all natural watercourses, to ensure adequate drainage at all low points along streets, to control erosion, and to intercept stormwater runoff along streets at intervals reasonably related to the extent and grade of the area being drained. Facility design shall accommodate the following standards: storm sewers and swales, 10 year storm; detention basins, 25 year storm; and culverts, other stream crossings, 50 year storm. All subdivision proposals shall be reviewed to determine whether such proposals will be reasonably safe from flooding. If any part of the proposed subdivision is located within the Floodplain District established in the Zoning By-Law, currently §179-3F, the proposal shall be reviewed in conformance with the following: 4391. The proposal shall be in conformance with §179-3F of the Zoning By-Law. 4392. The proposal is designed consistent with the need to minimize potential flood damage, including the location and construction of all public utilities and facilities, such as gas, electrical, and water systems. 4393. Adequate drainage systems have been provided to reduce exposure to flood hazards, and base flood elevation (level of the 100-year flood) data shall be provided for proposals where the land to be		Consider updating subdivision regulations to include Low Impact Development (LID) requirements for stormwater management.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		subdivided exceeds five (5) acres, for that portion within the Floodplain District.		
Buffer Areas	Regulation – Subdivision Rules and Regulations	All dwellings and structures shall be located a minimum of 50 feet from adjacent properties, and 100 feet from adjacent surface waters or wetlands. Buffer areas shall be retained in their natural vegetative state to the maximum extent feasible, in accordance with G.L. c. 131, s. 40, the Wetlands Protection Act, except where adjacent to agriculturally used property.	Flooding	Effective.
Erosion Control	Regulation – Subdivision Rules and Regulations	Regulates grading/construction resulting in slopes greater than 15%, or clearing of more than 2 acres of vegetation. Requires hillsides to maintain a certain percentage of vegetation.	Flooding	Effective.
Impervious Cover	Regulation – Subdivision Rules and Regulations	Dimensional table includes maximum lot coverage by impervious surfaces, ranging from 30% in the rural district to 80% in the expedited permitting district.	Flooding	Effective
Watershed Protection Districts	Regulation – Subdivision Rules and Regulations	The purpose of the Water Shed Protection Districts is to promote the health, safety, and general welfare of the community by ensuring an adequate quality and quantity of drinking water for the residents, institutions, and businesses; to preserve and protect existing and potential sources of drinking water supplies; to conserve the natural resources of the Town; and to prevent temporary and permanent contamination of the environment. Uses other than single-family residential on a lot with more than 80,000 square feet are allowed only by Special Permit from the Planning Board, which must take into consideration the simplicity, reliability, and feasibility of the control measures proposed and the degree of threat to groundwater quality which would result if the control measures failed.	Flooding, Ice Jams	Effective.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Earth Removal	Regulation – Subdivision Rules and Regulations	The removal from any premises of more than 50 cubic yards of sand, gravel, stone, topsoil, loam, or similar materials within any twelve-month period shall be allowed only on special permit from the Board of Appeals. Following removal, all excavated areas shall be restored by grading to provide for drainage and by planting with cover vegetation.	Flooding	Limited Effectiveness for controlling impacts from stormwater runoff. Consider adding (1) stormwater management and (2) flood prevention and mitigation to the list of criteria evaluated by the Board of Appeals when reviewing a Special Permit application for earth removal.
Site Plan Review	Regulation – Subdivision Rules and Regulations	Site Plan Review is required for construction or expansion of a parking lot for a municipal, institutional, commercial, industrial, or multi-family structure; and for Grading, clearing, or other land development activity except for the following: landscaping on a lot with an existing dwelling, clearing necessary for percolation and other site tests, work incidental to agricultural activity, or work in conjunction with an approved subdivision plan or earth removal permit. Site Plans must include the location of wetlands, streams, waterbodies, drainage swales, areas subject to flooding and unique natural features and storm drainage.	Flooding	The site plan review process has been updated since the last plan to require proposals to minimize the volume of cite and fill, the number of removed trees 6" caliper or larger, the length of removed stone walls, the area of wetland vegetation displaced, the extent of stormwater flow increase from the site, soil erosion, and threat of air and water pollution. The review is effective now that it aims to limit stormwater runoff.
Stormwater Bylaw	Regulation – Subdivision Rules and Regulations	This bylaw is applicable to all new development and redevelopment, including site plan applications, subdivision applications and applications for earth removal permits. The bylaw shall apply to any land disturbance activities that will result in an increased amount of stormwater runoff or pollutants from a parcel or contiguous parcels of land, or that will alter the drainage characteristics of a parcel of land, The bylaw establishes the Planning Board as the Stormwater Authority and requires a Stormwater Permit for all new development and redevelopment, except in the case of specifically exempted activities.	Flooding	Effective.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Stormwater Management	Regulation – Subdivision Rules and Regulations	Def Plan must include: •Drainage calculations prepared by the applicant's engineer, including design criteria, drainage area and other information sufficient for the Board to verify the size of any proposed drain, swale, drainfield, culvert, bridge, or catch basin. •Calculations are to be made separately for each drainage facility showing its location, the total upstream drainage area, the percentage of impervious surfaces in the drainage area, the runoff per acre, the design runoff, facility size, slope and capacity, and the velocity of water through it. •Description of any areas subject to ponding or flooding, existing or proposed flood control or wetland easements, estimated increase of peak runoff caused by altered surface conditions, and methods to be used to return water to the soils. Drainage Requirements: •Where determined to be appropriate to the Board, stormwater may be carried on the surface of the ground and recharged (herein, "open system") rather than piped to surface water (herein, "closed system"). •Peak stream flows and runoff at the boundaries of the subdivision in a twenty-five (25) year frequency storm shall be no higher following development than prior to development, unless authorized by the Board after consultation with the Conservation Commission, and determination that the receiving wetlands or water bodies may absorb the increase, or that the provision of detention capacity is sufficient	Flooding	Effective.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		Design Standards: •Storm sewers and swales: 10 year storm •Detention basins: 25 year storm •Culverts, other stream crossings: 50 year storm Swales should carry a 10-yr storm		
Town of Deerfield Best Development Practices Guidebook	Practice	The Deerfield Best Development Practices Guidebook is a set of guidelines for developers, designers and community boards intended to advance greener growth and cleaner water in the Town. It will help local builders, businesses and community residents to use effective, low-cost measures that can cleanse runoff from their property and prevent it from harming water supplies and habitats. The Guide describes the preferred design and construction practices in Deerfield for stormwater management, erosion and sedimentation control, landscape design, and site planning and provides a checklist for designers.	Flooding	Effective.
Deerfield Master Plan	Plan	Inventories natural features and environments in the Town, including many that contain floodplain areas such as wetlands, aquifer recharge areas, farms, rivers, streams, and brooks. Provides a framework for guiding development in Town.	Flooding	Effective in establishing priorities for environmentally sensitive development that will mitigate flooding impacts. Town wetlands should be more extensively mapped.
Participation in the National Flood Insurance Program (NFIP)	Practice	As of 2018, there are 28 flood insurance policies in effect in the Town.	Flooding	Somewhat effective, provided that the Town remains enrolled in the National Flood Insurance Program. The Town should consider becoming a part of FEMA's Community Rating System.
Design Guidelines	Regulation – Subdivision Rules and Regulations	All subdivisions should be designed to reduce: •Cut and fill •Area of vegetation disturbance, esp. within 200 ft of a waterbody, on slopes over 15%, and on easily erodible soils	Flooding, Landslides	Effective.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		•Number of mature trees removed •Extent of waterways altered or relocated •Erosion and siltation •Flood damage •Disturbance of important wildlife habitat/botanical features		
Expedited Permitting District	Regulation	Requires stormwater and erosion control to meet DEP stormwater standards. Gives priority to preservation of existing vegetation. PB may allow reduction in parking requirements if implementing TDM measures.	Flooding, Landslides	Effective.
Large Scale Ground Mounted Solar Installations	Regulation	Requires proposed changes to landscape, locations of wetlands and NHESP areas, existing trees 10" caliper or greater, and stormwater drainage which must comply with the Town's Stormwater Bylaw, as part of site plan. •Requires list of hazardous materials to be stored on site and plan to prevent release into the environment •Requires O&M plan includes stormwater management and vegetation controls. •Conditions include minimizing environmental impacts by avoiding land clearing and fragmentation of open space, preserving natural habitat and limiting use of hazardous materials. •Access roads shall be constructed to minimize grading, removal of stone walls or street trees and minimize impacts to environmental or historic resources. •Does not allow use of herbicides. •Clearing of land should be limited to what is necessary for the	Flooding, Landslides	Effective.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		construction/operation of the installation. •Decommissioning - Requires restoration of the site to its natural preexisting condition, including stabilization or re-vegetation of the site as necessary to minimize erosion.		
Performance Standards for by-right manufacturing uses	Regulation	Stormwater Management and erosion and sedimentation control shall be consistent with the DEP's Stormwater Regulations and the Town of Deerfield's Stormwater Regulations as may be amended.	Flooding, Landslides	Effective.
State Building Code	Regulation	The Town of Deerfield has adopted the Massachusetts State Building Code, including the Stretch Energy Code Appendix (780 CMR 115.AA).	Flooding, Severe Winter Storms, Severe Wind, Earthquakes	Effective.
Town of Deerfield Open Space and Recreation Plan 2014	Plan	Inventories natural features and promotes natural resource preservation in the Town, including areas in the floodplain, such as wetlands, aquifer recharge areas, farms and open space, rivers, streams, brooks.	Multiple Hazards	Effective.
Design Standards - Required Improvements	Regulation – Subdivision Rules and Regulations	Includes design standards that specify new roadway alignment (Section 4220) and maximum grades for roads (Section 4240). In addition, all electrical, telephone, and other utility wires shall be placed below ground in a subdivision, unless the Board determines that such placement is not feasible or is not in the best interests of the Town (Section 4420).	Severe Winter Storms	Effective.
Wireless Communications District	Regulation – Subdivision Rules and Regulations	Requires a special permit from the Zoning Board of Appeals. Wireless facilities should be set back from property lines at a distance equal to the vertical height of the tower. Facilities are not permitted within 500 feet of a residential lot line.	Severe Wind	Effective.
Below ground utility wires	Regulation – Subdivision Rules and Regulations	Requires that all electrical, telephone, and other utility wires shall be placed below ground in a subdivision, unless the Board determines that such	Severe Wind	Effective.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		placement is not feasible or is not in the best interests of the Town.		
Debris Management Plan	Plan	Natural disasters can precipitate a variety of debris, including trees, construction, and demolition materials and personal property. After a natural disaster, potential threats can be minimized through implementation of a debris management plan.	Flooding, Severe Wind, Earthquakes	Will be effective when completed. Town can develop their own or participate in the Regional Debris Management Plan.
Animal Disposal Procedures	Practice	Provisions should be made for possible catastrophic loss of livestock as a result of severe weather.	Multiple Hazards	Effective for mitigating possible harmful effects from livestock loss. Refer to the Animal Carcass Disposal Plan created through a collaboration between the FRCOG and the Franklin County Solid Waste District for step-by-step guidance in determining how to dispose of animal carcasses, including burial, composting, and off-site disposal.
Burn Permits	Practice	Residents receive burn permits from Shelburne Control.	Wildfires	Effective.
Plan Review for Fire Protection	Regulation – Subdivision Rules and Regulations	Provision shall be made for fire protection in the subdivision. The applicant shall review plans for fire protection with the Chief of the Town Fire Department and reach an agreement as to the method of providing adequate fire protection. A subdivision plan shall be approved only upon presentation of evidence to the Board, subject to the approval of the Fire Chief, that adequate provisions for fire protection have been made.	Wildfires	Effective.
Public Education and Outreach	Program	The Fire Department has an ongoing educational program in the schools. They also educate homeowners about general fire safety when issuing burn permits.	Wildfires	Effective.
Dam Permits	Regulation	State law requires a permit for the construction of any dam.	Dam Failure	Effective. Ensures dams are adequately designed.
Dam Inspections	Practice	DCR has an inspection schedule that is based on the hazard rating of the dam	Dam Failure	Effective. Owners of High Hazard Potential and certain

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		(low, significant, high hazard). FERC requires Emergency Action Plans for all high hazard dams it oversees.		Significant Hazard Potential dams are also responsible for preparing Emergency Action Plans.
Evacuation Plans	Plan	Comprehensive evacuation plans would ensure the safety of the citizens in the event of dam failure.	Dam Failure	Not Effective. The preparation of inundation mapping and evacuation plans is expensive for owners of dams. Owners of High Hazard Potential dams should prepare inundation area mapping and up to date evacuation plans in cooperation with the Town.
Site Review	Regulation – Subdivision Rules and Regulations	Applicants should identify if new development is in inundation areas.	Dam Failure	Effective for identifying areas of development requiring evacuation. Try to minimize new development in inundation areas by requiring to the extent possible that new lots be located outside of inundation areas.
Zoning Bylaws	Regulation – Subdivision Rules and Regulations	There are special regulations in place regarding structures being constructed, including dams, in flood hazard or floodplain areas.	Dam Failure	Effective. Revise Flood Plain Overlay District according to FRCOG Model Bylaw to address the proposed construction of subdivisions in dam breach inundation areas.
Earth Removal	Regulation	Requires a Special Permit for removal from any premises of more than 50 cubic yards of sand, gravel, stone, topsoil, loam, or similar materials within any twelve-month period, unless part of approved building permit or farming activity. Following removal, all excavated areas shall be restored by grading to provide for drainage and for slopes not to exceed one foot vertical to two feet horizontal, and by covering with four	Landslides	Effective.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
		inches of topsoil, and by planting with cover vegetation, all of which shall have been established prior to release of the bond.		
Groundwater Protection	Regulation	Prohibits or requires a Special Permit for uses that could impair groundwater resources. In addition: "For any proposed activity on a lot which will render more than 15 percent of the total lot area or more than 2,500 sq. ft. impervious, a system for groundwater recharge must be provided that does not degrade groundwater quality, by stormwater infiltration basins or similar system covered with natural vegetation. Dry wells shall be used only where other methods are infeasible. Such basins and wells shall be preceded by oil, grease and sediment traps to facilitate removal of contaminants."	Drought	Effective.
2018 MVP Resiliency Plan	Plan	Climate Change resiliency plan and recommended action items	All hazards	Effective. Data and action incorporated into Multi-Hazard Mitigation Plan.
Reverse 911	Practice	Deerfield has in place a contract with Emergency Communications Network to deliver emergency notification messages through the smart911 system.	All hazards	Semi-effective. There is a need to expand the system to include more residents.
Sheltering Plan	Plan	Deerfield has sheltering programs in place at the Frontier Regional High School, Deerfield Elementary School, and South Deerfield Fire Department. The Fire, Ambulance and DPW garage can also provide emergency shelter and support emergency communications.	All hazards	Semi-effective. Improved coordination is needed between Deerfield and the Bement School, Deerfield Academy, and Eagle Brook. The Senior Center is also known to be vulnerable to flooding.

4.3 HAZARD MITIGATION GOAL STATEMENTS AND ACTION PLAN

As part of the multi-hazard mitigation planning process undertaken by the Deerfield Multi-Hazard Mitigation Planning Committee, existing gaps in protection and possible deficiencies were identified and discussed. The Committee 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 Deerfield has limited capabilities and resources (especially staffing) to be able to expand and improve upon existing policies and programs when the town identifies a need for improvement.

Hazard Mitigation Goals

Based on the findings of the Risk Assessment, public outreach, and a review of previous town plans and reports, the Deerfield 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 Committee examined the results of the Risk Assessment (see Section 3) and used the results to prioritize the identified hazards. The Committee evaluated the natural hazards that can impact the town based on probability of occurrence, severity of impacts, area of occurrence and preparedness. Those hazards receiving the highest Overall Hazard Vulnerability Rating were assigned the highest priority, as shown in Table 4-2. The highlighted hazards in Table 4-2 where those identified as High Priority in the 2018 MVP Workshop and Plan.

Table 4-2: Deerfield Hazard Priority Level Rating

Natural Hazard	Overall Hazard Vulnerability Rating	Priority Level
Severe Winter Storms	1-High Risk	High
Flooding	1-High Risk	Highest
Tornadoes	3-Low Risk	Medium
Dam Failure	3-Low Risk	High

Table 4-2: Deerfield Hazard Priority Level Rating		
Natural Hazard	**Overall Hazard Vulnerability Rating**	**Priority Level**
Hurricanes / Tropical Storms	2-Medium Risk	High
Severe Thunderstorms / Wind / Microbursts	1-High Risk	High
Extreme Temperatures	1-High Risk	Low-Medium
Earthquakes	3-Low Risk	Low
Landslides	2-Medium Risk	Low-Medium
Drought	2-Medium Risk	Low
Wildfires	3-Low Risk	Low
Invasive Species	1-High Risk	Low

Prioritization of Action Items

The Hazard Mitigation Committee identified several strategies that are currently being pursued, and other strategies that will require additional resources to implement. Strategies are based on previous experience, as well as the hazard identification and risk assessment in this plan.

Prioritization Methodology

The Deerfield Hazard Mitigation Planning Committee 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 Committee 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 Deerfield 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 2020 Deerfield Multi-Hazard Mitigation Prioritized Action Plan is shown in Table 4-3. 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".

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Critical Facilities & Infrastructure	Continue to work with an engineering consultant to identify, assess, develop engineering plans and cost estimates to address failing and undersized culverts; localized flooding; and hazards to infrastructure, including evacuation routes. Secure funding to install replacement structures that are climate resilient.	Flooding, Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Highway Department Emergency Management Director	High	MVP, FEMA, DER, Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S, E, I	Very High	New Action Item. Priority projects/locations were identified in the 2018 MVP Plan and as part of the update of this Multi-Hazard Mitigation Plan. These projects are: ✓ Mill Village Road (south of intersection with Log Plain Road); ✓ Kelleher Drive (at North Main Street intersection); ✓ Route 5 (near Richardson's Candy Kitchen); ✓ Wapping Road (north of Greenough Crossing Road); ✓ Broughams Pond Road (west of intersection with Old Ferry Road); ✓ Captain Lathrop Drive; ✓ Hillside Road; ✓ River Road in its entirety; ✓ McClellan Road; ✓ Thayer Street; ✓ Private culverts along North Main Street. Other areas of concern include: Stillwater Road, Depot Road, Graves Street, and Mountain Road
Critical Facilities & Infrastructure	Hire an engineering consultant to identify flood proofing options and bank stabilization measures for the Stillwater Road Public Water Supply wells to protect this infrastructure from flooding and fluvial erosion hazards and implement recommended mitigation measures. Anchor storage garage to make the structure more flood resilient	Flooding, Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Deerfield Fire and Water District	High	MVP, FEMA, Town	Year 2	S, E, I	High	New Action Item.

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Critical Facilities & Infrastructure	Secure and leverage multiple sources of funding to conserve priority parcels, particularly farmland, in Deerfield's extensive 100-year floodplain areas to reduce flood and fluvial erosion hazards and threats to critical infrastructure.	Flooding, Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Conservation Commission, Select Board, Private Landowners	High	MVP, Community Preservation Act funds, Agricultural Preservation Restriction (APR) program	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S, E, I	High	New Action Item. Priority locations were identified in the 2018 MVP Plan and as part of the update of this Multi-Hazard Mitigation Plan. These locations are: ✓ North and South Meadows of Old Deerfield ✓ Along the Deerfield River in west Deerfield ✓ Bloody Brook watershed
Critical Facilities & Infrastructure	Hire a consultant to complete a town-wide drinking water assessment in order to determine what percentage of the town's population is adequately served by the existing water districts and which ones are not. Once underserved areas have been identified, potential sources of drinking water need to be identified and protected. Many residents on River Road are served by private deep wells that are not potable due to hardness and natural sources of arsenic found in the red rock aquifer that runs north and south in the valley.	Extreme Temperatures, Drought	South Deerfield Water District, Deerfield Water District	Medium-High	MVP, Town, DEP	Year 5	S	Medium	New Action Item.
Education & Awareness	Develop a formal system for departments to record costs and property damages from natural hazard events. Encourage businesses and residents to report property damages and costs, and farmers to report crop damages and costs to the Town to be incorporated into FEMA Damage Assessment Forms and the Town's database.	All Hazards	Town Administrator, Emergency Management Director	Low	Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S, E, I	2014 High / 2020 High	MEMA trained Town staff on form filling and Pre-loaded FEMA damage assessment forms are online (2018). Highway Department vehicles equipped with record taking notebooks (2015).

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Local Plans & Regulations	Continue to review and update, as appropriate, Town of Deerfield land use regulations, including Subdivision Rules & Regulations, Floodplain Overlay Zoning District, etc. to include climate resiliency provisions such as Best Management Practices (BMPs) for River Corridor areas (including Active River Areas mapped by The Nature Conservancy) - see FRCOG's River Corridor Toolkit; further restricting or limiting new development within the 100-year floodplain and River Corridor, Low Impact Development (LID) stormwater practices, etc.	Flooding, Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Planning Board, Conservation Commission, Zoning Board of Appeals	Low	Municipal Vulnerability Preparedness Program (MVP), Town, District Local Technical Assistance (DLTA)	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, E, I	2014 Low-Medium / 2020 Medium-High	Several related Action Items from the 2014 Plan were combined and updated for the 2020 Plan. The Town has made significant progress on these Action Items. Recommended Site Plan Review updates were completed. Draft revisions to the Floodplain Overlay District were presented at a Planning Board Public Hearing on February 3, 2020. With MVP funding, the Town is currently drafting revisions that include LID stormwater BMPs.
Local Plans & Regulations	Using Assessors' data and other available information, expand and update the Vulnerability Assessment for properties located within the 100-year floodplain, including information on crop damages, if available. Rotated crops, and products not considered "crops", (such as high-end ornamentals), are difficult to track for damages/losses.	Flooding, Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Planning Board	Low	MVP, Town	Year 2	S, E, I	2014 Medium / 2020 Medium	Partially implemented with focus on Land Conservation mapping under previous MVP Action Grant. Work is continuing under FY20 MVP Action Grant
Local Plans & Regulations; Education & Awareness	Support local and regional, watershed-wide open space protection efforts, particularly in floodplain areas.	Flooding, Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Town Administrator, Planning Board, Select Board, Community Preservation Committee	Low	Town, Volunteers, FRCOG, Creating Resilient Communities, MVP, FLT, CPA	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, I, E	2014 Medium / 2020 Medium	Still relevant and ongoing. Update of the town's Open Space & Recreation Plan will need to be done in 2020

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Critical Facilities & Infrastructure	Hire a consultant to conduct groundwater testing and a feasibility study of pumping existing wells in South Deerfield to lower the groundwater level to help alleviate localized urban flooding and provide backup municipal drinking water supply.	Flooding	Town Administrator, Highway Department, Emergency Management Director, South Deerfield Water District	High	MVP, Town, FEMA	Year 2	S, I, E	2014 High / 2020 Medium	DEP was contacted to discuss this project. Further testing needed for presence of EDB to determine suitability for public drinking water supply. Priority has been changed to Medium for 2020. The cost-effectiveness of lowering groundwater levels to alleviate localized flooding needs to be evaluated.
Critical Facilities & Infrastructure Local Plans & Regulations	Hire a consultant to conduct a fluvial geomorphological assessment of Bloody Brook watershed and other smaller drainage areas that are contributing to fluvial erosion and flooding hazards along the Connecticut and Deerfield Rivers in the Town of Deerfield. Identify priority sites and develop conceptual designs and cost estimates for projects to restore floodplain access and reduce flooding and erosion hazards.	Flooding Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Town Administrator, Highway Department, Emergency Management Director	Medium-High	MVP, Town, FEMA	Year 2	S, I, E	2014 High / 2020 High	Related Action Items from the 2014 Plan have been consolidated and the Action Item description updated for the 2020 plan. This Action Item would build upon the USGS Flood Inundation Mapping completed for a section of the Deerfield River.
Education & Awareness	Conduct public outreach and education about the risk of potential flooding associated with the dumping of yard waste in local streams. Provide easier, safer alternatives for yard waste disposal.	Flooding Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Highway Department, Emergency Management Director, Select Board, Town Administrator	Low	Town, Volunteers	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, I, E	2014 High / 2020 High	The Town conducted outreach in 2015. Due for new public outreach initiative.

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 2020**	**Status**
Critical Facilities & Infrastructure	Hire a consultant to update the engineering designs and cost estimates for the project to stabilize eroding river bank and mitigate fluvial erosion and flood hazards on the Deerfield River to prevent future erosion and flooding of Little Meadow Road and the sewer line from Deerfield Academy to the Old Deerfield Wastewater Treatment plant (WWTP). Conduct an assessment of the vulnerability of the South Deerfield WWTP and provide recommendations and cost estimates for flood proofing.	Flooding Hurricanes, Tropical Storms, Severe Thunderstorms, Microbursts	Wastewater Treatment Department	High	MVP, Deerfield Academy, Town, FEMA,	Year 2	S, I, E	2014 High 2020 High	Both the Old Deerfield and South Deerfield wastewater treatment plants are vulnerable to flooding hazards. In 2016, storm flooding caused increased fluvial erosion and undermined the riverbanks near the Old Deerfield WWTP. The Town implemented an emergency repair (riprap and gravel) to armor the bank. However, this is a temporary solution and a long-term, sustainable and climate resilient solution is needed to protect this drinking water supply. In 2019, Deerfield residents voted to fund the $19M repairs needed by the South Deerfield WWTP. Deerfield has secured a 40-year, approximately $8 million loan (at 2.125 percent interest) and a $2.6 million grant from the U.S. Department of Agriculture. The project's first phase will cost about $11 million. Additional upgrades, like raising the sides of the tanks, are still needed to strengthen the facility's climate resiliency.
Critical Facilities & Infrastructure	Identify locations of existing beaver activity and dams in Deerfield that pose a risk to private property and town infrastructure if the dams were to fail. Evaluate areas for potential flooding and explore the feasibility of controlled breaching of dams to limit the potential for accidental breaches.	Dam Failure Flooding	Highway Department, Emergency Management Director	Low	MVP, Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, I, E	2014 High 2020 High	The Town currently monitors beaver activity and this will continue.

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Critical Facilities & Infrastructure	Update and amend the town's land use regulations and Subdivision Rules and Regulations to include provisions for requiring undergrounding of utilities for new development and redevelop projects along Routes 5/10 in Deerfield to reduce the risk of damage to infrastructure from severe winter storms. / Work with Eversource on a phased undergrounding program for electric lines, focusing first on the Route 5 corridor.	Severe Winter Storms	Planning Board / Highway Department, Select Board	Low / High	Town, Eversource	Year 4 / Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S, I, E	2014 Medium / 2020 Low for updating regulations; High for working with Eversource on undergrounding program.	Action Item description has been updated from 2014 to include a related Action Item identified in the 2018 MVP Plan. .
Local Plans & Regulations	Identify Town-owned forested areas that are at higher risk for wildfires (near businesses, residential areas, high-wire utilities, etc.) to implement climate resilient forest management practices that reduce the risk of fire hazards (such as the removal of slash). Coordinate with utility company for tree clearing work.	Wildfire	Conservation Commission, Planning Department, Fire Department	Low-Medium	MVP, Town, DCR	Year 3	S, I, E	2014 Low / 2020 Low	Related Action Items from the 2014 Plan have been consolidated and the Action Item description updated for the 2020 plan.
Local Plans & Regulations	Formalize a protocol for communications with upstream towns (Colrain, Shelburne) and data sources (USGS gages, USGS Flood Inundation Mapper, field inspections) to monitor the Deerfield and Connecticut Rivers for potential ice buildup and ice jams and flood hazards. Create a phone tree for ice jams on the Connecticut River. Formalize procedures for issuing and disseminating emergency alerts to residents	Flooding	Emergency Management Director, Fire Department, Board of Health	Low	Town, MVP	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, I, E	2014 High / 2020 High	Related Action Items from the 2014 Plan have been consolidated and the Action Item description updated for the 2020 plan. There is an informal protocol in place that relies on specific individuals. A formal protocol is needed to assign responsibilities to Town staff/volunteer board members and ensure continuity if there is staff turnover.

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Local Plans & Regulations	To reduce the risk of landslides, review and amend, if necessary, the town's Zoning Bylaws and Subdivision Rules and Regulations to include a provision that sets limits on land clearing and directs development to stable slopes and soils..	Landslides	Planning Board	Low	Town, DLTA	Year 5	S, I, E	2014 Medium / 2020 Medium	Related Action Items from the 2014 Plan have been consolidated and the Action Item description updated for the 2020 plan.
Local Plans & Regulations Education & Awareness	Continue to monitor the activities at the East Deerfield Rail Yard to ensure the clean-up of documented released of hazardous materials, to limit future releases, and to plan for and coordinate emergency responses in the event of a release or other hazard event.	Manmade Hazards	Town Administrator, Select Board, EMD	Low	Pan Am Railroad as potentially responsible party	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, E, I	2014 High / 2020 High	This is an ongoing project and the Town has a local point of contact that serves as a liaison between MassDOT and the town.
Local Plans & Regulations Education & Awareness	Continue to review and drill evacuation procedures for the flood prone and dam inundation areas in Town.	Flooding Dam Failure	Emergency Management Director, Highway Department	Low	Town MVP	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, E, I	2014 High / 2020 High	Related Action Items from the 2014 Plan have been consolidated and the Action Item description updated for the 2020 plan. On November 11, 2018, the Town participated in a regional exercise with WRHSAC and reviewed After Action Report. A MVP funded table top exercise is planned in 2020 in conjunction with the schools.
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 regional agencies to identify a location(s) in the City for the temporary storage of contaminated and/or hazardous debris, as well as construction/demolition debris and white goods from natural hazard events.	Multiple Hazards	DPW , Franklin County REPC, Franklin County Solid Waste District	Low	MVP, Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, E	2014 High / 2020 High	Action Item description has been updated and carried over from 2014 plan.

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Local Plans & Regulations	Continue participation in Pioneer Valley Mosquito Control District	Flooding, Vector-borne Diseases	Board of Health, Select Board	Low-Medium	Town, MVP	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, E	High	New Action Item.
Education & Awareness	Coordinate with the Department of Public Health (DPH) to provide public education and outreach to residents about preventing vector-borne diseases (ticks and mosquitoes).	Vector-borne Diseases	Board of Health	Low	Town, DPH	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S	Very High	New Action Item.
Education & Awareness	Coordinate with the Farm Service Agency (FSA) and Mass. Dept. of Agricultural Resources (MDAR) to provide public education and outreach to farmers about testing and remediation of potentially contaminated silt deposited on farm fields and inundated crops.	Flooding	Agricultural Commission, Board of Health	Low	Town, FSA, MDAR	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	E	2014 High / 2020 Medium	Carried over from 2014 plan. Ongoing as necessary.
Education & Awareness	Coordinate with the Department of Public Health (DPH) to provide public education and outreach to residents whose wells have flooded about testing for contaminants and remediation options.	Flooding	Board of Health	Low	Town, DPH	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S	2014 High / 2020 High	Carried over from 2014 plan. Ongoing as necessary.

Table 4-3: 2020 Deerfield 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)**	**Priority 2014 / 2020**	**Status**
Local Plans & Regulations	Follow-up with UMass regarding all the chemicals used on-site at the UMass livestock and turf farm facility, including locations, containment, security, application frequencies and quantities. Work with UMass to evaluate incident response needs/vulnerabilities, the potential impacts on abutters, and potential impacts on natural resource impacts. Determine whether the facility is in the 100-year floodplain.	All Hazards	EMD, Board of Health	Low	Town, MVP	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, I, E	Medium-High	New Action Item.

Table 4-4: Town Completed or Obsolete 2014 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**
Education & Awareness	Develop and implement an annual program to improve household disaster preparedness. Use available pamphlets and other information to educate the public on how to prepare for hazards and disaster, including encouraging residents to prepare by stocking up the necessary items and planning with family members for how to respond during a disaster.	All Hazards	Town Administrator, Emergency Management Director, Select Board	Low	Town, Volunteers	S, I	High	Completed The town developed the Deerfield Neighborhood brochure in 2015. The town is switching over to smart911 notification system, a project funded by the MVP program.
Local Plans & Regulations	Enforce State Building Code and provide training to the Building Inspector, as needed, to ensure new buildings are designed and constructed to reduce the risk of damage from high winds. Encourage construction of new homes with safe rooms to provide shelter during a tornado, hurricane or other storm event with high winds.	Wind, Microbursts, Tornados	Building Department	Low	Town	S, E, I	Medium	Obsolete Covered by the current edition of State Building Code. Enforcement of the State Building Code is underway and ongoing by the Town of Deerfield. The Local Project Team determined that it is not necessary to include this as an Action Item in the 2020 Plan.
Local Plans & Regulations	Research, update and amend the Deerfield Zoning Bylaws that regulate wireless communication facilities to include provisions related to preventing wind-related damage in fall zone areas to reduce the risk to life and property from high winds associated with hurricanes and tropical storms.	Wind, Microbursts, Tornados	Planning Board	Low	Town	S, E, I	Medium	Obsolete Covered by the current edition of State Building Code. Enforcement of the State Building Code is underway and ongoing by the Town of Deerfield. The Local Project Team determined that it is not necessary to include this as an Action Item in the 2020 Plan.
Local Plans & Regulations	Ensure Compliance with the Massachusetts State Building Code. Provide training to the Building Inspector, as needed, to ensure that all new construction complies with the appropriate seismic requirements of the State Building Code. Participate in trainings offered by FEMA's National Earthquake Technical Assistance Program (NETAP).	Earthquakes	Town Administrator, Building Commissioner, Emergency Management Director	Low	Town	S, E, I	High	Obsolete Covered by the current edition of State Building Code. Enforcement of the State Building Code is underway and ongoing by the Town of Deerfield. Inspectors attend trainings. The Local Project Team determined that it is not necessary to include this as an Action Item in the 2020 Plan.
Local Plans & Regulations	Seek funding to update the FEMA floodplain maps for Deerfield.	Flooding	Emergency Management Director	High	FEMA,	S, I, E	High	Obsolete FEMA is conducting a Risk Mapping, Assessment,

Table 4-4: Town Completed or Obsolete 2014 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**
								and Planning (Risk MAP) project for the Middle Connecticut Watershed that will produce digital floodplain maps for the Town in approximately 5-7 years.
Local Plans & Regulations	Compile a list of the types, quantities and method of on-site storage of agricultural chemicals used by the farms in Deerfield and include it in the Comprehensive Emergency Management Plan (CEMP). This information will 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.	Manmade Hazards	Emergency Management Director	Low	Town	S, I, E	High	Completed
Local Plans & Regulations	Review the list of underground storage tanks and identify those that are located in the floodplain or in a dam inundation area and include this information in the CEMP.	Manmade Hazards	Emergency Management Director	Low	Town	S, I, E	High	Completed
Local Plans & Regulations	Update the list of all entities certified for pesticide and herbicide use and include in the CEMP, including private and public schools that use these substances maintenance of playing fields.	Manmade Hazards	Emergency Management Director	Low	Town	S, I, E	High	Completed
Critical Facilities & Infrastructure	Purchase generator for Deerfield Elementary School so that it can be used as a back-up shelter.	All Hazards	Emergency Management Director, Select Board, Town Administrator	Low	Town	S	High	Completed in 2016
Local Plans & Regulations	Consider becoming a part of FEMA's Community Rating System.	Flooding	Emergency Management Director, Select Board, Town Administrator	Low-Medium	Town, MEMA/FEMA, Non-profits – D.A.	S, I, E	Medium	Obsolete The Town does not have the staff capacity for this program.
Critical Facilities & Infrastructure	May 2018 purchased generator for Town Hall for continued operations.	All Hazards		Low				Completed in May 2018 Not included as an Action Item in 2014 Plan.
Education & Awareness	Educate homeowners about the risk of wildfires and brushfires and how to reduce the risk by adopting general fire safety techniques.	Wildfire	Town Administrator, Fire Department	Low	Town	S, E, I	High	Completed The South Deerfield Fire District provides education/outreach materials online.
Critical Facilities & Infrastructure	Seek funding to increase the staff of the Fire Department's inspection and safety unit.	Wildfire	Town Administrator, Fire Departments	Medium	Town	S, E, I	Low	Completed Two full time staff were added in 2018.

Table 4-4: Town Completed or Obsolete 2014 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	In order to reduce the risk and potential loss of life from dam failure, perform an inspection of the dam at Eaglebrook School and map the dam's inundation area.	Dam Failure	Eaglebrook School	Low-Medium	DCR Office of Dam Safety, Eaglebrook School	S, I, E	Low	Obsolete The Town is not responsible for this dam. DCR Office of Dam Safety determines the inspection schedule, etc. The Town could continue conversations with Eaglebrook School about the inspection and inundation mapping.
Local Plans & Regulations	Execute an MOU with Yankee Candle, Co. to use the facility as a staging area.	Multiple Hazards	Town Administrator, Emergency Management Director, Select Board	Low	Town	S	High	Completed in 2013. Due to change in ownership, the MOU should be reviewed.
Local Plans & Regulations	Work with the School Committee and Frontier Regional School staff to establish a protocol for the use of the school as a shelter and/or staging area.	Multiple Hazards	Town Administrator, Emergency Management Director, Select Board	Low	Town, Frontier Regional School District	S	High	Completed to greatest extent currently possible.
Local Plans & Regulations	Coordinate with the Massachusetts Police and MassDOT to establish a protocol for communication with the Town regarding detours onto surface arteries from Route 91.	Flooding	Town Administrator, Highway Department, Emergency Management Director, Police Department	Low	Town, REPC	S,I	High	Completed by Police Chief in 2015.

5 PLAN ADOPTION AND MAINTENANCE

5.1 PLAN ADOPTION

The Franklin Regional Council of Governments (FRCOG) provided support to the Deerfield Multi-Hazard Mitigation Committee as they underwent the planning process. Town officials such as the Emergency Management Director and the Town Administrator 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 Deerfield Multi-Hazard Mitigation Plan was completed, copies were disseminated to the Committee for comment and approval. The Committee 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 Committee members on the front cover).

Copies of the Final Review Draft of the Multi-Hazard Mitigation Plan for the Town of Deerfield were distributed to Town boards and officials, and to surrounding towns for review. Copies were made available at the Town Hall and the library, and 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 Approval Pending Adoption. The plan was granted Approval Pending Adoption status by FEMA on August 25, 2020 and on September 9, 2020 the Deerfield Selectboard voted to adopt the plan. FEMA approved the plan on September 29, 2020.

5.2 PLAN MAINTENANCE PROCESS

The implementation of the Deerfield Multi-Hazard Mitigation Plan will begin following its approval by MEMA and FEMA and formal adoption by the Deerfield 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 (Table 4-3). The Deerfield Multi-Hazard Mitigation Planning Committee will oversee the implementation of the plan.

Monitoring, Evaluating, and Updating the Plan
The measure of success of the Deerfield Multi-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

Annual Meetings

The Deerfield Multi-Hazard Mitigation Planning Committee 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 Committee 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 Committee will review and update the plan every five years. The meetings of the Committee will be organized and facilitated by the Deerfield Town Administrator 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 Committee 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 Committee 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 Committee 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 Multi-Hazard Mitigation Planning Committee 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 Committee may decide to undertake the update themselves, request assistance from the Franklin Regional Council of Governments, or hire another consultant. However the Committee decides to proceed, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The updated Deerfield Multi-Hazard Mitigation Plan will be forwarded to MEMA and to FEMA for approval.

As is the case with many Franklin County towns, Deerfield’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 Committee. As the Committee meets regularly to assess progress, it should strive to identify shortfalls in staffing and funding and other issues which may hinder Plan implementation. The Committee can seek technical assistance from the Franklin Regional Council of Governments to help alleviate some of the staffing shortfalls. The Committee 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
Pre-Disaster Mitigation (PDM) Program	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	
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

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
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
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

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
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
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

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
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
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 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
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				

Incorporating the Plan into Existing Planning Mechanisms

2014 Multi-Hazard Mitigation Plan

The Town of Deerfield has taken steps to implement findings from the 2014 Multi-Hazard Mitigation Plan into the following policy, programmatic areas, and plans: the 2018 Municipal Vulnerability Preparedness (MVP) Resiliency Plan. The Town of Deerfield has been working to incorporate flood resiliency benefits into their identification and prioritization of projects for their MVP Action Grants. In FY19, the Town applied for and an Action Grant to replace two top priority culverts with more resilient culverts with improved wildlife passage and developing a land conservation priority plan for protecting key parcels in the Deerfield River floodplain, amongst other projects. In June 2019, The State awarded Deerfield with a $278,023 grant to implement these flooding resiliency projects and in February 2020, the town received $572,250 in MVP funding for their project - Flood Resiliency through Green Infrastructure in Deerfield.

2020 Multi-Hazard Mitigation Plan

Upon approval of the Deerfield Multi-Hazard Mitigation Plan by FEMA, the Committee will provide all interested parties and implementing departments with a copy of the plan, with emphasis on Table 4-3: 2020 Deerfield Hazard Mitigation Prioritized Action Plan. The Committee 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:

- Fire Department
- Emergency Management Director
- Police Department
- Public Works / Highway Department
- Planning Board
- Zoning Board of Appeals
- Conservation Commission
- Franklin County Regional Emergency Planning Committee
- Building Inspector
- Select Board

Some possible planning mechanisms for incorporating the Deerfield Multi-Hazard Mitigation Plan into existing planning mechanisms to the fullest extent possible could include:

- Incorporation of relevant Hazard Mitigation and climate change information into the Open Space and Recreation Plan. There are opportunities to discuss findings of the hazard mitigation plan and incorporate them into the Environmental Inventory and Analysis section of the OSRP and to include appropriate action items from the hazard mitigation plan in the OSRP Action Plan.

- Any future development of master plans and scenic byway plans could incorporate relevant material from this plan into sections such as the Natural Resources section and any action plans.
- When the Final Draft Multi-Hazard Mitigation Plan for the Town of Deerfield 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 Multi-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 Deerfield's current Bylaws.

Continued Public Involvement

The Town of Deerfield is dedicated to continued public involvement in the hazard mitigation planning and review process. During all phases of plan maintenance, the public will have the opportunity to provide feedback. The 2020 Plan will be maintained and available for review on the Town website through 2025. Individuals will have an opportunity to submit comments for the Plan update at any time. Any public meetings of the Committee 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 – Public Participation

Town of Deerfield
Multi-Hazard Mitigation Plan
Update Underway
May 8, 2019

The Town of Deerfield, in partnership with the Franklin Regional Council of Governments (FRCOG) Planning Department, is updating the 2014 Multi-Hazard Mitigation Plan for Deerfield. Once the updated Plan is approved by FEMA and adopted by the Town, the Town will be eligible for state and Federal grant monies to fund pre- and post-disaster mitigation projects. This project builds on the work completed by the Town to be designated a MVP (Municipal Vulnerability Preparedness) Community.

The purpose of this Multi-Hazard Mitigation Plan update is to identify natural and other hazards that may impact the community; conduct a risk assessment to identify infrastructure at the highest risk for being damaged by hazards; inventory and assess current Town hazard mitigation policies, programs, and regulations; and identify action steps to prevent damage to property and loss of life.

The Deerfield Multi-Hazard Mitigation Plan Committee will meet several times to compile new and updated information for the Plan. All meetings of the Committee are open to the public; meeting notices and agendas can be found at the Deerfield Town Offices, 8 Conway Street, South Deerfield, MA 01373 or on the Town's website https://www.deerfieldma.us/.

To find out more about this project and how you can become involved, please contact Kimberly Noake MacPhee, FRCOG Land Use and Natural Resources Program Manager, at (413) 774-3167 x130 or kmacphee@frcog.org.

HazMit Plan Update Stakeholders (2019 -2020)

Name	Representation	Email Address
Laurie McComb	Deerfield Police/Amherst Fire	ljlankowski@yahoo.com
Emily Boss	Franklin Land Trust	rkhubbard@verizon.net
John Paciorek, Jr.	Deerfield Police Chief	jpaciorek@police.deerfield.ma.us
Bill Swasey	Deerfield Fire Chief	wswasey@southdeerfieldfire.org
Keith Milne	Deerfield WWTP	kmilne@town.deerfield.ma.us
Kevin Scarborough	Deerfield PDW Superintendent	kscarborough@town.deerfield.ma.us
Katherine Williams	Richardson's Candy Kitchen	rck@richardsonsoncandy.com
Nancy Sadoski	Old Deerfield Country Store	
Tim Neumann	Pocumtuck Valley Memorial Association	pvmaoffice@deerfield.history.museum
Christopher Wilson	Head of School, Bement School	cwilson@bement.org
Keith Finan	Deerfield Academy	kfinan@deerfield.edu
Chuck Williams	Deerfield Academy	cwilliams@deerfield.edu
Rachel Blain	Eaglebrook School	rblain@eaglebrook.org
Chip Williams	Williams Farm	williamsfarmsugarhouse@gmail.com
Jay Savage	Savage Farm	jsavage35@comcast.net
Skip Yazwinski	Yazwinskis' Farm	syazwinski@gmail.com
Peter Melnik	Melnik Farm	melnikfarm@comcast.net
Kim Snyder	Historic Deerfield	ksnyder@historic-deerfield.org
Lynn Rose	Former Planning Board	lynnfaith@comast.net
Steve Barrett	Deerfield Conservation Commission	Barrett127@aol.com
Mark Wightman	Developer	Maw10@comcast.net
Ken Cuddeback	Bement School Business Manager	kcuddeback@bement.org
John Waite	Deerfield Planning Board	johnw@fccdc.org
Tom Clark	Deerfield Agricultural Commission	clarkdalefarms@comcast.net
Paul and Stacy Chipley	Chipley Gardens	
Jaap Molenaar	Pioneer Gardens	jaap@pioneergardens.com
Daren Melnik	Old Deerfield Fire District	DMelnikTrucking@verizon.net
Laurie Boosahda	Frontier Regional School	
Scott Hall	Great River Hydro	shall@greatriverhydro.com
Brian Nartowicz	Deerfield Water Superintendent	deerfieldfire@crocker.com

HazMit Planning Local Project Team (2019 - 2020)

Name	Representation	Email Address
Carolyn Shores Ness	Member, Select Board and Board of Health	acornhillfarm@hotmail.com
Kevin Scarborough	Superintendent, Deerfield Highway Department	kscarborough@town.deerfield.ma.us
John Paciorek, Jr.	Police Chief, Deerfield Police Department	jpaciorek@police.deerfield.ma.us
Tevor D. McDaniel	Chair, Select Board	tmcdaniel@town.deerfield.ma.us
Zachary Smith	South County EMS Director	zsmith@town.deerfield.ma.us
Robert Walden	Building Inspector	rwalden@town.deerfield.ma.us
Diana M. Schindler	Interim Town Administrator	townadmin@town.deerfield.ma.us
Richard Calisewski	Health Agent	rcalisewski@town.deerfield.ma.us

Abutting Towns

Town	Phone Number	Address
Town of Sunderland	713-665-1441	12 School Street, Sunderland MA 01375
Town of Whately	413-665-4400	4 Sandy Lane, South Deerfield MA 01373
Town of Conway	413-369-4235	32 Main Street, Conway MA 01341
City of Greenfield	413-772-1500	14 Court Square, Greenfield MA 01301
Town of Montague	413-863-3200	1 Avenue A, Turners Falls, MA 01376
Town of Shelburne	413-625-0300	51 Bridge Street, Shelburne, MA 01370

Deerfield Multi-Hazard Mitigation Plan Update

Project Meeting / Work Group meeting

June 26, 2019

Sign-in Sheet

Please Print Clearly

Name	Affiliation	Mailing Address/ Email	Phone Number
Carolyn Shores Ness	BOS/BOH	acornhillfarm@hotmail.com Old Albany Rd	774-5824
Diana Schindler	TA	execasst@town.deerfield.ma.us	(413) 665-1400 x104
Kimberly MacPhee	FRCOG	kmacphee@frcog.org	413-774-3167
Richard Calisewski	BOH	RCALISEWSKI@TOWN.DEERFIELD.MA.US	665-1400

MEETING AGENDA

TOWN OF DEERFIELD
MULTI-HAZARD MITIGATION PLAN UPDATE PROJECT

Wednesday June 26, 2019
11:00 a.m. – 12:30 p.m.
Deerfield Town Hall

Project Facilitator: Franklin Regional Council of Governments

1. Introductions
2. Overview of Project and Timeline
3. Discuss Integration of Work with MVP Activities
4. Review 2014 Multi-Hazard Mitigation Plan Action Plan (attached)
5. Update Current Mitigation Strategies (Table 4-1 to be distributed at the meeting)
6. Schedule Next Meeting

TOWN OF DEERFIELD

Office of the Selectboard & Board of Health
8 Conway Street
South Deerfield, MA 01373
Voice: *413.665.1400*
Facsimile: *413.665.1411*
Web: *www.deerfieldma.us*

MEETING AGENDA

TOWN OF DEERFIELD
MULTI-HAZARD MITIGATION PLAN UPDATE PROJECT

Tuesday, September 17, 2019
12:30 – 2:30 p.m.
Deerfield Town Hall

Project Facilitator: Franklin Regional Council of Governments

1. Introductions.
2. Discussion of Deerfield's Risk to Each Hazard Based on the Location, Extent, Probability, and Severity of Hazards.
3. Review of Draft Critical Facilities & Infrastructure Map.
4. Review of Draft Environmental Resources Map.
5. Review Draft 2020 Multi-Hazard Mitigation Prioritized Action Plan. *Note: the 2020 Action Plan includes 2018 MVP Action Items and updates as well as 2014 Action Items to be carried forward* (document will be distributed at the meeting).
6. Confirm Next Meeting Date.

September 17, 2019

Sign In Sheet

MULTI-HAZARD MITIGATION PLAN UPDATE PROJECT

(Please print legibly)

Name	Address	Email	Phone
Trevor R. McDaniel	5 Sherman Drive	TMcDaniel@Town.deerfield.MA.US	413-575-0871
Carolyn Shores Ness	10 Old Albany Rd	acornhillfarm@hotmail.com	413-774-5824
Diana M Schindler	Town Hall	townadmin@town.deerfield.ma.us	(413) 665-1400 x105
ZACHARY SMITH	88 Greenfield Rd	ZSmith@Town.Deerfield.ma.us	413.512.5250
Kimberly MacPhee	FRCOG	kmacphee@frcog.org	413-774-3167
Mike Lupinski	Town Hall	ata@town.deerfield.ma.us	413.665.1400 x104
ROBERT WALDEN	Building DEPARTMENT	RWALDEN@town.deerfield.ma.us.	413-665-1400 x110

10-2-19

MEETING AGENDA

PUBLIC MEETING on MULTI-HAZARD MITIGATION PLAN UPDATE and MUNICIPAL VULNERABILITY PREPAREDNESS

1) Welcome and Introduction to Purpose of Meeting

   - Carolyn Shores Ness, Deerfield Selectboard

2) Municipal Vulnerability Preparedness (MVP) Program
   a. Background on MVP Program
   b. Deerfield's Approved MVP Plan
   c. Projects Included in Deerfield's Funded MVP Action Grants
   d. Discussion of Ideas for Next MVP Grant
   e. Amendments to MVP Plan

   - Christopher Curtis, Conservation Works

3) Multi-Hazard Mitigation Plan Update Project
   a. Discuss Deerfield's Risk to Each Hazard Evaluated in the Multi-Hazard Mitigation Plan
   b. Review of Draft Critical Facilities & Infrastructure Map
   c. Review of Draft Environmental Resources Map
   d. Discuss Updates to MVP Vulnerability Map
   e. Discuss Hazard Problem Statements and Projects to Include in the 2020 Multi-Hazard Mitigation Prioritized Action Plan.

   - Kimberly Noake MacPhee, Franklin Regional Council of Governments

10-2-19

SIGN-IN SHEET

PUBLIC MEETING on MULTI-HAZARD MITIGATION PLAN UPDATE and MUNICIPAL VULNERABILITY PREPAREDNESS

NAME	ADDRESS	EMAIL
Roger Sadesky	160 Hillside Rd	
CHRIS HARRIS	13 EASTERN AVE	harris.chris.j@att.net
Carolyn Shores Ness	10 Old Albany Rd	acornhillfarm@hotmail.com
Trevor D. McDaniel	5 Sherman Drive	Trevor.d.McDaniel@gmail.com
Kimberly MacPhee		FRCOG kmacphee@frcog.org
Chris Curtis	88 S. Mill River Rd.	chcurtis89@gmail.com

TOWN OF DEERFIELD

Office of the Selectboard & Board of Health
8 Conway Street
South Deerfield, MA 01373
Voice: *413.665.1400*
Facsimile: *413.665.1411*
Web: *www.deerfieldma.us*

MEETING AGENDA

TOWN OF DEERFIELD
MULTI-HAZARD MITIGATION PLAN UPDATE PROJECT

Tuesday, January 21, 2020
1:00 – 2:30 p.m.
Deerfield Town Hall

Project Facilitator: Franklin Regional Council of Governments

1. Introductions.
2. Discuss Updates to Section 3 Hazard Identification and Risk Assessment of the Draft Plan, including draft Hazard Problem Statements and draft Manmade Hazards section.
3. Review Updates to Table 4.1 Existing Mitigation Strategies.
4. Review 2nd Draft 2020 Multi-Hazard Mitigation Prioritized Action Plan (document will be distributed at the meeting).
5. Discuss Public Comment Period and Public Meeting.

Deerfield Hazard Mitigation Plan Update Meeting

Tuesday, January 21, 2020

1:00 p.m.

Deerfield Town Hall, 8 Conway Street, South Deerfield, MA 01373

Name	Affiliation	Contact
Carolyn Shores Ness	Selectboard/BOH	acornhillfarm@hotmail.com
Robert Walden	Building Commissioner	RWalden@Town.Deerfield.ma.us
John Paciorek Jr	Police Department	jpaciorek@police.deerfield.ma.us
Kevin Scarborough	Dfld Highway	KScarborough@Town.Deerfield.MA.US
Michael A Phillips	Dfld Highway	Mickel665@AOL.COM
John T. Pumila	CITIZEN - FINANCE	
ALEX HERCHENREDER	RESIDENT - ZONING BOARD	AHERCHENREDE@UMASS.EDU
Albert N Olmsted	Fin Com	skipolmstead@verizon.net

Press Release
FOR IMMEDIATE RELEASE

Contact: Kayce Warren, Town Administrator, 413-665-1400 x105

Town of Deerfield
Multi-Hazard Mitigation Plan
DRAFT AVAILABLE for REVIEW
February 26, 2020

The Deerfield Multi-Hazard Mitigation Plan Update Committee, in partnership with the Franklin Regional Council of Governments (FRCOG) Planning Department, has prepared a draft 2020 Multi-Hazard Mitigation Plan that is ready for public review. Once the 2020 Plan is approved by FEMA and adopted by the Town, Deerfield will be eligible for state and Federal grant monies to fund pre- and post-disaster mitigation projects. The purpose of this Multi-Hazard Mitigation Plan update is to identify natural and other hazards that may impact the community; conduct a risk assessment to identify infrastructure at the highest risk for being damaged by hazards; inventory and assess current Town hazard mitigation policies, programs, and regulations; and identify action steps to prevent damage to property and loss of life.

A Public Forum will be held on Wednesday, February 26th at 6:15 p.m. at the Deerfield Municipal Offices located at 8 Conway Street, South Deerfield, MA to present the draft plan and solicit feedback from stakeholders.

The draft plan will be available at https://www.deerfieldma.us/ and a paper copy will be available at the Town Administrator's Office and the Tilton Library on February 27th.

Public Comment Period to run until March 13, 2020

Comments can be submitted to:
Kimberly Noake MacPhee
Franklin Regional Council of Governments
12 Olive Street, Suite 2
Greenfield, MA 01301
kmacphee@frcog.org or 413.774.3167 x130

MULTI-HAZARD MITIGATION PLAN

POSTED ON: FEBRUARY 26, 2020 - 12:28PM

Town of Deerfield
Multi-Hazard Mitigation Plan
DRAFT AVAILABLE for REVIEW
February 26, 2020

The Deerfield Multi-Hazard Mitigation Plan Update Committee, in partnership with the Franklin Regional Council of Governments (FRCOG) Planning Department, has prepared a draft 2020 Multi-Hazard Mitigation Plan that is ready for public review. Once the 2020 Plan is approved by FEMA and adopted by the Town, Deerfield will be eligible for state and Federal grant monies to fund pre- and post-disaster mitigation projects. The purpose of this Multi-Hazard Mitigation Plan update is to identify natural and other hazards that may impact the community; conduct a risk assessment to identify infrastructure at the highest risk for being damaged by hazards; inventory and assess current Town hazard mitigation policies, programs, and regulations; and identify action steps to prevent damage to property and loss of life.

A Public Forum will be held on Wednesday, February 26th at 6:15 p.m. at the Deerfield Municipal Offices located at 8 Conway Street, South Deerfield, MA to present the draft plan and solicit feedback from stakeholders.

The draft plan will be available at https://www.deerfieldma.us/ and a paper copy will be available at the Town Administrator's Office and the Tilton Library on Feb.27th.

Public Comment Period to run until March 13, 2020
Comments can be submitted to:
Kimberly Noake MacPhee
Franklin Regional Council of Governments
12 Olive Street, Suite 2
Greenfield, MA 01301
kmacphee@frcog.org or 413.774.3167 x130

Town of Deerfield
Multi-Hazard Mitigation Plan Update
Public Forum

February 26, 2020

SIGN IN PLEASE

Name	Affiliation	Email
Kayce Warren	Town of Deerfield Town Admin	you have it!
David Wolfram	Town of Drfld - Selectboard	wolfram27@comcast.net
Trevor McDaniel	" " " "	tmcdaniel@town.deerfield.ma.us
Carolyn Shores Ness	" " " "	acornhillfarm@hotmail.com
Kevin Scarborough	Town of Deerfield DPW Supt	Kscarborough@town.deerfield.ma.us
Lynn Rose	Resident	lynnfaith@comcast.net
Matthew Plotkin	Resident	Matthew.A.Plotkin@Gmail.Com
Alex Heghenroeder	Resident	AHEGHENROEDER@UMASS.EDU
Chris Curtis	resident	chcurtis89@gmail.com

DEERFIELD HAZARD MITIGATION PLAN UPDATE PUBLIC FORUM

Deerfield Town Offices
Wednesday, February 26, 2020

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.

Deerfield Multi-Hazard Mitigation Plan 2014

- 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

2014 Multi-Hazard Mitigation Plan
Hazard ID & Vulnerability Assessment

Potential Hazards Identified for Deerfield
Dam Failure
Severe Winter Storm/Ice Storm
Earthquake
Hurricane
Wind Storms, Microbursts, etc.
Tornado
Ice Jam
Flood
Wild Fire/Brush Fire
Landslide
Drought - 2020
Invasive Species -2020
Temperature Extremes -2020

A changing climate is exposing us to greater risk.

Massachusetts' Changing Climate

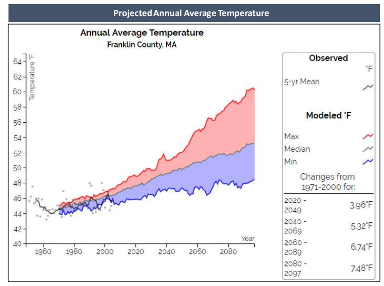
- **Changing weather**
  - Higher temperatures
  - Shorter winters
  - More frequent & intense storms
  - Droughts
- **Amplifies existing risks**
  - Community and regional infrastructure
  - Local and regional economies
  - Public health
  - Natural resources and our environment

Goal for Building Resilience to a Changing Climate:

Protect life, property, natural resources and the economy

Higher Temperatures

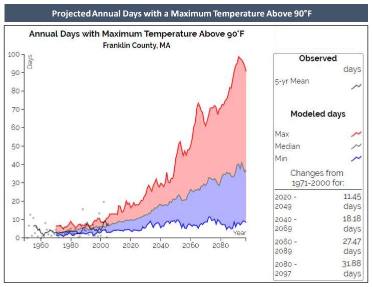
Projected Annual Average Temperature



The average annual temperature is projected to increase from 45.3°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

Source: Resilient MA, 2018

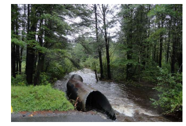
Extreme Temperatures



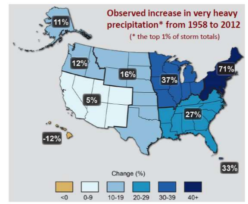
- Projected to increase by 18 days by the 2050s, and by 32 days by the end of the century for a total of 36 days over 90°F
- 1971 to 2000 average of 4 days per year

Source: Resilient MA, 2018

Changes in Precipitation



Observed Increase in Heavy Precipitation



- Total annual precipitation is projected to increase by 3 inches by mid-century, and by 4 inches by the end of this century
- Less snow / more rain in winter
- Heavier precipitation events overall

Source: Resilient MA, 2018

Extreme Weather Events

- Tropical storms
- Tornadoes
- Thunderstorms
- Snow storms
- Drought

The frequency, intensity, duration and geographic extent of these extreme storms is likely to increase.

2020 Hazard Identification & Risk Analysis

- **Identify Past, Current and Future Hazards**
- **Discuss How Climate Change Increases the Risks from these Hazards**
  - **Infrastructure**
  - **Society**
  - **Environment**
- **Determine Top Priority Hazards**
  - Which hazards pose the greatest threat to the town currently and in the future?
- **2018 Municipal Vulnerability Preparedness (MVP) workshop results incorporated**

2020 Hazard Identification & Risk Analysis

Deerfield Hazard Identification and Risk Analysis

Type of Hazard	Location of Occurrence	Probability of Future Events	Impact	Overall Hazard Vulnerability Rating
Severe Winter Storms	Large	Very High	Limited but Critical for ice storms	1
Flooding	Medium	Very High	Critical	1
Tornadoes	Isolated	Moderate	Critical	3
Dam Failure	Medium	Very Low	Catastrophic	3
Hurricanes / Tropical Storms	Large	Moderate	Critical	2
Severe Thunderstorms / Wind / Microbursts	Medium	Very High	Critical	1
Extreme Temperatures	Large	Very High	Critical	1
Earthquakes	Large	Very Low	Catastrophic	3
Landslides	Isolated	High	Limited	2
Drought	Large	Moderate	Critical	2
Wildfires	Medium	Very Low	Minor	3
Invasive Species	Large	Very High	Critical	1

1=High
2=Medium
3=Low

Vulnerability Assessment

For each hazard, the following information is included:

- Potential Impacts of Climate Change on the Hazard
- A Description of the Hazard, including:
  - Location
  - Extent
  - Previous Occurrences
  - Probability of Future Events, and
  - Impacts
- Discussion of the vulnerability of the town:
  - Society (including Vulnerable Populations)
  - Health Impacts
  - Economic Impacts
  - Infrastructure Impacts
  - Environmental Impacts

Table 3-25: Estimated Vulnerable Populations in Deerfield

Vulnerable Population Category	Number	Percent of Total Population *
Population Age 65 Years and Over	881	17%
Population with a Disability	552	11%
Population who Speak English Less than "Very Well"	45	1%
Vulnerable Household Category	**Number**	**Percent of Total Households ***
Low Income Households (annual income less than $35,000)	396	20%
Householder Age 65 Years and Over Living Alone	210	10%
Households Without Access to a Vehicle	67	3%

*Total population = 5,049; Total households = 2011
Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Mitigation Strategies

- Hazard Problem Statements
- Evaluation of Current Mitigation Strategies
- Status of 2014 Action Plan Items
- 2020 Action Plan

Flood Hazard Problem Statements
• Ice jams have occurred historically on the Deerfield River and present a potential flood risk.
• FEMA floodplain maps are critically important to successful mitigation but are outdated. FEMA is currently updating maps and when the project is complete, the Town will have access to digital floodplain mapping, which will help in the permitting of new construction and floodproofing in areas such as the Bloody Brook watershed, which is impacted by chronic flooding.
• While the chance is low, a catastrophic dam failure at the one of the major hydroelectric dams on the Connecticut or Deerfield Rivers upstream of the Town would result in devastating flooding to many parts of Deerfield. There are six major dams of concern on the Deerfield River, including Harriman Dam, where a failure would result in floodwaters reaching Deerfield in 4 hours. Moore Dam is of concern on the Connecticut River.
• Emergency and Evacuation plans between the Town and its schools, including private schools, such as Bement School, Deerfield Academy, and Eaglebrook, need improved coordination and planning. Evacuations would be needed at Deerfield Academy and Bement School, and roads would be inundated if large upstream dams on the Deerfield River were to fail. Evacuation planning, improved communication, and notification protocols with Great Hydro relating to upstream Deerfield River Dams are of particular concern.
• The Town needs more current and robust evacuation plans and a central communication system on road flooding. Flood-prone roads include Route 5/10, Mill Village Road, and Wapping Road. If Routes 5/10 are closed due to flooding, Deerfield loses an important north-south evacuation route.
• Severe flood events, including flooding from TS Irene, as well as ongoing flooding have significantly eroded riverbanks and degraded riparian habitat on the Deerfield River, Connecticut River, and Bloody Brook. Adjacent roads, farms, homes and businesses throughout the Town are more vulnerable to future flooding. Compromised riverbanks are in need of restoration and reinforcement, flood-prone roadways may need to be raised.
• More needs to be done to protect flood storage areas in Deerfield's flood zone. Floodplain zoning needs improvement and land conservation is needed, especially in the north and south meadows of Old Deerfield, along the Deerfield River in west Deerfield, and in farmed areas within the Bloody Brook watershed.
• There is a need to promote farm practices, such as no till agriculture, that limit the risk of phosphorous and nitrogen fertilizer carried by heavy precipitation or flood waters entering the river.

Next Steps

- Review the 2020 Action Items and identify any actions that are missing.
- Provide comments on the plan by March 13, 2020. The plan will be available on the Town of Deerfield website on February 27th.
- Comments may be submitted to Kimberly Noake MacPhee, FRCOG kmacphee@frcog.org or 413.774.3167 x130.

THANK YOU!

Comments received
at 2-26-20 Public Forum

itigation Prioritized Action Plan				
ntial ding rce	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	Priority 2014 / 2020	Status
EMA, Town	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate	S, E, I	Very High	New Action Item. Priority projects/locations were identified in the 2018 MVP Plan and as part of the update of this Multi-Hazard Mitigation Plan. These projects are: ✓ Mill Village Road (south of intersection with Log Plain Road); ✓ Kelleher Drive (at North Main Street intersection); ✓ Route 5 (near Richardson's Candy Kitchen); ✓ Wapping Road (north of Greenough Crossing Road); ✓ Broughams Pond Road (west of intersection with Old Ferry Road); ✓ Captain Lathrop Drive; ✓ Private culverts along North Main Street. Other areas of concern include: Stillwater Road, Depot Road, Graves Street, and Mountain Road
FEMA, wn	Year 2	S, E, I	High	River Road in its entirety – McCellan Road New Action Item. Thayer Street

Hillside Road

Mitigation Prioritized Action Plan

tential nding ource	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	Priority 2014 / 2020	Status Medium
, Town, EMA	Year 2	S, I, E	2014 High 2020 ~~Low~~ Medium	DEP was contacted to discuss this project. Further testing needed for presence of EDB to determine suitability for public drinking water supply. Priority has been changed to ~~Low~~ for 2020. The cost-effectiveness of lowering groundwater levels to alleviate localized flooding needs to be evaluated.
, Town, EMA	Year 2	S, I, E	2014 High 2020 High	Related Action Items from the 2014 Plan have been consolidated and the Action Item description updated for the 2020 plan. This Action Item would build upon the USGS Flood Inundation Mapping completed for a section of the Deerfield River.
own, nteers	Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate.	S, I, E	2014 High 2020 High	The Town conducted outreach in 2015. Due for new public outreach initiative.

Table 4-3: 2020 Deerfield Hazard M

Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Pot Fur So
Local Plans & Regulations	To reduce the risk of landslides, review and amend, if necessary, the town's Zoning Bylaws and Subdivision Rules and Regulations to include a provision that sets limits on land clearing and directs development to stable slopes and soils..	Landslides	Planning Board	Low	Town
Local Plans & Regulations Education & Awareness	Continue to monitor the activities at the East Deerfield Rail Yard to ensure the clean-up of documented released of hazardous materials, to limit future releases, and to plan for and coordinate emergency responses in the event of a release or other hazard event.	Manmade Hazards	Town Administrator, Select Board, EMD	Low	MassD ot pote respo par
Local Plans & Regulations Education & Awareness	Continue to review and drill evacuation procedures for the flood prone and dam inundation areas in Town.	Flooding Dam Failure	Emergency Management Director, Highway Department	Low	To M
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 regional agencies to identify a location(s) in the City for the temporary storage of contaminated and/or hazardous ~~flood~~ debris. from natural hazard events	Multiple Hazards	Franklin Co Solid Waste District DPW , Franklin County REPC	Low	MV To

construction debri
white goods -

Vector-borne Diseases

Hazard Profile

Likely Severity

The Town of [town name] chose to examine the hazard of vector-borne diseases in their community. Vector-borne disease are defined by the CDC as illnesses in humans derived from a vector, including mosquitoes, ticks, and fleas that spread pathogens. Examples of mosquito-borne diseases include Chikungunya, Eastern Equine Encephalitis (EEE), Zika, and the West Nile Virus. Examples of tick-borne diseases include Lyme Disease, Anaplasmosis/Ehrlichiosis, Babesiosis, and Powassan.

The damage rendered by vector-borne diseases can be significant in a community, and can drastically affect quality of life, ability to work, loss of specific bodily functions, increase life-long morbidity and increase mortality.

Probability

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.

The Berkshires provide 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 Berkshire County, and a lengthening warm season, among other characteristics of the Berkshire environment, has increased tick and mosquito populations significantly. Cases of Lyme in Berkshire County have increased by [fill in with Berk data]. Additionally, Massachusetts has seen cases of once non-existent or very rare tick borne illnesses rise, including Anaplasmosis/Ehrlichiosis (848 cases in 2016, can be fatal), Babesiosis (518 cases in 2016, significantly higher than any other state, can be fatal), Lyme (198 cases in 2016), Powassan (5 cases in 2016, fatality rate is 10%), Spotted fever rickettsiosis (8 cases in 2016, 20% untreated cases are fatal), and Tularemia (5 cases in 2016).

Geographic Areas Likely Impacted

The Town of [town name] in its entirety 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.

Historic Data

In the United States in 2016, a total of 96,075 cases were reported, 1,827 of which were reported in the state of Massachusetts. In Berkshire County, [drop in local data and data source]. The CDC indicates that cases of vector-borne diseases are substantially underreported. Tickborne 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 tickborne cases, but spotted fever rickettsioses, babesiosis, and anaplasmosis/ehrlichiosis cases also increased. During the years of 2004 to 2016, nine vector-borne human diseases were reported for the first time from the United States and US territories. According to the CDC, vector-borne diseases have been difficult to prevent and control, and a Food and Drug Administration (FDA) approved vaccine is only available for yellow fever virus. Insecticide resistance is widespread and is increasing.

Vulnerability Assessment

People

Vector-borne illness have a significant impact on humans and on a community, and significantly affect health, long-term morbidity and mortality, quality of life, and can significantly reduce a persons' ability to work or contribute to the community in other ways. In addition to the direct effect of vector-borne illnesses on a person, pesticides and herbicides used to control populations of vectors can also negatively impact human health.

Built Environment

Vector-borne illnesses pose little threat to the built environment in a community. Overtime we may see changes in development 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 significantly affect the natural environment, including vegetation and other animal populations. Reducing populations of ticks and mosquitos can reduce the food source for other dependent animal populations. Additionally, diseases carried by insects can affect wildlife as they do humans. There is also the risk of people reacting to the threat of disease by altering the environment to not support habitat, severely damaging long-term ecosystem health.

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 can cause life-long morbidity or mortality will reduce the overall economic participation and output of the population in a municipality. There will also be the impacts on outdoor recreation, which is a major revenue driver for Berkshire County. People today choose to or are advised by officials to avoid outdoor activities in fear of tick and mosquito bites.

Future Conditions

Continued changes to the climate, extreme precipitation events, issues with control of stormwater, changes to animal and vector populations, and continued increases in insecticide resistance will lead to a continued 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, increase opportunities for residents to get ticks from tick bites tested, reduce the cost and burden of testing ticks for individuals, and increase the level of education and awareness of current and new vector-borne illnesses with the public and practitioners so treatment can be expedited. Municipalities should implement educational programs for residents and visitors for bite-prevention and detection.

References:

CDC May 1, 2018 https://www.cdc.gov/ncezid/dvbd/vital-signs/2016-data.html

CDC September 9, 2019 https://www.cdc.gov/climateandhealth/effects/vectors.htm

CDC May 3, 2018 https://www.cdc.gov/mmwr/volumes/67/wr/mm6717e1.htm

CDC December 13, 2018 https://www.cdc.gov/tularemia/diagnosistreatment/index.html

CDC 2020 https://wwwn.cdc.gov/nndss/conditions/spotted-fever-rickettsiosis/case-definition/2020/

CDC July 17, 2019 https://www.cdc.gov/powassan/index.html

Dept. of Health, Rhode Island https://health.ri.gov/diseases/ticks/?parm=26

New York State Dept. of Health
https://www.health.ny.gov/diseases/communicable/ehrlichiosis/fact_sheet.htm

Appendix B – FEMA Plan Review Tool

LOCAL MITIGATION PLAN REVIEW TOOL - Final
Town of Deerfield, 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 Deerfield, MA	**Title of Plan:** Town of Deerfield Multi-Hazard Mitigation Plan	**Date of Plan:** Draft July 8, 2020

Single or Multi-jurisdiction plan? SINGLE	**New Plan or Plan Update?** UPDATE
Regional Point of Contact: Kimberly Noake MacPhee, P.G., CFM Land Use & Natural Resources Planning Program Manager - FRCOG 12 Olive Street, Suite 2 Greenfield, MA 01301 Phone: 413-774-3167 x130 Fax: 413-774-3169 Email: KMacPhee@frcog.org	**Local Point of Contact:** Kayce D. Warren, Town Administrator Town of Deerfield 8 Conway Street South Deerfield MA 01373 Ph: 413-665-1400 ext 105 Fax: 413-665-1411 Email: townadmin@town.deerfield.ma.us

State Reviewer:	**Title:**	**Date:**
Jeffrey Zukowski	MA Hazard Mitigation Planner	7/18/2020 (Saturday)

FEMA Reviewer:	**Title:**	**Date:**
Marie-Annette (Nan) Johnson Brigitte Ndikum-Nyada	Region I Community Planner FEMA Community Planner	7/20/20 – 8/7/2020 8/7/20 – 8/13/20; 8/25/20, 9/28 -929/20
Date Received in FEMA Region I	7/20/2020 & 8/24/2020 & 9/28/2020	
Plan Not Approved	8/13/2020	
Plan Approvable Pending Adoption	8/25/2020	
Plan Adoption	9/9/2020	
Plan Approved	**9/29/2020**	

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))	Section 1; pages 1-5 Appendix A	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))	Section 1; pages 3-5 Appendix A	X	
A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1))	Section 1; pages 4-5 Appendix A	X	
A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))	Section 1; page 5	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))	Section 5; pages 258-260; p.267	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))	Section 5; pages 258-260	X	
<u>ELEMENT A: REQUIRED REVISIONS</u>			
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))	Section 3; pages 22-220	X	
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))	Section 3; pages 22-220	X	

1. REGULATION CHECKLIST **Regulation** (44 CFR 201.6 Local Mitigation Plans)	**Location in Plan** (section and/or page number)	**Met**	**Not Met**
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))	Section 2; pages 6-16 Section 3; pages 22-220	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))	Section 2; page 9 Section 3; pages 49-50	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))	Section 4; pages 222-241	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))	Section 2; page 9 Section 3; pages 49-50	X	
C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))	Section 4; page 242	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))	Section 4; pages 246-257	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))	Section 4; pages 246-257 Table 5.1, 261-265	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))	Section 5; pages 266-267	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))	Section 2; pages 6-16 (pp 9)	X	
D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))	Section 4; pages 221-257	X	
D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))	Section 4; pages 242-257	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))	Appendix B – pages 254-255, 258		
E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? (Requirement §201.6(c)(5))			
ELEMENT E: REQUIRED REVISIONS			
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:

- There is an Appendix C that is not identified in the Table of Contents. It also has no content.

Element A: Planning Process

Strengths:

- Well done! The Town's update effectively provided a planning process with good local involvement of its agencies and some stakeholders and that was accessible to the public. The information used in the process incorporated current information with a good review of the Town's relevant documents and an analysis of its updated risk assessment. The plan maintenance has been thought out and is based on insights from what worked or didn't since the last approved plan. Includes good documentation of the process.

Opportunities for Improvement:

- Continue to provide lessons learned and other insights of what has worked well or not and any successes to share for the next planning period.
- Consider specifying the content of the public comments received and more detail about how they were incorporated into the plan.
- The community is encouraged to consider inserting final adoption documents within the first few pages of the approved plan.
- Consider placing the Adoption resolution up in the first few pages of the plan to give it more visibility. It is currently located between several miscellaneous public meeting documents and Appendix C (East Deerfield Railyard NPDES Permit Information).

Element B: Hazard Identification and Risk Assessment

Strengths:

- The risk assessment is effective in conveying the Town's risk and in supporting its Mitigation Strategy. Specific areas of flooding are identified, along with the number of residents, buildings in the floodplain, and the vulnerability of specific populations related to these locations. This will be a great resource for the community. Continue the good work!
- Vulnerable populations, health and economic impacts are included in the vulnerability assessment.
- The problem statements for each hazard are clearly visible and can provide a good basis for which the Strategy can clearly respond to the needed long-term solutions. For flood hazards this was effectively accomplished. (See next section for opportunities.).
- The community's greatest vulnerabilities are easily identified through inclusion of problem statements for each hazard.

Opportunities for Improvement:

- Ensure all-natural hazards (not only flooding) have mitigation focused problem statements.

- Ensure the problem statements are reflective of the various Town stakeholders to see if all the diverse perspectives have been captured. And, that these reflect an inclusive decision-making process when determining the importance or urgency of these vulnerabilities. Such as - inclusive of the local businesses, tourism, recreation, historic, cultural, and environmental interests.
- While the hazard assessment is thorough, clarify the rationale for omitting hazards, if any.
- Ensure the data used in the risk assessment is current to the plan's submission.
- Note that repair and maintenance problems need to be approached by looking at long-term solutions. Identify in the risk assessment why these may have been only short-term fixes which will continue to be vulnerable unless they are met with long-term design improvements, standards, or programs.
- See Element D for more opportunities with regards to connecting the changes in risk from development that has occurred since the previous plan's formal approval.

Element C: Mitigation Strategy

Strengths:

- This hazard mitigation plan has presented an effective strategy that should serve the Town well over the next planning period. It has successful provided a comprehensive range of long-term risk reduction alternatives. Additional preparedness actions were added (consider distinguishing these to avoid confusion).
- A very thorough review of the Town's capabilities was conducted and presented in the plan.

Opportunities for Improvement:

- The mitigation actions need more supportive *mitigation* goals. Currently, majority of the goals are written to support preparedness rather than mitigation. For the next plan update, here are a few mitigation related goals to consider: *Discourage future development in hazard prone areas, such as flood plains; Protect and preserve irreplaceable cultural and historic resources located in hazard prone areas; Ensure that critical infrastructure is protected from natural hazards; Develop programs and measures that protect residences and other structures from natural hazards and Evaluate all of the Town's existing policies and practices related to hazards and identify potential gaps in protection.*
- Consider relocation options or improvements to alleviate the need to evacuate or have vulnerable populations at risk (i.e., long-term solutions = mitigation). When short-term solutions are included, then recognize their limitations and differences within the mitigation strategy.

Element D: Plan Update, Evaluation, and Implementation (*Plan Updates Only*)

Strengths:

- The community profile has provided good insights into the Town's changes in development. However, this information must be tied into the risk assessment. These changes are important in the updates to reflect whether the different types of changes in development are decreasing or increasing or having no effect on the Town's risks to its hazards.
- A good review of the Town's progress was provided in the actions being carried forward.
- Job well done, by highlighting the information in the revised draft plan, required to address

element D1.a.

Opportunities for Improvement:

- Provide sections for successes and insights to the Town's progress. Be clear on any changes in its priorities as well.
- Include the method for updating the plan should there be a disaster or event in the Town.
- Consider summarizing any overall trends in the way priorities have changed, in order to make these changes easier to understand. Potential ways in which priorities may have changed include placing more emphasis on mitigation rather than preparedness, focusing on flooding or erosion vulnerabilities, emphasizing on a certain type of mitigation actions, etc.
- Consider including a discussion on how mitigation activities have increased the community's resilience and support other long-term community planning goals.
- Including a discussion of lessons learned about implementing mitigation actions would strengthen the plan, as would a short narrative on some "success stories" about their implementation.
- Describe if and how changes in development since the last plan have increased or decreased the community's vulnerability.

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

- FEMA Climate Change: Provides resources that address climate change.
- 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 RiskMAP: Technical assistance is available through RiskMAP to assist communities in identifying, selecting, and implementing activities to support mitigation planning and risk reduction. Attend RiskMAP 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.
- 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.