This draft plan is being offered for public review and comment February 9th through March 2nd 2022

Please send comments to the Town of Otis' consultant, Lauren Gaherty, at lauren@berkshireplanning.org

We also invite you to learn more and see what steps you can take at home.

Visit Resilient Otis at https://arcg.is/18LKD9

DRAFT Town of Otis Hazard Mitigation and Climate Adaptation Plan

February 9, 2022

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CHAPTER 1: INTRODUCTION

Purpose

The purpose of hazard mitigation planning is to reduce or eliminate the need to respond to hazardous conditions that threaten human life and property. Hazard mitigation can be an action, activity, process, or physical project designed to reduce or eliminate the long-term risks from hazards.

The Town of Otis Hazard Mitigation and Climate Adaptation Plan (HMCAP) was prepared in order to meet the requirements of the Code of Federal Regulations, Title 44 CFR § 201.6 pertaining to local hazard mitigation plans. Title 44 CFR § 201.6(a)(1) states that "a local government must have a mitigation plan approved pursuant to this section in order to receive hazard mitigation project grants. A local government must have a mitigation plan approved pursuant to this section in order to apply for and receive mitigation project grants under all other mitigation grant programs." As the HMCAP will illustrate, the Town's eligibility for FEMA's hazard mitigation grants is crucial. The Town of Otis HMCAP also benefited from the Municipal Vulnerability Preparedness (MVP) planning process, which enabled the Town to integrate local effects of climate change into their hazard mitigation action plan.

The Town of Otis established the following mission statement for their hazard mitigation and climate adaptation planning process:

> *The defined mission for the Town of Otis Hazard Mitigation Plan is to identify risks, eliminate or reduce the loss of life, property, infrastructure and cultural & environmental natural resources of the Town from disasters and to develop sustainable cost-effective actions to mitigate those risks and the impacts of natural hazards.*

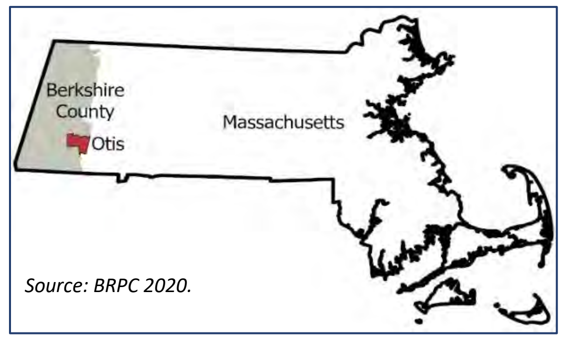
In accordance with Title 44 CFR § 201.6 the local mitigation plan is the representation of the Town's commitment to reduce risks from natural hazards, serving as a guide for decision makers as they commit resources to reducing the effects of natural hazards. Additionally, the HMP is meant to serve as the basis for the Commonwealth of Massachusetts to provide technical assistance and to prioritize project funding.

Background

Location

The Town of Otis is located in southern Berkshire County, Massachusetts. It is a Town nestled quaintly against the gentle slopes of the Berkshire Range, endowed with cold water streams and several lakes and ponds, some of which are open for public recreation and are lined with residential development. It is surrounded to the north by the town of Becket, to the east by Blandford and Tolland, to the south by Sandisfield, and to the west by Monterey and Tyringham.

Fig. 1.1. Location of Otis within Massachusetts



Source: BRPC 2020.

Community Setting

The Town of Otis covers an area of approximately 38 square miles (~24,353 acres), with two distinct topographical regions. These include ridges, steeply sloped terrain with deeply incised streams, west of the Farmington River, and the plateau that expands to the East, where Otis Reservoir, Big Pond and Benton Pond are located. This topography has determined the location of much of the town's development and its settlement patterns, which are generally limited due to slope and shallow depth to bedrock. See Fig. 1.2 for topographical layout and development locations. In the lowlands, wetland areas and water resources have helped to shape development patterns. The predominant land uses in Otis are forest (75%), wetlands (12%), water (6%) and open lands (4%), the last of which includes developed open space (such as camps), grasslands, farm fields. Residential, commercial, industrial lands combined cover one percent of the Town (MassGIS, 2016).

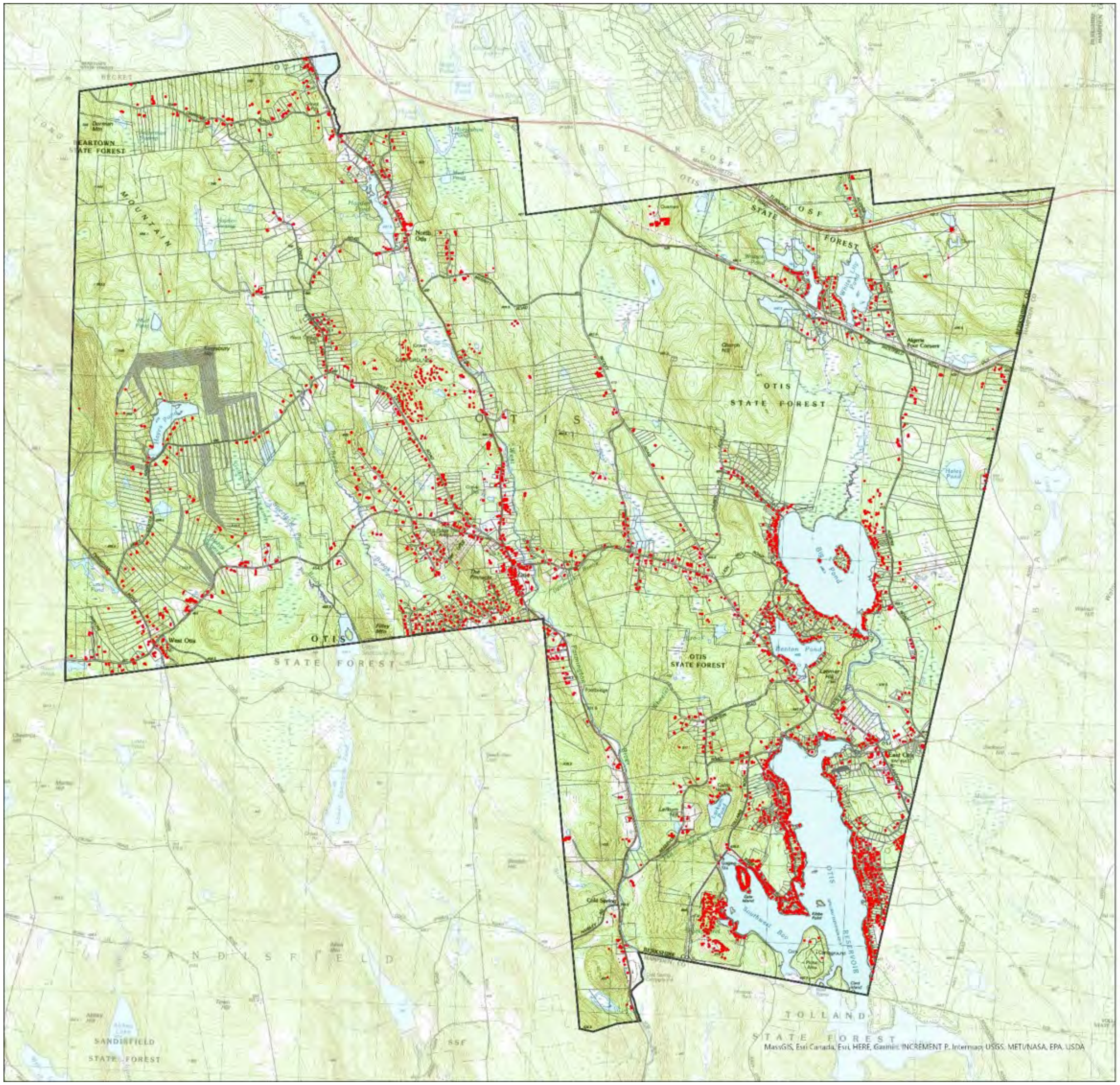
Climate change has and will have many impacts in our community. Some of the largest risks and challenges the community is expected to face include (but are not limited to):

1. Rain & snow impacts on our gravel roads; increased maintenance & repair time & costs
2. Flooding of rivers, streams, ponds, lakes causing damage to homes, property, roads, culverts.
3. Extreme rain /snow events can overwhelm dams both manmade & beaver dams. Breaching of beaver dams have washed out roadways, culverts and stream beds.
4. Forest Fires: With large amounts of forest lands within our Town, there is a risk of forest fires and with the potential for drought caused by climate change this risk increases exponentially.
5. Impacts of greater full-time populations upon all Town infrastructures and the environment. We are seeing this now, as a result of the Coronavirus Pandemic.
6. The Town has an abundance of natural resources, open spaces and wildlife that we respect & protect, therefore the Town seeks Nature-based solutions, or NBS, using plans that leverage nature to accomplish sustainability, climate, and resiliency goals.

Mitigation Planning History

The Town of Otis was included in the 2012 regional *Berkshire County Hazard Mitigation Plan* with 18 other Berkshire County municipalities. More recently, Otis conducted the Massachusetts Municipal Vulnerability Preparedness (MVP) Planning process in 2021, concurrent with the development of this HMCAP. This *Hazard Mitigation and Climate Adaptation Plan* (HMCAP) is a single-jurisdiction plan that both updates the 2012 *Berkshire County Hazard Mitigation Plan* and incorporates the data and findings arising out of the *MVP Plan*. The goal of the MVP process was to develop a set of Actions for addressing Priority Hazards, using the Community Resilience Building (CRB) Workshop process and methodology as a key stakeholder tool.

Fig. 1.2. Topographical Map and building locations



Town of Otis Topographic Map

Buildings
Property Lines

0 0.5 1 Miles

N

Berkshire Regional Planning Commission

This map was created by the Berkshire Regional Planning Commission and is intended for general planning purposes only. This map shall not be used for engineering, survey, legal, or regulatory purposes. MassGIS, MassDOT, BRPC or the municipality may have supplied portions of this data.

CHAPTER 2: PLANNING PROCESS

44 CFR § 201.6(b) & 44 CFR § 201.6(c)(1)

Introduction

This chapter outlines the development of the Town of Otis HMCAP. It identifies who was involved in the process, how they were involved, and the methods of public participation that were employed. An open public involvement process during the drafting stage was essential to the development of the HMP. A discussion of how the community will continue public participation in the plan maintenance process (44 CFR § 201.6(c)(4)(iii)) will be discussed in Chapter 4.

The Town retained the Berkshire Regional Planning Commission (BRPC) to aid them in developing the HMCAP and the MVP Plan. The Otis HMCAP is a compilation of data collected by BRPC, information gathered from the Otis Hazard Mitigation and Climate Action Planning Committee (the Planning Committee) during meetings, and interviews conducted with key stakeholders outside of working meetings. The Plan reflects comments provided by participants and the public through the MVP planning process, the Planning Committee, local officials and citizens, neighboring towns, and ultimately MEMA and FEMA.

Planning Meetings and Public Participation

44 CFR § 201.6(c)(1)

During the planning process there was opportunity for public comment and the opportunity for neighboring communities, local and regional agencies or partners involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process. Making the document available to the public for review meets requirements of 44 CFR § 201.6(b)(1), and solicitation of comment from neighboring towns meets requirements of 44 CFR § 201.6(b)(2), pertaining to involvement of regional partners in the planning process. See Appendix A for documentation.

In August 2020 the Town of Otis formed the Planning Committee to develop both a HMCAP and a MVP Plan. Grants from Federal Emergency Management Agency (FEMA) through the Massachusetts Emergency Management Agency (MEMA) and from the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) made this comprehensive mitigation and climate change planning process feasible. Members of the Planning Committee include planning board members and representatives from key governmental departments, and are listed in Table 2.1.

The Planning Committee held a series of meetings to assemble data on the Town's infrastructure, identify known hazards to residents, including seasonal visitors, and review existing plans, procedures, bylaws and protections already in place. The Planning Committee met 11 times, all of which were posted in accordance with the Massachusetts Open Meeting Law.

Table 2.1: Otis Hazard Mitigation and Climate Adaptation Planning Committee

Name	Affiliation
Brandi Page	Town Administrator
Larry Gould	Building Inspector, Technology Committee, Energy Committee, Wind Turbine Operator
Hal Kobrin	Planning Board
Derek Poirier	Highway Superintendent
Jennifer Daily	Planning Board
Daniel Hamill	Police Chief
Keith O'Neil	Wastewater / Sewer

The Planning Committee utilized several strategies to educate the community about natural hazards and climate change, promote the planning process, and solicit input. All public presentations were publicly noticed in accordance with the state's Open Meeting Law and were widely announced through the Town of Otis website and its email news announcement system. Public engagement strategies included:

- Public Survey – 110 responses. A public survey to gauge community concerns and solicit information was offered online and via paper copies March-May 2021. This survey was announced via the Town's website and through the Otis Observer newsletter.
- Resilient Otis StoryMap. This interactive website was created early in the project and remains open today. It was designed to provide scientific data on natural hazards and climate change impacts in broad user-friendly concepts and easy-to-understand language that is appropriate for the average citizen and use in local school classrooms. Links to original data sources were provided. Additionally, the StoryMap provided residents with practical steps that they could undertake to better prepare for emergency situations, increase environmental resiliency and reduce fossil fuel use. The link to Resilient Otis was featured in local newsletter articles, was provided to MVP Workshop participants, and offered during each public participation event. As of December 2021 the site had more than 700 visits. The link to Resilient Otis is https://arcg.is/18LKD9 .
- December 9, 2020. A public listening session was held to raise awareness of the project and begin to solicit additional public input. The session included a powerpoint presentation that provided background data on hazards and climate change and invited attendees to share their own experiences with natural hazards and potential mitigation strategies.
- *Otis Observer* Newsletter. A series of articles were published in the monthly *Otis Observer*, the local newsletter that has a subscription of ___. The April 2021 article introduced the project and promoted the public survey; the August 2021 article discussed climate change temperature trends; the September 2021 article discussed climate change precipitation trends; and the January 2022 article presented the findings of the MVP Workshops.
- September 20 & 27, October 6, 2021. MVP Workshops were held using the Community Resilience Building framework. The workshops were held via Zoom technology. The workshops and results are described in more detail below.

- February 9, 2022. A second public listening session was held to solicit public input on project findings and encourage the public to review and comment on the *Draft Hazard Mitigation and Climate Change Adaptation Plan*. The session included a powerpoint presentation of the major findings and proposed priority actions that emerged from the project. The session also included polling questions where participants were asked to vote for action items that they felt should be prioritized for implementation. In addition to public postings and announcements issued by the Town of Otis, posters advertising the session were placed in local businesses and gathering places. Email invitations to attend the session were sent directly to all MVP Workshop participants. The event was also publicized in the Berkshire Eagle, the region's local newspaper.
- February 9 – March 2, 2022. The Draft Otis Hazard Mitigation and Climate Adaptation Plan was offered for public review and comment, and was made available on the Town of Otis website and in paper form.

Materials related to public engagement can be found in Appendix A.

Municipal Vulnerability Public (MVP) Workshops

In the autumn of 2021, the Town of Otis held three two-hour MVP Workshops via Zoom technology. The workshops offered a unique community-driven process, based on scientific data but additionally enriched with local experience and dialogue, where participants identify top hazards, current challenges and strengths. This community planning process is a major tool offered by the Massachusetts MVP Program, a state initiative to address climate change. The findings of this process informed and are incorporated into this Hazard Mitigation Plan.

The workshops followed the established Community Resilience Building (CRB) Workshop framework and guidance materials. The CRB process guides workshop participants as they set out to develop a profile of the community's 1) infrastructural, 2) environmental, and 3) societal components that are impacted by natural hazards and climate change. The overall objective of the workshops was to create a climate-related Natural Hazard and Climate Change Risk Matrix for the Town of Otis that:

- Defined top local natural and climate-related hazards of concern;
- Identified existing and future strengthen and vulnerabilities;
- Developed prioritized actions for the Community; and
- Identified immediate opportunities to collaboratively advance actions to increase resilience.

Each of the three workshops focused on one community component: 1) Infrastructural (held Sept. 20), 2) Environmental (held Sept. 27), and 3) Societal (held Oct. 6). Each individual workshop consisted of three main segments:

1. Short introductory presentation of data and thought-provoking questions
2. Small breakout group discussion and matrix development
3. Reconvening of all participants to report out and identify priority actions

Over the course of the three workshops, 24 people participated. The workshops were attended by a mix of Town officials, interested citizens, and state agency and non-profit representatives (see Table 2.2 for the list of participants). The major findings of the MVP workshop series are discussed in more detail in Chapter 4, Mitigation Strategies, of this plan.

Table. 2.2. Attendees of Municipal Vulnerability Preparedness Workshops

Name of Workshop Attendee*	Agency or Affiliation	Number of Workshops Attended
Hal Kobrin	Otis Planning Board, HMCAP Planning Committee	3
Jennifer Daily	Otis Planning Board, HMCAP Planning Committee	3
Brandi Page	Otis Town Administrator, HMCAP Planning Committee	2
Larry Gould	Otis Building Inspector, Special Projects Coordinator, Energy Committee, Technical Committee, HMCAP Planning Committee	3
Derek Poirier	Otis Highway Superintendent, HMCAP Planning Committee	1
Daniel Hamill	Otis Police Chief, Emergency Management Director	2
Sonia Morrison	Otis Historical Commission, Otis Historical Society	2
Theresa Gould	Otis Select Board, Finance Board	2
Larry Southard	Otis Select Board	1
Arlene Tolopko	Otis School Committee	2
Phil Firsenbaum	Otis Woodlands	3
Michael Boyes	Otis Woodlands	3
Susan Ebitz	Otis Library	2
Jim Ebitz	former Select Board and EMD	1
Kathleen Bort	Otis Library	1
Patricia Strauch	Otis Observer newsletter	1
Ned Wilson	Sunbug Solar Co.	1
Daniel Wollman	Resident	1
Becky Cushing	MassAudubon, Western Regional Director	2
Michael Fabiano	MassDOT, Assistant Maintenance Engineer	1
Aimee Petras	Farmington River Watershed Association	2
Amer Raza	MassDOT, Environmental Engineer	1
Tom Ryan	MA DCR Service Forester, Southern Berkshire	1
Carianne Petrik	MVP Coordinator, Berkshire & Hillstowns Region	1

**Note: Names in bold represent Otis residents.*

Public Comment on the Draft HMCAP

The *Draft Otis Hazard Mitigation and Climate Adaptation Plan* was offered for public review and comment February 9th through March 2nd 2022. It was made digitally available on the Town of Otis website and in paper form. The opportunity to comment was publicized via the Town of Otis' website, social media accounts and public notification email distribution list, the last of which has approximately 550 subscribers. Posting of the plan was promoted at the February 9th listening session and invitations to review and comment on the plan were sent directly to abutting towns and the Southern Berkshire Regional Emergency Planning Committee. See Appendix A.

Incorporation of Existing Information

44 CFR § 201.6(b)(3)

No plan should be created in a silo, particularly a hazard mitigation plan because of its applicability to land use, city services, and vulnerable people. This HMCAP update incorporates relevant data and information from existing plans, studies, reports and technical information. Main data sources and local plans include:

- Otis Master Plan, 2016.
- Otis Open Space and Recreation Plan, 2016.
- Berkshire County Hazard Mitigation Plan, 2012.
- Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP), 2013, 2018.
- Becket Hazard Mitigation Plan DATE
- Monterey Hazard Mitigation and Climate Adaptation Plan, 2021
- New Marlborough Hazard Mitigation and Climate Adaptation Plan, 2021
- Southern Berkshire Regional Shelter Plan, Concept of Operations, 2016

This plan should be used in conjunction with other local and regional plans.

Plan Structure

The next chapter of this plan will analyze and assess risk, profiling each hazard with potential to affect the Town of Otis. After a general profile of the Town's assets and vulnerabilities, each hazard analyzed includes a hazard profile and vulnerability assessment. Hazard profiles consist of likely severity, probability, geographic areas likely impacted, and historic data. The vulnerability Assessment includes hazard effects on people including vulnerable groups, the built environment including infrastructure, the natural environment, the economy, and future conditions to the extent reasonably foreseen in consideration of climate change.

Hazard Mitigation Goals

In developing this plan, the Town of Otis established the following goals for this HMCAP:

1. Identify hazard risks throughout the Town
2. Develop and implement sustainable, cost effective and environmentally sound risk-reduction (mitigation) projects.
3. Protect the lives, health, safety and property of the citizens of Otis.
4. Protect public services and critical facilities, including infrastructure, from loss of use during natural hazard events and potential damage from such events.
5. Involve stakeholders to enhance the local capacity to mitigate, prepare for and respond to the impacts of natural hazards.
6. Develop, promote and integrate mitigation action plans.
7. Promote public understanding of and support for hazard mitigation.

CHAPTER 3: RISK ASSESSMENT

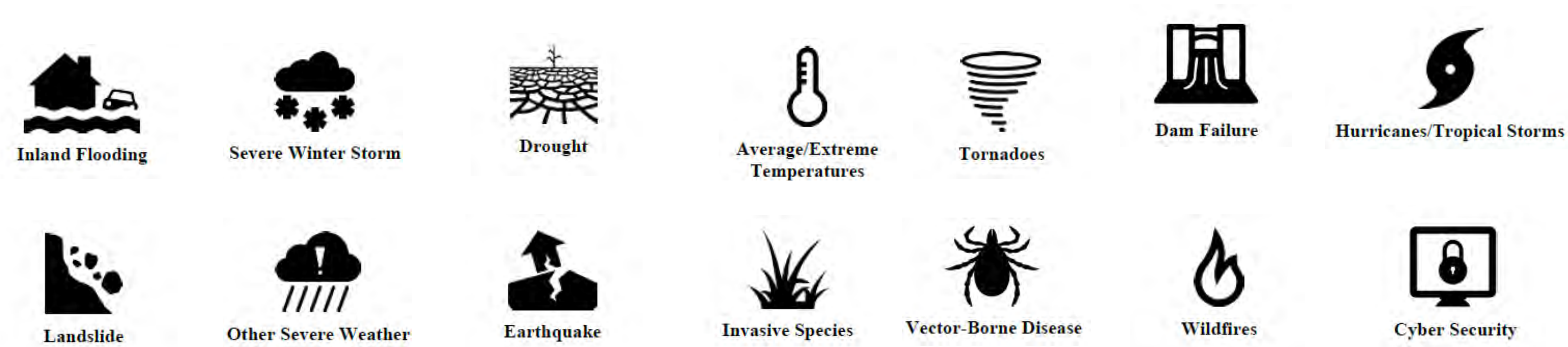
44 CFR § 201.6(c)(2)

FEMA Requirements

In accordance with 44 CFR § 201.6 (c)(2), this risk assessment provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. The risk assessment is an analysis of the hazards and risks facing the Town of Otis and contains detailed hazard profiles and loss estimates to serve as the scientific and technical basis for mitigation actions. This chapter also describes the decision-making and prioritization processes to demonstrate that the information analyzed in the risk assessment enabled the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. This section also provides information on previous occurrences of hazard events and on the probability of future hazard events with consideration of climate change (44 CFR § 201.6(c)(2)(i).

Hazard Identification and Risk Assessment Processes

In order to identify potential hazards that can affect the Town of Otis several resources were utilized. The information outlined in the 2012 *Berkshire County Hazard Mitigation Plan* served as a foundation on which to build. The hazards identified in the 2012 plan were Flooding, Dam Failure, Wildfire, Snow, High Wind, and Other Natural hazards (i.e. severe storms and tornadoes). In order to build upon this list, the 2018 *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (SHMCAP) for the Commonwealth of Massachusetts was consulted and Otis completed the MVP planning process. Accounting for the location, natural and built environments, history, and scientific studies of the area, it was determined that the Town of Otis must plan for the following hazards:



This plan also includes a section on Invasive Species and a section Cyber Security hazards because this is a growing threat that could disable critical facilities and the essential services they provide to the community.

People

Otis is a small town in the Berkshires with a relatively low year-round population of 1,393 people. According to the 2019 ACS, the year-round population is made up of approximately 690 households, with an average of two people per household. Generally, elementary school students attend Farmington River Elementary School, located in Otis, but middle and high school students attend either the Lee or Berkshire Hills school districts, which are located outside of Otis. The median age of residents is 54.5 years of age, 20% higher than the median age of Berkshire County as a whole and 1.4 times that of the state[1]. The aging population could have effects on town services, particularly first response demands, as well as its housing and recreation needs in the coming years.

According to the 2019 ACS 5-year estimate, approximately 7% of Otis residents are below the poverty level. In general, these populations, together with seniors and individuals with disabilities, are more vulnerable to the impacts of natural hazard events and climate change. In rural Otis, these populations are scattered throughout the 38 square miles of Otis, and their status and location are not always known to municipal staff.

Second homeowners are a major portion of Otis' seasonal population. Of the Town's approximately 1,700 housing units, 40% are occupied (typically indicating year-round residents) while 60% are vacant (ACS, 2019). Nearly 96% of the current housing stock is comprised of single-family residences. The vast majority of the vacant housing units represent seasonal housing, with most second homers originating in the NYC Metro area, and others from the Boston and Springfield metro areas. Other seasonal populations include visitors in the Town's overnight camps and campgrounds. Otis estimates that there are approximately 1,000 second homes. Since the onset of the COVID-19 pandemic in the spring of 2020, there has been a significant influx of seasonal homeowners moving more full time into their houses or cottages in Otis. During the pandemic many people across the nation have learned that they can conduct most or all of their work from home, making rural areas attractive in such uncertain times. Some seasonal residents have become semi-permanent residents until the pandemic subsides, while others may become full-time residents, making Otis their permanent or primary home. A significant increase in the number of permanent residents, including families with school-age children, will have far-reaching impacts on higher usage and demands for Town services and infrastructure. Incoming permanent residents, particularly young adults, also offer a new pool of residents that could be tapped for volunteer positions in emergency response or town government.

[1] *2019 ACS 5-year est., with at least 10% margin of error for the total value. Source: https://censusreporter.org/profiles/06000US2500351580-otis-town-berkshire-county-ma/.*

Natural Environment

The predominant land uses in Otis are forest (75%), wetlands (12%), water (6%) and open lands (4%), the last of which includes developed open space (such as camps), grasslands, farm fields. Residential, commercial, industrial lands combined cover one percent of the Town (GIS, 2016). See Fig. 3.1 for reference. Within the Town are a wealth of natural resources, including cold water fisheries, eight state-listed “Great Ponds” and more than 2,700 acres of wetlands. Wetlands serve as habitat for a wide variety of plant and animal species and often function as critical nursery and breeding areas. Wetlands are the most productive ecosystems on the planet, measured by the amount of biomass or living biological tissue they help to produce. Other valuable ecosystem services provided by wetlands include water purification, flood storage and control, and shoreline stabilization. Almost 1/3 of the Town’s wetland areas are coniferous forest wetlands, made up mostly of hemlock or red spruce. According to the Massachusetts Division of Fisheries & Wildlife (DFW) BioMap2 biodiversity project, over 5,000 acres of Otis have been designated as “Core Habitat” (~20% of total acreage) (Otis & BRPC, 2016b). Core Habitat is hosts unique plant communities and rare plant and animal species. The large blocks of unfragmented or minimally fragmented forest provide habitat for wildlife needing large territories to complete their life cycle and provides travel corridors for those who need to migrate.

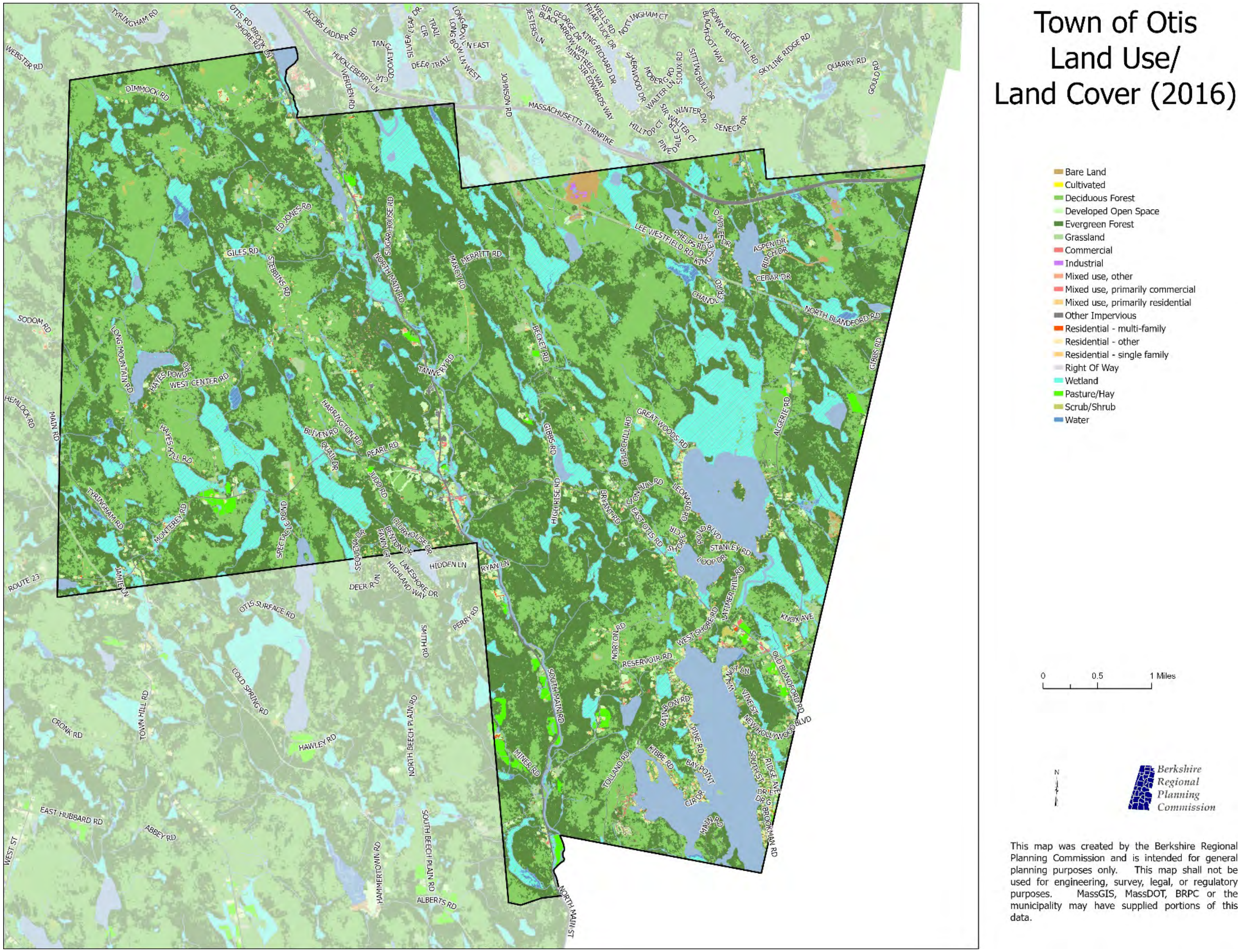
Otis is a hilltown which sits at headwaters of three watersheds: the Farmington River Watershed, the Housatonic River Watershed and the Westfield River Watershed. The vast majority of Otis is located in the West Branch Farmington River Watershed. The west branch of the Farmington River originates at Hayden Pond, and runs south-eastward through Otis Center and into Connecticut, where water eventually flows into the Connecticut River and Long Island Sound. The western portion of the Town drains into Hop Brook, and ultimately into the Housatonic River Watershed, while the northeast corner of Town drains into the Westfield River Watershed.

Built Environment

Historically, the higher density developments have been centered in the village centers and around the Town’s water resources (Big Pond, Otis Reservoir, etc.). Between 1971 and 1999, residential acreage almost doubled (Otis & BRPC, 2016a). It was during these years that large subdivision communities were developed. In the 1970s the Otis Woodlands community was developed, consisting of approximately 250 homes, half of which are in Otis and half of which are in Sandisfield. Most lots here are approximately one acre in size, although larger ones are available. In the 1990s the Harrington Woods and Louden Bethlehem subdivisions were developed. These latter developments reflect the trend to place large homes on large lots. Most recently a new subdivision development consisting of approximately 45 units is being proposed. Setting aside of 20 acres for open space has been proposed.

New development in the village centers has been minimal. In recent years, new development is more scattered, being almost exclusively focused on residential parcels with relatively large lot sizes. There has also been an increase in renovations, additions and alterations to existing structures, part of which involves weatherizing and creating year-round homes out of summer cabins.

Figure 3.1: Town of Otis Land Use



Critical facilities are the buildings and infrastructure hubs that are necessary for continued municipal operations during a hazardous event or those that house vulnerable populations. In Otis municipal operations include municipal facilities, and vulnerable populations are located at the three overnight children's camps. The Otis Town Hall is the Town's local shelter, with an estimated capacity for 50 people; it has a backup generator, kitchen and shower facilities. This building has been used for sheltering during the 2008 Ice Storm. A larger, regional shelter has been established for the Southern Berkshire Region in the town of Great Barrington, approximately 20 miles from Town Hall.

In addition to the children's camps, there are six campgrounds in which transient populations are congregated in close proximity. These sites may be filled to capacity during the summer months, but are sparsely populated or closed during off-season months. Table 3.1 lists Otis' Critical Facilities and Figure 3.2 provides a map of the critical facilities and areas of concern.

Table 3.1: Otis Critical Facilities

Type	Name	Address
Fire	Otis Fire Station	15 South Main Road
	East Otis Fire Station # 2	10 Pine Road
Police	Police Department	1 North Main Road
Health Services	Otis Ambulance	15 South Main Road
	Otis Fire Station	15 South Main Road
Town Offices	Town Hall	1 North Main Road
Emergency Operations Center	Otis Fire Station	15 South Main Road
Alternate Emergency Operations Center	Otis Town Hall & Community Center	1 North Main Road
Public Works	Wastewater Treatment Plant	353 North Main Road
	Highway Department	417 North Main Road
	Maintenance Department / Compactor	536 West Center Road
State Highway Garage	MassDOT Garage	298 North Main Road
Otis Wind Turbine	Otis Wind Turbine	1908 Algerie Road
Schools	Farmington River Regional School	555 North Main Road
Shelter	Town Hall Community Center	1 North Main Road
Vulnerable Populations	Farmington River Regional School (high children population)	555 North Main Road
	Camp Bonnie Brae (overnight camp; high children population)	951 Algerie Road
	Berkshire Soccer Academy (overnight camp; high children pop.)	620 Reservoir Road
	Camp Lenox (overnight camp; high children population)	2042 North Main Road
Dense Transient Populations	Mountain View Campground (campground)	1856-1954 South Main Road
	Camp Overflow (campground)	700 Tolland Road

	Klondike (campground)	759 North Main Road
	Laurel Ridge in neighboring Blandford (campground)	40 Otis Tolland Road
	Tolland State Forest (campground)	410 Tolland Road

There are approximately 110 miles of roads in Otis. The Town is served by two major state roadways: Route 8 (North Main and South Main Roads) which runs north-south and Route 23 (Monterey Road and East Otis Road) which runs east-west. The historic Otis Center Village is located at the junction of these two roads. A portion of Interstate 90 runs through the northeast corner of town, but there are no exits in Otis through which to access this road. These roadways are maintained by the Massachusetts Department of Transportation (MassDOT).

Table 3.2. Road Maintenance Responsibility by Entity

Maintenance Responsibility	Road Miles	Percent of Total Miles
Commonwealth of Mass.	23.52	21.4%
Town of Otis	43.91	39.9%
Private	42.50	38.5%
Total	109.93	99.8%

Source: BRPC, 2013. Town of Otis Road Condition Report, 2016.

The Otis Highway Department maintains approximately 44 miles of road in Town, which is approximately 40% of the total miles. These roadways include Tyringham Road, Becket Road, Lee Westfield Road, Reservoir Road, Tolland Road, and West Center Road, to name a few. Private contractors maintain the remainder of Otis's roadways, which total 42.5 miles (38.5% of total), many of which are also gravel roads. These roads are generally private ways serving seasonal homes clustered around the lakes/ponds and in subdivision developments. These private roads serve neighborhoods that are often much more densely developed than the scattered development seen along Town roads and connectors.

Many of the roads in Otis are gravel roads, which are particularly susceptible to extreme weather events and altered weather patterns caused by climate change. Many of the gravel roads were built to provide simple vehicle access to summer cottages located around the many ponds in Town or built within country subdivisions. Some of the older gravel roads are only one lane wide, making it difficult for large or emergency vehicles to safely pass. The Town does make an effort to widen these roads when it conducted repairs, but many are privately owned and maintained, and widening is not undertaken as consistently.

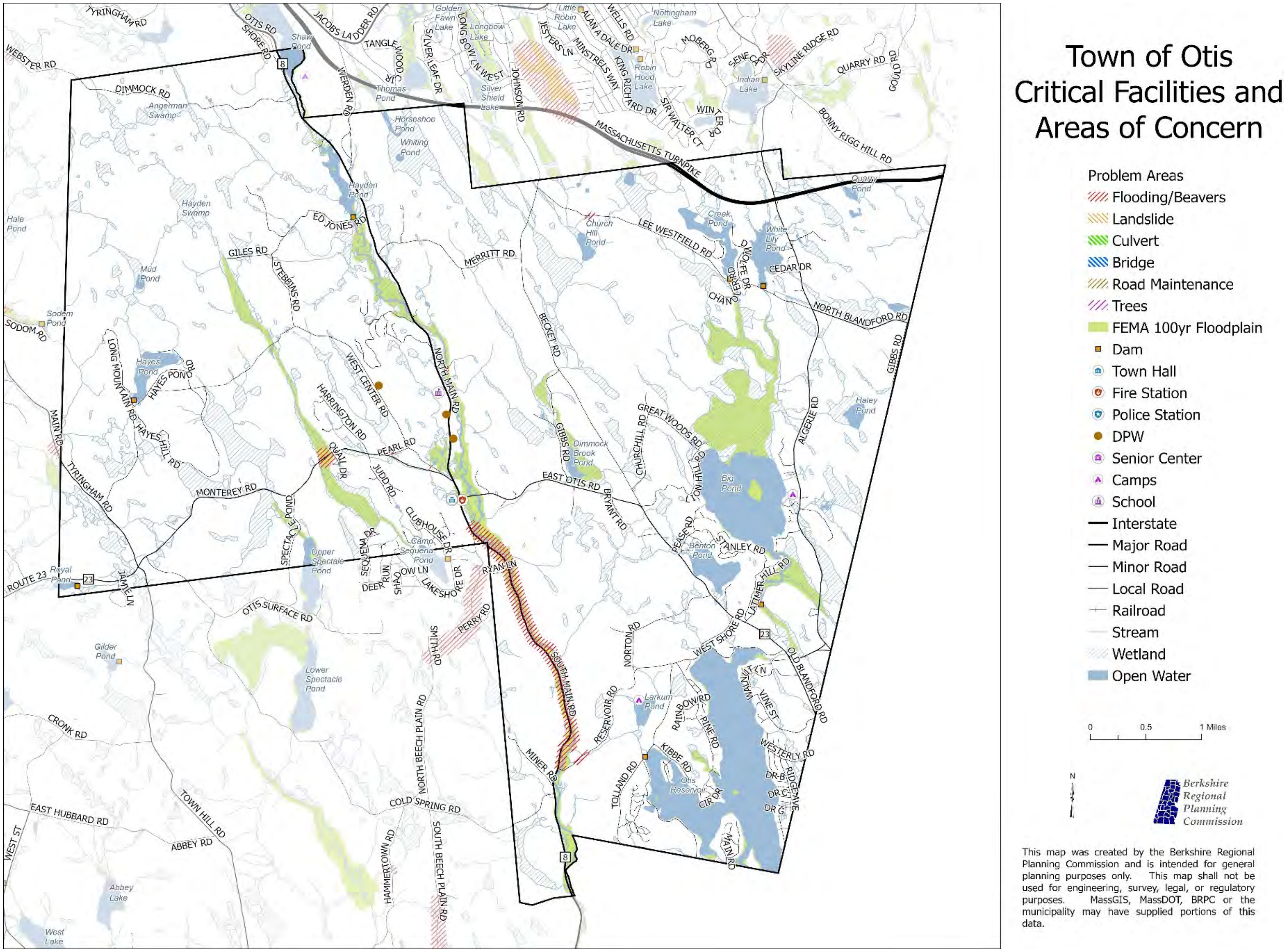
In general, gravel roads were built to accommodate low or moderate summer traffic and were not built with a base that can withstand high traffic numbers or heavy loads. However, as more homeowners turn summer cottages into year-round residences, the roads are now experiencing a greater number of vehicle trips all year long. This increased use can lead to road damage and failure. The Highway Department is already experiencing greater workload and costs related to road maintenance and repairs caused by extreme weather events and heavier traffic volumes. Large rainfall events routinely wash-out gravel roads, beaver dams are breaching and washing out roads and destroying culverts, and winters with numerous freeze/thaw events require multiple grading trips instead of one in springtime. Late winter/early spring 2021 was an exceptionally difficult mud season.

The Highway Department would like to address its gravel roads that are failing due to washouts and the increased number of annual freeze/thaw cycles. To mitigate these issues on a more permanent, long-term basis will require that the roads undergo full-depth reconstruction to establish a proper sub-base. This would be required to properly reconstruct the road whether it remained gravel or was converted to blacktop. In recent written testimony to the Massachusetts legislature, the Town Administrator of Ashfield, a rural town in Franklin County, estimated that it costs $300,000-4,000 per mile to rebuild a gravel road, and $1 million per mile to rebuild and pave a road.[2]

Otis has one small sewer system and wastewater treatment plant that serve the area around Otis Center Village. The plant treats wastewater from approximately 70 Otis homes as well as the fire department, town hall, elementary school and post office. There is no public drinking water system in Otis; all potable water is supplied by private wells. According to MassGIS, there are 43 public water supply wells in Otis, which serve town and public buildings, camps, restaurants, and places of business. There are also public shared well systems around Big Pond and Otis Reservoir.

[2] *Jin, Danny, 1-26-22. "Mud season has long caused driving headaches in Western Mass. A new proposal asks the state to look at the issue." Berkshire Eagle, Pittsfield, MA*

Figure 3.2: Town of Otis Critical Facilities and the Mapped Floodplain



Economy

More than 60% of employed residents commute to work outside of Otis, while the remaining 40% work within the Town. The Town's business base is largely comprised of small local businesses, including gravel/rock mining, small local stores and restaurants, overnight camps, campgrounds and a small ski area. These businesses are dispersed throughout the Town. The Farmington River Regional School is an important local employer.

Prioritization

Table 3.3 illustrates the first step in the process of prioritizing hazard mitigation actions in addition to the profiling of local impacts during the risk assessment. The method of prioritization meets requirements of 44 CFR § 201.6(c)(3)(iii). After reviewing the information from the 2012 regional hazard mitigation plan and new hazard data, discussing weather patterns and natural hazards that the Town was recently experiencing, and considering changing weather patterns expected due to climate change, the Planning Committee worked through and attempted to quantify potential effects of natural hazards on Otis, its citizens and the environment. Hazards other than flooding are difficult to prioritize without this or a similar ranking system.

Table 3.3: Hazard Prioritization for the Town of Otis

Hazard	Area of Impact Rate	Frequency of Occurrence Rate	Magnitude / Severity Rate	Hazard Ranking
	1=small 2=medium 3=large	0 = Very low frequency 1 = Low 2 = Medium 3 = High Frequency	1=limited 2=significant 3=critical 4=catastrophic	
Severe Winter Event (Ice Storm, Blizzard, Nor'easter)	3	3	2	8
Flooding (include Ice Jam, Beaver Activity)	2	3	2	7
Change in Average/Extreme Temperature	3	2	2	**7**
Drought	3	2	2	7
Hurricane & Tropical Storms	3	1	2	6
Severe Storms (High Wind, Thunderstorms)	2	2	2	6
Dam Failure	3	0	3	6
Invasive Species and Forest Pests	3	2	1	6
Vector-borne Diseases	3	2	1	6
Tornado	1	1	2	4
Wildfire	2	1	1	4
Cyber Security and Operations	2	0	2	4
Landslide	1	0	1	2
Earthquake	1	0	1	2

	Area of Impact
1=small	isolated to a specific area of town during one event
2=medium	occurring in multiple areas across town during one event
3=large	affecting a significant portion of town during one event
	Frequency of Occurrence
0=Very low frequency	events that have not occurred in recorded history of the town, or that occur less than once in 1,000 years (< 0.1% per year)
1=Low frequency	events that occur from once in 100 years to once in 1,000 years (0.1% to 1% per year)
2=Medium frequency	events that occur from once in 10 years to once in 100 years (1% to 10% per year)
3=High frequency	events that occur more frequently than once in 10 years (greater than 10% per year)
	Magnitude/Severity
1=limited	injuries and/or illnesses are treatable with first aid; minor "quality or life" loss; shutdown of critical facilities and services for 24 hours or less; property severely damaged < 10%
2=significant	injuries and/or illnesses do not result in permanent disability; shutdown of several critical facilities and services for more than one week; property severely damaged < 25% and > 10%
3=critical	injuries and/or illnesses result in permanent disability; complete shutdown of critical facilities for at least 2 weeks; property severely damaged 25--50%
4=catastrophic	multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged >50%

Hazard Profiles

Severe Winter Storms

Hazard Profile

Snow and other winter precipitation occur very frequently across the entire Commonwealth. According to the 2018 SHMCAP, the average annual snowfall for the snowiest municipality in each of four regions are:

- Chatham (Cape Cod and Islands): 28.9 inches
- Milton (Eastern MA): 62.7 inches
- East Brimfield (Central MA): 59.0 inches
- Worthington (Western MA): 79.7 inches

Worthington is a hilltown north of Otis with slightly higher elevations, and so Otis' annual snowfall would be slightly lower. Severe winter storms in Otis typically include heavy snow, blizzards, Nor'easters, and ice storms. A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below a quarter mile. These conditions must be the predominant condition over a three-hour period. Extremely cold temperatures are often associated with blizzard conditions but are not a formal part of this 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 (MEMA, 2013).

A Nor'easter is typically a large counterclockwise wind circulation around a low-pressure center often resulting in heavy snow, high winds, and rain. Strong areas of low pressure often form off the southern east coast of the U.S, moving northward with heavy moisture and colliding with cooler winter inland temperatures. Sustained wind speeds of 20-40 mph are common during a nor'easter, with short-term wind speeds gusting up to 50-60 mph or even to hurricane force winds (MEMA, 2013).

Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects creating ice build-ups of ¼ inch or more that can cause severe damage. An ice storm warning, now included in the criteria for a winter storm warning, is for severe icing. This is issued when ½ - inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the pulling down of power lines and trees (MEMA, 2013).

Likely Severity

Periodically, a storm will occur which is a true disaster, and necessitates intense, large-scale emergency response. The main impacts of severe winter storms in the Berkshires is deep snow depths, high winds and reduced visibility, potentially resulting in the closing of schools, businesses, some governmental operations and public gatherings. Loss of electric power and possible closure of roads can occur during the more severe storms events.

The magnitude or severity of a severe winter storm depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day (e.g., weekday versus weekend), and time of season. (MEMA, 2013)

NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale from one to five. RSI is based on the spatial extent of the storm, the amount of snowfall, and the combination of the extent and snowfall totals with population. Data beginning in 1900 is used to give a historic perspective (MEMA 2013, NOAA 2018).

Table 3.4 Regional Snowfall Index Ranking Categories

Category	Description	RSI-Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18+

Source: MEMA 2013.

Of the 12 recent winter storm disaster declarations that included Berkshire County, only two events were ranked as Extreme (EM-3103 in 1993 and DR-1090 in 1996), one was ranked Crippling (IM-3175 in 2003) and two were ranked as Major (EM-3191 in 2003 and DR-4110 in 2013). It should be noted that because population is used as a criteria, the storms that rank higher will be those that impact densely populated areas and regions such as Boston and other large cities and, as such, might not necessarily reflect the storms that impact lightly populated areas like the Berkshires. For example, one of the most famous storms in the Commonwealth in modern history was the Northeastern Blizzard of '78, which dropped over two feet of snow in the Boston area during 65 mph winds that created enormous drifts and stranded hundreds of people on local highways. The storm hit the snow-weary city that was still digging out of a similar two-foot snowstorm 17 days earlier. On the Berkshires, things were not that severe, with 11-19 inches of snow falling in the county over the course of the 33-hour storm. Winds of up to 50 mph and dropped visibility to zero. Berkshire County was not listed in the disaster declaration.

The Northeast States Consortium has been tracking one- and three-day record snowfall totals. According to their data, 99% of the one-day record snowfall events in the region typically yield snow depths in the range of 12”-24”, while the majority of three-day record snowfall events yield snow depths of 24”-36” (Table 3.5).

Table 3.5. Record Snowfall Events and Snow Depts for Berkshire County

Record Snowfall Event	Snowfall 12”–24”	Snowfall 24”–36”
1-Day Record	99%	1%
3-Day Record	36%	64%

Source: Northeast States Consortium, 2017

One of the most serious storms to impact communities in the Berkshires was the Ice Storm of December 11, 2008. The storm created widespread downed trees and power outages all across New York State, Massachusetts and New Hampshire. Over one million customers were without electricity, with 800,000 without power three days later and some without power weeks later. Living conditions were acerbated by extremely cold temperatures in the days following the event. According to many officials and residents, this storm was one of the most severe to impact the Town in recent years. Roads all across Otis were impassible due to downed trees, limbs and power lines. Algerie Road was especially hard hit. With the help of the three-man Highway Department, several volunteers from the Fire Department and local hardy residents using chainsaws and heavy equipment, the Town was able to open most of the major roads within two days. Restoring electricity was a much longer endeavor, with some residents regaining power within four days, while other, more rural residents waiting more than two weeks.

While severe winter weather emergency declarations became more prominent starting in the 1990s, it is not believed that this reflects more severe weather conditions than the Berkshires experienced in the 40+ years prior to the 1990s. Respected elders across Berkshire County comment that snow depths prior to the 1990s were consistently deeper that what currently occurs in the 2010-20s.

Probability

The majority of blizzards and ice storms are viewed by people in the region as part of life in the Berkshires, an inconvenience and drain on municipal budgets. Residents and municipal staff expect to deal with several snow storms and a few Nor’easters each winter. During the years 1953-2017 the Commonwealth experienced 59 significant winter storm events, 35 of which were classified as “major” or greater (EOEEA & MEMA, 2018). The National Climatic Data Center (NCDC), a division of NOAA, reports statistics on severe winter storms from 1993 through 2017. During this 24-year span, Berkshire County experienced 151 severe winter storms, an average of six per winter. This number varies each winter, ranging from one during 2006 to 18 during 2008. The Town’s location in the Berkshire Highlands places it at a high-risk for winter storms. The severe storms that the County gets are added to the higher annual snowfall the County normally has due to its slightly higher elevation relative to its neighboring counties in the Pioneer and Hudson River Valleys. From 1998 to 2017, the NCDC reported 28 ice storm events across the Commonwealth. All the storms within that period occurred between November and February, most frequently occurring in late December and early January. Ice storms of lesser magnitudes impact the state on at least an annual basis (EOEEA & MEMA, 2018).

Using history as a guide for future severe winter storms, it can be assumed that Otis will be at risk for approximately six severe winter storms per winter. The highest risk of these storms occurs in January with significant risk also occurring in December through March. The region is getting less snowfall than previous years and can expect less snowfall in future years, however this does not mean the County will not experience years with high snowfall amounts (2010-11 had over 100 inches). The trend indicates that the yearly snowfall total will continue to go down. It should be noted that although total snow depths may be reduced in the future, warmer winter temperatures will likely increase the number and severity of storms with heavy, wet snow or ice, which can bring concerns for road travel, human injuries, and risk of roof failures.

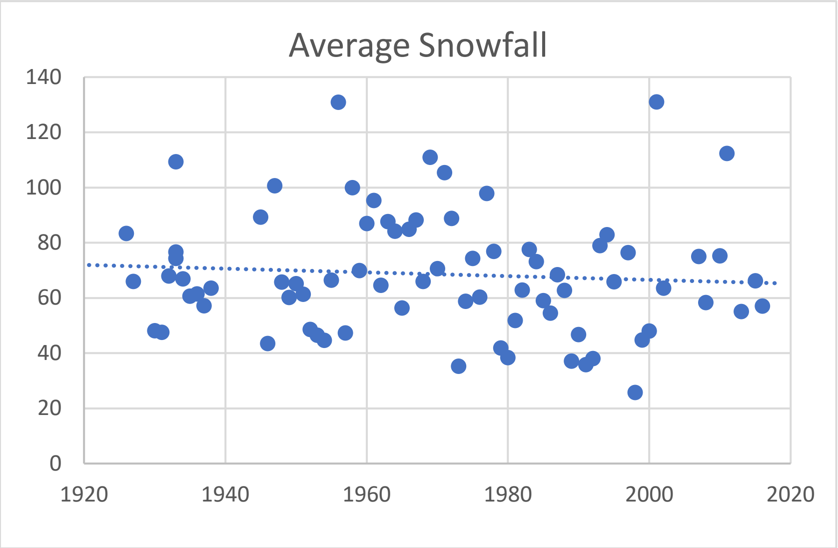
Geographic Areas Likely Impacted

Winter storms are the most common and most familiar of Massachusetts hazards which affect large geographical areas. Severe winter storm events generally occur across the entire area of Otis, although higher elevations may have slightly higher snow depths. In general, scattered power outages are restored within hours of occurring and the majority are restored within 24 hours. However, some of the least densely-populated areas along gravel roads are lower on the priority list for emergency service repairs, particularly Dimmock Road and West Center. One area of concern for the Town is the Town-owned wind turbine. Ice build-up and high winds that could damage the structure and its equipment force the turbine to shut down, thus resulting in the loss of electricity generation and revenue.

Historic Data

Although the entire community is at risk from severe winter storms, the higher terrains in the county tend to receive higher snowfall amounts, and these same areas may receive snow when the lower elevations received mixed snow/rain or just rain. Snow and other winter precipitation occur very frequently across the entire region. Snowfall in the region can vary between 26 and 131 inches a year, however it averages around 65 inches a year, down from around 75 inches a year in 1920. As can be seen in Figure 3.3, the average snowfall levels are trending downward.

Figure 3.3: Average Snowfall in Berkshire County



Source: NOAA, BRPC 2017.

In Berkshire County, there are several notable blizzards and Nor'easters that have buried the region in historic snow depths. According to a recent feature in the *Berkshire Eagle* newspaper that summarized historical news articles, there have been several notable winter storms. The Blizzard of 1888 began the evening of March 11 and lasted three days. Reported snow totals vary from 36 to 42 inches. What made the storm so memorable was the huge snowdrifts that came with it and the aftermath. A train traveling from Albany on the Boston and Albany Railroad was caught in the "Washington Cut," the name given to a granite outcropping on Washington Mountain three miles outside Hinsdale. There, 72 passengers remained for two days as efforts were made to free them from the snowdrifts that reached the top of the train cars. Passengers dined on raw eggs, which they took from a crate in the baggage car. A train lost 32 carloads of hogs, which froze to death during the night. Six carloads of sheep and another of cattle were saved, however. Fortunately, a spate of warm weather arrived days later, helping to melt the snow and clear roads.

In March 1916 a cold spell and a series of storms would cut travel between towns and keep supplies from reaching the hinterlands. Although a two-day storm March 8 and 9 only brought 20” of snow, the county would receive an additional 44” by the end of the month. With no break in the cold temperatures, snowdrifts reaching upward of 20’ became common, making roads impassable. On March 23, the *Berkshire Eagle* newspaper reported that the closure of the Lee-Otis line for the past two weeks had created a kerosene shortage in Otis. Residents had resorted to killing a "community steer" and its tallow was divided among the town's residents for candle-making. Farmers dug in deep, many taking up residence in their barns alongside their livestock, where they oversaw the arrival of lambs and calves. Trolley service came to a standstill for more than three weeks in some areas. The 22-foot drifts still remained when the Berkshire Street Railway Co. was finally able to break through April 12.

A storm in February 1934 dropped 2-3’ of snow across the county, creating 12’ snow drifts in Savoy and closing three major highways. Horses and a fire sleigh were brought back into service in North Adams and postal carriers donned snowshoes to deliver the mail. A storm that lasted 16 days in February-March of 1947 left more than 45” of snow across the county, with a one-day total of 16” falling on March 3. Additional notable storms through 2011, which were recorded in local news but not included as part of disaster declarations, occurred in 1969, 1987, 2001, 2002, 2007.[3]

A two-day Nor-easter in 1992 dropped almost three feet of snow in the Town of Otis. According to local accounts, some of the Town’s plow trucks and other equipment broke down or were otherwise damaged due to the heavy snow load and other factors. The National Guard was dispatched with heavy military equipment and graders to plow the Town roads.

Since 2000, two severe ice storm events have occurred in the region. The storms within that period occurred in December and January, but ice storms of lesser magnitudes may impact the region from October to April, and on at least an annual basis. Based on all sources researched, known winter weather events that have affected Massachusetts and were declared a FEMA disaster are identified in the following sections. Of the 18 federally declared winter storm-related disaster declarations in Massachusetts between 1954 to 2018, Berkshire County has been

[3] *Berkshire Eagle, 2-2-19. “Memorable blizzards, nor'easters from 1888 to the present in the Berkshires.”*

included in 12 of those disasters. None have been declared in for the county since 2013. The number of disaster declarations for severe winter events in which Berkshire County was included is more than double that of declarations for non-winter, non-flood-related severe storm events.

Table 3.6: Severe Winter Weather – Declared Disasters that included Berkshire County 1992-2017

Incident Period	Description	Declaration Number
12/11/92-12/13/92	Nor'easter with snow 4'+ in higher elevations of Berkshires, with 48" reported in Peru and Becket; snow drifts of 12'+; 135,000 without power across the state; Otis has an unofficial total of 33 inches*; National Guard responded to clear roads in Otis**	DR-975
03/13/93-03/17/93	High winds & heavy snow; generally 20-30" in Berkshires; blizzard conditions lasting 3-6 hrs; snowdrifts of 10' reported with up to 70 mph winds*	EM-3103
01/07/96-01/08/96	Blizzard of 30+" in Berkshires, with strong to gale-force northeast winds; MEMA reported claims of approx. $32 million from 350 communities for snow removal	DR-1090
03/05/01-03/06/01	Heavy snow across eastern Berkshires to Worcester County; several roof collapses reported; $21 million from FEMA	EM-3165
02/17/03-02/18/03	Winter storm with snow of 12-24", with higher totals in eastern Berkshires to northern Worcester County; $28+ million from FEMA	EM-3175
12/06/03-12/07/03	Winter Storm with 1'-2' across state, with 36" in Peabody; $35 million from FEMA	EM-3191
01/22/05-01/23/05	Blizzard with heavy snow, winds and coastal flooding; highest snow falls in eastern Mass.; $49 million from FEMA	EM-3201
04/15/07-04/16/07	Severe Storm and Flooding; wet snow, sleet and rain added to snowmelt to cause flooding; higher elevations received heavy snow and ice; $8 million from FEMA	DR-1701
12/11/08-12/12/08	Major ice storm across eastern Berkshires & Worcester hills; at least ½" of ice accreted on exposed surfaces, downing trees, branches and power lines; 300,000+ customers without power in state, some for up to 3 wks.; $49+ million from FEMA	DR-1813
01/11/11-01/12/11	Nor'easter with up to 2' within 24 hrs.; $25+ million received from FEMA; Savoy received 40.5" and N. Adams received 33"*	DR-1959
10/29/11-10/30/11	Severe storm and Nor'easter with 1'-2' common; at peak 665,000 residents state-wide without power; 2,000 people in shelters statewide; $70+ million from FEMA statewide; Peru received 32"*	DR-4051
02/08/13-02/09/13	Severe Winter Snowstorm and Flooding; $65+ million from FEMA statewide	DR-4110

Source: MEMA 2018.
**Additional source of information: Berkshire Eagle, 2-2-19. "Memorable blizzards, nor'easters from 1888 to the present in the Berkshires."*
***Source: local residents at MVP Workshop*

Vulnerability Assessment

People

In rural areas such as Otis, homes and farms may be isolated for days, and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches. 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.

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 creating blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chill. They 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 (MEMA & EOEEA, 2018).

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.

According to the 2019 ACS 5-year estimate, approximately 7% of Otis residents are below the poverty level. 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). These populations are spread out throughout Otis, and their status and location are not always known to municipal staff.

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 flood 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. The ability of emergency responders to respond to calls may be impaired by heavy snowfall, icy roads, and downed trees (MEMA & EOEEA, 2018).

Built Environment

Severe winter storms can damage the built environment by collapsing roofs under the weight of snow, making roads impassable due to snow or ice, damaging roads by freezing or unintended damage due to snowplows, freezing and bursting pipes, downing trees and power lines, and the flooding damages that result from melting snow. Higher elevations tend to freeze and have heavier snow depths than the lower elevations. Downed trees and power lines closed roads and caused town-wide power outages throughout Otis during the Ice Storm of 2008.

Fig. 3.4. Trees and power lines were damaged throughout Otis during the 2008 Ice Storm.

Photo courtesy Hal Kobrin, 2008.

Natural environment

Winter storms are a natural part of the Massachusetts climate, and native ecosystems and species are well adapted to these events. However, 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, the latter of which can alter 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. 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, coastal flooding, and inland flooding. These impacts can include direct damage to species and ecosystems, habitat destruction, and the distribution of contaminants and hazardous materials throughout the environment (MEMA & EOEEA, 2018).

Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain municipal and state financial resources due to the cost of staff overtime, snow removal and wear on equipment. Rescheduling of schools and other municipal programs and meetings can also be costly. The potential secondary impacts from winter storms also impact the local economy including loss of utilities, interruption of transportation corridors, and loss of business operations and functions, as well as loss of wages for employees.

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. These damages can stress trees and reduce the quality of the trees in forests that are being managed for timber. 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 (MEMA & EOEEA, 2018).

Future Conditions

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. Although no one storm can be linked directly to climate change, the severity of rain and snow events has increased dramatically in recent years. The amount of precipitation released by storms in the Northeast has increased by 55 percent from the baseline level (recorded from 1901 to 1960) and present-day levels (measured from 2001 to 2012) (USGCRP, 2014 as cited in MEMA & EOEEA, 2018). Winter precipitation is predicted to more often be in the form of heavy wet snow, ice or rain rather than the fluffier snow that had been more typical for the region. The transition to wetter snow, rain and ice formation has implications for how roads and other infrastructure will be maintained. It also increases the risk of having to shut down the Town’s wind turbine.

Inland Flooding

Hazard Profile

Inland 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 inland flooding (U.S. Climate Resilience Toolkit, 2017). Common types of local or regional flooding are categorized as inland flooding including riverine, ground failures, ice jams, dam overtopping, beaver activity (tree removal, dam construction, and dam failure), and development runoff. 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." (FEMA, 2011b as cited in MEMA & EOEEA, 2018[4]). The hazards that produce these flooding events in the region include hurricanes, tropical storms, heavy rain events, winter rain-on-snow, thunderstorms, and recovering beaver populations. This Inland Flooding section will focus on flood impacts due to severe precipitation events that result in impacts approaching the 100-year event or caused significant damages. Flooding due to Dams, Hurricanes/tropical storms, Winter-related flooding and Thunderstorms are discussed in other sections of this plan

Fig. 3.5. Beaver dam and impoundment on Cone Brook

Photo courtesy Hal Kobrin, 2021.

Likely severity

In general, the severity level of flood damage is affected by flood depth and flood velocity. The deeper and faster flood flows become, the more power they have to carry heavy debris, erode banks and cause damage. 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. (MEMA, 2013) However, flood damage to homes and buildings can occur even during shallow, low velocity flows that inundate the structure, its mechanical system and furnishings.

[4] *Massachusetts Emergency Management Agency & the Executive Office of Energy and Environmental Affairs developed the MA State Hazard Mitigation and Climate Adaptation Plan, 2018* https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. The 100-year flood elevation or discharge of a stream or river has a 1% chance of occurring or being exceeded in any given year. In this case the statistical recurrence interval would be 100 years between the storm events that meet the 100-year discharge/flow. Such a storm, with a 1% chance of occurrence, is commonly called the 100-year storm. Similarly, the 50-year storm has a statistical recurrence interval of 50 years and an “annual flood” is the greatest flood event expected to occur in a typical year. It should be understood, however, that these measurements reflect statistical averages only; it is possible for two or more floods with a 100-year flood discharge to occur in a short time period.

Probability

The extent of the area of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood), most commonly termed the 100-year floodplain area, is a tool for assessing vulnerability and risk in flood-prone communities. The 100-year flood boundary is used as the regulatory boundary by many agencies, including FEMA and MEMA. It is also the boundary used for most municipalities when regulating development within flood-prone areas. The FEMA Flood Insurance Rate Maps (FIRM) developed in the early 1980s for Berkshire County, typically serve as the regulatory boundaries for the National Flood Insurance Program (NFIP) and municipal floodplain zoning. A structure located within a the 100-year floodplain on the NFIP maps has on average a 26% percent chance of suffering flood damage during the term of a 30-year mortgage (MEMA, 2013). Increases in precipitation and extreme storm events will result in increased inland flooding.

Table 3.7: Recurrence Intervals and Probabilities of Occurrences

Recurrence interval, in years	Probability of occurrence in any given year	Percent chance occurrence in any given year
500	1 in 500	0.2
100	1 in 100	1
50	1 in 50	2
25	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

According to the data and local residents, flooding periodically occurs at specific areas in Otis during times of extreme precipitation or springmelt. Due to steep slopes and minimal soil cover, hilltowns such as Otis are particularly susceptible to flash flooding caused by rapid runoff that occurs during heavy precipitation or in combination with spring snowmelt. These conditions contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding. Berkshire County has frozen ground conditions for more of the year than most of Massachusetts.

Historic Data

There have been dozens of severe precipitation events that caused flooding in the Berkshire County region, the more severe of which are listed with a brief description in Table 3.8. Between 1938 and 2017, four flood events equaling or exceeding the 1% annual chance flood have been documented the Berkshire County region, those being in 1938, 1949, 1955 and 2011. These four events are bolded in Table 3.8. Not all these events were documented to a 1% chance storm for the region around Otis. The most recent flood event, Tropical Storm (T.S.) Irene in 2011 was determined to be a 1% chance flood event in northern Berkshire County and a 2% chance storm (50-year recurrence) in Pittsfield according to the USGS Housatonic River stream gauge. The most notable flood event that occurred in Otis was during (T.S.) Irene, when the Farmington River overflowed ist banks and flooded the South Main Road corridor. Some areas were under 6-7 feet of water. The road was completely closed to travel for a few days and many residents were driven from their homes, some rescued by boat by volunteer firefighters.

Table 3.8. Previous Flooding Occurrences in the Berkshire County Region

Year	Description of Event
1936	Widespread flooding occurs along the northern Atlantic in March 1936. Widespread loss of life and infrastructure.
1938	"The Great Hurricane of 1938" was considered a 1% annual chance flood event in several. The Hoosic River flooded downtown areas of North Adams, with loss of life and extensive damage to buildings.
Dec. 31, 1948 - Jan. 1, 1949	The New Year's Flood hit North Adams severely wiping out buildings along the Hoosic River and with many of areas registering the flood as a 1% annual chance flood event.
1955	Hurricanes Connie and Diane combined to flood many of the communities in the region and registering in 1% - 0.2% annual chance flood event (100-500-year flood event) (FEMA 1977-1991).
May 1984	A multi-day storm left up to 9" of rain throughout the region and 20" of rain in localized areas. This was reported as an 80-year flood for most of the area and higher where the rainfall was greater (USGS, 1989).
Sept. 1999	The remnants from Hurricane Floyd brought between 2.5-5" of rain and produced significant flooding throughout the region. Due to significant amounts of rain and the accompanying wind, there were numerous reports of trees down.
Dec. 2000	A complex storm system brought 2-4" of rain with some areas receiving an inch an hour. The region had numerous reports of flooding
Mar. 2003	An area of low pressure brought 1-2" of rain, however this and the unseasonable temperatures caused a rapid melting of the snowpack.
Aug.t 2003	Isolated thunderstorms developed that were slow moving and prolific rainmakers. Flooding led to the evacuation of Berkshire residents.
Sept. 2004	The remnants from Hurricane Ivan brought 3-6" of rain. This, combined with previously saturated soils, caused flooding throughout the region.
Oc. 2005	A stationary cold front brought over 6" of rain and caused widespread flooding throughout the region.
Nov. 2005	Widespread rainfall across the region of 1-1.5", which was preceded by 1-2 feet of snow, resulted in widespread minor flooding.
Sept. 2007	Moderate to heavy rainfall occurred, which lead to localized flooding.

Mar. 2008	Heavy rainfall ranging from 1-3" impact the area. Combined with frozen ground and snowmelt, this led to flooding across the region.
Aug. 2008	A storm brought very heavy rainfall and resulted in flash flooding across parts of the region.
Dec. 2008	A storm brought 1-4" of rain to the region, with some areas reporting ¼ to 1/3 of an inch an hour of freezing rain., before changing to snow. Moderate flooding and ponding occurred throughout the region.
June 2009	Numerous slow-moving thunderstorms developed across the region with intense rainfalls and up to 6" of hail. This led to flash flooding in the region.
July 2009	Thunderstorms across the region caused heavy rainfall and flash flooding.
Aug. 2009	An upper-level disturbance moved across the region during the afternoon hours and triggered isolated thunderstorms causing road flooding.
Oct. 2009	A low-pressure system moved across region bringing a widespread heavy rainfall to the area; 2-3" of rain was reported across the region.
Mar. 2010	Heavy rainfall of 1.5-3" across the region closed roads due to flooding.
Oct. 2010	The remnants from Tropical Storm Nicole brought 50-60 mph winds and 4-6" of rain resulting in urban flooding.
Mar. 2011	Heavy rainfall combined with runoff from snowmelt due to mild temperatures resulted in flooding of waterways, roads, and basements.
July 2011	Scattered strong to severe thunderstorms spread across the region resulting in small stream and urban flooding.
Aug. 2011	Two distinct rounds of thunderstorms occurred producing heavy rainfall and localized flooding of roads.
Aug. 2011	Tropical Storm Irene tracked over the region with widespread flooding and damaging winds. Riverine and flash flooding resulted from 3-9 inches of rain within a 12-hour period. Widespread road closures occurred throughout the region. This event was a 1% annual chance flood event.
Sept. 2011	Remnants of Tropical Storm Lee brought 4-9" of heavy rainfall to the region. Due to the saturated soils from Tropical Storm Irene, this rainfall lead to widespread flooding on rivers as well as small streams and creeks.
Aug. 2012	Remnants from Hurricane Sandy brought thunderstorms repeatedly bringing heavy rains over the region. Upwards of 4-5" of rain occurred and flash flooding caused the closure of numerous roads.
May 2013	Thunderstorms brought wind and heavy rainfall caused flash flooding and road closures in areas.
Aug. 2013	Heavy rainfall repeatedly moved across the region with more than 3 inches of rain in just a few hours. Streams and creeks overflowed causing flash flooding. Roads were closed and water rushed into some basements.
Sept. 2013	Showers and thunderstorms tracked over region and resulted in persistent heavy rain, flash flooding and road closures.

June 2014	Slow moving showers and thunderstorms developed producing very heavy rain over a short period of time. This led to some flash flooding and road closers, especially in urban and poor drainage areas.
June 2014	Showers and thunderstorms repeatedly passed over the same locations with heavy rainfall and significant runoff, causing flash flooding in some areas. Many roads were closed and some homes were affected.
July 2014	A cluster of strong to severe thunderstorms broke out causing heavy rainfall and flash flooding with 3-6” of rainfall occurring.
May 2016	Bands of slow-moving showers and thunderstorms broke out over the region. Heavy rainfall repeatedly fell over the area resulting in flash flooding and some roads were temporarily closed.
Aug. 2017	Widespread rain moved through the area resulting in isolated flash flooding.

Table Source: BRPC 2018 (unless otherwise noted)

Vulnerability Assessment

Geographic areas likely impacted

Otis has relatively few acres of land identified as the 100-year floodplain. Of a total of 24,353 acres within the Town, only 2,183 acres (nine percent) of land is within the floodplain. The largest expanse of floodplains are associated with a vast wetland complex north and upstream of Big Pond, along with a smaller wetland/floodplain area downsteam of the Pond. Floodplains surround and follow the West Branch Farmington River along the full length of its corridor through the middle of Otis. Main Road / Route 8, the major north-south travel corridor through the Town, follows the river, crossing it several times as it flows southward. Another area of 100-year flood plain encompasses the length of Benton Brook, beginning near Giles Road, flowing under Monterey Road (Rt. 23), Lakeshore Drive and extending south to the town boundary with Sandisfield. Otis has two large lakes and several small ponds which are surrounded by residential development. The largest are Big Pond and Otis Reservoir, the first of which flows into the second. The ability to pro-actively draw down Big Pond before a severe flood event is less than that of Otis Reservoir, due to the design of the Big Pond dam. These ponds have floodplain of variable widths along their shorelines. Other smaller ponds include Benton Pond, White Lily Pond and Hayes Pond. Floodplain areas are shown in the maps in light green in Figures 3.9 and 3.11.

There are several areas throughout Otis that are of concern for flooding, the main areas being listed here:

- South Main Road (Rt. 8): The Farmington River parallels the road in this section and often reaches bank full level, threatening the road during high flow events. Beaver activity is active along the length of the road. Luckily, to date, the river has seldom flooded the road and barred traffic. Recent damaging flooding occurred during T.S. Irene in 2011, when the road corridor was under several feet of water and residents had to be rescued by boat (see Fig. 3.6). This route is a major commuting, commercial and tourist north-south route through the Otis and the region, as well as a major emergency response route. Severe flooding could prohibit emergency response vehicles, as they will not be able to get to the southern part of town without a substantial detour.

Fig. 3.6. Flooding of South Main Rd. during T.S. Irene 2011

Source: Alan Qubeck, as published in Ann. Rept. Town of Otis Dec. 2011

- Monterey Road (Rt. 23): High water levels occur regularly in the Benton Brook area, and sometimes floods the roadway during heavy precipitation events or spring melt. To date floods have not been high enough to warrant closing of the road. Local calls to raise the road have been made in the past, but have not been pursued. MassDOT, the state entity that owns and maintains the road, has stated that the road crossing over Benton Brook is not undersized, and that the flooding is the result of beaver activity. Beaver controls have been installed at the site. Like Route 8, this road is a major travel way for the Town, especially linking the Big Pond and Otis Reservoir communities to Otis Center and beyond.
- Lakeshore Drive: This is the only in and out egress for the Otis Woodlands residential community. Floodwaters of Benton Brook, which flows through a bridge underneath the road, threaten safe transport during severe precipitation storms.
- Reservoir Road is in danger of damage or failure if water from Otis Reservoir is ever released in large quantities due to dam failure or heavy rain releases. The three six-foot culvert there are not able to handle large volumes of water. Flooding and damages occurred here when the dam owner was testing the dam gate and was not able to get it back in place as quickly as needed. The high volume of water caused a large tree to fall into the stream and blocked the culverts, damaging and undermining a section of the road. The Town is currently looking into installing a full-span bridge that would meet the state stream crossing standards, which, although costly, would provide better long-term protection.
- Tannery Road: This road is subject to flooding by the Farmington River. The existing crossing is undersized and is rated one of the worst in the state. The constriction causes impoundment of water which overtops the road. Fortunately, work to replace and improve this crossing is due to start in 2022.
- Merritt Road: This road floods several times a year, due to beaver action. There are a network of dams in the wetlands in area.

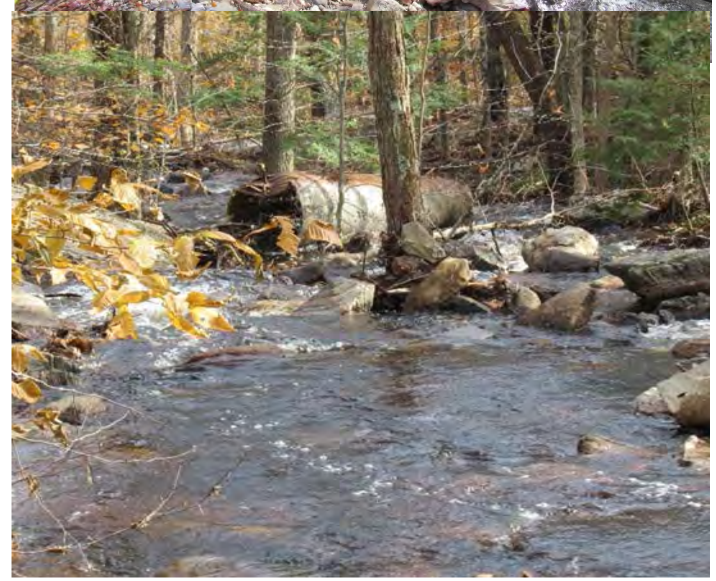
- Swamp Road: There is a low spot on this road where the water level comes close to flooding the road. This was most severe during T.S. Irene.

In addition to these sites, there are several areas where severe rain and flooding events overwhelm road drainage systems and wash out the gravel along roadway shoulders, causing undermining and sagging. This is particularly an issue in steeply sloped areas where runoff flows downhill at an accelerated rate and gathers at the bottom of the hill, overwhelming road drainage. This type of damage occurs in areas such as Pine, Reservoir and West Center Roads. Frequent repairs in these areas include adding new fill materials to replace what was washed away. Additionally, many of the drop inlets are deteriorating due to age. The Town has engaged a consultant to conduct a "street scan" evaluation to determine the best way to address this issue. Repeated erosion and washing away of road fill can impact water quality and stream morphology.

Flooding and wash outs of gravel road is a constant and ongoing issue in many areas of Otis. Severe rain events damage gravel roads, particularly those on steeply sloped terrain. Regrading, adding fill and repair/replacement of drainage systems is required to restore safe travel conditions.

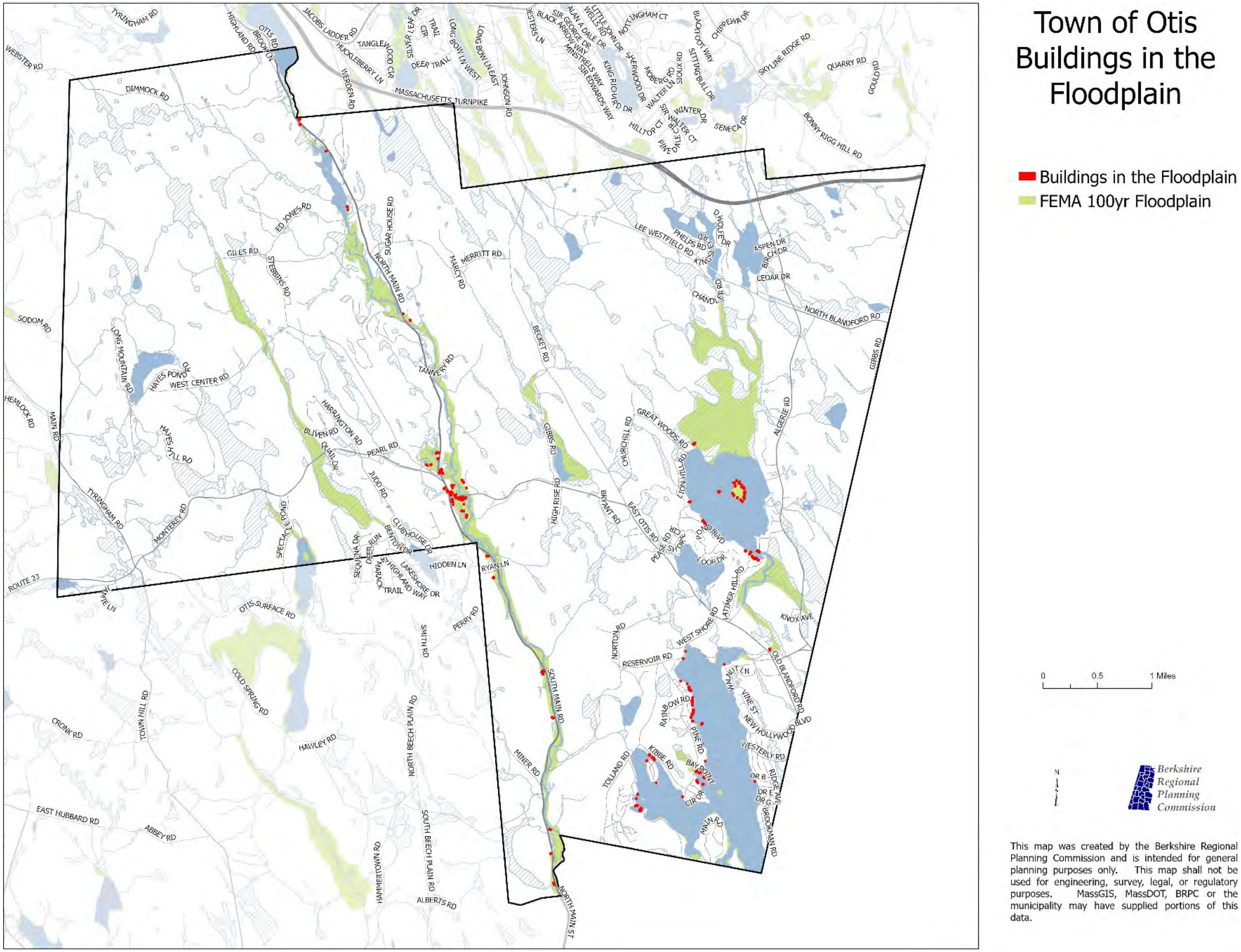
Beaver activity can also damage these roads. As an example, Stebbins Road was washed out due to the breaching of a large beaver dam that was approximately 20 feet wide and 10 feet deep. The water released from the impoundment blew out the road culvert, which had to be replaced. A similar washout occurred on Stebbins Road in 2019, where the sudden release of impounded water completely blew out the culvert and washed it downstream (Figs. 3.7, 3.8).

Figs. 3.7 & 3.8. Top: Stebbins Rd. damage at Cone Brook crossing due to beaver dam breach; Bottom: Stebbins Rd. culvert washed downstream



Photos courtesy Hal Kobrin, 2021.

Figure 3.9: Town of Otis Floodplain Development



People

The impact of flooding on life, health, and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time is provided to residents. Populations living in or near floodplain areas may be impacted during a flood event. Flooded streets and roadblocks can also make it difficult for emergency vehicles to respond to calls for service, particularly in rural areas such as Otis.

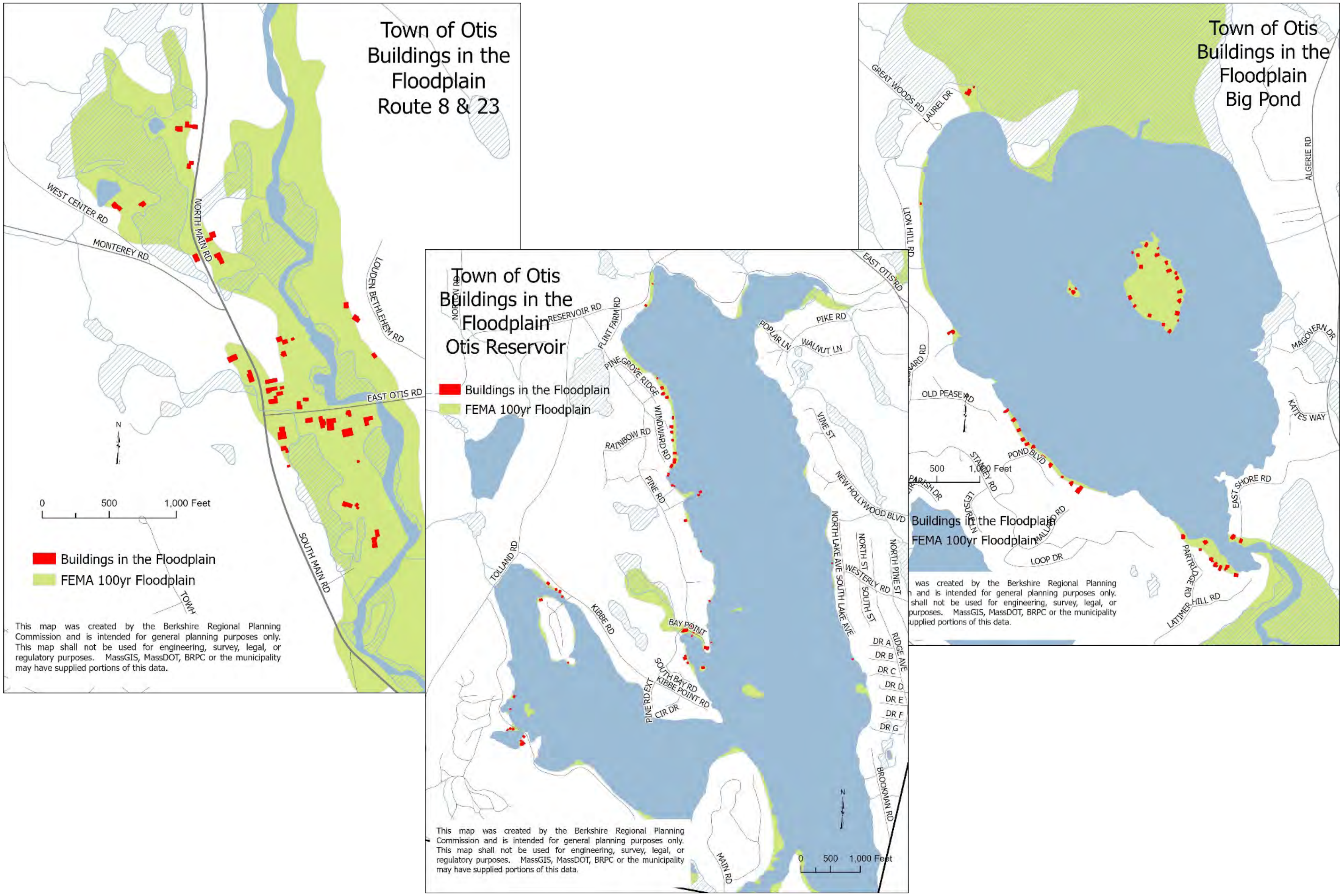
According to MassGIS and assessor parcel data, there are 119 residential buildings and four mixed-use buildings in the 100-year floodplain in Otis. According to 2019 data from the American Community Survey, there are an average of 2.2 people per household in the Town. Presuming that people occupy both the residential and mixed-use buildings, potentially 271 people could be impacted by flooding during a 100-year storm event (123 units * 2.2 people = 270.6 total people). This figure captures only those people whose homes are located within the floodplain. It does not capture people who might be stranded due to roads washing out, bridges being compromised or destroyed, or flooding of properties not in floodplain but impacted from debris blocking streams channels, bridges or culverts. For example, there are approximately 200 homes within the Otis Woodlands development, and the Lake Shore Drive bridge over Benton Brook is the only egress that serves these homes. Loss of this bridge, which is within the floodplain, would completely isolate this population. Ten or 12 families were rescued by the Fire Department and temporarily displaced when flooding during T.S. Irene caused the Farmington River to overflow its banks along South Main Road (Fig. 3.10).

The total number of injuries and casualties resulting from typical riverine flooding is generally limited due to advance weather forecasting, warnings and evacuations. The historical record from 1993 to 2017 indicates that there have been two fatalities in in Massachusetts associated with flooding, both in Topsfield during the Mother's Day Flood of 2006, and five injuries associated with two flood events in March 2010. 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, which are 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.

Fig. 3.10. Fire Dept. Volunteers respond to flooding along South Main Rd. during T.S. Irene 2011

Source: Alan Qubeck, as published in Ann. Rept. Town of Otis Dec. 2011

Fig. 3.11. Buildings within the 100-year Floodplain in Otis Center Village and around Big Pond and Otis Reservoir



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 as cited in MEMA & EOEEA, 2018)

Built Environment

A GIS analysis based on the of the Flood Insurance Rate Map (FIRM) flood hazard areas indicates that there is a total of 2,183 acres of 100-year floodplain within the Town, which is approximately 9% of total land area. Of these, 39 acres are developed, which is 1.8% of total floodplain area. It should be noted that the FIRM map for Otis was drafted in December 1983, almost 40 years ago. As precipitation patterns and flow regimes change in a warming climate, the boundaries of the 100-year floodplain could shift. It will be important for the Town to discourage development in the areas known to be seasonally or temporarily inundated, regardless of whether these areas are within the current FIRM boundaries.

Looking at the maps in Figures 3.9 and 3.11, it is clear that the majority of buildings in the floodplain are along the shorelines of Big Pond and Otis Reservoir, while another cluster of buildings are along the West Farmington River, in historic Otis Center Village in the vicinity of the intersection of Monterey Road and South Main Road (Routes 8 and 23). Table 3.9 summarizes the potential lost value of buildings and their contents. For the purposes of this analysis, the value of contents for residential buildings is 50% of property value, mixed use is 75% of property value, and commercial is 100% of property value. The Fire Station on South Main Street is in the 100-year floodplain. The fire station serves the majority of the town as well as well as hosting the Otis Ambulance and the primary emergency operations center. To date this facility has never flooded, although a 100-year flood has not been documented to occur since the building was constructed in WHEN>?? The building itself is constructed on higher ground than the surrounding area, and could remain dry during a 100-year event, but it is likely that the main traffic routes, Routes 8 and 23, would be under water, limiting the facility's use for emergency operations. It may be prudent to determine if the Fire Station is above the 100-year flood level to ensure continuity of operations. Several businesses and historic buildings are also located in the Center Village and are within the floodplain.

The majority of buildings in Otis located within the mapped 100-year floodplain area are seasonal homes clustered around Big Pond and Otis Reservoir. Many of these buildings were constructed decades ago as seasonal cottages, most of which do not have basements and are perched on piers 18”-24” off the ground. It is not known if this elevated construction may protect or reduce flood risk to these structures. The homes on the island on Big Pond are all built on piers due to the presence of ledge in this area. Town officials are not aware of serious flooding issues related to homes along these ponds.

Table 3.9 summarizes the number and types of buildings in the floodplain according to the GIS FIRM data, as well as the potential value of the building and building contents lost in a 100-year flood event. With the aid of GIS technology using FIRM boundaries and MassGIS parcel data, 126 buildings in Otis have been identified as being located in the 100-year floodplain. Of these, 119 are residential buildings (7% of total residential stock), four are mixed-use buildings (17% of total stock) and three are commercial buildings (17% of total stock). The total is less than the 179 buildings identified in the floodplain in the previous Hazard Mitigation Plan of 2012. This is because the advances in GIS technology now offer better identification of buildings within floodplain boundaries. It should be noted, however, that the delineation of the floodplain boundaries themselves is still only a very rough estimate. Locating site-specific boundaries involve expertise of surveys and/or engineering.

Table 3.9: Estimated Number of Buildings in the Floodplain and Potential Value Lost in a 100-Year Flood Event

Type	Number of Buildings	Value of Buildings	Value of Contents	Total
Residential	119	$16,554,300	$8,277,150	$24,831,450
Mixed Use	4	$871,700	$653,775	$1,525,475
Commercial	3	$790,500	$790,500	$1,581,000
Total	**126**	**$18,216,500**	**$9,721,425**	**$27,937,925**

Source: MassGIS Assessor Parcel Data 2020 and BRPC 2021.

The Town of Otis is a NFIP community. 44 CFR § 201.6(c)(2)(ii) requires all plans approved after October 1, 2008 must also address NFIP insured structures that have been repetitively damaged by floods. According to the FEMA Community Information System (CIS) data, there are currently 17 flood insurance policies in force in the National Flood Insurance Program (NFIP), obviously far less than the number of buildings that have been identified through GIS to be partially or wholly within the 100-year floodplain. The insurance premiums for these 17 policies totals $15,769, with an insurance coverage totaling $4,054,400. This is far less than the potential losses calculated using GIS data and building content values. According to the CIS data, there are five cases where flood insurance payments were made for a total of $32,005. According to FEMA records, two of the five were after T.S. Irene. All of these payments were on buildings that existed when the Town's Flood Insurance Rate Map (FIRM) was created in December 1983 and before the Town enacted floodplain zones and bylaws. "Pre-FIRM" buildings can be insured using subsidized rates are designed to help people afford flood insurance even though their buildings were not built with flood protection in mind. There are no repetitive flood loss properties within the Town of Otis (FEMA CIS, downloaded 5-19-21).

In Otis the rivers and streams tend to be dynamic systems, with stream channel and bank erosion common in both headwater and secondary streams. Fluvial erosion is the process where the river undercuts a bank, usually on the outside bend of a meander, causing sloughing and collapse of the riverbank. Fluvial erosion of stream and riverbanks can creep towards the built environment and threaten to undercut and wash away buildings, roads, and bridges. Many roads throughout the region follow streams and rivers, having been laid in the floodplain or carved along the slopes above the bank. Older homes, barns and other structures were also built in floodplain or just upgradient of stream channels in both rural and urban areas. Fluvial erosion can also scour and downcut stream and river channels, threatening bridge pilings and abutments. This type of erosion often occurs in areas that are not part of a designated floodplain (MEMA, 2013).

Flood waters can increase the risk of the creation of and dislodging of ice dams during the winter months. Blocks of ice can develop in streams and rivers to create a physical barrier or dam that restricts flow, causing water to back up and overflow its banks. Large ice jam blocks that break away and flow downstream can damage culverts, bridges and roadways whose openings are too small to allow passage (MEMA, 2013).

Electrical power outages can occur during flood storm events, particularly when storm events are accompanied by high winds, such as during hurricanes, tropical storms, thunderstorms and micro-bursts. Fortunately, most flooding in the Berkshire region is localized and have resulted in few widespread outages in recent years, and where it occurs service has typically been restored within a few hours.

Landslides on steep slopes can occur when soils are saturated and give way to sloughing, often dislodging trees and boulders that were bound by the soil. The damage from Hurricane Irene in 2011 to Route 2 in the Florida/Charlemont area was a combination of fluvial erosion from the Cold and Deerfield Rivers and a landslide on the upland slope of the road.

Flooding of homes and businesses can impact human safety health if the area of inundation is not properly dried and restored. Wood framing can rot if not properly dried, compromising building structure and strength. Undetected populations of mold can establish and proliferate in carpets, duct work, wall board and almost any surface that is not properly dried and cleaned. Repeated inundation brings increased risks of both structural damage and mold. Vulnerable populations, such as those whose immune systems are compromised by chronic illness or asthma, are at higher risk of illness due to mold.

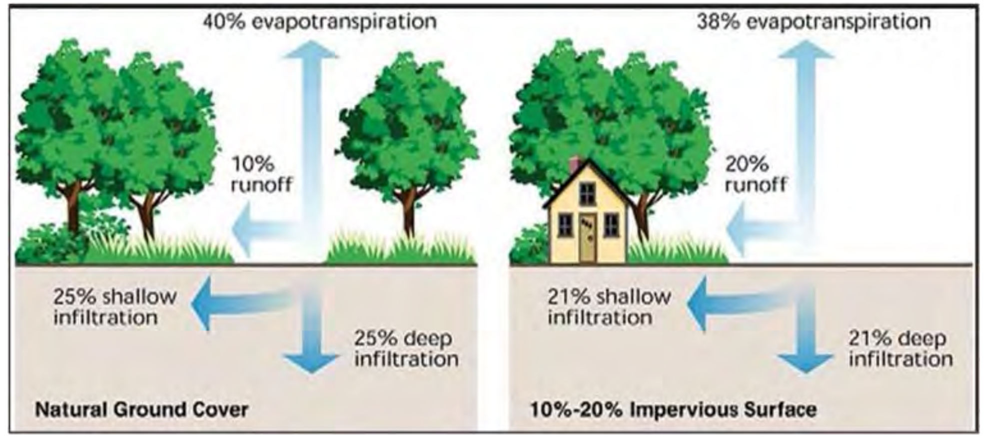
Natural Environment

Flooding has the potential to affect the natural environment in several ways. Septic systems can flood as can a wastewater treatment plant, contaminating the surrounding areas, posing health risks, and damaging the environment. A common effect of septic overflows due to flooding is nutrient overloads in nearby bodies of water that can kill native wildlife and vegetation. Flooding can spread chemical and bacterial contamination potentially harmful to people, the environment, and wildlife. Flooding can remove trees, other vegetation, rocks and soil causing erosion, high turbidity and the loss of community assets. Stormwater collects contaminants and sediment from roads and other surfaces and transports it into waterways if there is not a sufficient buffer to filter out the contaminants and sediment. Typically, there is no infrastructure in place to protect from nonpoint source pollution of this type.

Some level of stream channel and bank erosion and sedimentation naturally occur during severe storm events. In a natural landscape, standing stems, trunks and leaves of vegetation, as well as fallen logs, branches and leaf litter, physically block the path of stormwater runoff. Lessing the velocity of runoff causes it to drop its sediment and soil load and allows water to infiltrate into the soil. However, the rate of runoff, erosion and sedimentation increases when hard surfaces such as homes, roads and driveways replace forest vegetation and soils. This runoff rate can double in even modestly dense development. See Fig. 3.12 for a general overview.

Severe runoff, particularly along steeply sloped rural roads, can discharge sediment into streams, ponds and wetlands. The greater intensity of severe rain events increased the risk of sedimentation damages. As illustration of this concept, see Figure 3.13, where the forest in the foreground captured gravel from a washed out dirt road before it reached the lake seen in the background.

Fig. 3.12. Stormwater runoff doubles in modest development



Source: BRPC, MA Buffer Manual, 2003.

High concentrations of nutrients can be found in stormwater runoff adhered to sediment particles and dissolved in stormwater. Phosphorus, the nutrient of main concern for freshwater ecosystems, can overfertilize algae and noxious aquatic weeds, creating algae blooms and weed-choked shallow waters. Excessive plant growth and die-back lowers oxygen levels in lakes and ponds. One study in Maine found that even careful development of forest land into two-acre house lots caused a 2- to 10-fold increase in phosphorus concentrations in stormwater runoff (BRPC, 2003

Phosphorus readily adheres to sediment and soil particles and travels in stormwater runoff. It is estimated that 80%-90% of phosphorus reaches water bodies in this way. This is one reason that the Massachusetts Stormwater Management Policy requires developers to remove total suspended solids from post-developed stormwater runoff. Water quality degradation is also the reason that Massachusetts has prohibited the sale and placement of phosphorus-containing fertilizers on established turf lawns.

Unnatural levels of sediment being deposited into streams, ponds and lakes can degrade habitat in a variety of ways. Sediment/gravel eroded from dirt roads and the fill associated with road beds, shoulders and culverts is easily dislodged and deposited into streams or the nearest water body during storm events. This is especially problematic in areas where chronic repair cycles occur: adding new fill to build roads back up, only to have it erode away again in the next storm. Sediment deposition cover streambeds, smothering aquatic life and fish eggs, lowering aquatic populations. Trout and their food sources are particularly susceptible to sedimentation impacts

Excessive sedimentation of lakes and ponds can create the shallower, warmer shoreline conditions that favor infestation of invasive aquatic plants such as Phragmites, purple loosestrife, Eurasian water milfoil, water chestnut and a host of others. Invasive species can be carried downstream and dispersed into new areas in flood waters, particularly those like Eurasian water milfoil and Japanese knotweed that readily spreads via broken plant fragments. A more detailed discussion of invasive plant species is found in the Invasive Species and Vector-borne section of this plan.

Fig. 3.13. Sediment transport from a washed out dirt road from a severe rain event. The forest captured the sediment before it reached the lake.

Source: BRPC, MA Buffer Manual, 2003.

Economy

There are several key commercial buildings located within the floodplain in the Otis Center Village, including the U.S. Post Office, a local bank branch and a general contractor. Loss or damage especially to the post office or bank could affect communications and services to businesses and residents alike. Additionally, the broadband hub that serves the Town is located at the Fire Station, the loss of which could limit communications and hamper emergency response during a flood event. The Center Village area is also the junction where Routes 8 and 23, the main commercial and commuter travel routes that serve Otis and the surrounding towns. Loss of these routes could require long detours along winding roads that were not constructed to safely serve commercial vehicles.

The impacts of flooding on the economy include the value of buildings and businesses potentially lost during a flood event, the loss of business revenue during the response and recovery period, economic loss due to an inability to commute to work or communicate, and the burden of paying for recovery and the rebuilding of infrastructure.

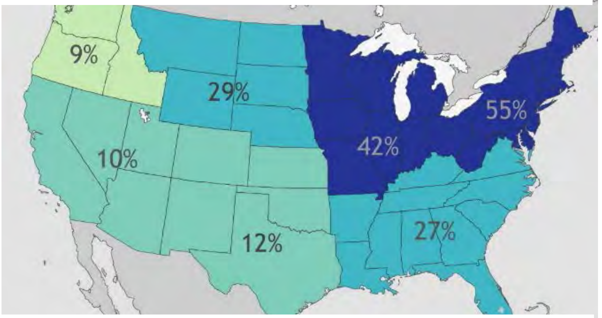
Future Conditions

Based on data gathered from the Northeast Climate Science Center's (NECSC) report, *Massachusetts Climate Change Projections*, the yearly precipitation total for Berkshire County has been experiencing a gradual rise over the last 70 years, rising from 40.1 inches in the 1960s to 48.6 inches in the 2000s (NECSC 2018). According to this same report, the Farmington River Watershed received an average of 51.4 inches of total precipitation during the baseline years 1971-2000. The watershed is projected to gain an additional 1.2" to 6.4" of precipitation annually by the 21st-century, and 1.7" to 9" annually by the end of the century. The greatest gains in precipitation are expected in the winter months.

Data from USGS streamflow gages across the northeast show a clear increase in flow since 1940, with an indication that a sharp "stepped" increase occurred in the 1970s. This is despite the fact that much of the land within many New England watershed has been reforested, and this type of land cover change would tend to reduce, rather than increase, flood peaks (Collins, 2008). The FIRM maps for Otis were developed in the early 1980s, and therefore the recurrence intervals and 100-year flood boundaries may no longer read true. Future development should therefore not only be directed away from mapped FIRM areas, but should reflect current conditions. For example, if areas in Otis are found to be flooding more often than in the past, or certain pond or streambanks are eroding more severely, it may be prudent to discourage or deny new building development in those areas.

The scientific community agrees that climate change is altering the weather and precipitation patterns of the northeastern region of the U.S. Climate change will likely alter how the region receives its precipitation, with an increase of it falling in the form of severe or heavy events. NOAA has documented that extreme or heavy precipitation events have grown more frequent since the start of the twentieth century, and such events are likely to become even more frequent over the twenty-first. Heavy precipitation is defined by NOAA as those heavy rain or snow events ranking among the top 1 percent (99th percentile) of daily events, has increased 55% in the Northeast between 1958-2012.[5] It should be noted that during this period, a nine-year drought from 1961-1969, the drought of record for this region, occurred during this period. As such, this may underestimate the overall trend for future projections.

Figure 3.14. Increase in Precipitation Falling in Top 1% of Extreme Precipitation Events 1958-2016



Source: NOAA, Climate.gov, 2021.

The NESCS data for Farmington River Watershed projects that days of heavy precipitation (defined as $\leq$1" of precipitation per day) will increase. Days where precipitation will be delivered in heavier rain events of 2" or greater per day will also increase, and these are the events that can more typically overwhelm storm drain systems and flood roads and properties. During the baseline years 1971-2000, the Farmington River Watershed experienced an approximate average of one of these days per year. By mid-century it is projected that the watershed will experience an average of 1.61 days per year (a 60% increase) under a high greenhouse gas emissions scenario, and will increase to two days per year (100% increase) by end of century.[6]

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[5] *https://www.climate.gov/news-features/featured-images/prepare-more-downpours-heavy-rain-has-increased-across-most-united-0*

[6] *NECSC, 2018, MA Climate Change Projections*

Studies have also reported increases in precipitation in both developed and undeveloped watersheds across the northeast, with the increases being observed over a range of precipitation intensities, particularly in categories characterized as heavy and extreme storm events. These events are expected to increase both in number and in magnitude. Some scientists predict that the recurrence interval for extreme storm and flood events will be significantly reduced. One study concluded that the 10-year storm may more realistically have a recurrence interval of 6 years, a 25-year storm may have a recurrence interval of 14 years and the 100-year storm may have a recurrence interval of 49-years. The same study predicts that if historic trends continue that flood magnitudes will increase, on average, by almost 17% (Walter & Vogel, 2010).

This trend has direct implications on the design of municipal infrastructure that can withstand extreme storm and flood events, indicating that all future designs must be based on the most updated precipitation and stream gauge information available. The replacement of the traditional TR40 rainfall frequencies data (1961) with the NOAA Atlas 14 acknowledges the recent changes in precipitation trends. More mid-winter cold/thaw weather pattern events could increase the risk of ice jams. Many studies agree that warmer temperatures in late winter will result in more rain-on-snow storm events, leading to higher spring melt flows, which typically are already the highest flows of the year

It may be prudent, therefore, to slightly overdesign the size of new stormwater management and flood control systems so that they have the capacity to accept the increase in flow or volume without failing. For many piped systems, such as culverts, drainage ditches and swales, the slight increase in size may provide a large increase in capacity, and for very little increase in cost. If space is available, an increase in the capacity of retention/detention ponds may also be cost effective. Bioretention cells can be engineered so that they can increase their holding capacity for extreme storm events with little incremental cost. The size of the engineered soil media, which is a costly component of the system, may remain the same size as current designs call for, but a surface ponding area surrounding the central soil media is increased to serve as a holding pond.

Change in Average Temperatures/ Extreme Temperatures

Hazard Profile

Temperature is a fundamental measurement of describing climate, which is the prevailing weather patterns in a given area. Climate determines the types of plant and animal species that are able to survive in a region, and changes in climate will have significant impacts on the landscape because most species will not have the time to evolve and adapt over multiple generations to the new climate[7]. Data from several scientific sources indicate that 2011-2020 was the warmest decade recorded,[8] and this increase drives our weather patterns. The ocean's waters act as a "heat sink," and those warmer waters influence air temperatures and spawn a greater number and increased intensity of storms. In the Northeast we will generally see more frequent and more intense precipitation, heat waves, longer fall and spring, and warmer winters with heavier snow.

Likely severity

Relative to the rest of the Commonwealth, the Town of Otis is somewhat protected from extreme heat by the Town's higher elevation and the forested landscape. The environment and people have adapted to cooler conditions; however, extremes in hot and cold still can and will occur, particularly in the changing climate. Homes here have traditionally been built with heating systems and some level of insulation to keep in warmth, but few were built with central air conditioning systems.

NOAA utilizes data to determine average temperature using land-based weather station measurements and by satellite measurements that cover the lowest level of the Earth's atmosphere. In moderate climate like in the Berkshires, the most severe impacts of the change in average temperature will be on our environmental composition, as well as on our vulnerable populations, particularly the elderly, people with underlying health conditions and low-income residents.

[7] *https://www.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature*

[8] *https://climate.copernicus.eu/2020-warmest-year-record-europe-globally-2020-ties-2016-warmest-year-recorded#:~:text=The%20Copernicus%20Climate%20Change%20Service%20(C3S)%20today%20reveals%20that%20globally,2020%20the%20warmest%20decade%20recorded*

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 (MEMA & EOEEA, 2018).

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.

Probability

According to extensive scientific study, the global changes in climate will lead to temperature shifts as weather patterns are altered. In general air temperatures are increasing across the globe, with relatively higher increases in the Northeast than in most other portions of the U.S. The Massachusetts Climate Change Clearinghouse (resilient MA) is a gateway to data and information relevant to climate change adaptation and mitigation across the state. It provides the most up-to-date climate change science and decision support tools to support scientifically sound and cost-effective decision making for policy-makers, practitioners, and the public. As part of this effort, the clearinghouse is linked to the Department of Interior's Northeast Climate Adaptation Science Center (NECASC), which is hosted by the University of Massachusetts, Amherst. NECASC is part of a federal network of eight Climate Adaptation Science Centers created to work with natural and cultural resource managers to gather the scientific information and build the tools needed to help fish, wildlife, and ecosystems adapt to the impacts of climate change.

NECASC is the main source used in this hazard mitigation plan to understand observed and projected changes in temperatures. Climate change projections for Massachusetts are based on simulations from the latest generation of climate models included in the Coupled Model Intercomparison Project Phase 5 (CMIP5). As part of this work, the state created projections on county- and major watershed-level information, derived by statistically downscaling CMIP5 model results using the Local Constructed Analogs (LOCA) method (Pierce et al., 2014).[9] As noted in the CMIP5 models, the state-wide temperatures are expected to rise and cause these projections for the mid-21st century (2050s), as relative to the observed 1971-2000 baseline average.

Cooling degree days (CDD) are a measure of how much and for how long outside air temperature was higher than a specific base temperature. CDDs are the difference between the average daily temperature and 65°F, which has been determined to be a temperature that does not typically call for use of indoor cooling systems. For example, if the temperature mean is 90°F, subtract 65 from the mean and the result is 25 CCDs for that day. Similarly, heating degree days are those where the temperature is lower than 65°F. The details for projections for mid-century and 2090s are outlined in Table 3.10.[10]

[9] *https://resilientma.org/datagrapher/?c=Temp/state/maxt/ANN/MA/*
[10] *https://resilientma.org/datagrapher/?c=Temp/state/maxt/ANN/MA/*

- Mean annual temperatures in MA are expected to be 2.8-6.2°F warmer than over recent decades.
- There will be 7-26 more days per year when daily maximum temperatures exceed 90°F.
- There will be 19-40 fewer days when minimum temperatures fall below 32°F (a decline of 13-27%).
- Total heating degree days will be 11-24% lower, but cooling degree days will be 57-150% higher.

Table 3.10. Projected Statewide Temperature Changes from Observed 1971-2000 to Projected 2050s and 2090s

Variable	Observed value 1971 - 2000 average	Change by 2050s	Change by 2090s
Annual average temperature	47.5°F	Increase by 2.8 - 6.2°F	Increase by 3.8 - 10.8°F
Number of days per year with daily Total max > 90°F	5 days	Increase by 7 - 26 days	Increase by 10 - 63 days
Number of days per year with daily Total min < 32°F	146 days	Decrease by 19 - 40 days	Decrease by 24 - 64 days
Heating degree-days per year (HDD)	6839 Degree-Day °F	Decrease by 773 - 1627	Decrease by 1033 - 2533
Cooling degree-days per year (CDD)	457 Degree-Day °F	Increase by 261 - 689	Increase by 356 - 1417

Source: https://resilientma.org/datagrapher/?c=Temp/state/maxt/ANN/MA/

Geographic Areas Likely Impacted

All of Otis is exposed to the impacts of increased annual and extreme temperatures. Winter temperatures are less consistent than in the past, with warm “false spring” periods becoming more common. This results in more freeze/thaw events that begin earlier in the year and extend outward. In other words, more of the infamous New England “mud season” that wreaks havoc with the Town’s dirt roads.

Historic Data

According to according to scientists from NOAA's National Centers for Environmental Information (NCEI), the last seven years prior to 2020 were the hottest years on record, as ranked by their departure from the 20th century average temperature. Projections by NOAA and other scientific organizations across the globe expect the trend to continue upwards, with the magnitude of the change depending on the amount of greenhouse gas levels in the atmosphere. In general, the highest temperatures in the Berkshires occur in July, and the lowest tend to occur in January.

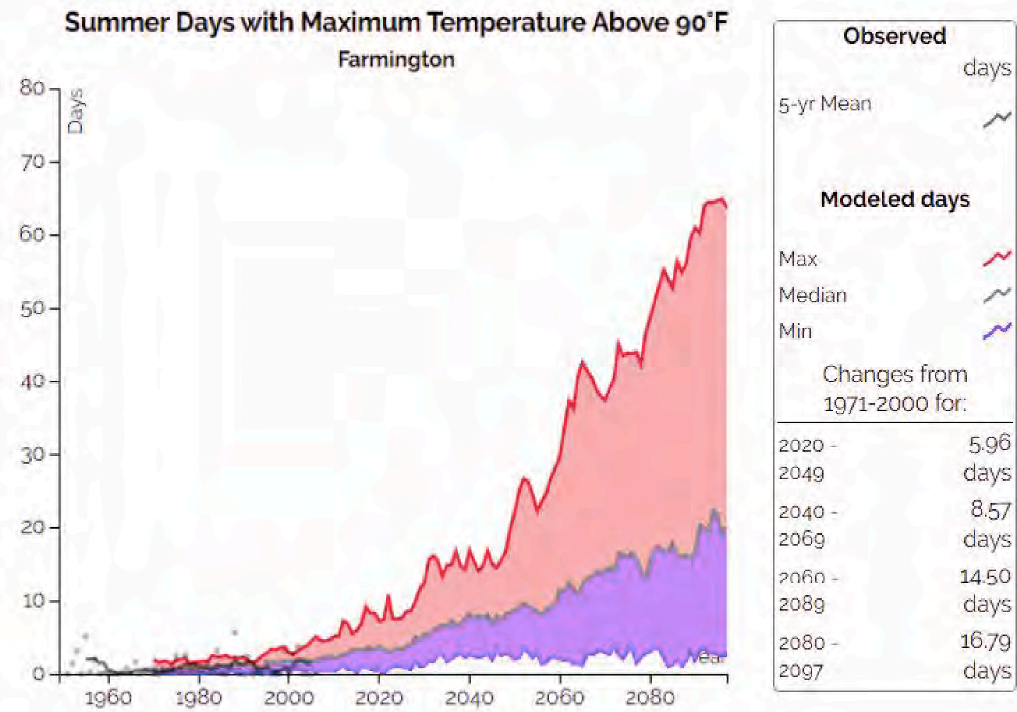
The following are some of the highest temperatures recorded for the period from 1895 to 2017, showing as comparison Boston and three Berkshire County locations (National Climatic Data Center, 2017.)

- Boston, MA 102°F
- Great Barrington, MA 99°F
- Adams, MA 95°F
- Pittsfield, MA 95°F

Historically, Otis has little experience with days when the air temperature exceeds 90°F, but that is projected to change as we see an increase in the number of days with dangerous levels of heat. As seen in Figure 3.15, during the years 1960-2000, there were few if any days where the temperature was above 90°F. During the baseline years 1971-2000 there was an average of less than one day per summer (0.94 days) when the temperature exceeded 90°F. The CMIP5 model offered by the NE CASC projects that the mean number of summer days when the air temperature exceeds 90°F will increase to 8.6 per year by mid-century and to 16.8 by the 2090s. Under a high-greenhouse gas emissions scenario, the maximum number of days when the air temperature exceed 90°F could reach 17 days per year by mid-century and 65 days per year by the 2090s (NE CASC 2017). The Farmington River Watershed was chosen for this analysis because the vast majority of Otis is located within this watershed.

Just as the summers tend to be cooler in the Berkshires than in other parts of the state, so too are the winters. Again, the slightly higher elevations of the Berkshire hills are largely responsible for the cooler temperatures.

Fig. 3.15. Observed and Projected Extreme Temperatures for Farmington River Watershed



Source: https://resilientma.org/datagrapher/?c=Temp/basin/tx90/!!A/Farmington/

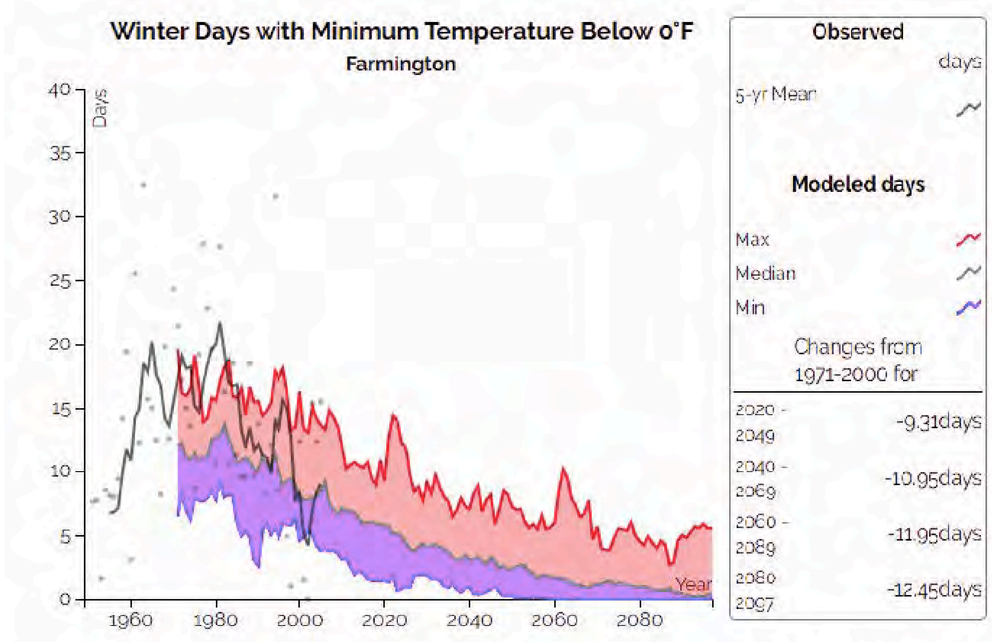
The following are some of the lowest temperatures recorded in the Berkshire region for the period from 1895 to 2017 (National Climatic Data Center, 2017).

- Lanesborough, MA –28°F
- Great Barrington, MA –27°F
- Stockbridge, MA –24°F
- Pittsfield, MA -19°F

In the same manner that climate change will increase summer high temperatures, so too will it effect lower winter temperatures. As illustrated in Figure 3.16, the number of observed winter days when the temperature dipped below 0°F has historically been unpredictable during the years 1960-2000. The 5-year mean trend line shows that there was quite a range where temperatures fell below 0°F, with as few as 3 days in 1960 and a high of 27 days in 1981. The baseline years of 1971-2000 averaged 14 days in the winter where the temperature fell below 0°F. By mid-century the mean days where temperatures will fall below 0°F will decrease by 12 days, and by 2090s there will likely not be any days where the temperature will fall that low. This will bring some relief and reduce risk to people and buildings from extreme low temperatures.

As described earlier in the Flood Risk Section of the plan, this change has implications for snow and ice management, with more rain-on-snow, snows being heavier, snow melts more often, bouts of mud season more frequent and ice formation more often.

Fig. 3.16. Observed and Projected Extreme Temperatures for Farmington River Watershed



Source: https://resilientma.org/datagrapher/?c=Temp/basin/tx90/JJA/Farmington/

Vulnerability Assessment

People

All residents in the Town of Otis are vulnerable to the health effects of extreme temperatures, with those who work outside directly at a greater risk. Others at greater risk are those individuals who have pre-existing medical conditions that impair their ability to regulate their body temperatures, or whose homes or work places are inadequately heated or cooled. According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include the following: (1) people over the age of 65, who are less able to withstand temperatures 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 reluctance to relocate to cooler environments.

Hot temperatures can also contribute to deaths from respiratory conditions (including asthma), heart attacks, strokes, other forms of cardiovascular disease, renal disease, and respiratory diseases such as asthma and chronic obstructive pulmonary disorder. Berkshire County has a higher level of asthma-related emergency room visits than other parts of the state. 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.

The NWS issues a Heat Advisory when the Heat Index is forecast to reach 100°-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 more 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. 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. Also, strong winds, particularly with very hot, dry air, can increase the risk of heat-related 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 (EPA, 2016). 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. It should be noted that temperature alone does not define the stress that heat can have on the human body – humidity plays a powerful role in human health impacts, particularly for those with pre-existing pulmonary or cardio-vascular conditions.

Fig. 3.17. Heat Index Chart and Human Health Impacts

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

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Source: EOEEA & MEMA, 2013.

Locally, a significant increase in heat-related deaths has not been reported in Berkshire County. When interviewed in 2016 about projected climate change impacts, local ambulance crews reported no increase in heat-related calls in recent years (BRPC & BCBOHA, 2016). However, many Berkshire communities since that time have begun to develop protocols for opening cooling centers. Otis has opened its cooling center during a heat event in 2019, posting its availability on the Town's Blackboard Connect emergency communications system. One person used the cooling center during this period.

What may be more concerning is the trend for higher nighttime temperatures. Warm nights are those where the minimum temperature stays above 70°F. As can be seen in Fig. 3.18, the number of nights where the temperature did not dip below 70°F has increased from a median of slightly more than three in the years 1950 – 1990, to greater than seven in the 2010s. Historically the cooler evening temperatures in the Berkshires has allowed residents to cool their body temperatures in the night air and to cool their homes by opening windows and using fans to bring in the cooler air. Human bodies need time to cool off, which typically occurs during sleep when core body temperature naturally dips. Without relief during the night the physiological strain on the body continues unabated. When it is both too hot and too humid for sweat to do its job of dissipating body heat, there can be fatal consequences like organ failure. Warmer and more humid nighttime temperatures will make it increasingly difficult to bring down the temperature in homes that are not equipped with air conditioning.

In the Berkshires, extreme cold temperatures are those that are well below zero for a sustained period of time, causing distress for vulnerable populations that are exposed to the temperatures when outside and straining home heating systems. The severity of extreme cold temperatures are generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when 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 is cooled at a faster rate causing the skin's temperature to drop (MEMA, 2013)

Fig. 3.19. Wind Chill Temperature Index and Frostbite Risk

Temperature (°F)

Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
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

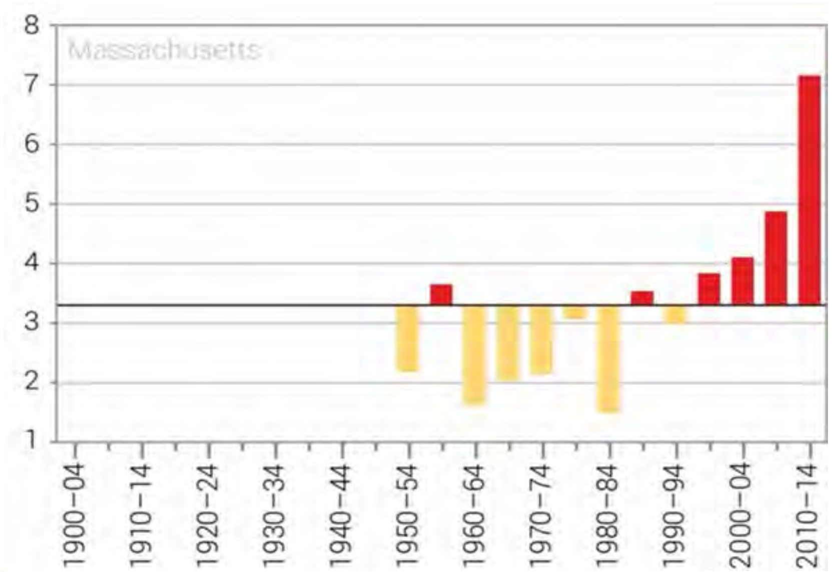
$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

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

Effective 11/01/01

Source: EOEEA & MEMA, 2013.

Fig. 3.18. Number of Nights When Temperatures Remain 70°F or Higher



https://statesummaries.ncics.org/ma

The NWS issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to –24°F for at least three hours, using only the 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 using only the sustained wind. In 2001 the NWS implemented a Wind Chill Temperature Index to more accurately calculate how cold air feels on human skin and to predict the threat of frostbite. According to the calculations, people can get frostbite in as little as 10 minutes when the temperature is -10°F degrees and winds are 15 miles per hour. (MEMA, 2013).

In Otis, mud season traditionally occurred once a year in early spring, when frozen roads thawed and became difficult to navigate or even impassible. However, in the past few years mud season conditions have changed, with mud season events occurring earlier and warm spells that temporarily thaw road surfaces and create several small mud season bouts in one year. The spring 2021 season was particularly difficult, with a March mud season that resulted in conditions in some areas that not even four-wheel drive vehicles could meet. Tow trucks were called to pull out some vehicles. In typical years, the Otis Highway Department lays down approximately $10,000-20,000 worth of gravel/stone during mud season, but in March 2021 the Department spend $20,000 in one week on straight stone in an effort to stabilize roads. Local residents are accustomed to mud season and adapt. However, for the past several years, summer cottage owners are renovating homes and become full-time residents. The COVID-19 pandemic has accelerated this rate. As such, many of them are not accustomed to driving in severe winter conditions or during mud season. The demand to pave dirt roads may become more intense as this housing trend continues.

Built Environment

All elements of the built environment are exposed to the extreme temperature hazards. 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 (resilient MA, 2018).

Extreme cold temperature events can damage buildings through freezing or bursting pipes and freeze and thaw cycles. Additionally, manufactured buildings (trailers and mobile homes) and antiquated or poorly constructed facilities may not be able to withstand extreme temperatures. The heavy snowfall and ice storms associated with extreme cold temperature events can also cause power interruptions. Backup power is recommended for critical facilities and infrastructure. 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 (resilient MA, 2018). 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.

The Berkshires are currently a moderately temperate climate, but an increase in summer temperatures will create higher peak summer electricity demands for cooling, particularly with an increase in the number of air conditioning units being installed. In the summer, the number of CDDs was 223 in the Farmington River Watershed for the baseline years of 1971-2000. The CDD rate is expected to increase by 74-208% (164-464 degree-days) by

Fig. 3.20. Local dirt road during mud season 2021

Photo courtesy Hal Kobrin, 2021.

mid-century, and by 26-81% (229-913 degree-days) by end of century. Historically CDD demand has been concentrated in the summer months, but as the climate warms, need for air conditioning can be expected to expand outward into the shoulder months of spring and autumn (MA Climate Change Projections by Basin, 2017).

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 (MassDOT, 2017). 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 (resilient MA, 2018).

Natural 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 (MCCS and DFW, 2010).

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 (MCCS and DFW, 2010). 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. Climate change is anticipated to be the second-greatest contributor to the biodiversity crisis, which is predicted to change global land use. 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. Between 1999 and 2018 (fiscal years), the Commonwealth spent more than $395 million on the acquisition of more than 143,033 acres of land and has managed this land under the assumption of a stable climate. As species respond to climate change, they will likely continue to shift their ranges or change their phenologies to track optimal conditions (MCCS and DFW, 2010). As a result, climate change will have significant impacts on traditional methods of wildlife and habitat management, including land conservation and mitigation of non-climate stressors (MCCS and DFW, 2010). Changing temperatures, particularly increasing temperatures, will also have a major impact on the sustainability of our waterways and the connectivity of aquatic habitats (i.e., entire portions of major rivers will dry up, limiting fish passage down the rivers). 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 (MCCS and DFW, 2010). As temperature increases, the length of the growing season will also increase. Since the 1960s, the growing season in Massachusetts increased by approximately 10 days (CAT, n.d. as cited in MEMA & EOEEA, 2018).

Climate change is also likely to result in a shift in the timing and durations of various seasons. This change will likely have repercussions on the life cycles of both flora and fauna within the Commonwealth. While there could be economic benefits from a lengthened growing season, a lengthened season also carries a number of risks. The probability of frost damage will increase, as the earlier arrival of warm temperatures may cause many trees and flowers to blossom prematurely only to experience a subsequent frost. Additionally, pests and diseases may also have a greater impact in a drier world, as they will begin feeding and breeding earlier in the year (Land Trust Alliance, n.d. as cited in MEMA & EOEEA, 2018).

Economy

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 (see Section 4.3.3 for additional information). Higher temperatures that result in greater concentrations of ozone negatively impact plants that are sensitive to ozone (USGCRP, 2009). Additionally, as previously described, changing temperatures can impact the phenology.

Above average, below average, and extreme temperatures are likely to impact crops—such as apples, cranberries, and maple syrup—that rely on specific temperature regimes (resilient MA, 2018). Unseasonably warm temperatures in early spring that are followed by freezing temperatures can result in crop loss of fruit-bearing trees. 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 (resilient MA, 2018 as cited in MEMA & EOEEA, 2018).

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 grows. Increased use of these treatments increases the risk of pesticides entering the food chain and could result in pesticide resistance, which could result in additional economic impacts on the agricultural industry (MEMA & EOEEA, 2018).

Future Conditions

According to NOAA, global temperature data document a warming trend since the mid-1970s. Temperature changes will be gradual over the years. However, for the extremes, meteorologists can accurately forecast event development and the severity of the associated conditions with several days lead time. High, low, and average temperatures in Massachusetts are all likely to increase significantly over the next century as a result of climate change. This gradual change will put long-term stress on a variety of social and natural systems and will exacerbate the influence of discrete events (MEMA & EOEEA, 2018). Increased electricity demand for CDDs throughout the northeast could stress the New England electricity grid system and lead to brownouts or controlled blackouts, stressing or injuring the health of vulnerable populations and possibly impairing functions of government and communications systems. For the Town of Otis, there will be a greater need to identify and maintain communications with vulnerable populations such as the elderly, people with underlying health problems, and low-income residents whose homes do not have cooling systems adequate to bring down indoor temperatures. As warming temperatures become more common the need for a cooling shelter may be necessary as a part of the emergency response strategy for the Town. The Town Hall can act not only as an emergency shelter for winter storm emergencies but as a cooling shelter during heat events as well. Air conditioning using air source heat pumps has been installed throughout the building.

Drought

Hazard Profile

Drought is a period characterized by long durations of below normal precipitation. Direct impacts of drought include reduced water supply, crop yield, increased fire hazard, reduced water levels, and damage to wildlife and fish habitat.

The Massachusetts Office of Energy and Environmental Affairs (EEA) and MEMA partnered to develop the *Massachusetts Drought Management Plan*, of which September 2019 is the most updated version. The state's Drought Management Task Force, comprised of state and federal agencies, was created to assist in monitoring, coordinating and managing responses to droughts and recommends action to minimize impacts to public health, safety, the environment and agriculture (EEA, MEMA, 2019). The Massachusetts Department of Conservation Resources staff compile data from the agencies and develop monthly reports to track and summarize current water resource conditions.

In Massachusetts, the determination of drought level is based on seven indices: Standardized Precipitation Index, Crop Moisture Index, Keetch-Byram Drought Index, Precipitation, Groundwater levels, Streamflow levels, and Index Reservoir levels. Determinations regarding the end of a drought or reduction of the drought level focus on two key drought indicators: precipitation and groundwater levels. These two factors have the greatest long-term impact on streamflow, water supply, reservoir levels, soil moisture and potential for forest fires. Precipitation is a key factor because it is the overall cause of improving conditions. Groundwater levels respond slowly to improving conditions, so they are good indicators of long-term recovery to normal conditions

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Likely severity

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. Droughts are not usually associated with immediate impacts on people or property, but they can have significant impacts on agriculture, which can impact the farming community of the region. As noted in the state Hazard Mitigation Plan, agriculture-related drought disasters are quite common, with 50-66% of the counties in the U.S. having been designated as disaster areas in each of the past several years. These designations make it possible for producers suffering losses to receive emergency loans. Such a disaster was declared in December 2010 for Berkshire County (USDA Designation # S3072). Farming in Otis is limited and of small scale, and in general there are less droughts here in Berkshire County than in other areas of the U.S.

For the purposes of the state *Drought Management Plan*, drought conditions are classified into five levels: 'Level 0-Normal' (i.e., No Drought), 'Level 1-Mild Drought' (formerly Advisory), 'Level 2-Significant Drought' (formerly Watch), 'Level 3-Critical Drought' (formerly Warning), and 'Level 4-Emergency Drought' (formerly Emergency). These levels were selected to provide distinction between different levels of drought severity and for adequate warning of worsening drought conditions. Six Drought Indices are used as the primary drivers of drought determinations: 1) Precipitation, 2) Streamflow, 3) Groundwater, 4) Lakes and Impoundments, 5) Fire Danger, and 6) Evapotranspiration (EEA & MEMA, 2019).

MassDEP has the authority to declare water emergencies for communities facing public health or safety threats as a result of the status of their water supply systems, whether caused by drought conditions or for other reasons. The Department of Public Health in conjunction with the DEP monitors drinking water quality in communities.

Probability

As described below, Berkshire County is generally at a lower risk of drought relative to the rest of the Commonwealth. However, that does not eliminate the hazard from potentially impacting the County and Otis. The recorded historic patterns show near misses of severe drought conditions. Increases in temperature lead to faster evaporation of reservoirs, waterways, soils, and greater evapotranspiration rates in plants.

Geographic Areas Likely Impacted

For the purposes of tracking drought conditions across the Commonwealth, the state has been divided into six regions, with the Western Region being made up of Berkshire County. For the purposes of this plan, the entire Town of Otis is at risk of drought.

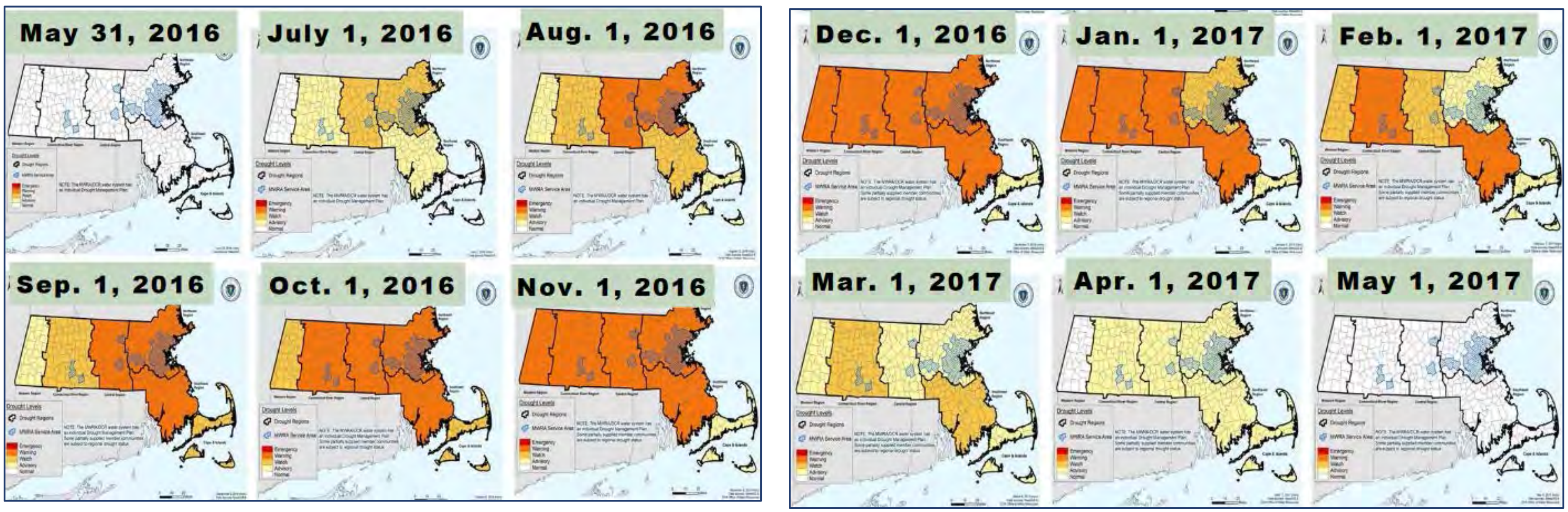
Historic Data

Massachusetts is relatively water-rich, with few documented drought occurrences. The most severe, state-wide droughts occurred in 1879-1883, 1908-1912, 1929-1932, 1939-1944, 1961-1969, 1980-1983, and 2016-2017. Several less-severe droughts occurred in 1999, 2001, 2002, 2007, 2008, 2010, 2014 and 2020. The nine-year drought from 1961-1969 is considered the drought of record. The longevity and severity of this drought forced public water suppliers to implement water-use restrictions, and numerous communities utilized emergency water supplies[11].

[11] *https://www.mass.gov/doc/massachusetts-drought-management-plan/download*

The most recent and significant drought in Massachusetts since the 1960s occurred during a 10-month span in 2016-17. In July 2016 Advisory and Watch drought levels began to be issued for the eastern and central portions of the state, worsening in severity until the entire state was under a Drought Warning status for the months of November-December 2016. Water levels began to recover in February 2017, with the entire state determined to be back to normal water levels in May 2017. In general, the central portion of the state faired the worse and Berkshire County faired the best, with the county entering the drought later and emerging from the drought earlier than most of the rest of the state. Berkshire County was under an Advisory (yellow on Fig. 3.21) or Watch status (gold) for five months and under a Warning status (orange) for three months during the height of the drought. The Massachusetts Water Resources Commission stated that the drought was the worst since the state's Drought Management Plan was first issued in 2001, and the most severe since the 1960s drought of record.[12]

Figure 3.21: Progression of the 2016-17 Drought



Source: https://www.mass.gov/files/documents/2017/09/08/drought-status-history.pdf

Vulnerability Assessment

People

[12] *MA Water Resources Commission, 2017. Annual Report, Fiscal Year 2017. Boston, MA.*

The entire population of Otis is exposed and vulnerable to drought. There is no public drinking water supply system in the Town; all drinking water is supplied through private wells. In general, those with shallow or low-yield drinking water wells are at higher risk than those with deeper wells. Residents and stakeholders who depend on water for their means of income, such as farmers and camp owners, could also be significantly impacted. The Berkshire region has not suffered a severe, emergency level drought since the 1960s, and it is unclear how well Otis would fair during a prolonged drought given changes in population, water use, and precipitation patterns.

Due to the great expanses of state forest and wildlife lands in the region, which attract hikers and campers, and a tourist-based economy that brings additional people to the region in the summer, the risk of wildfire would increase during a severe drought. Drought would reduce the capacity of local firefighting efforts, hampering control of wildfire. A more detailed discussion of wildfire and the Town's vulnerability is found in that section of the report.

Built Environment with Infrastructure and Systems

Drought does not threaten the physical stability of critical facilities in the same manner as other hazards such as wind-based or flood-related events. However, if drought led to wildfire across the entire Town, structures across Otis would be at risk. Wildfire could also damage or destroy electrical and communication systems.

Natural Environment

The natural environment is at greatest risk due to drought. Drought can lead to low flow and low groundwater levels, threatening the continued flow of streams and rivers. The cold-water fishery streams, on which native brook trout and other cold-water species depend for survival, could become too dry to too warm to sustain them. Lower, shallower lake and pond waters force aquatic life to congregate in smaller water volumes with lower oxygen levels, leading to stress and fish kills. Lower soil moisture causes vegetated to become stressed or die, causing trees and other vegetation to drop leaves and forbs to die back. The lower moisture reduces the ability of soil organisms to break down accumulated plant and animal matter. This combination of greater build-up of dry matter on the forest floor increases the risk of wildfire. These drier conditions can lead to decreases in plant and animal populations that need moist conditions to survive. Benefits of such conditions can mean lower populations of insects that carry pathogens, such as mosquitoes and ticks.

Economy

The economic impacts of drought can be substantial, and would primarily affect the agriculture, recreation and tourism, forestry, and energy sectors. Increased injury or die-back of forest trees could occur, especially if they are already stressed by ice damage, insect infestations and other factors, such as are occurring in Otis. This devalues timber stands for private woodlot owners and for the state. Decreased values bring decreased stumpage fees to the Town when forest sites are logged. Drier summers and intermittent droughts may strain irrigation water supplies, stress crops, and delay or cause harvest which may result in higher demand than can be locally supplied. This can increase importation of produce and drive up the price of food, leading to economic stress on a broader portion of the economy.

A drought could threaten the economic welfare of Otis. According to Mass. GIS, there are 43 public water supply wells, which are larger systems that serve restaurants, camps, stores and other places of business, as well as Town-owned and other public buildings. Additionally, they may include shared well systems around Big Pond and Otis Reservoir. Insufficient drinking water could decrease visitorship to local businesses that depend on seasonal tourism and second homeowners.

Future Conditions

Changes in winter temperatures will lead to less snowpack and more rain-on-snow events, leading to more surface runoff and less groundwater recharge, leading to less stream and river base flows. Higher temperatures in warmer seasons can more severely impact the reduced base flows due to higher rates of evaporation of moisture from soil and lower groundwater and surface water inputs. According to the state's Climate Change Adaptation Report, a continued high greenhouse-gas-emission scenario could result in a 75% increase in the occurrence of drought conditions lasting 1-3 months. Given that Otis is 75% forested, the risk of wildfire during drought conditions is a concern.

Hurricanes / Tropical Storms

Hazard Profile

Likely Severity

Tropical cyclones (tropical depressions, tropical storms, and hurricanes) form over the warm, moist waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico:

- A tropical depression is declared when there is a low-pressure center in the tropics with sustained winds of 25 to 33 mph.
- A tropical storm (T.S.) is a named event defined as having sustained winds from 34 to 73 mph.
- A hurricane is a storm with sustained winds reach 74 mph or greater. The hurricanes are categorized based on sustained winds; wind gusts associated with hurricanes may exceed the sustained winds and cause more severe localized damage.

When water temperatures are at least 80°F, hurricanes can grow and thrive, generating enormous amounts of energy, which is released in the form of numerous thunderstorms, flooding, rainfall, and very damaging winds. The damaging winds help create a dangerous storm surge in which the water rises above the normal astronomical tide. In the lower latitudes, hurricanes tend to move from east to west. However, when a storm drifts further north, the westerly flow at the mid-latitudes tends to cause the storm to curve toward the north and east. When this occurs, the storm may accelerate its forward speed. This is one of the reasons why some of the strongest hurricanes of record have reached New England (MEMA & EOEEA, 2018).

The severity of a hurricane is categorized by the Saffir-Simpson Hurricane Scale. This scale ranks hurricanes based on sustained wind speeds—from Category 1 (74 - 95 mph, minimal intensity) to Category 5 (156 mph or more, catastrophic intensity). Category 3, 4, and 5 hurricanes are considered "major" hurricanes. All winds are using the U.S. 1-minute average, meaning the highest wind that is sustained for one minute (MEMA, 2013). The Saffir/Simpson Scale described in Table 3.11 gives an overview of the wind speeds and range of damage caused by different hurricane categories. The Commonwealth has not been impacted by any Category 4 or 5 hurricanes; however, Category 3 storms have historically caused widespread flooding. In Berkshire County flooding tends to be the impact of greatest concern because hurricane-force winds here occur less often. Historical data show that most tropical storms and hurricanes that hit landfall in New England are seldom of hurricane force, and of those most are a category 1 hurricane. The category hurricanes that stand out are those from 1938, and 1954 (BRPC, 2012), and those resulted in devastating flooding. T. S. Irene in 2011 was the most destructive tropical storms in recent decades.

Table 3.11. Saffir/Simpson Scale

Scale No. (Category)	Winds (mph)	Potential Damage
Tropical Depression	< 38	NA
Tropical Storm	39-73	NA
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.

Source: BRPC, 2012.

Probability

Based on past reported hurricane and tropical storm data, the region can expect a tropical depression, storm or hurricane to cross the region every 14.5 years. However, the community may also be impacted by a tropical event whose path is outside of the region every 0.75 years. Based on past storm events and given that the center of the county is approximately 85 miles to the Long Island Sound and 115 miles to Boston Harbor, the Berkshires will continue to be impacted by hurricanes and tropical storms.

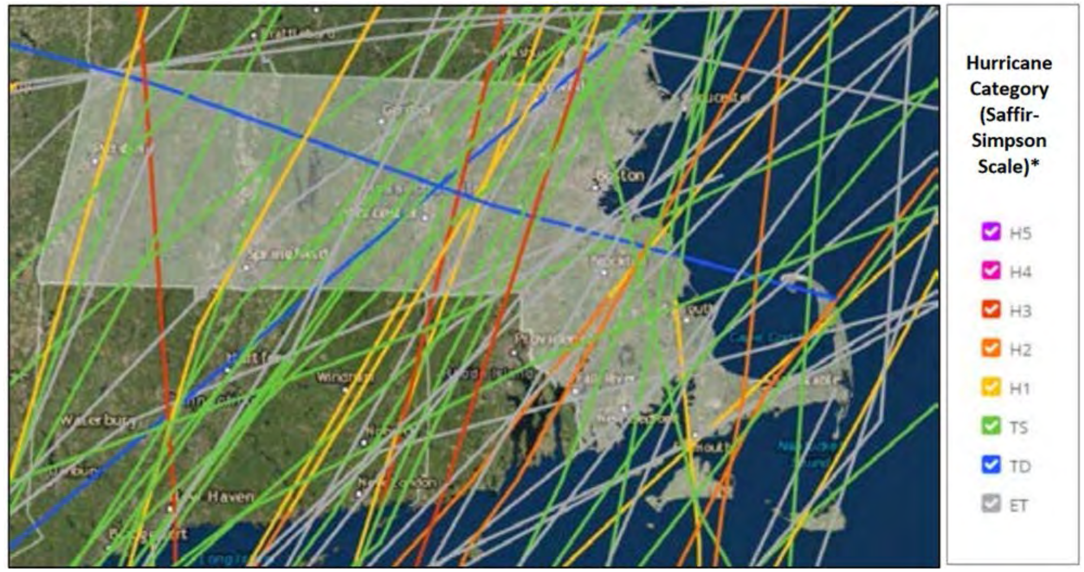
The NOAA Hurricane Research Division published a map showing the chance that a tropical storm or hurricane (of any intensity) will affect a given area during the hurricane season (June to November). This analysis was based on historical data from 1944 to 1999. Based on this analysis, the community has a 20-40% chance of a tropical storm or hurricane affecting the area each year (MEMA, 2013).

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.

Geographic Areas Likely Impacted

Otis and the Berkshire region are vulnerable to hurricanes and tropical storms, depending on each storm's track. 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. Historic storm tracks can be seen in the NOAA graphic, Figure 3.22. The graphic shows tropical storm tracks that have traveled through Massachusetts, where H = Hurricane, TS = Tropical Storm, and TD = Tropical Depression. In Otis, flooding along the Farmington River and Benton Brook, and washouts of gravel roads are areas most vulnerable to heavy rains that accompany these storms.

Figure 3.22: Historical Hurricane Paths within 65 miles of Massachusetts



Source: NOAA, as cited in MEMA & EOEEA, 2018

Historic Data

Although high winds are always of concern, it is the heavy rains and associated flooding that historically have caused the most injuries, deaths and damage in the Berkshire County region. The National Oceanic and Atmospheric Administration (NOAA) has been keeping records of hurricanes since 1842. From 1842 to 2018, there have been several tropical storms that passed directly through Berkshire County (see Fig. 3.22) and Table 3.12. The Great Hurricane of 1938 remains one of the most memorable historic storms, with almost seven inches of rain falling over a three-day period. The flooding from the Hoosic River caused severe damages in North Adams. In the Berkshires, two deaths occurred, many other people were injured, and 300 people were left homeless. The West Shaft Road bridge in North Adams was lost, as was the Wally Bridge in Williamstown.   The damages from this storm, following devastating flooding and damages from events in 1901, 1922, 1927 and 1936, and combined with that from a severe rain event in 1948, led to the construction of the flood control chutes on the Hoosic River in Adams and North Adams.

Hurricane Gloria caused extensive damage along the east coast of the U.S. and heavy rains and flooding in western Massachusetts in 1985. This event resulted in a federal disaster declaration (FEMA DR-751). In October 2005 the remnants of Tropical Storm Tammy followed by a subtropical depression produced significant rain and flooding across western Massachusetts. It was reported that between 9 and 11 inches of rain fell. The heavy rainfall washed out many roads in Hampshire and Franklin Counties. The Green River flooded a mobile home park in Greenfield, with at least 70 people left homeless. Following these events, the mobile home park was demolished, and the site was turned into a town park. Localized flooding in Berkshire County was widespread, with several road washouts. This series of storms resulted in a federal disaster declaration (FEMA DR-1614) and Massachusetts received over $13 million in individual and public assistance (MEMA, 2013).

Table 3.12. Tropical Depressions, Storms and Hurricanes Impacting Berkshire County

Name	Category	Date
Not Named	Tropical Depression	8/17/1867
Unnamed	Tropical Storm	9/19/1876
Unnamed	Tropical Depression	10/24/1878
Unnamed	Category 1 Hurricane	8/24/1893
Unnamed	Tropical Storm	8/29/1893
Unnamed	Tropical Depression	11/1/1899
Unnamed	Tropical Depression	9/30/1924
Unnamed	Category 2 Hurricane	9/21/1938
Able	Tropical Storm	9/1/1952
Gracie	Tropical Depression	10/1/1959
Doria	Tropical Storm	8/28/1971
Irene	Tropical Storm	8/28/2011
Sandy	Hurricane	10/30/2012

Source: NOAA, MEMA & EOEEA, 2018.

Tropical Storm Irene (August 27-29, 2011) produced significant amounts of rain, storm surge, inland and coastal flooding, and wind damage across southern New England and much of the east coast of the U.S. In Massachusetts, rainfall totals ranged between 0.03 inches (Nantucket Memorial Airport) to 9.92 inches (Conway, MA). Wind speeds in Massachusetts ranged between 46 and 67 mph. These heavy rains caused flooding throughout the Commonwealth and a presidential disaster was declared (FEMA DR-4028). The Commonwealth received over $31 million in individual and public assistance from FEMA. (MEMA, 2013)

Locally in Otis, heavy rains during T.S. Irene caused the most extensive flooding in many decades, with the Farmington River overflowing its banks and flooding South Main Street (Rt. 8) and adjacent properties. Floodwaters were six to seven feet deep along the road corridor. The floodwaters caused the closing of the road for several days and forced the evacuation of several residents, some of which had to be moved in boats with the help of the Otis Fire Department volunteers. Also during this storm event the Reservoir Road bridge was damaged and closed. Monterey Road (Rt. 23) road was also closed, as the culverts were overwhelmed and the road was eroded and began to fail.

Regionally, TS Irene (DR-4028-MA) is the most memorable storm event in recent history due to the flooding that occurred in northern Berkshire and Franklin Counties in Massachusetts, and in southern Vermont. It caused flood levels equal to or greater than a 100-year flood event in Williamstown and North Adams. In Williamstown 225 mobile home households, many elderly and low income, permanently lost their homes in the Spruces Mobile Home Park. Extensive flooding in the Deerfield River watershed caused, among other damages, the closing of Route 2 in Florida/Charlemont (due to collapse of the road and a landslide) and damages to structures in Shelburne Falls. Immediately after this even the USGS recorded flood levels and recalculated and red-delineated the boundaries for the 100-year floodplain for the Hoosic River as it flows through portions of North Adams and Williamstown. This is one of the very few areas where floodplain maps have been updated since the 1980s.

Hurricane Sandy, in late October 2012, was another notable severe storm that caused damages. The impacts from this storm were unusual, in that it was the high winds, not flooding, that caused damages. According to articles in the local Berkshire Eagle newspaper, the NWS reported a 61-mph wind gust in Otis, with similar gusts of 58 mph at the Pittsfield Airport. County-wide approximately 5,000 electricity customers were without power. Approximately 40-70% of Otis residents were without power for a day or two due to downed power lines, and restoration of power was severely hampered by the significant amount of trees and limbs that littered the roads and power line corridors.[13]

Vulnerability Assessment

People

It is believed that the only fatalities that occurred due to tropical storms in Berkshire County was during the hurricane of 1938, and those were from flooding, not high winds. Otis first responders report that 10-20 families along South Main Street had to be evacuated during T.S. Irene, the first time in memory that floodwaters were that deep and extensive. No deaths or serious injuries were reported.

High winds from tropical storms and hurricanes can knock down trees, limbs and electric lines, can damage buildings, and send debris flying, leading to injury or loss of life. Economically distressed, elderly and other vulnerable populations are most susceptible, based on several factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Findings reveal that human behavior contributes to flood fatality occurrences, and this was seen during flooding of The Spruces in Williamstown when some residents only left their homes when forcibly removed by emergency personnel. 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 such as near the railroad tracks, town garage, or transfer station.

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 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 (MEMA & EOEEA, 2018).

[13] *Dobrowski, Tony. Berkshire County escapes major damage from Hurricane Sandy, Berkshire Eagle, 10-31-12.*

Built Environment

Hurricanes and tropical storms can destroy homes with wind, flooding, or even fire that results from the destructive forces of the storm. Critical facilities are mostly impacted during a hurricane by flooding, and these impacts are discussed in the flooding section of this plan. Wind-related damages from downed trees, limbs, electricity lines and communications systems would be at risk during high winds. 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. Heavy rains can lead to contamination of well water and can release contaminants from septic systems (DPH, 2014 as cited in MEMA & EOEEA, 2018). Additionally, 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.

Several residential, commercial and industrial buildings were destroyed during the floods of 1938, 1949 and 1955 in northern Berkshire County during tropical storm events. Most recently the full destruction and permanent removal of all homes in The Spruces mobile home park in Williamstown demonstrates the vulnerability of structures due to flooding.

Natural Environment

The environmental impacts of hurricanes and tropical storms are similar to those described for other hazards, including inland flooding, severe winter storms and other severe weather events. 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, 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. Invasive aquatic species and floodplain species such as knotweed are readily dispersed when plant fragments are transported by floodwaters. If the storm spreads pollutants into natural ecosystems, contamination can disrupt food and water supplies, causing widespread and long-term population impacts on species in the area.

Economy

Hurricane/tropical storm events can greatly impact the economy, including loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Due to the wind and water damage, and transportation issues that result, the impact to the economy can potentially be very high. The Commonwealth received over $31 million in individual and public assistance from FEMA during presidential disaster declared (FEMA DR4028) for T.S. Irene in 2011 (MEMA & EOEEA, 2018). Regional storm impacts are discussed in more detail in the Inland Flooding section of this plan.

Future conditions

The Northeast has been experiencing more frequent days with temperatures above 90°F, increasing sea surface temperatures and sea levels, changes in precipitation patterns and amounts, and alterations in hydrological patterns. According to the Massachusetts Climate Change Adaptation Report, large storm events are becoming more frequent. Although there is still some level of uncertainty, research indicates the warming climate may double the frequency of Category 4 and 5 hurricanes by the end of the century and decrease the frequency of less severe hurricane events. The 2020 Atlantic hurricane season closed with a record-breaking 30 named storms and 12 landfalling storms in the continental United States. The season surpassed the 28 named storms from 2005, with the second-highest number of hurricanes on record. This is the fifth consecutive year with an above-normal Atlantic hurricane season, with 18 above-normal seasons out of the past 26. This increased hurricane activity is attributed to the warm phase of the Atlantic Multi-Decadal Oscillation — which began in 1995 — and has favored more, stronger, and longer-lasting storms since that time. Such active eras for Atlantic hurricanes have historically lasted about 25 to 40 years. [14]

[14] *NOAA, at https://www.noaa.gov/media-release/record-breaking-atlantic-hurricane-season-draws-to-end*

Severe High Winds and Thunderstorms

Hazard Profile

High winds and thunderstorms occur outside of notable storm events, but still can cause significant damages. These events primarily include high winds and thunderstorms. Otis, like other Berkshire County communities, has experienced numerous thunderstorms and high wind events including microbursts. Wind is air in motion relative to the surface of the earth. 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 (MEMA & EOEEA, 2018).

Likely Severity

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. Massachusetts is susceptible to high winds from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Sometimes, wind gusts of only 40 to 45 mph can cause scattered power outages from downed trees and wires. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations that can weaken the root systems and make them more susceptible to the winds' effects. Winds measuring less than 30 mph are not considered to be hazardous under most circumstances.

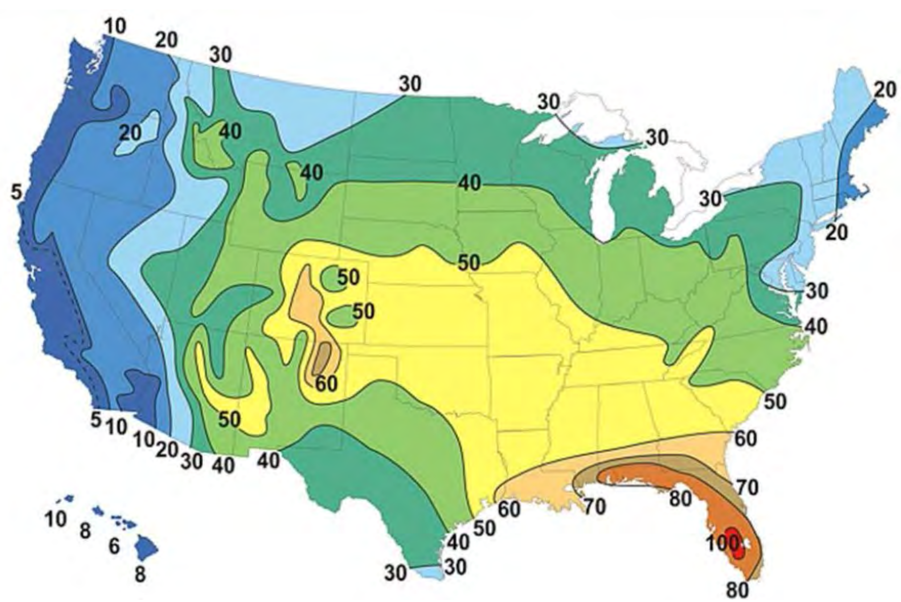
A thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013). The severity of thunderstorms can vary widely, from commonplace and short-term events to large-scale storms that result in direct damage and flooding. Widespread flooding is 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 (MEMA & EOEEA, 2018).

Probability

Over a ten-year period (January 1, 2008 through December 31, 2017), a total of 435 high wind events occurred in Massachusetts for an annual average of 43.5 events occurred per year. High winds are defined by NWS as sustained non-convective winds of 35 knots or greater (~40 mph) or lasting for one hour or longer, or gusts of 50 knots or greater (58 mph) for any duration (NCDC, 2018). However, many of these events may have occurred as a result of the same weather system, so this count may overestimate the frequency of this hazard. 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.

Three basic components are required for a thunderstorm to form: moisture, rising unstable air, and a lifting mechanism. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise—by hills or mountains, or areas where warm/cold or wet/dry air bump together causing a rising motion—it will continue to rise as long as it weighs less and stays warmer than the air around it. As the warm surface air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool, releasing the heat, and the vapor condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both have electrical charges. When a sufficient charge builds up, the energy is discharged in a bolt of lightning, which causes the sound waves we hear as thunder. An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms (MEMA & EOEEA, 2018).

Figure 3.23: Annual Average Number of Thunderstorm Days in the U.S.



Source: NOAA NWS, MEMA & EOEEA, 2018.

Lightning strikes primarily occur during the summer months. According to NOAA, there has been one fatality and 43 injuries as a result of lightning events from 1993 and 2012 in the Commonwealth (NCDC, 2012). Although thunderstorms with lightening may increase due to a more volatile atmosphere, the chance of death or injury is likely to remain low

Geographic Areas Likely Impacted

All of Otis is vulnerable to high winds that can cause extensive damage. Even more so than high wind, thunderstorms have the potential of impacting residents and infrastructure. Microbursts can also occur anywhere associated with thunderstorms.

Historic Data

It is difficult to define the number of other severe weather events experienced by Otis each year. Figure 3.23 shows number of annual thunderstorm days across the United States. According to a map created by NOAA and NWS, and featured in the SHMCAP, Western Massachusetts experiences approximately 30 thunderstorm days each year.

Microbursts occur throughout Berkshire County, downing trees, utility lines and sometimes causing damage to property. Otis has experienced microbursts, but to date these have resulted in limited tree or utility damages. In the Berkshires microbursts are often accompanied by heavy rainfall that can cause additional damage from flooding. According to news media reports, several recent thunderstorm/microburst events have caused damages in the communities of Williamstown, North Adams, Cheshire, Lanesborough, Pittsfield, Lee, and Stockbridge. Figure 3.24 shows microburst damage in Cheshire, Berkshire County, in 2016.

Fig. 3.24. Microburst damage in Cheshire, 7-18-16

Vulnerability Assessment

People

The entire population of Otis 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. An event that struck Pittsfield and other central Berkshire communities in July 2011 caused extensive damage and was responsible for the death of a man in Hinsdale who was struck by a falling utility pole. WMECO called in 339 out-of-state work electric crews and 14 out-of-state tree crews to remove trees and repair damaged lines.[15]

The most common problem associated with severe weather is loss of utilities. Severe windstorms causing downed trees can create serious impacts on electricity 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 systems and cause loss of electricity to power oxygen and other life-sustaining equipment. Downed wires can create the risk of fire, electrocution, or an explosion. People who work or engage in recreation outdoors are also vulnerable to severe weather, including downed live wires or lighting strikes.

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

[15] *McKeever, Andy, 1-27-11. "Pittsfield Slammed by Surprise Microburst Storm," iBerkshires.*

isolation of these populations is a significant concern. 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.

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 (Andrews, 2012). 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 (UG, 2017). 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 (MA SHMCAP, 2018).

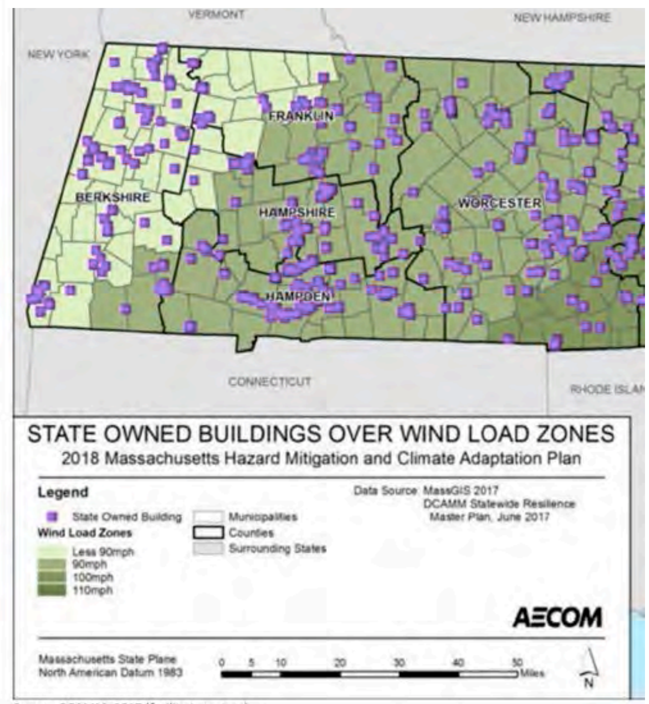
Built Environment

All elements of the built environment are exposed to severe weather events such as high winds and thunderstorms. Damage to buildings is dependent upon several factors, including wind speed, storm duration, path of the storm track, and building construction. The state is divided into four risk categories, the limits of which are defined by the Massachusetts State Building Code (9th Ed.). National wind data prepared by the American Society of Civil Engineers serve as the basis of these wind design. Generally speaking, structures should be designed to withstand the total wind load of their location. Massachusetts used these load zone determinations to determine risk to state facilities from wind hazards, and this map shows that Otis is located in the second lowest load zone set at 90 mph (see Fig. 3.25).

Public safety facilities and equipment may experience a direct loss (damage) from high winds. Roads may become impassable due to flash flooding, 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 and sewer systems may not function if power is lost (MEMA & EOEEA, 2018).

Source: MEMA & EOEEA, 2018.

Fig. 3.25. Wind Load Zones for Massachusetts According to MA State Building Code



Source: DCAMM, 2017 (facility inventory)

Natural Environment

As described under other hazards, such as hurricanes and nor'easters, 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 Section 4.1.1 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 (MEMA & EOEEA, 2018).

Economy

Agricultural losses due to lightning and the resulting fires can be extensive. Forestry species and agricultural crops, equipment, and infrastructure may be directly impacted by high winds. Trees are also vulnerable to lightning strikes.

According to the NOAA's Technical Paper on Lightning Fatalities, Injuries, and Damage Reports in the U.S. from 1959 to 1994, monetary losses for lightning events range from less than $50 to greater than $5 million (the larger losses are associated with forest fires, with homes destroyed, and with crop loss) (NOAA, 1997). 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 (MEMA & EOEEA, 2018).

Future Conditions

Research into the impact of climate change on severe storms such as thunderstorms has looked at the impact of the increased convective available potential energy (CAPE) on frequency and intensity of storms, and a decrease in wind shear as the Artic warms. Some studies show no change in the number of storms, but an increase in intensity due to more energy and evaporated moisture available to fuel storms. Other studies have shown an increase in the number and intensity of storms because the increase in CAPE compensated for a decrease in wind shear[16]. We can expect greater impacts of severe storms in the region while the exact changes are still being determined. Educating residents to be prepared emergency situations where loss of electricity occurs and maintaining an emergency communications system that can be used to reach isolated residents during power outages will become more important, especially to meet the needs of an increasingly elderly population.

[16] *https://earthobservatory.nasa.gov/features/ClimateStorms*

Dam Failure

Hazard Profile

Likely severity

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. The height of the dam is determined by the height of the dam at the maximum water storage elevation. The storage capacity of the dam is the volume of water contained in the impoundment at maximum water storage elevation. Size class may be determined by either storage or height, whichever gives the larger size classification.

Table 3.13: Dam Size Classification

Category	Storage (acre-feet)	Height (feet)
Small	>= 15 and <50	>= 6 and <15
Intermediate	>= 50 and <1000	>= 15 and <40
Large	>= 1000	>= 40

The classification for potential hazard shall be in accordance with table 3.14. The Hazard Potential Classification rating pertains to potential loss of human life or property damage in the event of failure or improper operation of the dam or appurtenant works. The hazard potential classification for a dam has no relationship to the current structural integrity, operational status, flood routing capability, or safety condition of the dam or its appurtenances[17]. Poor condition indicates a dam that presents a significant risk to public safety due to deficiencies such as significant seepage, erosion or sink holes, cracking of structural elements, or vegetation undermining the structural stability of the dam. In Massachusetts the Office of Dam Safety is the regulating authority that oversees dam safety.

Table 3.14: Dam Hazard Potential Classification

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

[17] *https://www.mass.gov/files/documents/2017/10/30/302cmr10.pdf*

Probable future development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification. Even dams which, theoretically, would pose little threat under normal circumstances can overspill or fail under the stress of a cataclysmic event such as an earthquake or sabotage.

Dam owners are legally responsible for having their dams inspected on a regular basis. High hazard dams must be inspected every two years, Significant Hazard dams must be inspected every five years, and Low Hazard dams must be inspected every 10 years. In addition, owners of High Hazard dams must develop Emergency Action Plans (EAPs) that outline the activities that would occur if the dam failed or appeared to be failing. Owners of Significant Hazard dams are strongly encouraged to also develop EAPs. The Plan would include a notification flow chart, list of response personnel and their responsibilities, a map of the inundation area that would be impacted, and a procedure for warning and evacuating local residents in the inundation area. The EAP must be filed with local and state emergency agencies (BRPC, 2012).

Probability

Dam failures, which are defined as uncontrolled releases of impounded water due to structural deficiencies in the dam, can occur due to heavy rain events and/or unusually high runoff events (MEMA, 2013). Severe flooding can threaten the functionality or structural integrity of dams. Factors that contribute to dam failure include design flaw, age, over-capacity stress and lack of maintenance (BRPC, 2012). Maintenance, or the lack thereof, is a serious concern for many Berkshire communities. By law dam owners are responsible for the proper maintenance of their dams. If a dam were to fail and cause flooding downstream, the dam owner would be liable for damages and loss of life that were a result of the failure.

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

There are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what the dam was designed to handle. For example, more extreme precipitation events could increase the frequency of intentional discharges. Many other climate impacts—including shifts in seasonal and geographic rainfall patterns—could also cause the flow behavior of rivers to deviate from previous hydrographs. When flows are greater than expected, spillway overflow events (often referred to as “design failures”) can occur. These overflows result in increased discharges downstream and increased flooding potential. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures (MEMA & EOEEA, 2018).

Table 3.15 lists the dams that are located in Otis, providing a summary of Hazard Code, condition and location. The Hazard Code information was received from Office of Dam Safety records dated 2004, as were the Inspection Condition. As such, the condition of the dams may not reflect current dam conditions. Inspection dates were obtained from USACOE data 2018. The location of the dams is found on the Critical Facilities Map (Fig. 3.2, found in the early pages of Section 3 of this plan).

The Otis Reservoir dam is the only High Hazard dam in Otis. Big Pond, which has its own dam, flows into Otis Reservoir. The Otis Reservoir dam was rehabilitated in 2012, in which new safety measures were installed within the dam and appurtenant structures. An inspection of the dam system following the rehabilitation project categorized the dam as being in Satisfactory condition. According to a 2018 database of dam information, a newer inspection in 2017 found the dam's condition to be in Fair condition.

Table 3.15: Dam Hazard Status for Otis

Name and Year Completed	Hazard Code	Size Class	Owner	Location
Big Pond Dam, 1973	Low	Non-jurisdictional	MA Dept. Cons. & Rec.	Big Pond Dam off Blandford Road
Hayden Pond Dam, 1886	Significant	Intermediate	Daniel Burack	Hayden Pond off Ed Jones Road
Hayes Pond Dam, 1840	Low	Small	Linda Penn	Hayes Pond off Long Mountain Road
Otis Reservoir Dam, 1888, 2012	High	Large	MA Dept. Cons. & Rec.	Otis Reservoir off Tolland Road
Royal (Acres) Pond Dam, 1920	Low	Non-jurisdictional	Unknown	Royal Pond off Monterey Road
The Creek Dam (Watson Pond), 1920	Low	Intermediate	Watson Pond Assoc., Inc.	Watson Pond off Lee Westfield Road
White Lily Pond Dam, 1965	Low	Intermediate	White Lily Pond Assoc., Inc.	White Lily Pond off Lee Westfield Road
Owl Lake dam	Significant	Intermediate	Otis Woodlands Club, Inc.	Lakeshore Drive off South Main Road

Source: BRPC, 2021.

Historic Data

Historically, dam failure has had a low occurrence in Berkshire County. However, it is a hazard that has been one of the most deadly. The deaths occurred during two dam failures in East Lee, from dams that impounded the same pond. On April 20, 1886 the Basin Pond dam breached and flooded East Lee, killing seven people and damaging almost every house along the Basin Pond Brook corridor on Water and Cape Streets. In 1965 a developer constructed a new dam at Basin Pond, and that one breached in March 1968, killing one person and damaging buildings along the brook corridor. The floodwaters damaged the Clarke Aiken paper mill to the point where it was demolished and the site abandoned, causing the loss of a key local employer.

In September 2004 an incident occurred at the Plunkett Lake dam in Hinsdale, a few towns north of Otis. On September 18, 2004, after the effects of Hurricane Ivan dropped more than three inches of rain on the area in 24 hours, the flash boards at the Plunkett Lake dam gave way. The Emergency Management Director for Hinsdale calculated that approximately 8 million gallons of water flooded the Housatonic River downstream of the lake, causing some minor flooding. There was no permanent damage or real estate damage, but the CSX rail line was undermined in the Hinsdale Flats area. This was largely due to beaver activity, where culverts were partially plugged; impeding and redirecting flood waters (BRPC, 2012).

In Otis, flood damages occurred to Reservoir Road when staff at DCR, the dam owner, was testing the dam gate and was not able to get it back in place as quickly as needed. The high volume of released water caused a large tree to fall into the stream and blocked the culverts, damaging and undermining a section of the road. The three six-foot culverts were not able to handle large volumes of water. The Town is currently looking into installing a full-span bridge that would meet the state stream crossing standards, which, although costly, would provide better long-term protection against dam releases.

Vulnerability Assessment

People

All populations in a dam failure inundation zone would be exposed to the risk of a dam failure. The potential for loss of life is affected by severity of the dam failure, the warning time, the capacity of dam owners and emergency personnel to alert the public and the capacity and number of evacuation routes available to populations living in areas of potential inundation. There is often limited warning time for a dam failure event. While dam failure is rare, when events do occur, they are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event from a television, radio or phone emergency warning system are highly vulnerable to this hazard. This population includes the elderly, young, and large groups of people who may be unable to get themselves out of the inundation area (MEMA & EOEEA, 2013).

High Hazard Dam owners are required to develop Emergency Action Plans (EAPs). The EAP describes the role and responsibility of the dam owner regarding public safety and lays out protocols that the owner should take in the event that an emergency situation should occur at the dam. The EAP defines emergency situations as conditions which have or could potentially lead to a sudden, uncontrolled release of water caused by failure of the dam. The Otis Reservoir EAP of 2013 includes an inundation map that shows how extensive flooding could be under certain failure scenarios, and estimates the timing when floodwaters might be expected to hit after the start of the failure. This inundation map was used as a basis for estimating potential damages during a worst-case scenario, which is a complete failure of the dam during a wet weather event. This EAP does not list property owner contact information for the properties within the inundation area, as some other EAPs have done for high hazard dams in the Berkshires. This list would be extremely helpful to local first responders who would be responsible for undertaking necessary evacuations.

A worst-case dam failure would flood the area around Larkum Pond, including the lower area of the Berkshire Soccer Camp, where its buildings near the lake could be flooded. Within nine minutes of a complete failure, flash flooding of Reservoir Road could start and within 33 minutes at its peak could be under 10-15 feet of water due to the flooding of Fall River, the outlet stream for Otis Reservoir. The length of the road would be flooded to its intersection of South Main Street (Rt.8). South Main Street itself would be flooded and likely unpassable for more than a mile within Otis and for several miles downstream in Sandisfield.

The entire Cold Spring Campground is within the inundation area of Otis Reservoir dam. South Main Street (Rt. 8), which is the campground's only transportation access, would likely be inundated upstream to the north, and thus unusable for evacuation of campers. Floodwaters are estimated to reach the area just upstream of the campground after 15 minutes of the dam failure, with peak floodwaters reaching the area in about 36 minutes. Water here is estimated to be 10-15 feet deep at peak flood stage.

Built Environment

All structures, critical facilities and transportation infrastructures in the dam failure inundation zone are vulnerable to damage. Flood waters may also potentially cut off evacuation routes, limit emergency access, and destroy power lines and communication infrastructure. South Main Street is a main north-south transportation route for people and commerce for all the communities along its corridor. In the worst-case scenario of a dam failure at Otis Reservoir dam, this route could be under 10-15 feet of water for several miles of its length and this could cut off emergency routes and delivery to all residents along this roadway. Many stretches of this section of road have no intersecting road, delaying emergency response even more. Intensive floodwaters could also damage or destroy power lines that run along the corridor. Fortunately, the Town's critical infrastructure (governmental operations, emergency response facilities, wastewater treatment) is not within the Otis Reservoir dam inundation area.

Natural environment

A dam failure would cause significant destruction to the natural environment. Before the dam changed the volume and area of water that would flow downstream of the dam, only vegetation able to withstand inundation would grow where the water flowed or saturated soils. Dam failure would likely cause the accumulation of downed trees and debris downstream including at culverts and bridges leading to further damage.

Economy

Damage to buildings and infrastructure can impact a community's economy and tax base. Buildings and property located within or closest to the dam inundation areas have the greatest potential to experience the largest, most destructive surge of water. The damage or loss of South Main Street resulting from flood waters from the worst-case scenario dam failure at Otis Reservoir would be devastating to residents and businesses who rely on this route for commuting and commerce. The repercussions of loss of this road would extend much farther than Otis due to the volume of trucks and goods that are transported over this route. Detours would likely add be extensive due to the rural nature of this region, adding substantial time and mileage to all commercial haulers who use the route.

Future Conditions

According to MEMA, dams are designed partly based on assumptions about a river's or pond'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 severe rain events cause hydrographic 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. If the number of severe storms increases, or becomes the new norm, early releases of water will impact lands and waterways downstream more often.

Dams are constructed with safety features such as spillways and lower level outlets to allow release of additional water discharges. 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 may not increase the probability of catastrophic dam failure, it may increase the probability of design failures (MEMA, 2013).

If climate change results in a greater number of severe precipitation events and shortens recurrence intervals them, as is predicted, it will require dam operators to become more vigilant in monitoring precipitation and temperature patterns. Individual rain events, particularly if occurring during periods of saturated or frozen soils that cannot absorb rainfall, may require that dam operators open spillways, flashboards and other safety features more often, causing a greater number of high discharge events and possible flooding on properties downstream of the dam.

Invasive Species and Forest Pests

Hazard Profile

The Town of Otis chose to examine the hazard of both plant and animal invasive species. Invasive species are a widespread problem in Massachusetts and throughout the country. The damage rendered by invasive species can be significant. The Massachusetts Invasive Plant Advisory Group (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. MIPAG is a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by EOEEA to provide recommendations to the Commonwealth to manage invasive species of plants. 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. Uncontrolled growth of invasive species can alter soils, increase erosion, and reduce habitat value for native wildlife. Early detection and rapid response are key components to successful invasive species control.

Likely Severity

The damage rendered by invasive species is significant. Experts estimate that about 3 million acres within the U.S. (an area twice the size of Delaware) are lost each year to invasive plants (from Mass.gov “Invasive Plant Facts”). The massive scope of this hazard means that the entire Commonwealth experiences 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, both on land and in aquatic systems. Areas with high amounts of plant or animal life may be at higher risk of exposure to invasive species than less vegetated urban areas; however, invasive species can disrupt ecosystems of all kinds (MEMA & EEA, 2018). Because plant and animal life is so abundant throughout Otis and the Berkshire region, the entire area is considered to be at high risk of invasive species infestation.

Probability

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, although Massachusetts has established prohibition on the propagation and sale of many invasive plant species. Invasive species can also be spread by animals, people, equipment and machines as they travel through the region’s landscape and waterways. Hikers, mountain bikers, ATVs and boaters can unwittingly spread invasive species if they travel from an infested area to a non-infested areas. As outdoor recreational tourism continues to increase in the Berkshires, this risk will also increase.

Several natural hazards increase the risk of invasive species spreading beyond their current ranges. Many invasive plant species are readily uprooted, transported and/or distributed to new areas during flood events. Plant fragments and seeds from semi-aquatic and aquatic plants such as Japanese knotweed, purple loosestrife, common reed, water chestnut, Eurasian water milfoil and curly leaf pondweed are spread in this fashion. Berries and seeds from terrestrial invasive plants are also distributed in this way, particularly if they are found in along river corridors or floodplain areas. Wind or ice storms that fragment or open up the tree canopy of forested landscapes can damage or stress the remaining trees and create the temporary conditions that allow invasive species to take hold and suppress regeneration of native trees.

The same wind storm that damaged the tree canopy may be the mechanism by which dispersal of invasive plant seeds arrive in the damaged forest. Wildfires in the Berkshires are typically surface fires, burning forest duff and damaging/killing seedlings and ground forbs. The die-back of plants on the forest floor temporarily could open the way for invasive understory species to take hold, such as honeysuckles species, buckthorn species, bittersweet and hardy kiwi vine. The risk of invasive infestation increases if the burned area is in close proximity to (and particularly downwind of) existing invasive species populations and seed sources. Risk if further increased if hikers and mountain bikers track seeds or plant fragments from the infested area prior to traveling through the burned site.

The risk of forest pests is dependent on their life cycle, their ability to disperse and the abundance of their preferred food source. The emerald ash borer is a very capable flyer, allowing it to move easily through the Berkshire landscape that is well endowed with ash tree species.

Risk of invasive aquatic species infestation from one riverine, pond and lake ecosystem to another is largely due to human activity, although transport and distribution by birds and mammals is also possible. Plant fragments and seeds, and aquatic animals, easily travel from one water body to another via kayak, canoes, boats and equipment, including waders. Big Pond, Otis Reservoir and several other ponds in Otis are publicly accessible waterbodies, and the many private shoreline homes all have access, putting the lake at high risk of being infested with invasive aquatic plant species. As water recreational activity increases, so too will the risk of infestation.

Geographic Areas Likely Impacted

All of Otis and the surrounding region is at risk of invasive species, including its lakes and ponds. Roadside ash trees are rapidly being infected and dying, increasing risk of limbs or trees falling onto adjacent properties or into the road and oncoming traffic. Japanese knotweed has proliferated and continues to spread along West Main Street, making monitoring and maintenance of road drainage systems more difficult. Ash trees infested with emerald ash borers are found throughout Otis, with the greatest risk along roadways and utility lines.

Invasive aquatic plant species threaten the ecology of the many ponds in Otis, including recreational ponds that draw visitors, seasonal homeowners and businesses to the Town.

Historic Data

Invasive species are a human-caused hazard, often resulting from release of foreign species brought into the country by the landscaping industry and pet trade. Invasive species are also inadvertently released when they escape from wood or produce products or from being unwittingly transported in shipping containers. 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.

Addressing the issue of propagating and selling of invasive plants within the landscaping nursery industry began in the 1990s. MIPAG conducted field research to determine the most invasive plant species in the region, and in 2005 published its first list of plants designated as invasive or likely to be invasive in Massachusetts. Out of this list emerged a list of plants for which importation and propagation is currently prohibited within the state of Massachusetts. The sale, trade, purchase, distribution and related activities for these species, including all cultivars, varieties and hybrids, are not allowed. The latest list, revised in 2017, includes 140 species. The full list can be viewed at this site: https://www.mass.gov/doc/prohibited-plant-list-sorted-by-common-name/download. Active links to details on each species is found on this site.

Fig. 3.26. Example of Japanese knotweed infestation in bloom

Source: Tom Heutte, USDA Forest Service, www.invasives.org.

As with many invasive plants, Japanese knotweed thrives in disturbed areas and once established can spread rapidly, creating monoculture stands that shade out and threaten native plant communities. Japanese knotweed can tolerate deep shade, high temperatures, high soil salinity and drought. It is commonly found along streams and rivers, in low-lying areas, disturbed areas such as rights-of-way, and around old home and farmsteads. The plant's shoots come up from a network of spreading rhizomes. These horizontal roots can reach lengths of 65 feet or more. Japanese knotweed has branched sprays of small greenish-white flowers from August to September. Although they have complementary male and female organs, those organs are vestigial and the flowers function unisexually. Japanese knotweed spreads primarily by seed (transported by wind, water, animals, humans, or as a soil contaminant), stem fragments, and by shoots sprouting from its system of rhizomes. [18]

[18] *http://nyis.info/invasive_species/japanese-knotweed/, based on USDA Forest Service Database.*

Forests damage from insect and other pests can be extensive, and many of these are invasive species from other continents or other regions of the U.S. According to the 2020 Massachusetts State Forest Action Plan, the annual tree canopy damage from insects and diseases in Massachusetts ranged from 23,563 acres in 2012 to 939,051 acres in 2017. The average annual area of canopy damage was 201,681 acres (about 6% of total forest area) between 2009 and 2018. The three primary agents of canopy damage in total over that period were gypsy moth (1,481,115 acres), winter moth (300,571 acres), and weather events such as snow, ice, wind, tornado, frost, or hail (75,244 acres). Table 3.16 summarizes the most serious infestations facing Western Massachusetts forests.

Table 3.16. Current Invasive and Nuisance Insect Threats to Otis Forests

Insect	Origin	Host Trees	DCR-Management Approach
Gypsy Moth	Introduced	Oaks, other deciduous species	Discovered in 1869, current management relies on natural population controls: naturally abundant virus and fungus populations regulate gypsy moth population cycles.
Winter Moth	Introduced	Maples, oaks, other deciduous trees (fruit)	Identified in state in 2003, it was introduced to Canada in the 1930s; a biocontrol species has been released and successfully established to manage populations in eastern MA.
Hemlock Woolly Adelgid	Introduced	Eastern hemlock	Discovered in 1989, two biocontrol species have been released in MA to limited establishment success.
Southern Pine Beetle	Native	Pitch pine	Population densities monitored through annual trapping; the impacts of climate change could significantly alter generation periods and devastate pitch pine stands.
Emerald Ash Borer	Introduced	All ash species	Discovered in 2012, three biocontrol species, were successfully released in MA; continued releases are planned.
White Pine Needlecast	Native	Eastern white pines	Needlecast has been identified to be caused by multiple fungal pathogens; white pine defoliation is being monitored across the state.
Red Pine Scale	Introduced	Red pine	Control with insecticides has not been successful and natural enemies are ineffective in reducing the population.

Sources: https://www.mass.gov/service-details/current-forest-health-threats; MA State Forest Action Plan 2020.

As of 2014, White Ash was the 7th most common forest tree in the state, with the highest density of ash tree species residing in Berkshire County. As such it is a major component of our northern hardwood forests. The Emerald Ash Borer (EAB) was first discovered in Massachusetts in Dalton, in central Berkshire County, in 2012. Since then, it has been detected in every community in Berkshire County, with the exception of Otis and New Marlborough. However, it has been detected in every town surrounding Otis in the years 2019 and 2020, so it is likely that Otis the pest will be detected here within a year or two. As of January 2021, EAB can be found in 169 communities throughout the state, as well as all five other New England states.

Fig. 3.29. Hemlock Woolly Adelgid Infestation

Warmer winter temperatures are raising the survival rates of some insect pests and allowing them to expand their range. The Hemlock Woolly Adelgid is an insect that kills Eastern Hemlocks. This insect has been expanding northward, having crossed into the Housatonic River Valley from Connecticut in the early 2000s. In the Berkshires, hemlocks are valuable because they survive along steep ravines and help to hold soil in place. Streams within hemlock forests have a greater diversity of aquatic invertebrates to support fish as compared to those within hardwood forests. Native brook trout are three times more likely to be found in streams surrounded by hemlock, which provide cooler water temperatures and more stable flows.

Fig. 3.27. Top: EAB Adult
Fig. 3.28. Bottom: Damage done by EAB larvae under tree bark

Vulnerability Assessment

People

Aside from toxic species such as giant hogweed, which can cause severe burns if handled, 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. Those who rely on natural systems for their livelihood, such as timber production, or mental and emotional well-being are more likely to experience negative repercussions from the expansion of invasive species.

Built Environment

Figs. 3.30, 3.31. Below: EAB-infested trees along Robinson Road in neighboring Hinsdale MA in 2021. Left: close up of one of the trees; note the lightened, dead bark. Dead trees (dead crowns) and dying trees pose a risk to the power lines and transportation.

Source: BRPC, 2021.

Mature roadside trees provide natural and cultural benefits to the community, creating the rural New England landscape that defines the region. Trees help to hold roadside soils in place and can act as windbreaks. Accelerated die-back of roadside trees can occur due to invasive pests such as the EAB, or stressed and pulled down by prolific invasive vines such as bittersweet. Damage and die-off of these trees present increased risk to homeowners who live in close proximity, to utility lines and to travelers who frequent the roads they are located on. Buildings are expected to be directly impacted by invasive species under circumstances similar to our roadways. An example of such risk can be seen in Figures 3.30-3.31, where a line of several ash trees stand dead and dying along Robinson Road in Hinsdale, MA, posing a risk to electricity lines and the travel way. This area is a few towns north of Otis on Route 8. Infested trees can be spotted by the lighter and peeling bark, where the EAB has killed underlying tissue, and the die-back and eventual death of the crown.

Facilities that rely on native species, biodiversity or the health of surrounding ecosystems, such as outdoor recreation areas, public or botanical gardens or agricultural/forestry operations, could be more vulnerable to impacts from invasive species.

Natural Environment

Invasive species can trigger a wide-ranging cascade of lost ecosystem services. Additionally, they can reduce the resilience of ecosystems to future hazards by placing a constant stress on the system (MEMA & EOEEA, 2018). A 1998 study found that competition or predation by alien species is the second most significant threat to biodiversity, only surpassed by direct habitat destruction or degradation (Wilcove et al., 1998).

An analysis of threats to endangered and threatened species in the U.S. indicates that invasive species are implicated in the decline of 42% of the endangered and threatened species. In 18% of the cases, invasive species were listed as the primary cause of the species being threatened, whereas in 24% of the cases they were identified as a contributing factor (Somers, 2016). This indicates that invasive species present a significant threat to the environment and natural resources in the Commonwealth.

Aquatic invasive species pose a particular threat to water bodies. In addition to threatening individual native species, they can degrade water quality and wildlife habitat. Prolific growth and mass die-off of plant stems and leaves consumes oxygen, leading to lower levels that stress native aquatic animal populations and can lead to fish kills. Impacts of aquatic invasive species include:

- Reduced diversity of native plants and animals due to competition or oxygen reductions
- Declines in fin and shellfish populations
- Impairment of recreational uses, such as swimming, boating, and fishing
- Degradation of water quality
- Degradation of wildlife habitat
- Increased threats to public health and safety
- Diminished property values
- Local and complete extinction of rare and endangered species (EOEEA, 2002 as cited by MEMA & EOEEA, 2018)

Economy

Invasive species are widely considered to be one of the costliest natural hazards in the U.S. A widely cited paper found that invasive species cost the U.S. more than $120 billion in damages every year. One study found that in one year alone, Massachusetts agencies spent more than $500,000 on the control of invasive aquatic species through direct efforts and cost-share assistance. This figure does not include the extensive control efforts undertaken by municipalities and private landowners, lost revenue due to decreased recreational opportunities, or decreases in property value due to infestations. Individuals who are particularly vulnerable to the economic impacts of this hazard would include all groups who depend on existing ecosystems in the Commonwealth for their economic success (MEMA & EOEEA, 2018).

Forest-based employment in the recreation and tourism sector is quite broad, including not just the outfitters, guides, and sporting goods vendors, but also the full suite of support services, such as dining and lodging. These services facilitate and promote the enjoyment of the greater experience of engaging in forest-based recreation. Fall foliage viewing, camping, hiking, and snowmobiling are examples of exceedingly popular activities that hinge upon the greater forested landscape, but also require a host of support services to make them successful. Other noteworthy forest-based recreational activities include cross-country skiing, mountain biking, wildlife tracking, and birdwatching. A 2015 report estimated that about 9,000 people are employed in the diverse industries that support this sector, with a total annual payroll equivalent of $293 million.[19] This includes all individuals working in outdoor recreation activities and tourism based on maintaining a natural landscape. Many Otis businesses rely on an intact ecosystem, including overnight camps and campgrounds, where the scenic beauty and outdoor recreational opportunities complement Otis and the Berkshire region's international status as a cultural destination. Maintaining the water quality and aquatic habitat of the many lakes and ponds in Otis is key to drawing and maintaining seasonal homeowners, a key component of the Town's tax base.

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.

Future Conditions

Invasive species can trigger a wide-ranging cascade of lost ecosystem services. Additionally, they can reduce the resilience of ecosystems to future hazards by placing a constant stress on the system. Temperature, concentration of CO_2 in the atmosphere, frequency and intensity of hazardous events, atmospheric concentration of CO_2, and available nutrients are key factors in determining species survival. It is likely that climate change will alter all of these variables. As a result, climate change is likely to stress native ecosystems and increase the chances of a successful invasion. Additionally, some research suggests that elevated atmospheric CO_2 concentrations could reduce the ability of ecosystems to recover after a major disturbance, such as a flood or fire event, or after development of a large project. As a result, invasive species—which are often able to establish more rapidly following a disturbance—could have an increased probability of successful establishment or expansion. Other climate change impacts that could increase the severity of the invasive species hazard include the following (as cited in MEMA & EOEEA, 2018):

- Elevated atmospheric CO_2 levels could increase some organisms' photosynthetic rates, improving the competitive advantage of those species.
- Changes in atmospheric conditions could decrease the transpiration rates of some plants, increasing the amount of moisture in the underlying soil. Species that could most effectively capitalize on this increase in available water would become more competitive.
- Fossil fuel combustion can result in widespread nitrogen deposition, which tends to favor fast-growing plant species. In some regions, these species are primarily invasive, so continued use of fossil fuels could make conditions more favorable for these species.

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[19] *EOEEA, DCR, Bureau of Forest Fire Control & Forestry, 2020.*

- As the growing season shifts to earlier in the year, several invasive species (including garlic mustard, barberry, buckthorn, and honeysuckle) have proven more able to capitalize by beginning to flower earlier, which allows them to outcompete later-blooming plants for available resources. Species whose flowering times do not respond to elevated temperatures have decreased in abundance.
- Some research has found that forests pests (which tend to be ectotherms, drawing their body heat from environmental sources) will flourish under warming temperatures. As a result, the population sizes of defoliating insects and bark beetles are likely to increase.
- Warmer winter temperatures also mean that fewer pests will be killed off over the winter season, allowing populations to grow beyond previous limits.
- There are many environmental changes possible in the aquatic environment that can impact the introduction, spread, and establishment of aquatic species, including increased water temperature, decreased oxygen concentration, and change in pH. For example, increases in winter water temperatures could facilitate year-round establishment of species that currently cannot overwinter in New England (Sorte, 2014 as cited in MEMA & EOEEA, 2018).

Vector-Borne Disease

Hazard Profile

The Town of Otis chose to examine the hazard of vector-borne diseases in their community due to the proliferation of Lyme disease in the region. Vector-borne disease are defined by the CDC as illnesses in humans derived from a vector, including rodents, mosquitoes, ticks, and fleas that spread pathogens. 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. For the purposes of this study, the Town of Otis is focusing solely on risk from tick- and mosquito-borne diseases.

Likely severity

Lyme disease is caused by bacteria that are spread by infected black-legged (deer) ticks. If untreated, people with Lyme disease can develop late-stage and chronic symptoms that can become a factor in pre-mature death. The joints, nervous system and heart are most commonly affected, although severe heart damage can occur. Chronic, long term fibromyalgia may result from untreated Lyme disease.

- About 60% of people with untreated Lyme disease get arthritis in their knees, elbows and/or wrists. The arthritis can move from joint to joint and become chronic.
- Many people who don't get treatment develop nervous system problems. These problems include meningitis (an inflammation of the membranes covering the brain and spinal cord), facial weakness (Bell's palsy) or other problems with nerves of the head, and weakness or pain (or both) in the hands, arms, feet and/or legs. These symptoms can last for months, often shifting between mild and severe.
- The heart also can be affected in Lyme disease, with slowing down of the heart rate and fainting. The effect on the heart can be early or late.[20]

West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) are viruses that occur in Massachusetts and can cause illness ranging from a mild fever to more serious disease like encephalitis or meningitis. According to the *2020 Massachusetts Arbovirus Surveillance and Response Plan,* between 2002-2019 there have been 208 cases of WNV among Massachusetts residents resulting in at least 12 deaths, with all but three of these fatalities in individuals 80 years of age or older. Since 2000 there were 38 cases of EEE resulting in at least 20 deaths.[21]

[20] *https://www.mass.gov/service-details/lyme-disease*

[21] *Bharel, Monica; Cranston, Kevin, 2020. 2020 MA Arbovirus Surveillance and Response Plan, MA Dept. Public Health, Boston, MA.*

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 effected by differences in weather, human modification of the landscape, the diversity of animal hosts, and human behavior that affects vector/human contact.

An overabundance of ticks threaten the health of humans and wildlife. The black-legged (aka deer) tick, which carries Lyme disease, has rapidly expanded its range northward throughout Berkshire County. Environmental factors that favor tick survival rates and periods of activity are mild winters that can include snow cover (snow cover helps to insulate them from the severe, dry air temperatures that can kill them) and moist, humid conditions (ticks are less active in dry, windy conditions).

WNV first appeared in the U.S. in New York City in 1999. The principal mosquito vectors for WNV on the East may be abundant in urban areas, breeding easily in artificial containers, such as birdbaths, discarded tires, buckets, clogged gutters, catch basins, and other standing water sources. Several highly urbanized areas in Massachusetts have accounted for over 80% of the human WNV infections between 2001 and 2019. The risk of EEE in humans varies by geographical area in Massachusetts and is correlated with the location of the necessary swamp habitats. In Massachusetts, these areas occur across the state, but are most common in southeastern Massachusetts (MA DPH, 2020).

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.

Risk for mosquito-borne disease is almost fully eliminated by the first local hard frost, which kills most remaining adult mosquitoes, although the species that spreads WNV in warmer urban areas may find warm, protected areas to survive the winter. A hard, or killing frost/freeze, has variable definitions but is often considered to be when temperatures fall below 28ºF (MA DPH, 2020).

Geographic Areas Likely Impacted

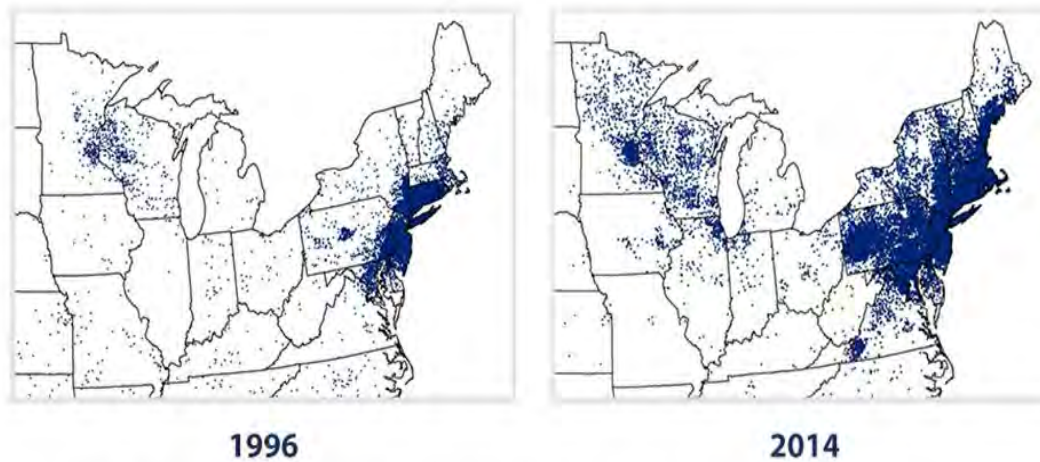
The Town of Otis in its entirety is likely already impacted by vector-borne disease and is likely to be increasingly impacted. Exposure to any outdoor area with tall grasses or ferns, shrubs and trees increases risk for tick-related disease. Wetlands and standing water sources increase risk of mosquito-related disease.

Historic Data

Black-legged (deer) ticks and the Lyme disease that they can carry spread northward into the Berkshires in the early 1990s In Berkshire County there was a 94.5% increase in Lyme disease 2005-2016. The CDC estimates that just 10% of cases of Lyme disease are actually reported, so the actual prevalence of disease is probably much higher.

In Berkshire County WNV has only been documented in Pittsfield and Lenox. As of 2020 EEE has not been recorded in the county (MA DPH, 2020). However, EEE has been detected in the southern Connecticut River Valley in Hampden County, east of Otis, so vigilance is warranted. See Figures 3.33 and 3.34 for locations in Massachusetts where these diseases have been recorded.

Fig. 3.32. Reported Lyme Disease Cases in 1996 and 2014



Data source: CDC (Centers for Disease Control and Prevention). 2015. Lyme disease data and statistics. www.cdc.gov/lyme/stats/index.html. Accessed December 2015.

Fig. 3.33. Municipality of Residence of West Nile Virus Human Cases, 2001-2019

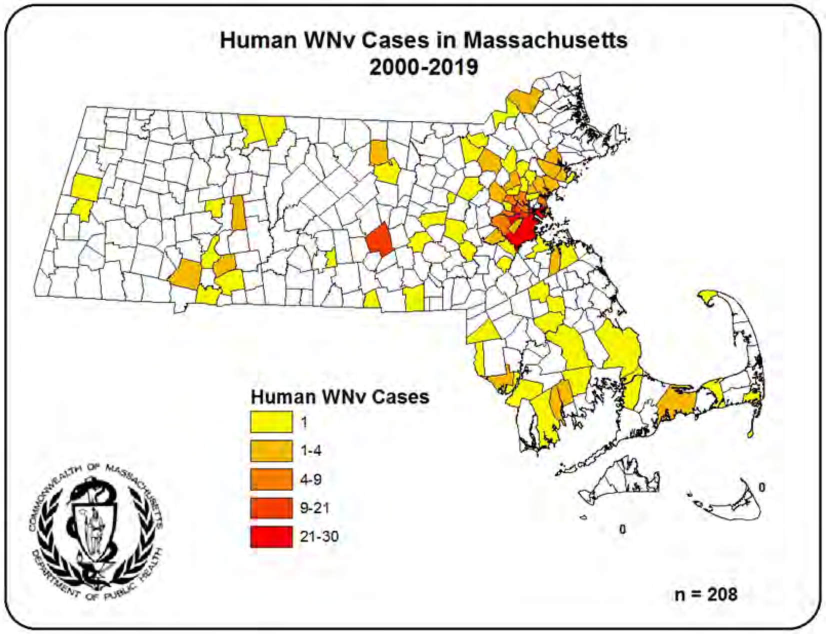
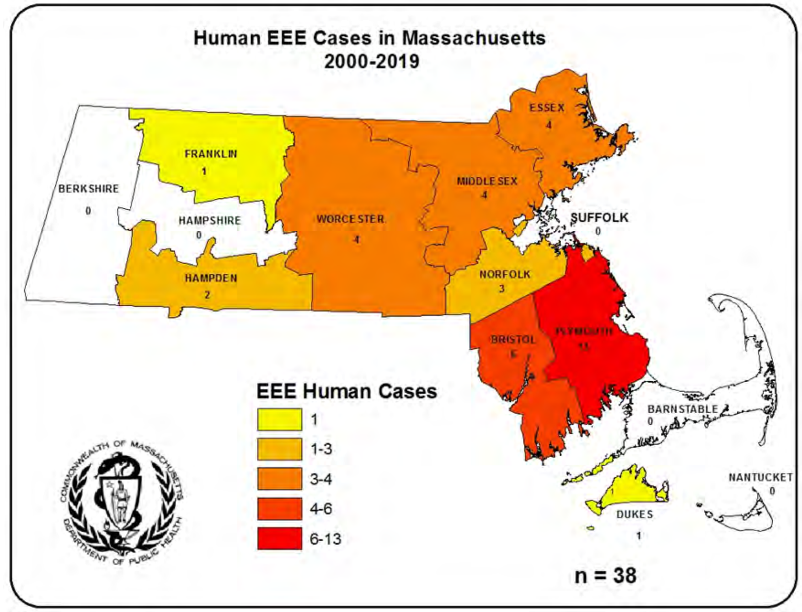


Fig. 3.34. County of Residence of EEE Human Cases, 2000-2019



Source for both graphics:: MA DPH, 2020.

Vulnerability Assessment

People

Vector-borne illness can have an impact on human health, significantly affecting overall 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.

There are 51 knowns species of mosquitos in Massachusetts and most mosquito bites will only cause itching or skin irritation. However, a few species can carry viruses that can cause illness. Mosquitos thrive in humid environments near water sources where they start their life cycles. They are ubiquitous throughout the region, found most often around wetland areas or damp forested areas. They can breed in small pools of shady, stagnant water in residential areas, including the inside of discarded rubber tires or old jugs or abandoned kiddie pools. There are two diseases carried by mosquitos in the Berkshires, West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE), which are being tracked by

Massachusetts. Luckily, as of 2021, the current risk in Otis of contracting WNV is categorized as Low (infection is unlikely) and EEE is categorized as Remote (not usually found in this area).[22] Warmer, moister conditions in the future could favor an increased risk.

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 patterns as people respond to the increase in disease carrying insects.

Natural Environment

Several tick species threaten the health of the area's small moose population, with some individuals suffering acute anemia and other related illness due to being infested by hundreds or thousands of them. Moose are not especially agile and are not able to scratch or bite them off as well as other animals.

Increases in vector-borne illnesses can increase the likelihood that a community would choose or need to use chemical pesticides and herbicides to control vector populations. The increased use of these products and chemicals can significantly affect the natural environment. Direct reductions in populations of ticks and mosquitos can reduce the food source for other dependent animal populations, severely damaging long-term ecosystem health. Although annoying, the vast majority of mosquitos are largely harmless, and they are actually a beneficial and substantial food source for fish such as trout and bass, as well as frogs, birds and bats. Learning to live with them rather than using chemical sprays is important for the protection of wildlife.

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.

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[22] *https://www.mass.gov/info-details/massachusetts-arbovirus-update, 11-28-21*

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.

Hazard Profile

Likely Severity

Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike damage could be significant, particularly if there is a home or other facility in its path. 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.

Figure 3.35. Enhanced Fujita Scale

Rating	Winds	Expected Damage
EF0	65-85 mph	**Minor damage.** Shingles or parts of roof peeled off; damage to gutters/siding; branches broken off; shallow-rooted trees toppled.
EF1	86-110 mph	**Moderate damage.** More significant roof damage; windows broken; exterior doors damaged or lost; mobile homes badly damaged or overturned.
EF2	111-135 mph	**Considerable damage.** Roofs torn off well-constructed homes; homes shifted off their foundation; mobile homes completely destroyed; large trees snapped or uprooted; cars may be tossed.
EF3	136-165 mph	**Severe damage.** Entire stories of well-constructed homes destroyed; significant damage to large buildings; homes with weak foundations may be blown away; trees begin to lose bark.
EF4	166-200 mph	**Extreme damage.** Well-constructed homes leveled; cars thrown significant distances; top story exterior walls of masonry buildings likely collapse.
EF5	> 200 mph	**Incredible damage.** Well-constructed homes swept away; steel-reinforced concrete structures critically damaged; high-rise buildings sustain severe structural damage; trees usually completely debarked, stripped of branches, and snapped.

Source: https://www.weather.gov

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.

Probability

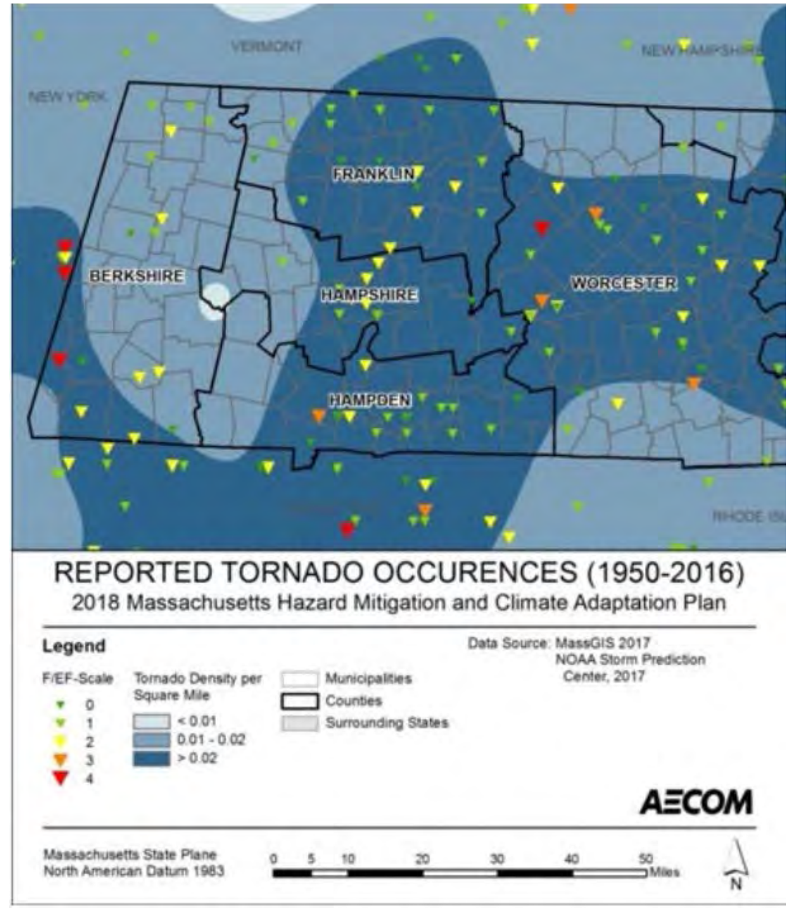
The location of tornado impact is totally unpredictable. Tornadoes are fierce phenomena which generate wind funnels of up to 200 MPH or more, and occur in Massachusetts usually during June, July, and August, although the county's most devastating was in Great Barrington in May. From 1950 to 2017, the Commonwealth experienced 171 tornadoes, or an average annual occurrence of 2.6 tornado events per year. In the last 20 years, the average frequency of these events has been 1.7 events per year (NOAA, 2018). Massachusetts experienced an average of 1.4 tornadoes per 10,000 square feet annually between 1991 and 2010, less than half of the national average of 3.5 tornadoes per 10,000 square feet per year (NOAA, n.d. as cited in MEMA & EOEEA, 2018).

According to the National Climatic Data Center, since 1950, there have been 13 tornados that have touched down or moved in a path across Berkshire County, and there are several others that occurred in adjacent counties and states in the region. This averages to one tornado striking the county approximately every 5.5 years. Of these, only two have been of a severity of an EF4, which indicates that such a severe tornado has a statistical recurrence rate of one in every 35 years.

Geographic Areas Likely Impacted

While the area impacted by a tornado will be limited at the time of the event, anywhere in Otis is susceptible. Figure 3.36 shows tornadoes reported in the central and western parts of Massachusetts through 2016. Figure 3.37 shows the known tornados and their paths as they traveled across Berkshire County.

Figure 3.36: Density of Reported Tornadoes per Square Mile



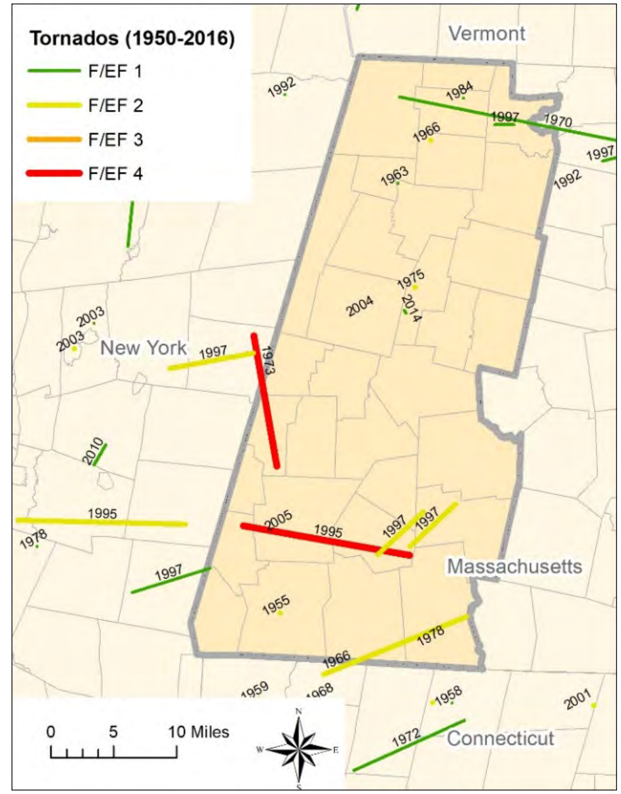
Source: MEMA, 2018, from NOAA Storm Prediction Center (SPC)

Historic Data

The National Climatic Data Center reports data on tornado events and does so as far back as 1950. Of the 13 tornados that have occurred in Berkshire County between 1950 and 2018, only one has occurred since 2007, an EF1 in July 2014 in Dalton. Four tornados occurred during a single storm on July 3, 1997. These have resulted in over $29 million in damage, seven deaths, and 60+ injuries. (NOAA, 2017).

The most memorable tornados in recent history occurred in West Stockbridge in August of 1973 (category F4) and in Great Barrington, Egremont, and Monterey in May of 1995 (category F4). In the West Stockbridge tornado four people died and 36 were injured, and in Great Barrington three people died and 24 were injured. The signs of the tornado's destruction are still visible today in Great Barrington from Rt. 7. The hill to the east is scarred where the tornado uprooted and toppled trees. In addition to being struck by the Great Barrington tornado of 1995, Otis' neighboring town of Monterey reports being hit by a few other tornadoes in the past decades, documented on the map as EF3 events that occurred in 1997. One of these tornadoes impacted northwest Otis by downing trees and power lines and leaving debris scattered in the West Center Road area. There are no known reports of injuries or damaged properties in Otis from this event.

Fig. 3.37. Tornados in the Berkshire Region and their Severity



Source: BRPC, 2017.

Vulnerability Assessment

People

In general, vulnerable populations include seniors, people with underlying health issues and disadvantaged populations. Individuals with limited communication capacity, such as those with limited internet or phone access, may not be aware of impending tornado warnings. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly that little, if any, advance warning is possible. This short warning time is part of why tornados are so dangerous. Tornado watches and warnings are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. (MEMA, 2018). Power outages resulting from tornado or high winds can be life-threatening to those who are dependent on electricity for life support.

In Otis, these warning systems are broadcast over local television and radio stations. In general, summer is a time to enjoy the great outdoors for both residents and visitors alike, and it is likely that most people would not be near a TV or radio if a tornado warning is issued. The population of Otis swells significantly during the summer months, when tornadoes are most likely to develop. Clusters of people are congregated in specific locations such as summer overnight camps, campgrounds, and around the shores of the lakes and pond. Homes around the ponds and lakes were built as summer cottages, with most lacking basements, having been built on piers. People in these structures are more vulnerable to tornadoes due to lack of fortified shelter. Visitors at the overnight camps and in campgrounds are more vulnerable should a tornado touch down there because none of the buildings have basements or other fortified areas to go.

Built Environment

All buildings and structures in Otis are at risk from tornados. Aside from potential damage to the buildings themselves, loss of electricity would mean that well pumps would not function and residents would lack drinking and waste water. If a tornado hit a large expanse of Otis and/or its neighboring towns, electricity could be out for days, as was the case when the ice storm of 2008 struck the Berkshire hilltowns.

All critical facilities and infrastructure are exposed to tornado events. High winds could down power lines and poles adjacent to roads (resilient MA, 2018). Damage to aboveground transmission infrastructure can result in extended power outages. 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 (MEMA & EOEEA, 2018). The hail, wind, debris, and flash flooding associated with tornadoes can cause damage to infrastructure, such as storage tanks, hydrants, and distribution systems. This can result in loss of service or reduced pressure throughout the system (EPA, 2015). 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 (EPA, 2015 as cited in MEMA & EOEEA, 2018).

Natural 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.

Economy

Forestry species and agricultural crops, equipment, and infrastructure may be directly impacted by tornadoes. 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 (MEMA, 2018).

Future Conditions

Tornado activity in the U.S. has become more variable, and increasingly so in the last two 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 (USGCRP, 2017 as cited in MEMA & EOEEA, 2018).

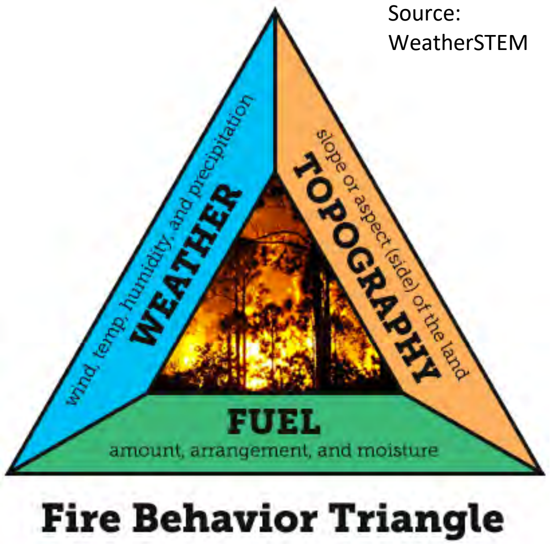
Wildfires

Hazard Profile

A wildfire can be defined as any non-structure fire that occurs in vegetative wildland that contains grass, shrub, leaf litter, and forested tree fuels. Wildfires in Massachusetts are caused by natural events, human activity, or prescribed fire. Wildfires often begin unnoticed but spread quickly, igniting brush, trees, and potentially homes (MEMA & EOEEA, 2018).

Likely severity

The "wildfire behavior triangle" reflects how three primary factors influence wildfire behavior: fuel, topography, and weather. 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.



Source: WeatherSTEM

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

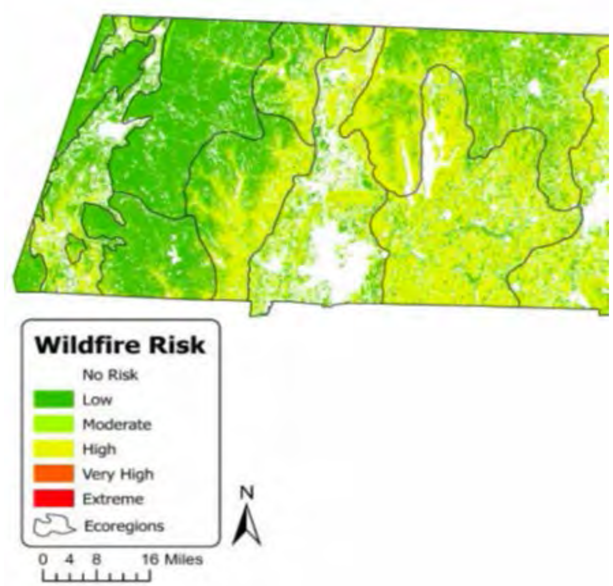
- Topography of a region or a local area influences the amount and moisture of fuel.
- Barriers such as highways and lakes can affect the spread of fire.
- Elevation and slope of landforms can influence fire behavior because fire spreads more easily uphill compared to downhill.

Probability

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, it is estimated that at least one notable wildfire will occur in the Commonwealth each year. Although Otis is 76% forested, the type of forest cover helps to reduce the risk of fire, making the probably of Otis being severely impacted as low.

According to the2020 Massachusetts State Forest Action Plan, there are relatively few natural forest fires in the state because lightning is almost always accompanied by rain. Fires occur primarily as a result of human activity; thus, the risk of forest fire increases in forest areas that are close to development and/or open to public use. A working group led by the U.S. Forest Service developed the Northeast Wildfire Risk Assessment model that considered three components: 1) fuels, 2) wildland-urban interface, and 3) topography (slope and aspect). These three characteristics are combined to identify wildfire prone areas where hazard mitigation practices would be most effective. As seen in Figure 3.38, Otis has been assessed to have Low Wildfire Risk. High and very high-risk areas have fire prone forest types (pitch pine-scrub oak and oak) and significant forest-human interaction, and large expanses of these areas are found in the eastern portion of the state.

Fig. 3.38. Wildfire Risk (NE Wildfire Risk Assessment)



Source: Northeast Wildfire Risk Assessment Geospatial Working Group 2009

However, local firefighters believe the model has a flaw in that it does not take into account human activity outside the wildland interface and intermix areas. Local firefighters and other first responders highlight the fact that many wildland fires occur in remote areas where campfires or discarded lit cigarettes were the cause of the fire and, due to lack of access, the fires can get an extensive start before fire crews and equipment can reach these areas. As an example, the two largest wildfires in Berkshire County within the last 100 years, that of April 2015 (272 acres burned) and May 2021 (950+ acres burned), were located in areas in Clarksburg assessed as Low Wildfire Risk. The cause of the 2015 was a campfire that got out of control along the Appalachian Trail. As of May 17, 2021, the cause of the 2021 fire has not been publicly announced.

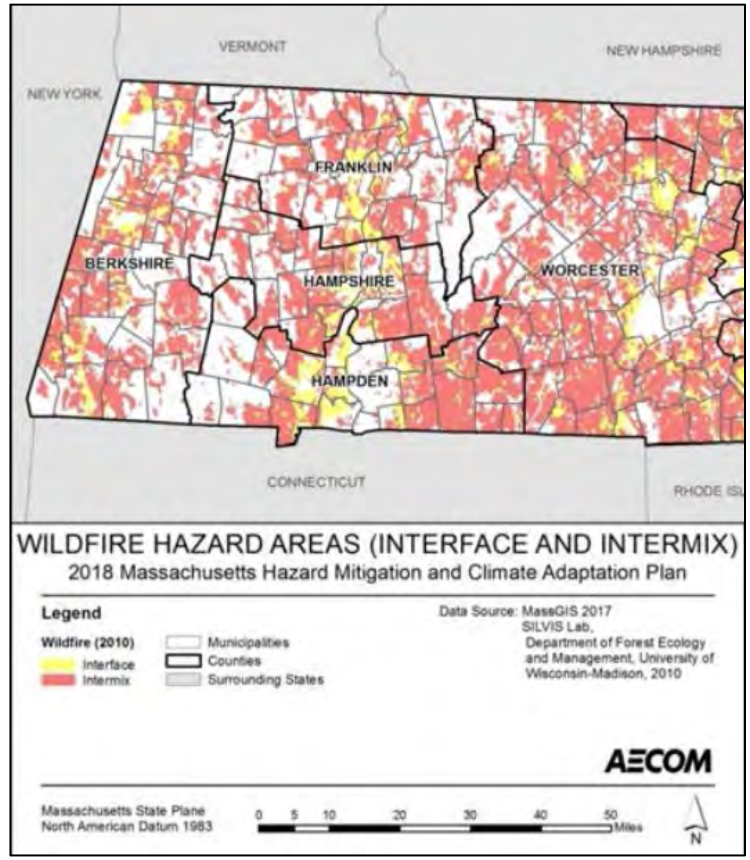
The assessment modeling had predicted that there was a low risk of wildfire in the areas in Clarksburg where the fires occurred, presumably because of a lack of wildland-urban interface (the fires burned remote areas within Clarksburg State Forest).

Geographic Areas Likely Impacted

Otis is vulnerable to fire across the Town. Fire risk and associated damages increases where there is a mix of development and forested land. While the risk of fire is relatively low for Otis compared to the Commonwealth as a whole, there is some hazard still posed by wildfire. Given increasing temperature and evaporation, drought and forest fire concerns are growing. Areas where campfires or discarded burning cigarettes can start wildfires are most at risk.

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. Although Otis does have oak forests, they are not the dominant forest type here. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface, shown in Figure 3.39. The SILVIS Lab at the University of Wisconsin-Madison Department of Forest Ecology and Management classifies exposure to wildlife hazard as "intermix" or "interface." Intermix areas (shown in Fig. 3.39 in dark pink) 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 areas (shown in yellow) 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 3.19. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard. Figure 3.19 shows the results of a geospatial analysis of fire risk by the Northeast Wildfire Risk Assessment Geospatial Work Group. As shown on the map, the modeling has designated a large portion of the central area of Otis as Intermix area. There are no areas designated as Interface.

Figure 3.39: Wildland-Urban Interface and Intermix



Source: EOEEA & MEMA, 2018.

Historic Data

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 (MEMA & EOEEA, 2018).

Based on the DCR Bureau of Forest Fire Control and Forestry records, in 1911, more than 34 acres were burned on average during each wildfire statewide. Since then, that figure has been reduced to 1.17 acres burned annually statewide (MEMA, 2013). According to the Massachusetts Fire Incident Reporting System, wildfires reported to DCR in the past five years are generally trending downward. According to this system there were 901 fire incidents, combined urban and wildland, in Berkshire County during the years 2007-2016, and of these 411 (46% of total) occurred in the City of Pittsfield, the urban center of the region. This same data reports that a total of 832 acres were burned in the county during those 10 years, 631 (76%) of which are reported as acres of wildland burned. This indicates that over this 10-year span an average of 63 acres of wildland burned annually in Berkshire County. Of the 901 incidents, only 12 burned more than 10 acres and two of these burned more than 100 acres. It should be noted that during this same time period there were two large wildland fires in the county: 168 acres in Lanesborough in 2008 and 272 acres in Clarksburg near the Williamstown border in 2015. If these incidents were considered statistic outliers and removed from the data, the average totaled burned acres during 2007-2016 would be 39 and the average wildland acres burned would be 19. In 2021 a wildfire started in eastern Williamstown and quickly moved eastward across the town border into Clarksburg, consuming approximately 950 acres of forest land. This fire was the largest to occur in the state since 1999, when 1,100 acres of land were burned in rugged, steep terrain on Tekoa Mountain in Russell, two towns east of Otis.

Figs. 3.40, 3.41. Wildfire in Clarksburg, MA 2015

Source: iBerkshires.com 2015.

The Town of Clarksburg has battled the two largest forest fires to occur within Berkshire County (2015 and 2021) since records have been kept. It is known that the 2015 fire started as a cooking fire at the Sherman Brook primitive campsite along the AT that got out of control. Forest conditions at the time were dry, a Class 4 High fire danger rating. The fire burned outward from its origins and eventually burned a total of 272 acres of forest land within the Clarksburg State Forest. The fire was first reported by a hiker who was on the AT on the afternoon of April 29, 2015. According to Incident Reports filled out at the time, the fire was largely a surface fire, burning hardwood leaf litter and Mountain Laurel shrub fuel and did not become a major tree or crown fire. Although crews thought that they had knocked the fire down by evening, new hot spots sprung out and crews had to actively fight the fire for the next two days before they were able to knock it down completely. Dry conditions allowed the fire to spread relatively quickly and keep smoldering. Crews spent a fourth day closing out the response. See Figures 3.40-3.41.

The fire was difficult to fight because the site was so inaccessible and because of the rugged and steep elevations that fire fighters had to traverse to reach the fire sites. Brush trucks and tankers were not able to reach the site, so crews at first had to hike in and use back packs and portable water pumps, refilling equipment in small mountain streams. Crews used shovels, chainsaws and leaf blowers to create fire breaks where they could. Firefighting improved once crews found a more accessible route to the fire site and were able to access and carry equipment closer to the site with ATVs. Finally, the tool that was able to really stop the fire was when DCR staff arranged to have a National Guard Black Hawk helicopter drop water on the fire, ferrying 500 gallons of water at a time from Mount Williams Reservoir in North Adams.[23]

Through mutual aid, more than a dozen fire companies from the region, including companies from Vermont, responded with crews and equipment. State DCR forest fire crews, including DCR's Chief Fire Warden, also responded. In all, Clarksburg's Fire Chief reports that 376 firemen responded over the course of four days. Despite the difficult terrain and conditions no serious injuries were reported.

The 2021 East Mountain fire started on Friday, May 14th off Henderson Road in Williamstown, and by the next day had swept eastward into Clarksburg and consumed more than 220 acres along East Mountain. By the end of day on May 16th the fire had quadrupled to almost 800 acres, and by the time the fire was 90% contained on May 18th it had consumed 950 acres of land, the majority in Clarksburg (Fig. 3.42). As in 2015, the fire occurred in rugged, steeply-sloped terrain that fire trucks or tankers could not access, so fire fighters and equipment had to be hauled to the sight on ATVs or, in many places where there are no trails, by foot. Firefighters

Fig. 3.42. Progression of the 2021 Williamstown/Clarksburg Wildfire as of May 17, 2021

Source: iBerkshires, 5-17-21

[23] *Daniels, T., 5-1-15. "Clarksburg Brush Fire Contained on Third Day", as reported in iBerkshires*

accessed the site from landings in Williamstown and North Adams. More than 120 firefighters from 19 different companies and agencies in Massachusetts and Vermont battled the fire for four days, including water dropping helicopters from the state police and National Guard.

Like the fire of 2015 this fire was predominantly a surface fire, burning leaf litter, twigs, branches and debris, fueled on by unusually dry conditions that officials believe are residual effects from the dry 2020 summer/fall season.[24] On the fourth day crews were mopping up hot spots, which consisted of areas with smoldering larger stumps and dead logs. One firefighter was hospitalized with non-life threatening injuries. Although the fire was in a rural, non-populated area, DCR has categorized the fire as a Type 3 Fire: one that is complex due to its size, the fact that it covered three municipalities involving multiple landowners and response agencies, and requiring a number of resources, including state staff and helicopters.

Vulnerability Assessment

People

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. In 2018 MEMA and EOEEA estimated the population vulnerable to the wildfire hazard by overlaying the interface and intermix hazard areas with the 2010 U.S. Census population data. The Census blocks identified as interface or intermix were used to calculate the estimated population exposed to the wildfire hazard. Interface or intermix areas are those where buildings intermingle with forest. In Berkshire County 131,219 persons were in Wildlife Hazard Areas. 55,486 in Interface areas, and 39,171 in Intermix areas. Refer to Figure 3.39 for these areas in Otis.

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 five, 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. Russell Deputy Fire Chief John Murphy was killed in 1999 while fighting the Tekoa Mountain forest fire.

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[24] *Guerino, Jack, 5-17-21. "Tuesday UPDATE: Forest Fire Operation Transitioning to 'Mop Up'", as reported in iBerkshires*

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.

Built Environment

All buildings and other facilities are vulnerable to wildfire through direct impacts of burning or indirect through cut off from utilities. If any portion of a communications or and electrical systems were impacted by wildfire it would impact a portion or the entire system.

Most roads 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 as well (MEMA & EOEEA, 2018).

Natural 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

Fig. 3.43. Fire on East Mountain, Clarksburg, MA. Photo taken May 16, 2021 from Stop & Shop parking lot on Route 2 in North Adams.

Source: Berkshire Eagle 5-18-21, "A volcanic-like glow over the Berkshires: Residents share their wildland fire photo." This photo taken by Brenda Armstrong.

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 (MEMA & EOEEA, 2018). The risk of hazardous materials releases is higher in the urban-wildland intermix and interface areas.

Economy

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 (MEMA & EOEEA, 2018).

According to the Incident Status Summary drafted by the state DCR Bureau of Forest Fire Control at the close of the Clarksburg State Forest Fire of 2015, the cost to put out that fire was estimated to be between $20,000-30,000. This figure was for state-incurred costs and did not include locate fire company costs. The cost to the Clarksburg Fire Company was in the low thousands of dollars for food, water, equipment and other direct costs; uncompensated were the hundreds of volunteer firefighters who attended the fire and the local citizens who came to the staging area and provided food and support to the firefighters and other first responders at the scene.

Future Conditions

While climate change is unlikely to change topography, it can alter the weather and fuel factors of wildfires. As noted in the Extreme Temperature section of this plan, the mean annual summer temperature is projected to increase 3-6°F by mid-century and 4-11°F by the 2090s, and the days where the summer temperature exceeds 90°F is expected to increase from zero days per year to nine days by mid-century and to 17 days by the 2090s. Hot dry spells create the highest fire risk, due to decreased soil moisture and increased evaporation and evapotranspiration. While in general annual precipitation has slightly increased Massachusetts in the past decades, the timing of snow and rainfall is changing. Less snowfall can lead to drier soils earlier in the spring and possible drought conditions in summer. More of our rain is falling in downpours, with higher rates of runoff and less soil infiltration. Such conditions would exacerbate summer drought and further promote high elevation wildfires where soil depths are generally thin. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods (MEMA, 2013).

Factors that may increase the risk of wildfire in the future include:

- Future acres burned is likely to increase without an increase in summer precipitation (greater than any predicted by climate models).
- Infestation from insects is also a concern as it may affect forest health. Potential insect populations may increase with warmer temperatures and infested dead and dying trees and limbs may increase fuel amount.
- Tree species composition will change as species respond uniquely to a changing climate.
- Wildfires cause both short-term and long-term losses. Short-term losses can include destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, and the destruction of cultural and economic resources and community infrastructure. (MEMA, 2013)

Cybersecurity Hazards

Hazard Profile

Likely Severity

The Town of Otis chose to examine the hazard of cybersecurity, which is defined as the defending of computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks. The damage rendered by cybersecurity can be significant. Municipalities may see their entire system compromised by cyber-attacks, which in worst case scenarios could close down governmental operations. It could require the municipality to expend significant financial resources to recover files and possibly, in the event of ransomware attack, pay a ransom to the hacker for retrieval of files. The power outage in 2003 that caused a two-day blackout in much of the Northeast was a result of a cyber-attack. This outage was related to at least 11 deaths and caused an estimated $6 billion in economic damages over two days (Wagner, 2016).[25]

Probability

As computers and connectivity become more pervasive in our lives, the number of vulnerabilities increases. The frequency of attacks impacting the government has increased over the last few years, leading to a higher probability that any one entity will be attacked. In 2018, government was the 7th most targeted industry for cybercrime and experienced 8% of the total attacks. Nation-state sponsored groups are the most likely to target this sector. These groups are likely to use, sell, or deliver compromised information to their respective governments, typically for economic or political gain (IBM 2019).[26] The most likely reason for attacks on a community like Peru is for ransom or to access personal information about residents.

Over the last three years, more than 42,000 vulnerabilities within software programs have been publicly disclosed. Vulnerabilities have increased over 5,400% in the years 2014-2019 (IBM 2019). These vulnerabilities provide more ways that criminals can access computer networks and compromise systems.

Like any organization, the greatest risk of cyber-attacks on municipal computer systems comes from the number and variety of people that work on these systems. There are a variety of factors that increase risk for municipalities.

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[25] *Wagner, Daniel, 2016. https://www.irmi.com/articles/expert-commentary/cyber-attack-critical-infrastructure*
[26] *IBM 2019 https://www.ibm.com/security/data-breach/threat-intelligence*

- Varied computer literacy: Municipal staff are hired for the various skills needed to run the many governmental departments and operations within a Town, and the level of computer literacy is varied. New staff typically are screened and go through background and reference checks, but few are evaluated as to their computer habits or their ability to recognize potential security issues.
- Staff turnover: New staff often inherit the same desk and computer as their predecessors, and for ease in transition often inherit their usernames and passwords.
- Personal emails and devices: For a variety of reasons, municipal staff may use their own accounts and devices for work, opening risk to municipal emails and accounts.
- Non-staff access: In addition to staff, elected and appointed board and committee members are often given access to municipal computer systems, with even less security oversight than staff.
- Limited ability to act quickly: Once a security breach has been identified, municipal staff may not be able to act quickly to contain the damage. Staff may not be trained or been given the authority to shut down systems or quickly hire consultants to help deal with the situation. If the cost of containment or ransom is high, it may require a vote of the selectboard or even Town Meeting to authorize funding to address the issue.

Cybersecurity is a constantly evolving discipline. Mitigation to reduce risk includes constant vigilance, including making sure equipment and software is up to date throughout the system. Someone in municipal government should be trained and given the responsibility for staying current with malware risk and for protecting the system as needed. Training more than one staff member will add redundancy to system oversight and maintain constant coverage. Lastly, train all municipal staff and anyone else using the system to avoid scams, malicious emails and attachments to reduce the risk of someone inadvertently allowing malware to enter the system.

Geographic Areas Likely Impacted

Municipal facilities are more likely to be targeted for cybercrime, but all residents and businesses are also at risk. In addition, the electrical grid and telecommunication networks throughout the region are at risk of attacks and could result in large sections of the Town being without power or communications.

Historic Data

Cyberattacks are a human-caused hazard, often spread by users who have inadvertently allowed access to their systems. In 2015 the theft of personal information of more than 22 million government employees from the computer systems of the Office of Personnel Management has far-reaching implications (Wagner, 2016). During 2016-2019, more than 11.7 billion records and over 11 terabytes of data were leaked or stolen in publicly disclosed incidents. These compromised records contain information such as social security numbers, addresses, phone numbers, banking/payment card information, and passport data. In some cases, health data may also be stolen (IBM 2019). The recent disclosure that the U.S. Pentagon and other high-ranking federal agencies had been hacked illustrates the breadth of the danger.

The recent ransomware on the Colonial Pipeline forced the closure of one of the nation's key fuel pipelines. The Colonial Pipeline is a 5,500-mile-long pipeline that carries 2.5 million barrels a day of gasoline, diesel, heating oil, and jet fuel on its route from Texas to New Jersey. Closure of the pipeline for 11 days in May 2021 prompted gasoline shortages and panic buying in the southeastern U.S., including in the nation's capital. Against the advice of its consultants and that of the FBI, Colonial paid $4.4 million to foreign hackers to release its systems. Had the shutdown gone on longer, it could have affected airlines, mass transit and chemical refineries.

Locally, at least two towns in Berkshire County and numerous municipalities across the state have been attacked with Ransomware within the last few years. One of the towns, as advised by its insurance company, paid the ransom to get its files back. In 2016, Berkshire Health Systems, the region's central health care system that includes the county's three hospitals, numerous physician practices and clinics, was attacked by malware. As recently as April 2021 the Massachusetts Auto Inspection System was shut down due to a cyber-attack. These attacks can cost the communities anywhere from tens of thousands of dollars to millions of dollars in ransom and countless hours restoring their systems and improving their resilience to a future attack.

Vulnerability Assessment

People

Cyberattacks rarely have direct, physical impacts on humans aside from the anguish caused by a breach. Personal identifiable information that may be stolen from a municipal system can cause disruption to people's lives, impacting their finances, security, and future. Municipal operations may be shut down during a breach, causing a delay in services, issuing permits or tax bills, or a host of other governmental functions. Cyber-attacks that impact the utilities may cause potential harm to those who rely on electricity for life support, heat, and water. Hospitals and medical facilities utilizing networked monitoring systems are vulnerable to hacking.

Built Environment

Cyberattacks on the built environment may result in the loss of power, communications and equipment failure in government offices. Attacks on the utilities would likely result in temporary loss of service, however utilities can also be attacked where the systems are taken control of and purposely overloaded, damaging the physical infrastructure, which will result in a costlier recovery and a longer recovery time. Government computer equipment can also be damaged or locked, preventing the use of that equipment unless a ransom is paid. This equipment can be replaced, but the data on the computers may not be recoverable, resulting in the loss of data and governmental records unless the computers have been properly backed up.

Natural Environment

Cyberattacks pose a threat to the natural environment as well. Systems such as wastewater or drinking water treatment plants are vulnerable to ransomware if they are connected to the internet, as hackers could control pumps, valves, chemical applications or many other parts of the systems. Chemical and other leaks from businesses can occur in the same manner. Fortunately, Peru does not have any such computer- or internet-controlled systems.

Economy

The economy is susceptible to the threat of cyberattacks due to the loss of utilities and computers causing a reduction in economic output. Computerized control systems known as a Supervisory Control and Data Acquisition (SCADA) systems allow industries and utilities remote controlling and monitoring of industrial processes. An attach in these systems can disrupt production, shut down operations completely or otherwise damage the business' output. The power blackout of 2003 was an attack on the utility's SCADA system. The weakest link in these systems is employees unwittingly opening emails or some other back-door way into the system (Wagner, 2016). The U.S. government estimates that malicious cyber activity costs the U.S. economy between $57 billion and $109 billion in 2016.[27]

Future Conditions

Continued expansion and connectivity of cyber assets will lead to a continued and growing threat to businesses, governments and individuals. Local governments will need to invest in cyber security to help mitigate the future risk of a cyber-attack. This will include upgrading computer systems, deploying security protections such as firewalls, and training users on identifying malicious activity and emails. Governments will also need to utilize professional computer staff or consultants to assist in protecting their assets and the data of their constituents

[27] *https://www.whitehouse.gov/wp-content/uploads/2018/03/The-Cost-of-Malicious-Cyber-Activity-to-the-U.S.-Economy.pdf*

Landslides

Hazard Profile

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 (MEMA & EOEEA, 2018).

Likely Severity

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, even under ideal conditions (MEMA & EOEEA, 2018). Estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. Information about previous landslides 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 (MEMA & EOEEA, 2018).

A study conducted in 2001 attempted to estimate landslide risk as a measure of destructiveness of landslide event. Destructiveness was defined as a function of the volume and velocity of material movement. For slow-moving slides, volume depended on the estimated depth of movements; for rapid moving debris flows it depended on the size of the catchment and the estimated volume of debris in source areas and along channels; while for fast-moving rock falls it depended on the maximum size of a single block as estimated from field observations. The expected landslide velocity depends on the type of failure, its volume and the estimated depth of movement. For a given landslide volume, fast moving rock falls have the highest landslide intensity, while rapidly moving debris flows exhibit intermediate intensity, and slow-moving landslides have the lowest intensity (Cardinali, et al, 2002). A summary of destructiveness is show in Table 3.17. As way of perspective, the Mohawk Trail landslide of 2011, the most recent and recognizable one to have occurred in the county, had an estimated volume of 5,000 cubic yards of material (see Figs. 3.45-3.46).

Table 3.17. Risk of Landslide Destructiveness

Estimate Volume (cubic yards)	Expected Landslide Velocity		
	Fast moving (rock fall)	Rapid moving (debris flow)	Slow moving (slide)
<0.001	Slight intensity	--	--
<0.6	Medium intensity	--	--
>0.6	High intensity	---	--
<654	High intensity	Slight intensity	--
654-13,080	High intensity	Medium intensity	Slight intensity
13,080–65,398	Very high intensity	High intensity	Medium intensity
>653,976	--	Very high intensity	High intensity
>>653,976	--	--	Very high intensity

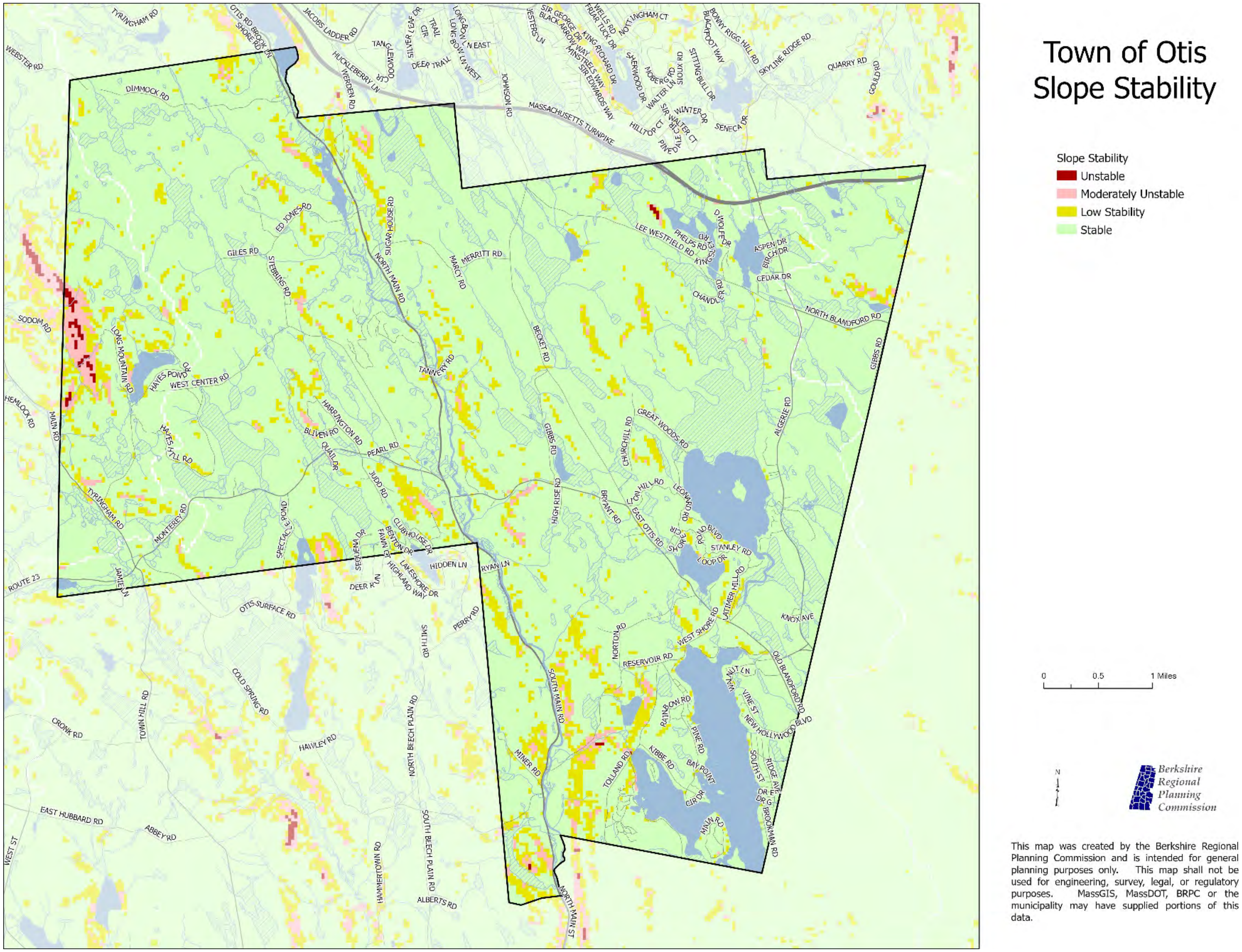
Source: Cardinali, et al, 2002.

Probability

For the purposes of this HMCAP, the probability of future occurrences is defined by the number of events over a specified period of time. Looking at the recent record, from 1996 to 2012, there were eight noteworthy events that triggered one or more landslides in the Commonwealth. However, because many landslides are minor and occur unobserved in remote areas, the true number of landslide events is probably higher. Based on conversations with the Massachusetts Department of Transportation (MassDOT), it is estimated that about 30 or more landslide events occurred in the period between 1986 and 2006 (Hourani, 2006). This roughly equates to one to three landslide events each year.

The probability of instability metric indicates how likely each area is to be unstable. 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 (MEMA & EOEEA, 2018). The results of this study for the Town of Otis are illustrated in Figure 3.44, with corresponding map legend on the following page.

Figure 3.44. Slope Stability Map



Source: BRPC, 2021, MassGIS 2017.

[1]**Relative Slide Ranking—**This column designates the relative hazard ranking for the initiation of shallow slides on unmodified slopes.

[2]**Stability Index Range—**The stability index is a numerical representation of the relative hazard for shallow translational slope movement initiation based on the factors of safety computed at each point on a 9-meter (~30-foot) digital elevation model grid derived from the National Elevation Dataset. The stability index is a dimensionless number based on factors of safety generated by SINMAP that indicates the probability that a location is stable, considering the most and least favorable parameters for stability input into the model. The breaks in the ranges of values for the stability index categories are the default values recommended by the program developers. [3]

Map Color Code	Predicted Stability Zone	Relative Slide Ranking[1]	Stability Index Range[2]	Factor of Safety (FS)[3]	Probability of Instability[4]	Predicted Stability With Parameter Ranges Used in Analysis	Possible Influence of Stabilizing or Destabilizing Factors[5]
	Unstable	High	0	Maximum FS<1	100%	Range cannot model stability	Stabilizing factors required for stability
	Upper Threshold of Instability		0 - 0.5	>50% of FS≤1	>50%	Optimistic half of range required for stability	Stabilizing factors may be responsible for stability
	Lower Threshold of Instability	Moderate	0.5 - 1	≥50% of FS>1	<50%	Pessimistic half of range required for instability	Destabilizing factors are not required for instability
	Nominally Stable	Low	1 - 1.25	Minimum FS=1	–	Cannot model instability with most conservative parameters specified	Minor destabilizing factors could lead to instability
	Moderately Stable		1.25 - 1.5	Minimum FS=1.25	–	Cannot model instability with most conservative parameters specified	Moderate destabilizing factors are required for instability
	Stable	Very Low	>1.5	Minimum FS=1.5	–	Cannot model instability with most conservative parameters specified	Significant destabilizing factors are required for instability

Factors of Safety—The factor of safety is a dimensionless number computed by SINMAP using a modified version of the infinite slope equation that represents the ratio of the stabilizing forces that resist slope movement to destabilizing forces that drive slope movement (Pack et al., 2001 as cited in MEMA & EOEEA, 2018). A FS>1 indicates a stable slope, a FS<1 indicates an unstable slope, and a FS=1 indicates the marginally stable situation where the resisting forces and driving forces are in balance.

[4]**Probability of Instability—**This column shows the likelihood that the factor of safety computed within this map unit is less than one (FS<1, i.e., unstable) given the range of parameters used in the analysis. For example, a <50% probability of instability means that a location is more likely to be stable than unstable given the range of parameters used in the analysis. [5]**Possible Influence of Stabilizing and Destabilizing Factors—**Stabilizing factors include increased soil strength, root strength, or improved drainage. Destabilizing factors include increased wetness or loading, or loss of root strength (Massachusetts Geologic Survey and UMass Amherst, 2013; Pack et al., 2001 as cited in MEMA & EOEEA, 2018).

Generally accepted warning signs for landslide activity include the following (MEMA & EOEEA, 2018):

- Springs, seeps, or saturated ground in previously dry areas
- New cracks or unusual bulges in the ground
- Soil moving away from foundations
- Ancillary structures, such as decks and patios, tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken waterlines and other underground utilities
- Leaning telephone poles, trees, retaining walls, or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels even though rain is still falling or has just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

Geographic Areas Likely Impacted

Landslides associated with slope saturation occur predominantly in areas with steep slopes underlain by bedrock or glacial till. 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 from organic material. 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 (Mabee, 2010 as cited in MEMA & EOEEA, 2018). Occasionally, landslides occur as a result of geologic conditions and/or slope saturation. Adverse geologic conditions exist wherever there are lacustrine or marine clays, as clays have relatively low strength. These clays often formed in the deepest parts of the glacial lakes that existed in Massachusetts following the last glaciation. (MEMA & EOEEA, 2018).

Although specific landslide events cannot be predicted like a storm, a slope stability map shows where slope movements are most likely to occur after periods of high-intensity rainfall. Unstable and Moderately Unstable slopes are found in various areas of Otis. There are 32 acres of land (less than 1/10 of 1% of total land area) in Otis that GIS has identified as being Unstable (seen as red areas in the map in Figure 3.44). There are 375 acres of land (2% of total) identified as Moderately Unstable (seen as pink areas in the map).

The underlying bedrock in Otis is granite and gneiss of the Berkshire Highlands, relatively hard materials that locally resist erosion. This creates the hilly landscape with deeply incised ravines. The area with the largest area of Unstable slopes is in the western portion of the Town, northwest of Hayes Pond, involving the steeply sloped hill that is formed south of Round Mountain in Tyringham. There is currently no road to access that area of Town. Another area of Unstable slopes is west of Watson Pond, north of Lee Westfield Road. A third small area of Unstable land is along the ravine of the Larkum Pond outlet stream, south of Reservoir Road. There are several areas of Moderately Unstable land throughout Otis, and like the Unstable land aeras, the Moderately Unstable lands are those associated with steeper slopes, many along stream ravines.

Historic Data

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 (Mabee and Duncan, 2013). This precipitation can cause slopes to become saturated. In Massachusetts, landslides tend to be more isolated in size and pose threats to high traffic roads and structures that support tourism, and general transportation. Landslides commonly occur shortly after other major natural disasters, such as earthquakes and floods, which can exacerbate relief and reconstruction efforts. Many landslide events may have occurred in remote areas, causing their existence or impact to go unnoticed. Expanded development and other land uses may contribute to the increased number of landslide incidences and/or the increased number of reported events in the recent record (MEMA & EOEEA, 2018).

The most severe landslide to occur in the Berkshire region occurred along the Mohawk Trail (Route 2) in Savoy during T.S. Irene in 2011 (Figs. 3.45-3.46). The

Fig. 3.45, 3.46. Landslide in Savoy, MA along Mohawk Trail August 2011

Source: Top: Mabee, Stephen B., Duncan, Christopher C. 2013. Slope Stability Map of Mass., MA Geological Survey. Bottom: courtesy Stan Brown of Florida, MA slide was 900 feet long, approximately 1.5 acres, with an average slope angle is 28° to 33°. The elevation difference from the top of the slide to the bottom was 460 feet, with an estimated volume of material moved being 5,000 cubic yards. Only the top 2 to 4 feet of soil material was displaced (BRPC, 2012). The soil and tree debris covered the entire width of Route 2 and caused its closure for weeks (see Fig. 3.46). The landslide has a significant impact on northern Berkshire County communities because Route 2 is a major east-west transportation route for that region.

Vulnerability Assessment

People

Populations who rely on potentially impacted roads for vital transportation needs are considered to be particularly vulnerable to this hazard. The number of lives endangered by the landslide hazard is increasing due to the state's growing population and the fact that many homes are built on property atop or below bluffs or on steep slopes subject to mass movement. 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. Additionally, landslides can result in injury and loss of life. Landslides can impact access to power and clean water and increase exposure to vector-borne diseases. In Otis, there are nine residential buildings located in the areas modeled to be Moderately Unstable; there are no buildings located within the Unstable land category. Using the 2.2 people per household figure for Otis, approximately 20 people are potentially at risk from landslide. Because landslide risk is not as predictable as some other hazards, such as being in floodplain, it is doubtful that all nine buildings would be impacted at one time.

Built Environment

There are nine buildings in Otis located within areas identified as Moderately Unstable slopes, all residential buildings. According to data extracted from assessor parcel information, the value of these nine properties is $2,346,000. There are no buildings located in areas identified as Unstable. Loss of these buildings could result in loss of life. There would also be significant issues with access of roads and neighborhoods.

Infrastructure located within areas shown as Unstable on the Slope Stability Map should be considered to be exposed to the landslide hazard. Highly vulnerable areas include mountain roads and transportation infrastructure, both because of their exposure to this hazard and the fact that there may be limited transportation alternatives if this infrastructure becomes unusable. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use. 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.

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 (MEMA & EOEEA, 2018).

Natural 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 forests, which in turn impacts the habitat quality of the animals that live in those forests (Geertsema and Vaugeouis, 2008 as cited in MEMA & EOEEA, 2018). Flora in the area may struggle to re-establish following a significant landslide because of a lack of topsoil.

Fig. 3.47. Mount Greylock in Adams, MA. 1990 landslide area still void of vegetation nine years later.

Source: BRPC, 1999.

Economy

Direct costs of landslide include the actual damage sustained by buildings, property, and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure. Additionally, ground failure threatens transportation corridors, fuel and energy conduits, and communication lines (USGS, 2003 as cited in MEMA & EOEEA, 2018). 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.

The cost associated with remediation work and cleanup of debris from four landslide-related events during the severe rainstorm of October 2005 that affected Massachusetts was $2.3 million. It cost $23 million to reopen the six-mile stretch of Mohawk Trail (Route 2) caused by T.S. Irene in 2011, which included debris flows, four landslides, and fluvial erosion and undercutting of infrastructure (Mabee & Duncan, 2013.) 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.

Future Conditions

Increased precipitation, severe weather events and other effects of climate change affecting the region may lead to a higher likelihood for landslides as soil and vegetative cover are impacted. Special attention should be paid to the risk of landslide in permitting development in steeply sloped areas.

Earthquakes

Hazard Profile

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, including Otis (MEMA & EOEEA, 2018).

Likely severity

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 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 seismograph-measured value of the amplitude of the seismic waves. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the 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. Earthquakes above about 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.

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 structural 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, with accompanying descriptions of what the earthquake will feel like to people in the area. Table 3.18 describes the intensity and the equivalent Richter Scale rating.

Table 3.18. Modified Mercalli Intensity Table and Description of Impacts

Equivalent Richter Scale Magnitude	Mercalli Intensity	Abbreviated Modified Mercalli Intensity Scale Description
NA	I	Felt by very few people; barely noticeable.
< 4.2	II	Felt by few people, especially on upper floors of buildings.
NA	III	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake; vibration similar to passing of a truck.
NA	IV	Felt by many indoors, few outdoors; may feel like heavy truck striking building.
< 4.8	V	Felt by almost everyone, some people awakened; small objects move, trees and poles may shake.
< 5.4	VI	Felt by all, many frightened; some furniture moved; few instances of fallen plaster; damage slight.
< 6.1	VII	Damage negligible in buildings of good design & construction; slight-moderate in well-built ordinary buildings; considerable damage in poorly designed & constructed.
NA	VIII	Buildings suffer slight damage if well-built, severe damage if poorly built. Some walls. Chimneys, factory stacks collapse.
< 6.9	IX	Damage considerable in specially designed structures; damage great in buildings with partial collapse; buildings shifted off foundations.
< 7.3	X	Some well-built wooden structured destroyed; most masonry and frame structured destroyed with foundations.
< 8.1	XI	Few, if any (masonry) structures remain standing; bridges destroyed.
> 8.1	XII	Damage total; objects thrown into the air.

Source: MEMA & EEA, 2018.

Probability

New England 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 (MEMA & EOEEA, 2018).

A 1994 report by the USGS, based on a meeting of experts at the Massachusetts Institute of Technology, provides an overall probability of occurrence. 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 (MEMA & EOEEA, 2018).

Because of the low frequency of earthquake occurrence and the relatively low levels of ground shaking that are usually experienced, the entirety of the Commonwealth and the Town of Otis can be expected to have a low to moderate risk to earthquake damage as compared to other areas of the country. However, impacts at the local level can vary based on types of construction, building density, and soil type, among other factors (MEMA & EOEEA, 2018).

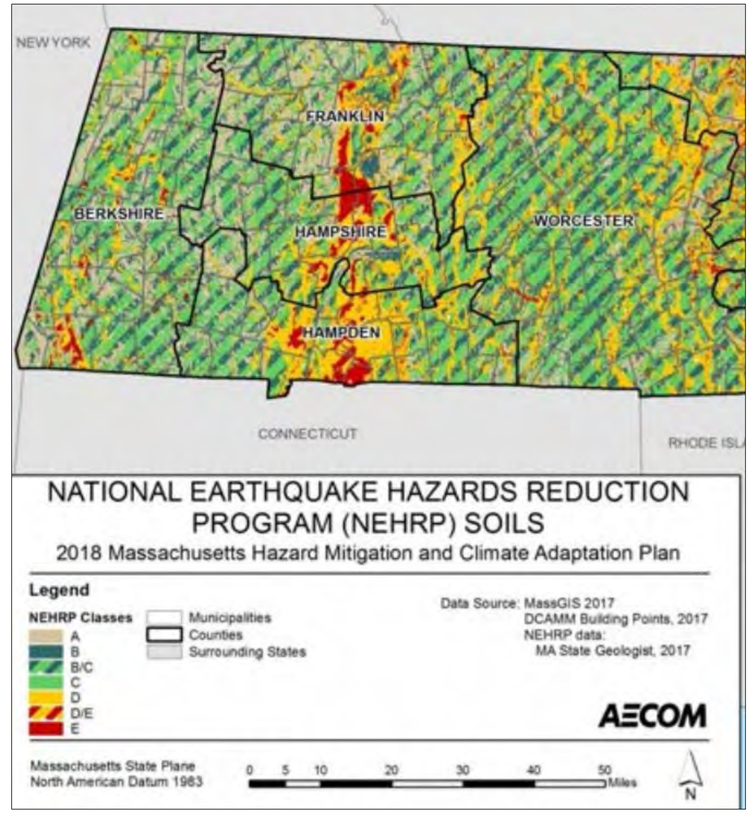
Geographic Areas Likely Impacted

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. Instead, a probabilistic assessment conducted through a Level 2 analysis in Hazus (using a moment magnitude value of five) provides information about where in Massachusetts impacts would be felt from earthquakes of various severities. For this plan, an assessment was conducted for the 100-, 500-, 1,000-, and 2,500-year Mean Return Periods (MRP). The results of that analysis are discussed later in this section (MEMA & EOEEA, 2018).

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 3.48. Soil types A, B, C, and D are reflected in the HAZUS analysis that generated the exposure and vulnerability results later in the section (MEMA & EOEEA, 2018).

Figure 3.48: NEHRP Soil Types in Western/Central Massachusetts



Sources: MEMA & EOEEA, 2018; Mabee and Duncan, 2017; Preliminary NEHRP Soil Classification Map of Massachusetts

Historic Data

In the morning of April 20, 2002, a 5.1-rated earthquake rattled homes and work people up throughout central and northern Berkshire County. Residents describe the affects as vibrating or shaking their homes, rattling hangings on the wall, and sounding loud like a train or large truck passing by. According to a local news article, no injuries were reported and the only local damages reported were a cracked home foundation on Houghton Street in Clarksburg.[28] Another earthquake in Virginia on August 23, 2011 was felt in Western Massachusetts.

In some places in New England, including locations in Massachusetts, small earthquakes seem to occur with some regularity. For example, since 1985 there has been a small earthquake approximately every 2.5 years within a few miles of Littleton, Massachusetts. It is not clear why some localities experience such clustering of earthquakes, but a possibility suggested by John Ebel of Boston College's Weston Observatory is that these clusters occur where strong earthquakes were centered in the prehistoric past. The clusters may indicate locations where there is an increased likelihood of future earthquake activity (MEMA & EOEEA, 2018).

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. Damaging

[28] *Gosselin, Lisa, 4-21-02. "Earthquake Wakes up Northeast," Berkshire Eagle.*

earthquakes have taken place historically in New England. 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 (MEMA & EOEEA, 2018).

Vulnerability Assessment

People

The entire population of Massachusetts 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 individuals across the Commonwealth. 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.

The populations most vulnerable to an earthquake event include people over the age of 65 and those living below the poverty level. 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.

Hazus performed for the *Massachusetts Hazard Mitigation and Climate Adaptation Plan* estimates the number of people that may be injured or killed by an earthquake depending on the time of day the event occurs. Results were calculated on the county level. Estimates are provided for three times of day representing periods when different sectors of the community are at their peak: peak residential occupancy at 2 a.m.; peak educational, commercial, and industrial occupancy at 2 p.m.; and peak commuter traffic at 5 p.m. Table 3.19 shows the number of injuries and casualties expected for events in Berkshire County of varying severity, occurring at various times of the day. Damages and loss due to liquefaction, landslide, or surface fault rupture were not included in this analysis. Estimated damages to the general building stock were generated at the Census-tract level.

Residents may be displaced or require temporary to long-term sheltering due to the event. The number of people requiring shelter is generally less than the number displaced, as some who are displaced use hotels or stay with family or friends following a disaster event. Shelter estimates from Hazus are intended for general planning purposes and should not be assumed to be exact. It should also be noted that, in Massachusetts, the season in which an earthquake occurs could significantly impact the number of residents requiring shelter. For example, if an earthquake occurred during a winter weather event, more people might need shelter if infrastructure failure resulted in a loss of heat in their homes. These numbers should be considered as general, year-round average estimates (MEMA & EOEEA, 2018). In Otis, emergency response would increase due to the increased population due to second homeowners and people at local camps.

Table 3.19: Estimated Number of Injuries, Causalities and Sheltering Needs in Berkshire County

Mean Return Period	100-Year MRP			500-Year MRP			1,000-Year MRP			2,500-Year MRP		
Time of Event	**2 am**	**2 pm**	**5 pm**	**2 am**	**2 pm**	**5 pm**	**2 am**	**2 pm**	**5 pm**	**2 am**	**2 pm**	**5 pm**
Injuries	0	0	0	4	6	4	9	13	10	22	35	25
Hospitalization	0	0	0	0	1	1	1	2	1	3	6	5
Casualties	0	0	0	0	0	0	0	0	0	1	1	1
Displaced Households	0			21			51			143		
Short-Term Sheltering Needs	0			12			29			82		

Source: MEMA & EOEEA, 2018 HAZUS

Built Environment

All elements of the built environment in the planning area are exposed to the earthquake hazard. Municipal water and sewer lines could be damages or destroyed. In addition to 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 (MEMA & EOEEA, 2018).

Earthquakes can damage power plants, gas lines, liquid fuel storage infrastructure, transmission lines, utilities 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 (MEMA & EOEEA, 2018). Damage to road networks and bridges can cause widespread disruption of services and impede disaster recovery and response (MEMA & EOEEA, 2018).

Earthquakes can also cause large and sometimes disastrous landslides and wildfires. Soil liquefaction is a secondary hazard unique to earthquakes that occurs when water-saturated sands, silts, or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Liquefaction may occur along the shorelines of rivers and lakes and can also happen in low-lying areas away from water bodies but where the underlying groundwater is near the Earth's surface. Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes (MEMA & EOEEA, 2018).

Natural 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 Section 4.3.2. 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 any industries 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 (MEMA & EOEEA, 2018).

Economy

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. The business interruption losses are the losses associated with the inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses of those people displaced from their homes because of the earthquake. Additionally, 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 (MEMA & EOEEA, 2018).

Table 3.20 summarizes the estimated potential building-related losses per earthquake scenario for Massachusetts. Lifeline-related losses include the direct repair cost for transportation and utility systems and are reported in terms of the probability of reaching or exceeding a specified level of damage when subjected to a given level of ground motion. 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.

Table 3.20. Building-Related Economic Loss Estimates, Hazus Probabilistic Scenarios and Transportation and Utility Losses for the Commonwealth of Massachusetts

Economic Losses for Berkshire County	100-Year MRP	500-Year MRP	1,000-Year MRP	2,500-Year MRP
Building-Related Economic Loss Estimates, Hazus Probabilistic Scenarios	$570,000	$25,660,000	$66,220,000	$200,810,000
Transportation and Utility Losses for the	$170,000	$7,800,000	$23,180,000	$74,200,000

Source: MEMA & EOEEA, 2018 Hazus.

Future Conditions

Earthquakes cannot be predicted and may occur at any time. Peak Ground Acceleration maps are used as tools to determine the likelihood that an earthquake of a given Modified Mercalli Intensity may be exceeded over a period of time, but they are not useful for predicting the occurrence of individual events. Therefore, geospatial information about the expected frequency of earthquakes throughout Massachusetts is not available. Unlike previous hazards analyzed in this plan, there is little evidence to show that earthquakes are connected to climate change (MEMA & EOEEA, 2018). However, there are some theories that earthquakes may be associated with a thawing Earth as the temperature increases.

CHAPTER 4: MITIGATION STRATEGY

44 CFR § 201.6(c)(3-5)

The Mitigation Strategy outlines how the Town of Otis intends to reduce potential losses identified in the Risk Assessment chapter. The Mitigation Strategy also reflects the needs identified throughout the planning process, which includes the findings of the public participation process and the gaps that were identified when the Town conducted a self-evaluation of its operations. The self-evaluation was conducted using FEMA's Capability Assessment Worksheet, found within FEMA's 2013 *Local Mitigation Planning Handbook.* The goals and objectives of the Town guide the selection of actions to mitigate and reduce potential losses. A prioritized list of cost-effective, environmentally sound, and technically feasible mitigation actions is the product of reviewing benefits and costs of each proposed project.

Existing Protections and Needs Analysis

The Town of Otis is fortunate in having natural mitigative infrastructure in the contiguous forests and wetland resources that dominate the landscape. Otis' undeveloped land serves as important green infrastructure performing ecosystem services including stormwater management, flood control and reduction, soil stabilization, wind mitigation, water filtration, and drought prevention amongst other benefits not easily quantified. One study by the Trust for Public Land found that for every $1 invested through the Land and Water Conservation Fund, there was a return on that investment of $4 from the value of natural goods and services[29]. As such, partnering with state and local conservation organizations to protect and maintain the hazard mitigation functions of the Town's natural landscape is a key component in overall efforts to reduce the impacts of natural hazards and disasters on the Town's people, property and wildlife habitats.

The Town of Otis has policies and regulations in place to direct development away from hazardous areas, most of which address flood risk. The Town participates in the National Flood Insurance Program, which enables homeowners, business owners and renters in participating communities to purchase federally backed flood insurance. In general, having flood insurance is required for mortgage or loan seekers whose buildings are located in floodplains or flood zones.

Large development projects are permitted only through the Special Permit process and require a Site Plan Review process. Project applications include the filing of Site Plans, which must be prepared by a registered engineer or surveyor. The Special Permit Granting Authority is the Zoning Board of Appeals (ZBA) and the Planning Board must approve the Site Plan. The ZBA will forward project applications to other Town boards for review and to receive recommendations from those boards (typically Conservation Commission, Board of Health, Building Inspector). To be approved the project shall be designed to minimize environmental impacts.

[29] *http://cloud.tpl.org/pubs/benefits-LWCF-ROI%20Report-11-2010.pdf*

In spring 2021 the Town amended its Floodplain Overlay District, replacing the former bylaw with the Massachusetts 2020 Model Floodplain Bylaws drafted by MEMA. Similar to the former bylaw, this overlay district restricts in the 1%-chance regulatory floodplain. The areas included in the Floodplain Overlay District are the boundaries based in the FIRM. The amended bylaw clarifies that the floodplain management regulations found in Overlay District takes precedence over any less restrictive conflicting local laws, ordinances or codes. The bylaw also clearly outlines the variance process, whereby proposed projects must meet the requirements set out by State law, and may only be granted if: 1) Good and sufficient cause and exceptional non-financial hardship exist; 2) the variance will not result in additional threats to public safety, extraordinary public expense, or fraud or victimization of the public; and 3) the variance is the minimum action necessary to afford relief. Records of variance applications and decisions must be kept on file.

Subdivision development is reviewed and permitted by the Planning Board and requires review by the Board of Health and the Building Inspector. The Planning Board may, by majority vote of its members, require the filing of an Environmental Impact Study that includes locations of all wetland resources areas, proposed changes in surface drainage and proposed methods to maintain sediment and erosion control. Subdivisions within the Floodplain Overlay District must be given special review to determine whether the project will be reasonably safe from flooding, including providing base flood elevation data.

Driveway zoning regulations state that “driveways shall be so constructed that the water from the driveway shall not drain onto the road,” and further that “in no instance shall the edges of the driveway entering into the road conflict with the flow of surface water runoff.” The Highway Department must approve of the diameter of culverts to allow proper drainage and flow within roadside ditches.

Floodplains and areas subject to flooding are partially protected from adverse development impacts through the Massachusetts Wetlands Protection Act (310 CMR 10.00), one of the most protective wetlands laws in the U.S. In the Act, the 100-year floodplain is one of several types of wetland resource and is termed Bordering Land Subject to Flooding. In the Act, “the boundary of Bordering Land Subject to Flooding is the estimated maximum lateral extent of flood water which will theoretically result from the statistical 100-year frequency storm. Said boundary shall be that determined by reference to the most recently available flood profile data prepared for the community within which the work is proposed under the National Flood Insurance Program.” The floodplain boundary is presumed accurate, but this “presumption is rebuttable and may be overcome only by credible evidence from a registered professional engineer or other professional competent in such matters. Where NFIP Profile data is unavailable, the boundary of Bordering Land Subject to Flooding shall be the maximum lateral extent of flood water which has been observed or recorded (310 Mass. Reg. 10.57).

Under the Wetlands Protection Act no one may “remove, fill, dredge, or alter” any wetland, floodplain, bank, land under a water body, land within 100 feet of a wetland, or land within 200 feet of a perennial stream or river, without a permit from the local Conservation Commission. The Act identifies several presumed “interests” or values to be protected: flood control, prevention of storm damage, prevention of pollution, and protection of fisheries, shellfish, groundwater, public or private water supply, and wildlife habitat. The term “alter” is defined to include any destruction of vegetation, or change in drainage characteristics or water flow patterns, or any change in the water table or water quality. The wetland regulations prohibit most destruction of wetlands and naturally vegetated riverfront areas, and require replacement of flood storage loss when floodplains are filled. Most activities, such as construction, landscaping, and grading, require a permit from the Conservation Commission. Where development is proposed that would impact floodplains, a civil engineer or hydrologist should calculate the flood elevation. The Act is locally administered by the Otis Conservation Commission.

Additionally, the Massachusetts Building Code (780 CMR 1.00-36.22) has some of the most stringent building code standards in the country, including construction within flood zone or floodplains, and this code has been adopted by the Town of Otis as its minimum building standards. Local municipal building inspectors must be certified by the state to be eligible for the position.

Despite these bylaws and regulations, incremental residential development continues to fragment habitat and install impervious surface area across Otis. In recent years the Town has seen the development of approximately two new homes built per year on undeveloped lots. More prevalent is the tear down of older summer cottages to build larger, more modern homes. Owners often try to expand the footprint of the new home if health and zoning setbacks allow for this. The result is incremental increases the impervious surface footprint of the properties which, unfortunately, are often along lake and pond shorelines. Larger impervious footprints can also increase surface runoff into streams and down driveways into roadways, particularly where steep slopes are involved.

The Otis Highway Department is a small but dedicated crew of three full-time staff, working under challenging financial constraints to maintain the road system throughout the Town. Staff frequently inspect culverts, bridges, drainage and drop inlets to ensure that they are clear of debris. Ongoing maintenance and repair of roads is often linked to severe storm events. Heavy rains often require the Department to regrade and replace gravel and stone on dirt roads damaged or washed out. The Town actively pursues state funding for road, bridge and culvert upgrades and replacements, despite the fact that the odds are stacked against small towns such as Otis in receiving priority state highway funding. Recent improvement projects that include culvert upsizing occurred on Lee Westfield Road, West Center Road, and expanded bridge spans in the upcoming Tannery Road bridge replacement. The Town is actively pursuing replacement of traditional culverts on Reservoir Road with an open-bottom culvert that will meet the state stream crossing standard. Demands for state and federal highway funding has for decades far outpaced the annual allocations given to the Berkshire County region. As a result, worthy road improvement projects languish on the regional Transportation Improvements Project list for years, sometimes decades.

Substandard and failing gravel roads are located throughout the Town, some of which are Town-owned and some of which are privately owned. Many Town roads are failing due to a combination of factors, including damage from increased usage and compaction, washouts, and increased freeze/thaw events. During deep winter and spring thaws, roads can become impassible, and residents have to wait for the road to refreeze before they drive on them. During severe such times, emergency response can be limited or delayed on these types of roads. Many private roads are narrow, having been created to serve summer cottage communities. These roads were never constructed to withstand the higher traffic volumes that they now experience, and certainly not designed to withstand winter use. The Highway Department typically lays stone and/or regrade gravel roads during severe mud conditions to repair them for vehicle use, spending up to $20,000 per year for materials. In March of 2021, the Department spent that amount during just one two-week span, indicating a more costly future trend. Full-depth reconstruction, and in some cases road-widening, of the roadway would need to be undertaken to address the failings on a long-term basis. The estimated cost of $300,000-400,000 per mile for gravel reconstruction and a cost of $1 million per mile for reconstruct and paving hinders the Town's ability to address this issue.

Public safety services are provided through the Otis Police Department, which currently employs one full-time chief and five to eight part-time officers. The Town is currently considering sharing the Police Chief duties with neighboring Becket to create a full-time position to oversee both police departments. Currently, the Police Chief also acts as the Town's Emergency Management Director. While the Department endeavors to provide police coverage for as many hours a day as possible, there currently is no coverage on the midnight shift. The Town has difficulty maintaining a full police roster, and this situation is expected to become more difficult with the loss of a part-time police academy process. The state's new police reform legislation and resulting police training requirements will mean that part-time officers will need to undertake significantly more hours of training. The Otis Fire Department is an all-volunteer organization with 26 members. The Otis Rescue Squad is a 13-member team with two full time EMTs.

One of the greatest strengths of the Otis community is its willingness to work together and watch out for neighbors' health and well-being. Local residents have an independent Yankee self-reliance, yet they are quietly generous and supportive of neighbors in need. Many residents with medical needs are known to local first responders. Emergency response and the highway department work well together in times of emergency, which was most evident when during the ice storm of 2008. As one Town official stated, "no one went home until all the town roads were open," adding that they also coordinated with and helped National Grid to remove trees and restore power lines throughout Otis. The Town also provided regional support during this event, serving as the utility's staging area for the region, with shelters and warming stations set up for local and regional first responders and utility workers.

In general, Otis residents are used to living in a rural area where the nearest store, doctors and other services are typically 30 minutes or more away. They are used to withstanding periods of isolation during winter storms and mud season, so residents are relatively capable of sheltering in place for a day or two if necessary. However, new residents and second homeowners who move into Otis may not be physically or mentally prepared to occasionally shelter in place. They often come from urban areas and are unfamiliar with rural conditions of isolation. They may not be stocked with food, fuel and other emergency supplies. As more new residents move into Otis, it may be useful to develop and promote educational materials on homeowner emergency preparedness. This issue was raised throughout the MVP workshops held as part of this planning process.

The Town actively participates in the Southern Berkshire Regional Emergency Planning Committee (REPC), an all-hazards regional planning committee that focuses on emergency and incident planning and response. The REPC's strength is the shared coordinated efforts and expertise of its 12 member communities, all of which are located in southern Berkshire County, along with other regional first responder members such as Hillcrest Hospital and Southern Berkshire Ambulance. All member towns of the REPC benefit from the coordinated efforts undertaken by the REPC, which includes formal mutual aid agreements, shared equipment and supplies, coordinated communications and public outreach programs, trainings and drill exercises.

Otis currently employs emergency communications to reach residents through the Blackboard Connect technology. Approximately 910 users are enrolled in this system, where they can receive phone messages and/or text alerts from the Town. This system is periodically used to alert residents of emergency situations or news. It was used to announce the opening of the Town's cooling center during a heat wave in July of 2019. Although useful, Town officials would like to increase enrollment, particularly as more seasonal homeowners are becoming full-time residents.

The Town of Otis has undertaken great strides in reducing the energy used to operate municipal buildings and departments. Town building energy systems have been updated/improved and photovoltaic solar systems have been installed at the Center and East Otis Fire Houses, Transfer Station, and Highway Garage. An air source heat pump system provides heat and air conditioning to the Town Hall building, which also serves as the Town's shelter. The Town-owned 1.5 MW wind energy turbine generates enough electricity to power 300-500 homes.

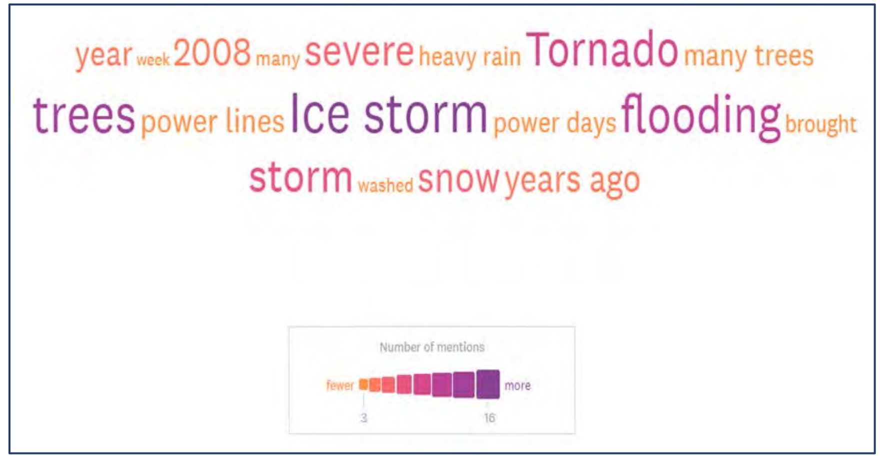
Resident Concerns

In developing this updated hazard mitigation plan, the Town of Otis undertook an extensive public participation effort. As a first step, the Town issued a public survey as a way to gather additional information on historic storm events, as well as to understand the concerns that residents, businesses and organizations have regarding natural hazards and climate change risk.

The survey was open spring through autumn of 2021 and was offered online via Survey Monkey and via paper copies in Town Hall. The extended length of the survey was intentional so that it could capture the concerns of Otis' second homeowners, which is substantial, as well as its seasonal business owners, such as camping facilities. A total of 111 responses were completed. Of this, 43% of respondents were year-round residents while 57% were seasonal residents. The responses received through the public survey has aided the Planning Committee and Town officials to develop and prioritize hazard mitigation and adaptation strategies.

The survey asked respondents to list where and when they had witnessed the occurrence of severe natural hazards in Otis. This question was open-ended to allow residents to answer without any prompts. Seventy respondents answered this question. Many specific roads were listed, confirming the areas of most concern already identified by Town officials.

Fig. 4.1. Most Common Responses to Severe Events Experienced in Otis



Source: Survey Monkey, 2021.

Flooding was the most commonly cited event that people listed, with T.S. Irene and Sandy being specifically listed as damaging events. Residents cited areas across Otis where roads were flooded and/or closed and people were isolated. The Ice Storm of 2008 was singly the most commonly-named hazard event, with 15% of respondents listing it specifically. Many respondents stated that they were without electricity for days, with individuals reporting that they were without power for three, six and nine days. The high percentage is significant when you consider the fact that the ice storm occurred in December 2008, when second homeowners are not living in Otis and thus would not be prone to list this event. More memorable events such as the fatal tornadoes that have hit the region and the snowstorm that caused the activation of the National Guard to Otis were also commonly listed. A “word cloud” of the responses helps to illustrate the words that were most often listed in responses (see Fig. 4.1).

The survey also asked respondents to choose and rank the top three hazards that concern them the most. The list of hazards included all the hazards evaluated in this hazard mitigation and climate adaptation plan, with the exception of Cyber Attacks. Flooding was broken out into two hazards – that of roads and of property – to aid the town in understanding how much private property impacts might be occurring in Otis. Flooding/washout of Roads was chosen as the hazard of most concern, with 46% of respondents ranking it #1 (of greatest concern) and 18% ranking it #2 (second greatest concern). In contrast, relatively few respondents voted Flooding of Your Property as a Top 3 concern, indicating that while many or most respondents have experienced closed roads or bridges, few have experienced flooding of their own property. Severe Winter Weather (snow, blizzards, ice storms) and Other Severe Storms (tropical storms/hurricanes, high winds, etc.) also received a high number of “Top 3” rankings. Vector-borne Diseases was voted by several respondents as being in the Top 3 concerns.

Lastly the survey asked respondents to choose and rank the reasons why they are so concerned about the hazards that they chose. Injury or Loss of Life was overwhelmingly ranked as respondents’ greatest concern, where 42% chose this as their #1 of the Top 3 concerns. Another 27% of respondents listed this concern as either their #2 or #3 Top 3 concerns. Loss of Electricity and Becoming Isolated also ranked high as Top 3 concerns.

Municipal Vulnerability Preparedness (MVP) Workshops

In the autumn of 2021, the Town of Otis held three two-hour MVP Workshops via Zoom technology. Each workshop began with a short presentation that helped to set the stage for the evening's discussion. The presentations began by providing natural hazard and climate change data specific to the evening's topic, drawing on past natural hazard events that have impacted the Town of Otis and the Berkshire region and offering scientific-based climate change projections. The presentations ended by asking contemplative questions that might stir workshop participants to development creative yet practical mitigation strategies.

At the conclusion of the presentations, participants were broken up into small, facilitated breakout groups. The number of breakout groups was determined by the number of participants. Attendance was highest in the first workshop on Infrastructure, which necessitated four breakout groups. The second workshop on Environment resulted in three breakout groups and the third on Society resulted in two breakout groups. In these small groups participants identified the Top Four Hazards that impact the Town, the vulnerabilities and strengths within the Town to respond to the hazards, and then began to develop action strategies to lessen hazard impacts and build community resilience. Information and strategies were recorded on matrix tables developed by the CRB process. Each small group ended this process by prioritizing the action strategies of greatest importance, choosing two of these as the most pressing actions that the Town should pursue for implementation.

The workshops ended by bringing all participants back together in one large workshop setting. Each small group reported on their discussion and brough forth to the reconvened group their top two priority actions. These actions were compiled into one list that was presented to the full group. Using an online polling technology, each individual participant chose two actions from the full list that they believed should be prioritized for implementation. The matrix tables that were developed during these workshops are found in Appendix __.

During the MVP workshops, each breakout group chose the Top 4 Hazards that they felt posed the greatest risks to the Infrastructural, Environmental and Societal components of Otis. All of the Top 4 Hazards that participants chose during the three workshops are listed in a summary table (see Table 4.1). As noted previously, there were nine breakout groups over the series of the three workshops. As can be seen in the summary table, the main risks that were common throughout the process were flooding and winter storms, listed prominently in each breakout group.

Table 4.1. Summary Table of Top Four Hazards listed during Workshops

Hazards Listed	Times Listed as Top 4	Times Listed as Top 4	Times Listed as Top 4	Total Listings
	Infrastructural Workshop (4 breakout groups)	**Environmental Workshop** (3 breakout groups)	**Societal Workshop** (2 breakout groups)	
Flooding (includes Downpours, Extreme Precipitation)	4	3	2	9
Severe Winter Storms (includes Ice Storms)	4	3	2	9
Invasive Species	1	2	2	5
High Winds	1	1	2	4
Severe Weather (unspecified)	2	0	0	2
Rising/Extreme Temperatures	1	1	0	2
Vector-borne Disease	1	0	0	1
Fire	1	0	0	1
Drought	0	1	0	1
Cyber-security	1	0	0	1

Source: BRPC, 2021.

Workshop #1, Infrastructural Component

Vulnerabilities

Providing safe transportation routes for all Otis residents emerged as the single, central theme throughout all breakout groups, with Flooding and Severe Winter Weather being cited by each breakout group as a top hazard. Areas of Town where flooded roads limit or prohibit safe transport were identified and discussed, and many of these areas are along the Town's main transportation routes such as South Main Road (Rt. 8) and Monterey Road (Rt. 23), which serve as critical commuting, emergency and commercial routes that link residents and businesses to outside services. These routes have a history of being flooded and, in some cases, completely closed down. These routes are maintained by MassDOT, and so coordination with this agency is key. Another area of concern that was specifically pointed out is the Lakeshore Drive bridge, which spans Benton Brook. The road is the only egress in and out of the Otis Woodlands neighborhood, which has more than 200 homes. The bridge has flooded in the past, isolating the entire community.

Other areas of great concern are unpaved roads that become dangerous or impassible during wash outs caused by severe storms or during freeze/thaw events and mud season. Again, safe and reliable passage is a common theme. In general, the Town has been experiencing an increase in the number of freeze/thaw events per year for the past several years, leading to more and longer periods where some roads become impassible to all but very hardy vehicles. For local residents who have lived on these roads for years or decades, mud season is considered as something that has to be endured each spring, where there are periods of time where the roads are impassible and/or closed. In recent years freeze/thaw cycles have become more frequent and severe due to periods of warmer weather, making life more inconvenient for them. The 2021 mud season was particularly inconvenient, due to the number of thaws and the duration of them. The number of vehicles that were stuck and had to be towed out of the mud was higher than usual. The increased towings may partly be due to COVID-19, during which many second homeowners moved to Otis year-round and spent their first winter here, inexperienced in how to navigate their first freeze/thaw events. It was also noted that many second homeowners lived on private roads, many of which are gravel (vulnerable to freeze/thaw) and some of which are narrow in width (and which become narrower after snowbank buildup). Educating newcomers about rural living and how to prepare for and endure periods of isolation, i.e. sheltering in place, was raised as an issue.

Strengths

Unlike many rural communities in Western Massachusetts, Otis is fortunate in that the Town owns and operates a broadband internet network that is available throughout the town. This system supports residential and commercial communications for personal, work, tele-med and other necessary services.

Regarding the electricity grid, it was noted that Eversource has improved their operations in several ways since the Ice Storm of 2008. The utility has proactively undertaken a rigorous maintenance program, removing overhanging limbs and dead/dying trees, and has made strides in improving their communications and coordination with local officials and MassDOT.

Priorities

Several individual actions called for assessment, prioritization and improvement of roads and culverts throughout Otis. Many roads were listed by name, including Routes 8 and 23, Lakeshore Drive, and Reservoir, West Center, Churchill, Becket, Dimmock and Stebbins Roads.

Eight Top 2 Priorities were brought by the four breakout groups to the full group for ranking. Participants were asked to vote for the Top 2 that they would prioritize for implementation. Table 4.2 lists the eight priority actions that emerged from the breakout groups. As noted in the table, assessing and rebuilding vulnerable gravel and paved roads and upsize/replace culverts was voted as the highest priority action strategy, with 69% of workshop participants voting for this action. Several other road infrastructure actions that are listed would support long-term road improvements and public safety concerns. Developing a plan for emergency response was voted as the second highest action that the Town should pursue. This action would address many of the emergency preparedness vulnerabilities that were identified during the workshop.

Table 4.2. Infrastructural Component: Top Priority Action Strategies

Top Priorities Brought to Full Group	Percent Votes
Assess and rebuild all vulnerable gravel and paved roads, and associated culvert upsizing/replacement.	69%
Develop plan for emergency response.	25%
Assess the number of households/users of high-speed internet; identify and address barriers; ensure that every school-aged child has access to a computer and internet.	19%
Utilities and road managers monitor and remove dead and dying trees.	19%
Address road flooding with a long-term maintenance plan.	19%
Tree clearing around powerlines and on more narrow roads.	19%
Study private roads that connect to critical infrastructure and consider maintenance plan; or [consider] Town maintenance in long-term.	19%
Create inventory of road ownership and condition; have a plan to ensure better access.	12%

Workshop #2, Environmental Component

Vulnerabilities

During this workshop there was general consensus that Otis' natural landscape is key to the community's quality of life and economic survival. Life-long residents, second homeowners and outdoor recreation businesses are drawn to Otis by its rural character and abundance of natural resources. However, the Town's forests and wetland resource habitats are vulnerable to impacts from existing and future development and from climate change. Participants raised concerns about how development can fragment habitat connectivity and degrade water quality. Participants discussed regulatory land use tools to protect natural resources, including enforcement of the state's Wetlands Protection Act and review of existing Town bylaws to ensure that development impacts are minimized.

To maintain habitat connectivity, participants favor identifying and prioritizing key parcels in Otis that should be targeted for conservation efforts. The vast majority of forest lands in Otis are owned by private landowners, so educational outreach to large landowners is key. Educational efforts should help landowners understand the local benefits of maintaining and protecting intact ecosystems. Technical assistance is available to help landowners set goals for the long-term management of their land, which could include timber/maple syrup production, specific rare species and/or bird habitat protection, water quality protection, recreational offerings, or a combination of goals. As forests and wetland resources face a changing climate, including invasive species, landowners will also need to consider managing their forests for resiliency. This includes strategies to combat invasive forest species. Despite the assistance available to landowners, most are unaware of these programs.

Participants cited a need to not only provide technical assistance, but also to provide financial incentives for owners of undeveloped land. More outreach to inform landowners of existing incentives (Chapter 61 tax abatement, conservation restrictions) is needed. More interestingly, the issue of carbon storage and sequestration was discussed within the breakout groups. Acknowledging the forests' ability to sequester carbon, participants began to identify strategies to help the Town and private landowners quantify that sequestration potential and somehow generate a revenue stream for those willing to conserve their land. The input provided by Tom Ryan of the DCR Forestry program, Becky Cushing of MassAudubon, and Carrieanne Petrik, all of whom attended this workshop, helped to inform and guide participants as they discussed these issues and developed action strategies.

The issue of invasives species was a major component of discussion. Many participants sited the impacts that invasive plant species are already having in Otis, and their concern that climate change could alter and facilitate invasive species' spread throughout the Town's forests and ponds. Actions were developed to control invasive species and promote the replanting of native species, offering a variety of means by which to achieve this objective, including plant sales utilizing local schools and businesses.

Runoff from roads into streams and ponds, particularly sedimentation from erosion and washouts of gravel roads, are ongoing problems in many areas of Otis. Once again actions were developed that called for assessing and pro-actively improving stream crossings and gravel roads to reduce sedimentation.

Strengths

Overall, Otis' vast extent of natural forest cover and the abundance of ponds and small streams were viewed as strengths by workshop participants. While it was acknowledged that these resources need protection, it was also noted that residents and youth are concerned about the environment and climate change impacts. This concern and interest, particularly in teenagers, was viewed with hope. Residents and second homeowners are more likely to take action if they are given the tools to do so. Therefore, directly engaging local youth and their parents through school programs can raise awareness and get results, such as providing information and hosting native plant/tree sales for home pollinator gardens or new landscaping options for lakefront properties.

Priorities

Five Top 2 Priorities were brought by the three breakout groups to the full group for ranking. Those priority actions that addressed long-term forest health and habitat connectivity were favored, followed closely by actions to protect water quality and road stability.

Table 4.3. Environmental Component: Top Priority Action Strategies

Top Priorities Brought to Full Group	Percent Votes
Work with DCR Mass. Forestry and other state entities/nonprofits to educate local residents on tree death, invasives, and actions residents can take.	58%
Ensure that large intact parcels are connected; prioritize conservation among parcels; also prioritize wildlife/habitat connectivity.	50%
Assess road infrastructure – assess culverts (undersized?) – gravel and dirt roads; identify areas susceptible to washouts – take preventative measures before storms.	42%
Allocate more resources toward road maintenance and stormwater BMPs that mitigate erosion.	33%
1 Overarching top action: broader education effort about actions that people can do to address impacts climate change.	17%

Workshop #3, Societal Component

Vulnerabilities

Emergency response planning dominated the discussion of this workshop. Although Top 4 Hazards were listed, most of the conversations and actions covered emergency planning and response that would address most hazard events. Overall, most participants of the workshop felt that the Town of Otis was generally prepared to face and respond to natural hazards, citing several strengths within the Town's operating systems. However, vulnerabilities persist, particularly in the difficulties in maintaining full rosters for fire, ambulance and police crews. The police department has relied on having part-time officers to fill in during summer or when needed, but new state mandates have increased the training that part-time officers must complete to retain their position. Although all Otis officers are dedicated, it is likely that many part-time officers will leave the force here in Otis and throughout the region.

The Town's population swells during the summer months, when second homes, overnight camps and campgrounds are in full operation. The influx of additional people does not bring with it an influx in first responder volunteers. Outside fire and ambulance support is provided through mutual aid, but neighboring towns face a similar situation in that they struggle to attract and maintain their own volunteers to answer calls.

Otis has in the past had an active Community Emergency Response Team (CERT), a group of citizen volunteers who were trained in basic emergency response skills and assisted professional first responders as requested. Workshop participants believe that the CERT seems to have become inactive and may not be able to provide the skills needed if called upon. Several actions were developed to address this issue.

Once again it was noted that there was only one egress in and out of Otis Woodlands, and that this route could be flooded and closed during severe flooding events.

Strengths

Otis employees, first responders, and civilian volunteers were lauded for their willingness to come together and work cooperatively to overcome hazards and disasters. Otis' emergency response crew (the highway department, fire company and police department) are all on call when such events are predicted, and civilians join work crews when needed. Local responders and neighbors check on neighbors during severe events. The Town Hall is equipped and ready to serve as a local shelter in the event of severe weather or electricity outages. The Highway Department does a good job of plowing during winter storms, and tries to maintain open roads during all events. It was noted that during a severe three-day blizzard several years ago, the National Guard was dispatched with heavy military equipment to Otis to plow roads when many of the Highway Department's equipment broke down due to the intense snow load. Again, it was noted that Eversource has improved their response times and the maintenance of their distribution system after the difficulties of the 2008 Ice Storm.

Long-time residents feel that they are generally prepared to shelter in place, having experienced times when they were isolated due to closed roads and/or power outages. Many have alternate heat sources, such as wood stoves, and/or generators, and have plans for sheltering in place for a few days. However, newcomers who move to Otis from urban or suburban areas appear to be less prepared for times of isolation in this rural atmosphere, particularly during the winter months. They try to travel muddy gravel roads when they've been closed rather than wait it out. They also may not be aware of the many services that the Town or seasoned neighbors can provide during these times. These services include Blackboard Connect, a reverse-911 emergency communications system that alerts residents of potential emergency situations and announcements. It can be used to inform residents of road closures and later of road re-openings, to announce when Town Hall is open as warming or cooling centers, and other important news. Many actions call for an outreach campaign to inform and guide all residents on how to prepare emergency preparedness plans so that they can safely shelter in place.

Priorities

Five Top 2 Priorities were brought from the two breakout groups to the full group for ranking. The action most favored was to educate residents about emergency preparedness planning and to inform them what emergency services the Town has to offer. Other actions support emergency response operations, including recruiting new volunteers and maintaining safe transportation routes.

Table 4.4. Societal Component: Top Priority Action Strategies

Top Priorities Brought to Full Group	Percent Votes
Get more information to residents (especially newcomers) on how to prepare for storms, loss of power; outreach through social media, town hall welcome packet, Blackboard Connect, Otis Observer and Town website.	90%
Need more volunteers to help with emergencies; inform the residents about the need for volunteers; reactive CERT	30%
Utilize incoming [federal] infrastructure funds to improve the roads	30%
Make sure Town Hall shelter is up to standards and is certified by the Red Cross so that Red Cross may be able to run the shelter if requested	30%
Create alternate routes for emergencies	20%

Prioritizing Actions

The actions herein listed are derived from a wide and varied public participation process. Town officials developed and prioritized a series of actions after having evaluated past hazard data and considering projected future trends. FEMA's Capability Assessment Worksheet was a valuable tool in helping Town officials identify Otis' strengths and weaknesses, as well as gaps in service and operations. The Town of Otis is responsible for taking the lead on most of the actions that have been developed, often in partnership with state agencies such as MassDOT or the Department of Conservation & Recreation. However, residents who participated in the MVP Workshops voiced their opinion that households and individuals need to also take responsibility for actions to reduce risk to their health and property, and to increase the resiliency of the community's ecosystem in the face of climate change. All residents need to be prepared to shelter in place during winter and other severe weather events and restrict travel on gravel roads during freeze/thaw mud season conditions. The development of an emergency preparedness outreach campaign, with some additional materials targeted to newcomers, can begin to address these issues. Landowners, particularly those with large holdings, need to understand the changes and challenges that Otis' ecosystems are facing so that they can participate in community-wide efforts to protect and minimize impacts to those ecosystems. A campaign to educate and empower private owners to take action on their lands can begin to address these issues. These broad actions are reflected in Table 4.5. Several specific action items to implement these broader educational and outreach campaigns are listed in the MVP Risk Matrix tables found in Appendix __ .

Overall, the MVP Workshop process resulted more than 80 individual actions to being to address Infrastructural, Environmental and Societal risks (Appendix __). These are the actions offered by workshop participants and transcribed during the breakout groups. These actions have been combined and prioritized into broader actions that succinctly incorporate the actions to address highest risk.

Table 4.5 provides a roadmap for the Town of Otis to increase resiliency and will be updated with the new plan in five years. *Actions in italic font are from the 2012 plan.* New actions are listed in regular font and those identified through the hazard mitigation and MVP planning processes.

The *Description of Action* column is a brief summary of the mitigation action the community has identified to reduce their vulnerability to a hazard or more broadly increase resilience.

The *Benefit* column explains what the action mitigates or how it could increase resiliency.

Implementation Responsibility reflects ownership and/or jurisdiction of a facility or action that will be mitigated or otherwise receive funding for improved resilience.

Priority of a project is High or Medium, determined by factors including conditions due to disaster events and recovery priorities; local resources, community needs, and capabilities; State or Federal policies and funding resources; hazard impacts identified in the risk assessment; development patterns that could influence the effects of hazards; climate change implications, and partners that have come to the table.

Timeframe - Short term projects are those that can and should be implemented immediately, within the five-year timeframe of this hazard mitigation plan. These projects are likely to have a favorable benefit-cost outcome, have the political and community support necessary, and are practicable. Long term projects likely require multiple steps before implementation, including studies, engineering, and gaining community support, and therefore will take more than five years to complete. Ongoing projects are those that may be implemented immediately but will require constant investment of resources for maintenance or other project requirements such as education.

The *Cost* column was estimated and categorized as follows:

High: Over $100,000
Medium: Between $50,000 - $100,000
Low: Less than $50,000
N/A: For some projects, cost is not applicable

Resources / Funding listed for each action are potential technical assistance, materials and funding for the type of project identified.

Notes / Updates from 2012 describes what actions have been taken since the completion of the *Berkshire County Hazard Mitigation Plan*, the plan in which Otis was a participant.

Table 4.5. Mitigation Action Plan for the Town of Otis

Actions in italic font are from the 2012 plan. New actions are listed in regular font and those identified through the hazard mitigation and MVP planning processes.

Description of Action	Benefit	Implementation Responsibility	Timeframe / Priority	Cost	Resources / Funding	Notes / Updates from 2012
Conduct a study of the Farmington River where it overflows onto Route 8 to determine solutions to flooding and implement findings	*Reduce risk of flooding and reduce the cost of maintaining the road*	*Town of Otis, MassDOT*	*4-6 year/ Medium*	*NA*	*Town, MassDOT, FEMA*	MassDOT jurisdiction; action not undertaken by Town
Replace culverts on Reservoir Road to reduce risk of flooding	*Improving drainage reduces the risk of flooding and reduces the cost of maintaining the road*	*Town of Otis*	*1-3 years/ High*	*High*	*Town, Dept. of Ecological Resources (DER), FEMA*	In progress; replacing three 6' culverts with open bottom span
Replace bridge on Tannery Road with a larger bridge to allow higher flows to pass	*Reduce flooding of the road and adjacent area*	*Town of Otis, MassDOT*	*1-3 years/ High*	*High*	*MassDOT*	In Progress; MassDOT overseeing bridge replacement 2022
Conduct beaver control activities in the area around Monterey Road to alleviate flooding	*Reduce or eliminate the risk of flooding from clogged infrastructure and adjacent flooding*	*Town of Otis, Mass DEP*	*4-6 years/ Medium*	*Low*	*Town, MSPCA*	MassDOT jurisdiction; beaver control methods have been installed and monitored
Replace old stone culvert on the Lee-Westfield Road with a larger culvert to reduce flooding	*Reduce the risk of flooding and reduce the cost of maintaining the road*	*Town of Otis*	*7-10 years/ Low*	*Medium*	*Town, FEMA*	Completed; 2 stone culverts replaced & enlarged ~2015

Description of Action	Benefit	Implementation Responsibility	Timeframe / Priority	Cost	Resources / Funding	Notes / Updates from 2012
Conduct a study of West Center Road to determine solution to reduce flooding and implement findings	*Reduce the risk of flooding and reduce the cost of maintaining the road*	*Town of Otis*	*4-6years/ Medium*	*Medium*	*Town, FEMA*	Completed; Opening widened; replaced old single culvert with double culverts
Conduct a study of Hayden Pond Dam and implement findings	*Reduce the risk of a failure and subsequent flooding*	*Dam Owner, Office of Dam Safety*	*1-3 years/High*	*NA*	*Dam Owner, Office of Dam Safety*	No action taken; private owner
Identify historic structures, businesses and critical facilities located in hazard-prone areas, including floodplains and dam failure inundation areas	*Help those facilities to be better prepared for the hazards and to prevent the loss or damages*	*Town of Otis, MEMA, Mass. Historical Commission*	*4-6 years/ Medium*	*NA*	*Town*	No action taken; no history of damages
Conduct assessment of all roads (public & private) with known hazard risk, focusing on dirt roads; develop recommendations to reduce risk and protect environment; share results with private road associations; develop capital improvement plan for Town roads	Improve safe travel throughout Town; reduce impacts to habitat; ensure emergency response access; aid Town in creating municipal long-term budgeting procedures	Highway Dept., private road owners, Selectboard	Short / High	Low / Medium	MVP; Housatonic Valley Assoc.; Fed. Infrastructure funds; Town; Ch. 90	New Action
Catalog and assess culverts and drainage systems; prioritize for improvement those at greatest risk; develop a long-term maintenance program	Reduce flood risk and environmental impacts; ensure safe travel and emergency access	Highway Dept., Selectboard; BRPC; HVA, BEAT	Short / High	Low / Medium	BRPC, HVA, Dept. of Ecological Restoration; MVP; EEA grant funds	New Action

Description of Action	Benefit	Implementation Responsibility	Timeframe / Priority	Cost	Resources / Funding	Notes / Updates from 2012
Research and identify most cost-effective approaches to improve long-term function of dirt roads; find examples of cost-effective working solutions, considering Geogrid technology; share recommendations with private road associations	Provide safe travel during increased number of freeze/thaw periods; ensure emergency response access; aid Town in creating long-term budgeting procedures	Highway Dept., MassDOT; Baystate Roads; Berk. Co. Highway Super. Assoc.; BRPC	Short / High	Low	MVP; Fed. Infrastructure funds; state funds; Town; Ch. 90	New Action
Implement findings of cost-effective approaches from above assessment; prioritize gravel portions of West Center, Becket and Dimmock Roads for improvements & pursue funding	Provide safe travel during increased number of freeze/thaw periods; ensure emergency response access	Highway Dept.	Short to Long / High	High	Fed. Infrastructure Fund; state funds; Town; Ch. 90	New Action
Assess flood risk of municipal buildings in Village Center	Reduce risk of injury and/or property damage; ensure Town government function and response	EMD, Fire Dept.	Short / Medium	Low	Town	New Action
Develop and distribute Emergency Preparedness Materials to help residents safely Shelter-in-Place; focus rural living and travel conditions; ensure vulnerable populations are enrolled in emergency alert system and wellness checklist	Promote self-sufficiency for public health and safety; direct limited emergency resources where needed most	EMD, Highway Dept., BRPC, REPC	Short and Ongoing / High	Low	BRPC, REPC	New Action
Conduct public outreach campaign to solicit new emergency response volunteers and reactive CERT	Provide adequate emergency response services when needed	EMD, REPC, Fire Dept.	Short / High	Low	REPC, Red Cross, MEMA	New Action

Description of Action	Benefit	Implementation Responsibility	Timeframe / Priority	Cost	Resources / Funding	Notes / Updates from 2012
Educate landowners about importance of maintaining forest and vegetative cover; provide guidance to forest owners; provide planting and restoration guidance and workshops to homeowners, businesses; host native plant sale events; establish a citizen conservation group to lead these efforts	Protect water quality; maintain forest sequestration and storage of carbon; maintain habitat connectivity to support ecological resiliency	DCR Forestry, Fish & Game, Audubon, local native plant nurseries, regional school district	Short and Ongoing / Medium	Low	EOEEA grant programs, MVP; Arbor Day Fdn., DCR Urban Community Forestry Challenge,	New Action
Revisit Otis zoning bylaws with Climate Change in mind; require developers to minimize land clearing and promote Low Impact and/or Smart Growth strategies; strengthen bylaw language where needed	Maintain land cover and soils to reduce peak flood and erosion potential and protect water quality; maintain forest sequestration and storage of carbon; maintain habitat connectivity to support ecological resiliency	Planning Bd.	Ongoing	Low	Citizen Planner Training Collaborative, BRPC; MA Smart Growth / Smart Energy Toolkit;	New Action
Investigate funding opportunities to facilitate land conservation and reduce fossil fuel use; possibilities include adopting Community Preservation Act and Green Communities Act	Land in its natural state maintains natural functions and improves long-term resiliency; reduce local greenhouse gas emissions	Energy Committee; Select Board	Long / Medium	Low	EOEEA, BRPC	New Action
Investigate establishment of a public drinking water supply system in the Village Center	Reduce salt contamination in drinking water in this area	Selectboard, Town Admin, Water Operator	Ongoing / Medium	Low	EOEEA, DEP, MassDOT, American Rescue Plan Act	New Action

Description of Action	Benefit	Implementation Responsibility	Timeframe / Priority	Cost	Resources / Funding	Notes / Updates from 2012
Verify condition of all dams and obtain safety operational procedures / emergency action plans from owners	Town largely unaware of condition of dams in Otis; proactively inform emergency response teams so they can proactively develop response plans	EMD, Selectboard; dam owners	Short / High	Low	DCR Office of Dam Safety	New Action
Revisit and update this HMCAP as needed	Maintain public awareness of natural hazards and climate change impacts; record Town's progress; increase long-term resiliency	EMD, Town Administrator; Highway Dept., Planning Board	Ongoing	Low	MVP, MEMA	New Action

CHAPTER 5: PLAN ADOPTION

44 CFR § 201.6(c)(5)

This Plan received official Approval Pending Adoption from FEMA on DATE and was formally adopted by the Otis Select Board on DATE. Subsequently it received final approval from FEMA on DATE.

CHAPTER 6: PLAN MAINTENANCE

44 CFR § 201.6(c)(4)

44 CFR § 201.6(c)(4) asks for a section of the HMCAP to describe the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle, process by which Otis will incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate, and how the community will continue public participation in the plan maintenance process (44 CFR § 201.6(c)(4)(iii)).

Plan Review and Updates

§201.6(c)(4)(i) (iii)

The Town of Otis will officially review needed updates for the plan on an annual basis. Specifically the Hazard Mitigation and Climate Adaptation Planning Committee, stakeholders, and partners will maintain and update the mitigation action tables, complete site visits and produce reports of completed or initiated mitigation actions to incorporate into the next plan revision, research and document new disaster information, and participate in resiliency- and mitigation-related initiatives available to the region.

Annual review is scheduled to occur during the late fall of each year. Under the leadership of the Planning Committee, the Town Administrator will track updates based on completed mitigation actions, new development, changing problem areas, and input from public involvement. As needed on an annual basis, these updates will be shared with BRPC, which maintains county-wide GIS data.

In reaching out the residents and neighbors of Otis, the Hazard Mitigation Planning Committee began building a network of interested residents that can enhance the next update. While the HMCAP must be updated every five years, Otis will begin the process of organizing and identifying funding for the plan update every 3.5 years. Recommendations listed in the FEMA Review Tool (following page) will be considered.

Integration in Future Planning

§201.6(c)(4)(ii)

This HMCAP will be used in all future planning efforts in Otis including comprehensive plan updates, transportation plans, and zoning changes.

The final adopted HMCAP will be made publicly available on the Town of Otis website for reference and comment. Any regional plans developed by BRPC or the Commonwealth should refer to the publicly available Otis Hazard Mitigation and Climate Adaptation Plan to ensure consistency with the vision for community resilience to hazards.

FROM SECTION 2 OF THE LOCAL MITIGATION PLAN REVIEW TOOL ISSUED BY FEMA, Dated

PLAN ASSESSMENT – INSERT FEAM FINAL COMMENTS HERE

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:

- N/A

References:

Berkshire Regional Planning Commission (BRPC), 2003. *Massachusetts Buffer Manual*, Pittsfield, MA.

BRPC, 2012. *Berkshire County Hazard Mitigation Plan*, Pittsfield, MA.

Commonwealth of Mass., 2021. Resilient MA Climate Clearinghouse website, https://resilientma.org/. This website hosts relevant data used throughout this plan, including the NE CASC data.

Federal Emergency Management Agency, 2013. Local Mitigation Planning Handbook, Wash, DC.

Mass. Emergency Management Agency (MEMA) & the Exec. Office of Energy and Environmental Affairs (EOEEA), 2013. *Massachusetts State Hazard Mitigation Plan (SHMP),* Boston, MA.

Mass. Emergency Management Agency (MEMA) & the Exec. Office of Energy and Environmental Affairs (EOEEA), 2018. *Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP),* Boston, MA.

Otis Master Plan Steering Committee & BRPC, 2016a. *Master Plan, Town of Otis, Massachusetts*, Pittsfield, MA.

Otis Master Plan Steering Committee & BRPC, 2016b. *Open Space and Recreation Plan, 2016-2021*, *Town of Otis, Massachusetts*, Pittsfield, MA.

APPENDICES:

APPENDIX A: PUBLIC PARTICIPATION DOCUMENTATION

PUBLIC SURVEY RESULTS

STORYMAP

PUBLIC LISTENING PPT DEC 2020

OSBSERVER ARTICLES

WORKSHOP POWERPOINTS x 3

WORKSHOP MATRICES

PUBLIC LISTENING SESSION FEB 2022 FLYER & POWERPOINT

PUBLIC POSTING OF PLAN ON TOWN WEB

PUBLIC ANNOUNCEMENTS FB, BERK EAGLE, DIRECT INVITATION TO REVIEW PLAN TO TOWNS & SBREPC, OTHERS