THIS SPACE RESERVED FOR PHOTOGRAPHS TO BE INSERTED.

ADDITIONAL HISTORIC PHOTOS/FIGURES ARE EXPECTED TO BE INSERTED WITHIN THE RISK ASSESSMENT SECTION

** DRAFT ** TOWN OF PERU

HAZARD MITIGATION AND CLIMATE ADAPTATION PLAN

August 10, 2021

ACKNOWLEDGEMENTS

The development of this *Peru Hazard Mitigation and Climate Adaptation Plan* has been made possible with financial support from the Hazard Mitigation Grant Program, issued by the Federal Emergency Management Agency and administered by the Massachusetts Emergency Management Agency (MEMA). The Town would like to thank the unerring support and guidance provided by MEMA's hazard mitigation staff throughout this planning process.

The Town of Peru would like to thank the members of the Peru Hazard Mitigation Planning Committee, who served as the advisory committee for this planning effort.

The Berkshire Regional Planning Commission provided technical assistance to the Town and the Planning Committee throughout the planning and approval processes

Table of Contents

CHAPTER 1: INTRODUCTION

Purpose

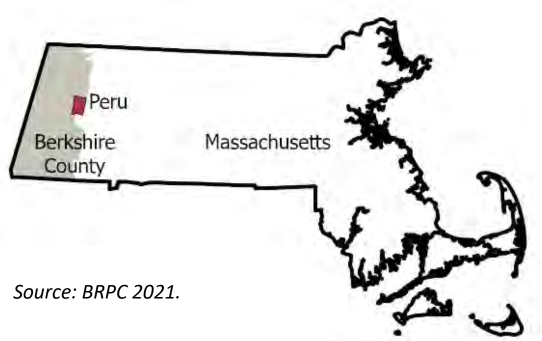
The purpose of hazard mitigation planning is to reduce or eliminate the need to respond to hazardous conditions that threaten human life and property. Hazard mitigation can be an action, activity, process, or physical project designed to reduce or eliminate the long-term risks from hazards.

The Town of Peru 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.” The Town’s eligibility for FEMA’s hazard mitigation grants is crucial.

The defined mission for the Town of Peru Hazard Mitigation and Climate Adaptation Plan is to identify risks, eliminate or reduce the loss of life, property, infrastructure and natural resources of the Town from disasters and climate change, 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

Fig. 1.1. Location of Peru within Massachusetts

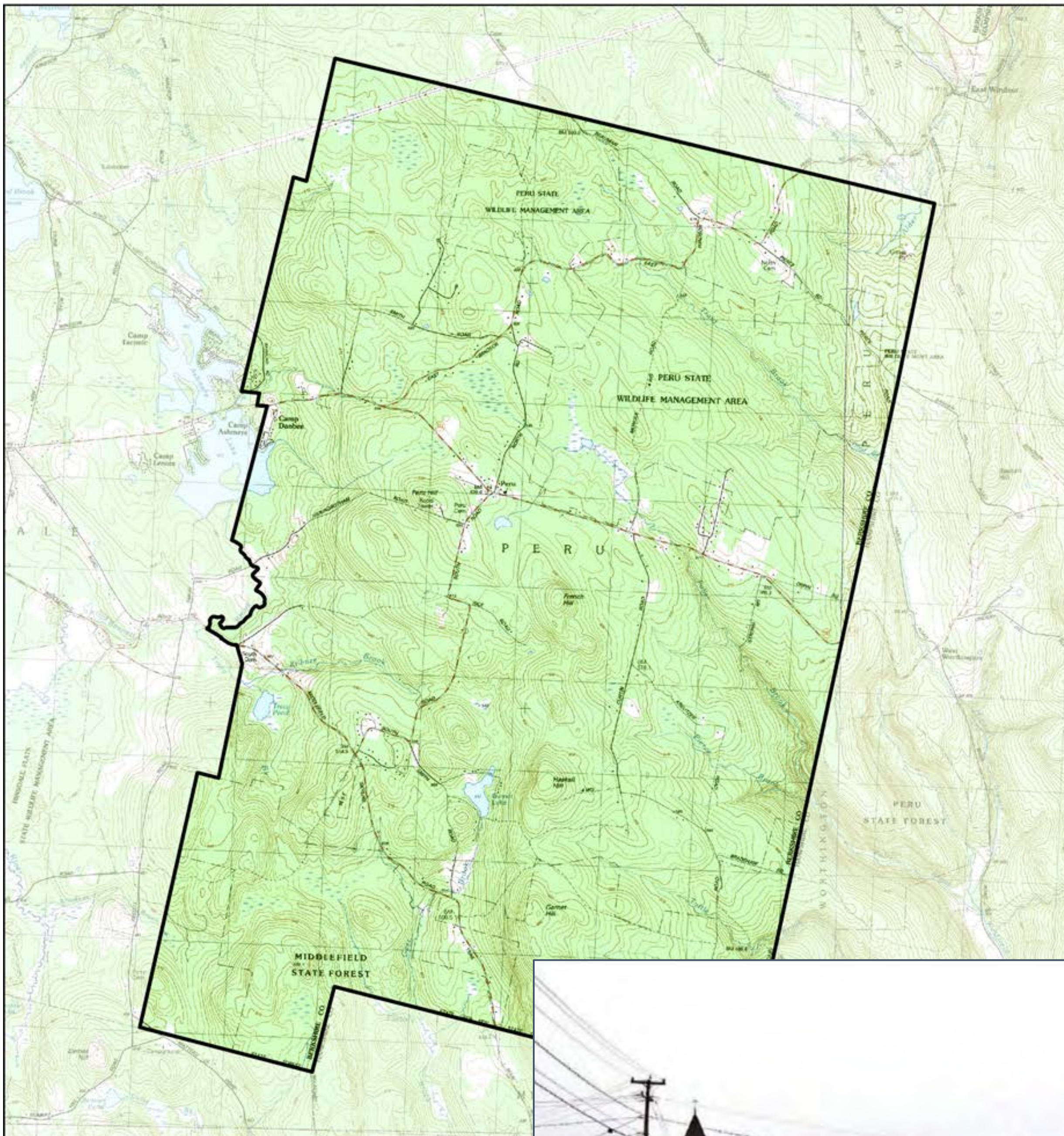


Source: BRPC 2021.

The Town of Peru is a small rural community located in east-central Berkshire County, Massachusetts. It is surrounded to the north by the town of Windsor, to the east by Cummington and Worthington, to the south by Middlefield and Washington, and to the west by Hinsdale.

The Town of Peru covers an area of approximately 26 square miles (~16,663 acres). The center of the Town is located along the top of the Berkshire Range, with relatively high elevations located throughout the Town, resulting in temperatures that are five to eight degrees cooler than the valley towns of the county. The Peru Town Hall has the distinction of being the highest town hall in elevation in Massachusetts. The Peru First Congregational Church at the center of the Town sits atop the dividing ridgeline that separates two major watersheds: the western portion of the Town drains into the Housatonic River Watershed while the eastern portion of the Town drains into the Westfield River Watershed. High elevation wetlands are found along the plateau area from the North Road / East Main Road intersection eastward. Peru’s elevation over its neighbors, the rolling terrain and winding country roads define the Town’s character and the independence of its inhabitants.

Fig. 1.2. Topographical Map of Peru



Source: BRPC, 2021.

Fig. 1.3. The Peru First Congregational Church sits atop the divide that separates the Housatonic and Westfield River Watersheds. The Town Hall and Highway Garage is located just to the east of this site.

Source: Town of Peru, 2021.

Mitigation Planning History

This HMCAP is the Town of Peru's first effort at hazard mitigation or climate change adaptation planning. The Town has conducted local and regional emergency preparedness planning through the coordinated efforts of the Central Berkshire Regional Emergency Planning Committee (REPC).

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 Peru's 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 Peru HMCAP is a compilation of data collected by BRPC, information gathered from the Peru Hazard Mitigation Planning Committee (the Planning Committee) during meetings, and interviews conducted with key stakeholders outside of working meetings. The Plan reflects comments provided by the Planning Committee, local officials and citizens, neighboring towns, and ultimately MEMA and FEMA.

Planning Meetings and 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 Appendices for documentation.

In February 2021 the Town of Peru formed the Planning Committee to develop the HMCAP. A grant from Federal Emergency Management Agency (FEMA) through the Massachusetts Emergency Management Agency (MEMA) made this comprehensive mitigation and climate change planning process feasible. Members of the Planning Committee include town department heads, Town Boards and representatives from the citizenry. The Planning Committee members 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 and review existing plans, procedures, bylaws and protections already in place. The Planning Committee met five times between February and June 2021, with all meetings open to the public and publicly posted in accordance with the Massachusetts Open Meeting Law. All meetings were held via Zoom technology due to the restrictions in place during the COVID-19 pandemic.

Table 2.1. Peru Hazard Mitigation Planning Committee

Name	Affiliation
Bruce Cullet	Peru Selectman, Peru Police Chief
Verne Leach	Peru Selectman, Peru Volunteer Fire Fighter
Kim Leach	Peru Town Clerk
Sam Haupt	Peru Planning Board, Peru Zoning Board of Appeals, Peru Vol. Fire Fighter, Peru Finance Committee
Justin Russell	Peru Highway Foreman
Caleb Mitchell	Peru Town Administrator
Lauren Gaherty	BRPC
Mark Maloy	BRPC
Emily Lange	BRPC

In an effort to reach as many residents as possible, the Town issued a public survey that asked respondent to describe the natural hazards that they had experienced and the concerns that worry them most about hazard events, including climate change impacts. The survey, which was offered online and in paper form was open for three months, during which the Town received a total of 42 responses. The Town promoted the survey and the planning process by placing notices on the Town's main web page and its Facebook feed, through half-page color flyers handed out at the Peru transfer station, through newsletter articles and through letters sent to the Town's small number of businesses.

The project and continued solicitation for citizen input were further promoted through a set of five featured articles in the Peru Live Wire, a monthly citizen newsletter that covers upcoming events and topics of interest relevant to Peru and its neighbors. The articles explained the hazard mitigation planning process, promoted the public survey, presented major findings, and encouraged residents to review and comment on all public materials created during the project. A full page article about the project and the public review process was also published in the Town of Peru 251st Annual Town Report.

On June 14, 2021, the Town hosted a public presentation to inform citizens of the major findings of the planning process. The presentation was held during a meeting of the Peru Select Board and in accordance with the Massachusetts Open Meeting Law. The presentation was promoted through the same channels as the public survey, via the town's web and facebook feeds, through articles in the Peru Live Wire and through direct mailings. During the presentation the public was invited to provide feedback on the major findings and to review the materials posted on the Town's website, including a copy of the presentation. At this time the public was also invited to review and comment on the draft HMCAP, which would be offered for public review. The presentation remained posted and available to the public throughout the public review period for the draft HMCAP.

Public Comment on the Draft MVP Plan and HMCAP

The Draft HMCAP, along with the public presentation, was posted on the homepage of the Town's website August 11-31, 2021. Paper copies of the draft plan were also placed in the Peru Town Hall and Library for those with little or no internet access. The plan's posting was announced in the August edition of the Peru Live Wire and at Peru Select Board meetings on August 16, 23 and 30, 2021. All neighboring Towns and the Central Berkshire Regional Planning Committee (REPC) were formally invited to review and comment on the Plan. See Appendix B for more details.

PLACEHOLDER – SIGNIFICANT PUBLIC COMMENTS ADDRESSED HERE

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, municipal and emergency services, and vulnerable people. This is especially important for small towns like Peru who work closely with their neighbors to address issues on a larger, regional scale. This HMCAP update incorporates relevant data and information from existing plans, studies, reports and technical information. The hazard mitigation plans of the neighboring towns of Hinsdale and Washington were particularly informative. Main data sources and local plans include:

- Town of Hinsdale Hazard Mitigation Plan, 2019
- Town of Washington Hazard Mitigation Plan, 2019
- Draft Town of Windsor Hazard Mitigation and Climate Adaptation Plan, 2020
- Berkshire County Hazard Mitigation Plan, 2012
- Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP), 2013, 2018
- BioMap2, Conserving the Biodiversity of Massachusetts in a Changing World, Peru, 2012.

This plan should be used in conjunction with other local and regional plans, specifically transportation and capital improvement programs and emergency preparedness planning.

Plan Structure

The next chapter of this plan will analyze and assess risk, profiling each hazard with potential to affect the Town of Peru. 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.

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 Peru and contains 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 Town 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).

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

The total population according to the according to the 2019 5-year estimate of the American Community Survey (ACS) is 823, with an average of approximately 32 people per square mile. There are approximately 349 households in Peru, with an average of 2.4 persons per household. The median age of the population is 49 years, slightly higher than Berkshire County but 25% higher than Massachusetts (which has a median age of 39.5 years). Median household income for Peru residents is $69,219, which is slightly higher than the median income for Berkshire County and is approximately 80% of the median household income for Massachusetts. Approximately 8.5% of persons live in poverty, slightly lower than Berkshire County as a whole, which is 10.9%.[1]

Peru is a bedroom community, where residents commute to employment centers in Berkshire County or in neighboring counties located in the Pioneer Valley. Due to its location in the Berkshire Hills, the average commute is approximately ½ hour, slightly more than that of typical Berkshire County residents. Less than one percent of residents work at home. There is no school in Peru – students attend regional schools in Berkshire County or the vocational school in Northampton. There are no retail or service businesses within Peru – residents must travel to neighboring communities for all their needs, including groceries, health care, vehicle fuels, etc.

Camp Danbee is a girls summer overnight camp located near the Hinsdale town line on West Main Street (Rt. 143). Girls attending are from grades one through nine, with younger campers making up the bulk of the camp's population. Approximately 400-500+ people are at the camp during the summer months, with the exact number depending on the number of girls attending in a given year. The exact number of camp counselors, sports and activities coaches, and support staff (including 24-hour nursing and an on-site doctor) correlates with the number of campers present. The camp may be rented during the shoulder spring and fall seasons when the girls camp is not operating.

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[1] *U.S. Census Bureau (2019). American Community Survey 5-year estimates. Retrieved from Census Reporter Profile page for Peru town, Berkshire County, MA http://censusreporter.org/profiles/06000US2500353050-peru-town-berkshire-county-ma/ Margin of error is at least 10 percent of the total value.*

Fig. 3.1. Layout of Camp Danbee Housing and Facilities

Source: Camp Danbee. 2021.

Economy

The Town's total FY21 budget was $2.45 million, made of up tax levy (78% of total revenue), state aid (11%), and other receipts (11%). The Town of Peru relies very heavily on tax revenue from the residential sector, which makes up 86% of the Town's tax base. Combined, commercial and personal property taxes provide an additional 13% of tax revenue and the industrial sector provides the remaining 1%.[2] Non-residential tax revenue is largely from Eversource for its utility distribution system, the ATT communications tower, and Camp Danbee. Additionally, the Town receives payment-in-lieu-of-taxes from the commercial solar power generating facility located in West Main Street.

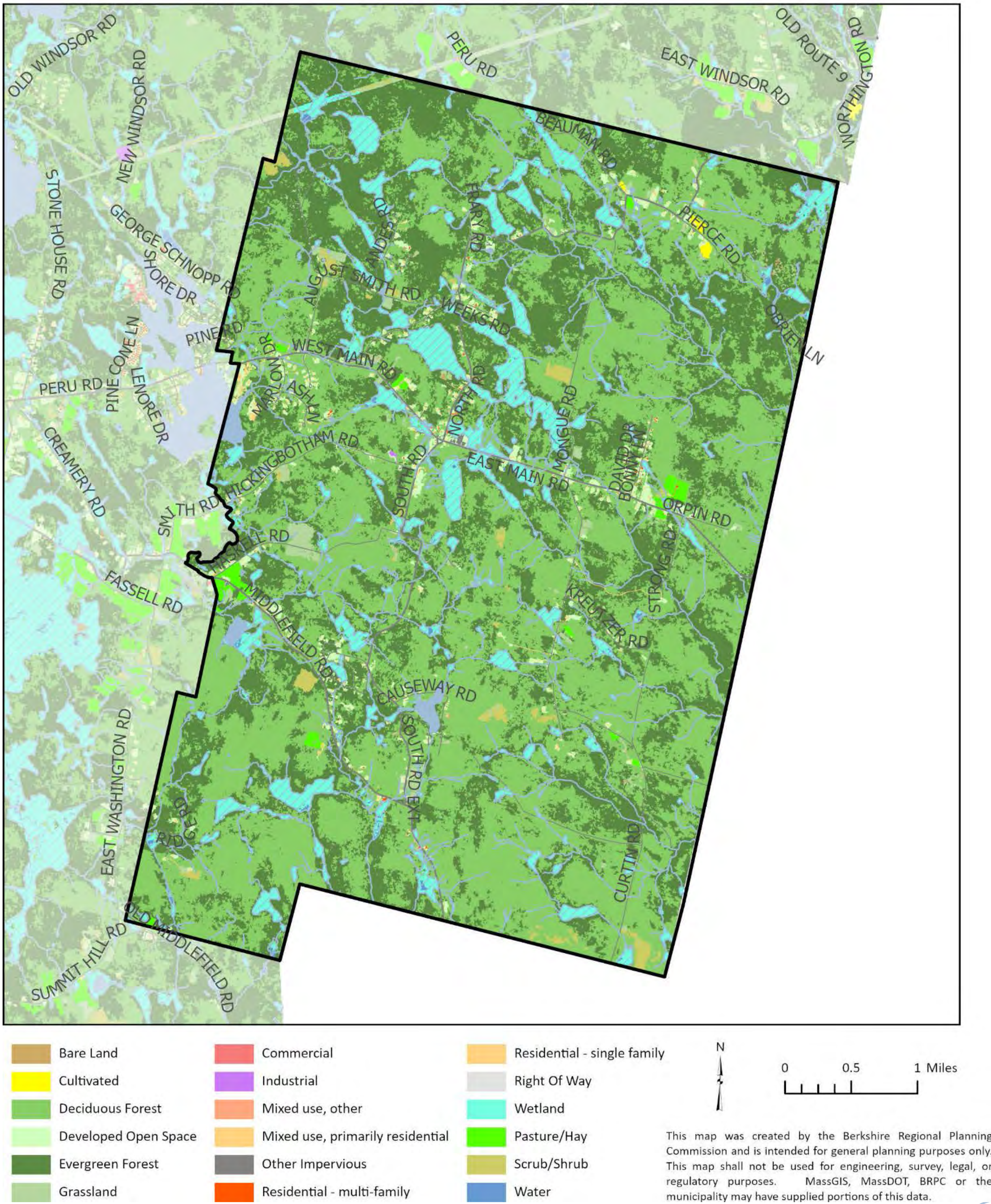
[2] *MA Dept. of Revenue, Div. of Local Services, Data Analytics and Resources Bureau, July 2021.*

Natural Environment

The predominant land uses in Peru are forest (87%), open water and wetlands (7%), and open lands (5%), the last of which includes lawns, grasslands, farm fields and. Residential, commercial, and industrial lands combined cover slightly more than one percent of the Town (MassGIS, 2016). See Figure 3.1 for reference. Peru's forests and wetlands are of high value given that they are relatively undisturbed by development and are found at higher elevations than typically found in southern New England. The Town hosts Landscape Blocks, which are large areas of intact predominately natural vegetation, consisting of contiguous forests, wetlands, rivers, lakes, and ponds. These large Landscape Blocks are most likely to maintain dynamic ecological processes such as buffering, connectivity, natural disturbance, and hydrological regimes, all of which help to support wide-ranging wildlife species and many other elements of biodiversity[3]. Four animal species of special concern and four plant species of special concern are found in the Town. These areas provide habitat for wildlife needing large territories to complete their life cycle and provides travel corridors for those who need to disperse or migrate. Moose is an example of the type of wildlife needing these areas. The Massachusetts Natural Heritage & Endangered Species Program (NHESP) has recorded several forest areas and wetlands in Peru that are intact and serve as Priority and Exemplary Natural Communities: Spruce-Fir Swamp, High-energy Riverbank, High-terrace Floodplain Forest, and Northern Hardwood/Hemlock/White Pine Forest. Approximately 47% of the land area of Peru is permanently protected from development, with land being owned and conserved by state conservation agencies and non-profit land conservation organizations.

[3] *NHESP, 2012.*

Figure 3.2: Town of Peru Land Use 2016



Built Environment

Peru does not have a defined village center, but the town-owned facilities are clustered together on East Main Road. Residential development is widely scattered along local roads. There are approximately 426 housing units in the Town; the majority of homes are single family homes (83% of total), with a fair amount of mobile homes (17%), which is more than double the rate in the county. Refer to the Land Use Map Figure 3.1.

Critical facilities are the buildings and infrastructure hubs that are necessary for continued operation during a hazardous event. The Town of Peru owns critical facilities, all of which are located within a few hundred feet of each other and which form the center of the Town. Camp Danbee is an overnight summer camp that hosts 400-500+ people during July and August. Table 3.1 lists Peru's Critical Facilities and Figure 3.3 provides a map of the critical facilities and areas of concern.

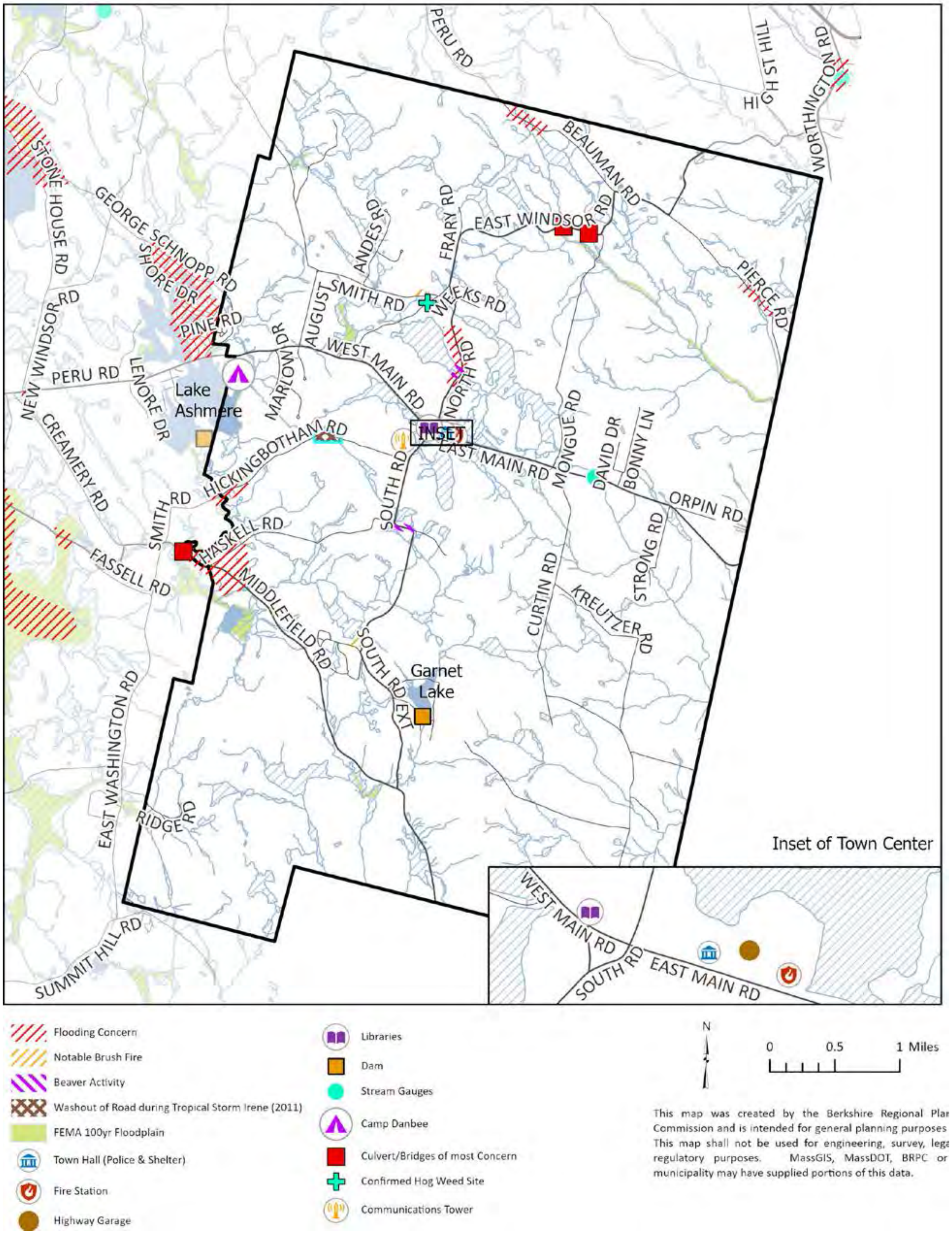
Table 3.1: Peru Critical Facilities

Facility and Function	Location
Town Hall: Town Offices, Police, Council on Aging, Public Meeting Space, Emergency Operations Center (EOC) Local Shelter	3 East Main Road
Fire Station: Public Meeting Space, Alternate EOC	11 East Main Road
Town Garage Property: Highway Department, Transfer Station	9 East Main Road
Library	6 West Main Road
Camp Danbee: summer camp group living, including children	101 West Main Road

There are approximately 38 miles of roads in Peru, all of which are owned and maintained by the Town, three of which travel through state-owned land. Additionally, the Town plows a few miles of privately-owned roads around Garnet Lake. The Town is served by one major east-west roadway, East Main/West Main Road (Route 143), which connects residents to work and services in Berkshire County to the west or in Hampshire and Hampden Counties to the east. Middlefield Road is a secondary and important east-west road and East Windsor Road is an important north-south route to Windsor and Route 9, a regional east-west travel way. Approximately 15 miles of road is unpaved gravel, including the road through state lands. The outer portions of Beauman, Pierce and Curtin Roads are not plowed in the winter as there are no residential homes there.

There is no public drinking water system; all potable water is supplied by private wells, including Camp Danbee. There is no sewer system in Peru, with the exception that Camp Danbee pumps its waste westward into the regional sewer system that serves Hinsdale, Dalton and Pittsfield.

Figure 3.3: Town of Peru Critical Facilities and Areas of Concern



Hazard Identification and Risk Assessment Processes

In order to identify potential hazards that can affect the Town of Peru, several resources were utilized. The information outlined in the 2012 *Berkshire County Hazard Mitigation Plan* and that found in the hazard mitigation plans of neighboring towns served as a foundation on which to build. The hazards identified in the 2012 regional 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. Accounting for the location, natural and built environments, history, and scientific studies of the area, it was determined that the Town of Peru must plan for the following hazards:

- Severe Winter Event (Ice Storm, Blizzard, Nor'easter)
- Hurricane & Tropical Storms
- Flooding (including Dams, Ice Jam, Beaver Activity)
- Severe Storms (High Wind, Thunderstorms,)
- Drought
- Invasive Species
- Annual / Extreme Temperatures
- Tornado
- Wildfire
- Invasive Species
- Landslide
- Earthquake
- Cyber Attacks

Prioritization and Hazard Profiles

Table 3.2 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 information from the 2012 regional hazard mitigation plan, discussing weather patterns and natural hazards that have occurred in the Town and the region since that time, 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 Peru and its citizens. Prioritization also considered public input that residents provided to the Planning Committee through a town-wide survey. Hazards other than flooding are difficult to prioritize without this or a similar ranking system.

Table 3.2: Hazard Prioritization for the Town of Peru

Hazard	Area of Impact Rate	Frequency of Occurrence Rate	Magnitude / Severity Rate	Hazard Ranking
	1=small 2=medium 3=large	**0 = Very low 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**
Hurricane & Tropical Storms	2.5	3	2	**7.5**
Flooding (including Dams, Ice Jam, Beaver Activity)	2	2	2	**7**
High Wind, Thunderstorms	2	2	2	**6**
Drought	2	2	2	**6**
Invasive Species	2	2	2	**6**
Annual / Extreme Temperatures	2	2	1	**5**
Tornado	2	1	2	**5**
Wildfire	2	1	2	**5**
Cyber Security	2	1	1	**4**
Landslide	1	0	2	**3**
Earthquake	2	0	1	**3**

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% - 1% per year)
2=Medium frequency	events that occur from once in 10 years to once in 100 years (1% - 10% per year)
3=High frequency	events that occur more frequently than once in 10 years (>10% per year)
Magnitude/Severity	
1=limited	injuries and/or illnesses are treatable with first aid; minor "quality of 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 two weeks; property severely damaged <50% and >25%
4=catastrophic	multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged >50%

Severe Winter Storms (Ice Storms, Nor'easters, Blizzards)

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 Peru's eastern neighboring town, with slightly lower elevations, and so Peru's annual snowfall would likely be slightly higher. Due to its higher elevations, Peru is typically 4-6°F colder than its neighboring communities, creating icy or snowy conditions in the Town when neighbors in Hinsdale and Dalton are receiving rain.

Severe winter storms in Peru 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 are deep snow depths, heavy ice accumulations, 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 3.3 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 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 3.4).

Table 3.4. Record Snowfall Events and Snow Depths 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.

Frequent and heavy snowfall is common in Peru, even when snowfall is light or nonexistent in neighboring communities. Two years ago the Town experiences a prolonged period of snowfall that required plowing, where in March 60 inches of snow fell in 20 days. [4]

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

[4] *As noted by Peru Highway Supervisor Justin Russell.*

by extremely cold temperatures in the days following the event. In Peru and other Berkshire hilltowns, there was widespread road closures due to downed tree limbs and power lines and power outages that lasted for days or up to a week. It took Peru crews and residents four days of non-stop work with chainsaws to open the Town's roads to travel.

Two severe ice storms again impacted Peru in the winter of 2019-2020. The ice build up was similar to that of the 2008 storm and the Town pre-emptively contacted MEMA to inform them of potential damages. Fortunately the temperature rose just enough to melt the ice and only a few outages resulted from these events.

While severe winter weather 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. According to the NOAA-NCDC storm database, over 200 winter storm events occurred in the Commonwealth between 2000 and 2012, therefore, the subset of severe winter storms are likely to continue to occur annually (MEMA, 2013). 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.

Using history as a guide for future severe winter storms, it can be assumed that Peru 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.

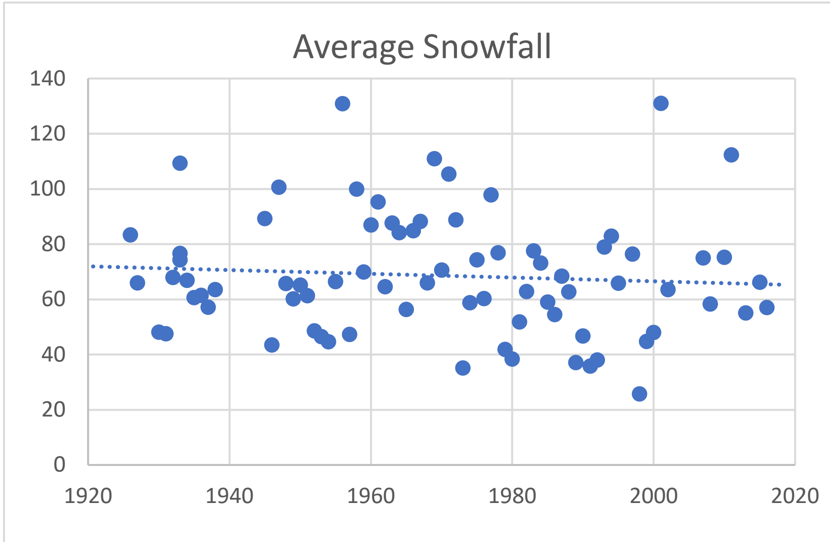
Geographic Areas Likely Impacted

Severe winter storm events generally occur across the entire area of Peru, although higher elevations typically have slightly higher snow depths or heavier ice accumulations. The lower elevations of the Town below August Smith Road and along Middlefield Road near the Hinsdale town line are generally the "freeze line" in Peru, where these lower elevations often receive less snow and ice damage than the rest of Town.

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 3.9, the average snowfall levels are trending downward.

Figure 3.4: Average Snowfall in Berkshire County



Source: NOAA, 2017.

The National Climatic Data Center, 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.

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.[5]

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 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 3.5: 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 Becket & Peru; snow drifts of 12'+; 135,000 without power across MA.	DR-975
03/13/93-03/17/93	High winds & heavy snow; generally 20-30" in Berkshires; blizzard conditions lasting 3-6 hrs; Pittsfield receives 22" in 24 hrs; snowdrifts of 10' across county.*	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: $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

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

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" and Pittsfield received 18" *	DR-4051
02/08/13-02/09/13	Severe Winter Snowstorm and Flooding; $65+ million from FEMA statewide	DR-4110

Source: MEMA 2018, unless otherwise noted.
** Berkshire Eagle, 2-2-19. "Memorable blizzards, nor'easters from 1888 to the present in the Berkshires."*

Vulnerability Assessment

People

Residents of Peru are a hardy bunch, surviving long harsh winters, maneuvering steep, slippery winding roads and surviving days without electricity. Loss of power means loss of water because all residents are serviced by private wells. Many residents have heat sources such as wood stoves and/or generators to allow them to safely shelter in place during severe events. Snowstorms are viewed by residents as just a part of life when you live in Peru, but ice storms have become more frequent and damaging. The Ice Storm of 2008 was the incident that has caused the most widespread damages and loss of electricity. At the height of the storm, more than 1 million customers were without electricity across the Northeast, some for more than two weeks. Although the Town does not have a formal list of residents who need wellness checks during emergency situations, first responders informally call on residents known to be elderly or needing medical care or electricity. Residents and volunteers also look out for needy neighbors.

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. 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 storm event. The ability of emergency responders to respond to calls may be impaired by heavy snowfall, icy roads, and downed trees (MEMA & EOEEA, 2018). In extreme storms 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. Although the Town opened its shelter during the Ice Storm, no one needed to stay there overnight, despite widespread and prolonged electricity outages.

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. Utility power line systems are especially vulnerable due to heavy snows and high winds that can accompany severe winter storms.

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. 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.

For Peru, the Ice Storm of 2008 was the most damaging and widespread in recent memory. Regionally, FEMA obligated more than $32 million to Massachusetts, state-related costs totaled more than $7 million, and municipal costs in the state totaled more than $5 million. National Grid claimed damages of more than $30 million across its territory. According to the state *Climate Action Plan*, small businesses without electricity across the state lost “tens of millions of dollars.”

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 (MEMA & EOEEA, 2018). This is the type of damage that woodlot owners in Peru have seen increase in recent years. There have been several ice storms that have damaged or broken crowns and taken down main limbs, permanently damaging trees and reducing their timber value.

Future Conditions

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 2016). 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 utility line infrastructure will be maintained.

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, where devastating and catastrophic damage will occur. 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 storm in recent decades.

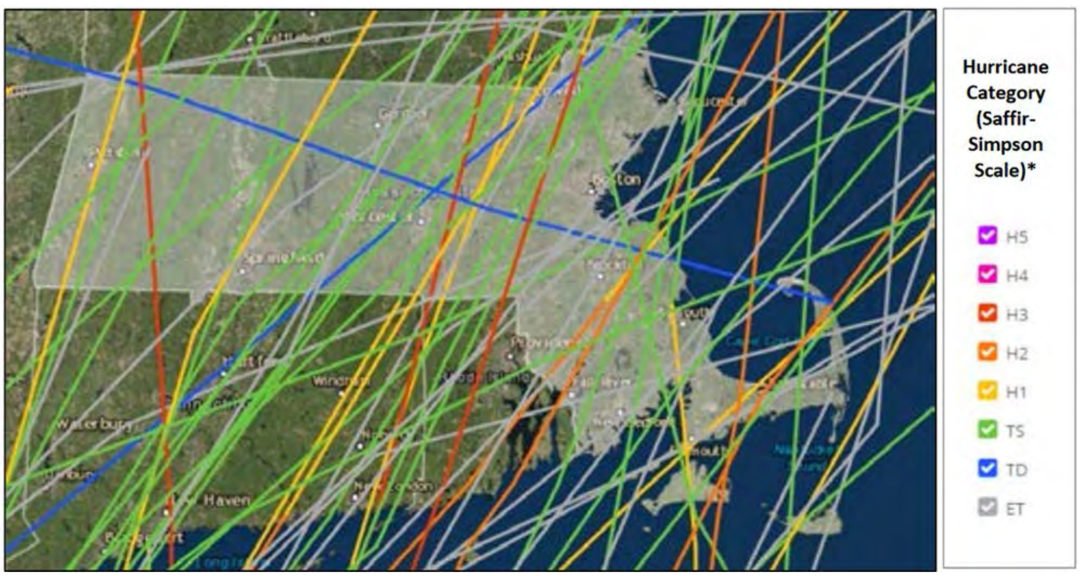
Probability

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 recurrence rate will likely increase due to rising ocean temperatures due to climate change.

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.

Figure 3.5: Historical Hurricane Paths within 65 miles of Massachusetts



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

Geographic Areas Likely Impacted

The entire Town of Peru is vulnerable to hurricanes and tropical storms, depending on each storm's track. Inland areas, especially those in floodplains, near waterways, or isolated in the hills and mountains are at risk for flooding from heavy rain and wind damage. The majority of the damage following hurricanes and tropical storms often results from residual wind damage and inland flooding, as was demonstrated during recent tropical storms. Historic storm tracks can be seen in the NOAA graphic, Figure 3.21. The graphic shows tropical storm tracks that have traveled through Massachusetts, where H = Hurricane, TS = Tropical Storm, and TD = Tropical Depression.

Historic Data

Table 3.6. 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

Source: NOAA, MEMA & EOEEA, 2018.

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.) and Table 3.6. 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)

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)

In Peru T.S. Irene caused damaging severe flooding along Bennett Brook (Hickingbotham and Middlefield Roads) and to the local roads that cross this brook. These damages are discussed in more detail in the Inland Flooding section of this plan. High winds accompanying this storm caused some downing of trees and/or limbs, but no large-scale power outages or damages.

Regionally, T.S. 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 in Berkshire County where floodplain maps have been updated since the 1980s.

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. 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).

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 hurricane-related 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. 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. [6]

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

Inland Flooding, including Dam Impacts

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). Common types of local or regional flooding are categorized as inland flooding including riverine, ground failures, ice jams, dam overtopping or failure, beaver activity (tree removal, dam construction, and dam failure), levee failure, and urban drainage. 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, 2011 as cited in MEMA & EOEEA, 2018[7]). The hazards that produce these flooding events in the Berkshire County region include spring melt, 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, and on potential dam failure risk. Hurricanes, tropical storms, winter-related flooding and thunderstorms will be discussed in other sections of this plan.

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.

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. Increases in precipitation and extreme storm events will result in increased inland flooding.

A dam is an artificial barrier that has the ability to impound water for the purpose of storage or flood control. Size class may be determined by either volume of water stored or height, whichever gives the larger size classification. An acre-foot is defined as enough water to cover one acre of land one foot deep, which equals slightly less than 326,000 gallons.

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. Low Hazard dams are those that are defined as being located where failure or mis-operation may cause minimal property damage to others, and loss of life is not expected. High Hazard dams are those where failure or mis-

[7] *MA MEMA & EOEEA, 2018 https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan*

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). 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[8].

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 and Low Hazard dams must be inspected every 10 years. High Hazard dam owners are required to develop and keep updated an Emergency Action Plan.

Table 3.7. Dams that could impact Peru

Name and Year Completed	Hazard Code	Size Class (acre-feet storage)	Inspection Condition & Date*	Owner
Garnet Lake Dam / 1964	Low	Intermediate ($\geq$50 and $\leq$1,000 acre-feet)	Fair / 2000 (2004) or NA / 2009 (2018)	Garnet Lake Assoc.
Lake Ashmere Dam / 1875, refurbished 2008-10	High	Large (>1,000 acre-feet)	Satisfactory / 2016	MA Dept. of Conservation & Recreation (DCR)

Source: Office of Dam Safety, 2004. Or USGS, 2018. Condition for Lake Ashmere dam provided by Dalton Multi-Hazard Mitigation Plan, 2018.

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), which delineates floodplain boudaries, was developed in 1981 for the Town of Peru. There are currently no buildings within the floodplain boundaries of 1981.

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. 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).

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

Table 3.8: 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

Due to steep slopes and minimal soil cover, hilltowns such as Peru are particularly susceptible to flash flooding caused by rapid runoff that occurs during heavy precipitation 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 (MEMA, 2018). Berkshire County has frozen ground conditions for more of the year than most of Massachusetts, and Peru has frozen ground longer than most other parts of the county. There is a 90% likelihood that the temperature will reach 28° by October 22nd, with the potential ground freezing conditions lasting until May 20th of the following year (NOAA, 1988 as cited by UMASS Extension accessed on March 12th, 2019).

Factors that contribute to dam failure include design flaw, age, over-capacity stress and lack of maintenance. 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. (BRPC, 2012). In Massachusetts the Office of Dam Safety, within the DCR, is the regulating authority that oversees dam safety.

The Massachusetts DCR conducted extensive repairs to the Lake Ashmere dam 2008-10, which likely reduces the risk of failure. However, during severe precipitation events the DCR, the agency responsible for ownership, maintenance and operation of the dam, releases water to reduce pressure on the dam and risk of flooding of shoreline property around the lake. This release can cause periodic high water levels in the outlet stream and threaten flooding of roads and property.

Historical 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 3.9. 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 3.9. Not all these events were documented to a 1% chance storm for the region around Peru. For example, 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 central and southern Berkshire County (using data from the USGS Housatonic River stream gage in Pittsfield). This event, however, caused severe road damage from flooding of Bennet Brook, the Lake Ashmere outlet stream.

Table 3.9. 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. 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.
Oct. 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	T.S. 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. In MA his event was a 1% annual chance flood event in the Hoosic River Watershed and a 50-year event in the Housatonic River Watershed. This event cause significant road damage in Peru.
Sept. 2011	Remnants of Tropical Storm Lee brought 4-9" of heavy rainfall to the region. Due to the saturated soils from T.S. Irene, this rainfall led to widespread flooding on rivers as well as small streams.
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.

Source: BRPC 2018 (unless otherwise noted)

According to the data and Peru residents, the more notable flood events that occurred in Peru were that of T.S. Irene and Lee (which followed closely on Irene's heels) in 2011. While this event caused flooding of road infrastructure at sites across Peru, some of the most significant damages were found along Bennett Brook, which is the outlet brook for Lake Ashmere. The meandering channel of the brook itself forms the Peru/Hinsdale town line as it travels under Hickingbotham and Middlefield Road. During this event, part of Hickingbotham Road was under 2-3 feet of water. The Bennett Brook stream crossing on Middlefield Road on the Peru/Hinsdale town line was under such pressure that the down-stream side of the box culvert was a geyser, threatening the road and travel. This area of the road did not flood, but water was at the road's edge.

When the storm hit, the Peru portion of Middlefield Road itself was in the midst of a full reconstruction. Although the road has been given a layer of blacktop, flooding washed out new fill and gravel along the sides of the road, undermining new blacktop, culverts and new drainage systems. Some areas of blacktop were damages and/or destroyed completely. Damages were extensive and the road was closed for a full week while repairs were made.

T.S. Irene caused flood damages in other sections of Peru. An upper portion of Hickingbotham Road completely washed out, isolating a homeowner for a day until crews could get to the site to restore the road. In some areas gravel losses from roads were 10-12 feet deep. Marlow Drive and Smith, Beauman and East Windsor Roads sustained damages from washouts and road edge erosion. The drainage system along West Main Road was eroded but the road itself did not sustain damage.

Sediment deposition into Lake Ashmere from its tributaries, including transport of gravel from eroded roadways, facilitated the creation of large alluvial fans at stream inlets. Sudden creation of such alluvial deposits can create the perfect growth medium for invasive aquatic species.

At one unnamed tributary to the lake, which travels through Camp Danbee, two feet of fine sediment was deposited atop the forest floor along stream corridor and floodplain. The spreading out of this sediment was likely caused by constriction and impoundment of flood waters at the culvert under a gravel road within the camp. See figure __. About a week later T.S. Lee brought additional rain and flooding due to soils still saturated by T.S. Irene.

Fig. ___ & ___. Unnamed Lake Ashmere tributary in Camp Danbee after T.S. Irene. Two-foot sediment deposition along stream upstream of gravel road crossing. Below: deposition downstream of road crossing. The lake is immediately downstream of this site.

Source: BRPC, 2011.

Historically, dam failure has had a low occurrence in Berkshire County. There have been 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.
More recently, in September 2004 an incident occurred at the Plunkett Lake dam in Hinsdale, Peru's western neighbor. 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).

Vulnerability Assessment

Geographic areas likely impacted

Peru has few acres of land identified as the 100-year floodplain. Of a total of 16,663 acres of land within the Town, only 132 acres (0.8%) of land is within the floodplain. Of floodplain acres, only 0.15 acres are developed (BRPC 2020). The largest expanse of floodplains are associated with Tracy Pond off Middlefield Road. Other floodplain areas are delineated within wetland areas off of West Main Road and lower Middlefield Road, and along East Trout Brook. Because most of Peru's brooks are first- and second-order headwater streams, they tend to be narrow with low flow volumes, which lowers the risk to people and property.

There are several areas throughout Peru where flooding of roads are of concern. Several sites along Middlefield Road are at risk of flooding in Peru and Hinsdale. In the Peru section, some drainage upgrades were installed during the reconstruction of the road in 2011. The MassDOT is about to undertake a major reconstruction of the road through Hinsdale, including where the road travels through a wetlands complex. During reconstruction, some of the culverts will be redesigned to meet the state stream crossing standards, which include larger, open bottom culverts. However, the Bennett Brook box culvert on the Peru/Hinsdale line is not being upsized, although Town officials believe that it should be. The only improvement to this site is to repair the wingwalls at the culvert. This culvert was under immense pressure during T.S. Irene in 2011. The loss of Middlefield Road due to flood damages would be devastating to Peru, as it would require long detours for residents and emergency response vehicles.

Flooding along Bennett Brook, which is the outlet stream for Lake Ashmere, has occurred in the past due to high spring melt levels and severe rain events. The brook has flooded roads and properties along the brook in Peru and Hinsdale, including Hickingbotham, Smith and Middlefield Roads in Peru. The flood inundation map developed for the Lake Ashmere dam indicates that a full dam failure would flood extensive areas in Peru, Hinsdale and Dalton, including homes, regional schools, businesses and roadways. The location of the dam is shown in Fig. 3.2.

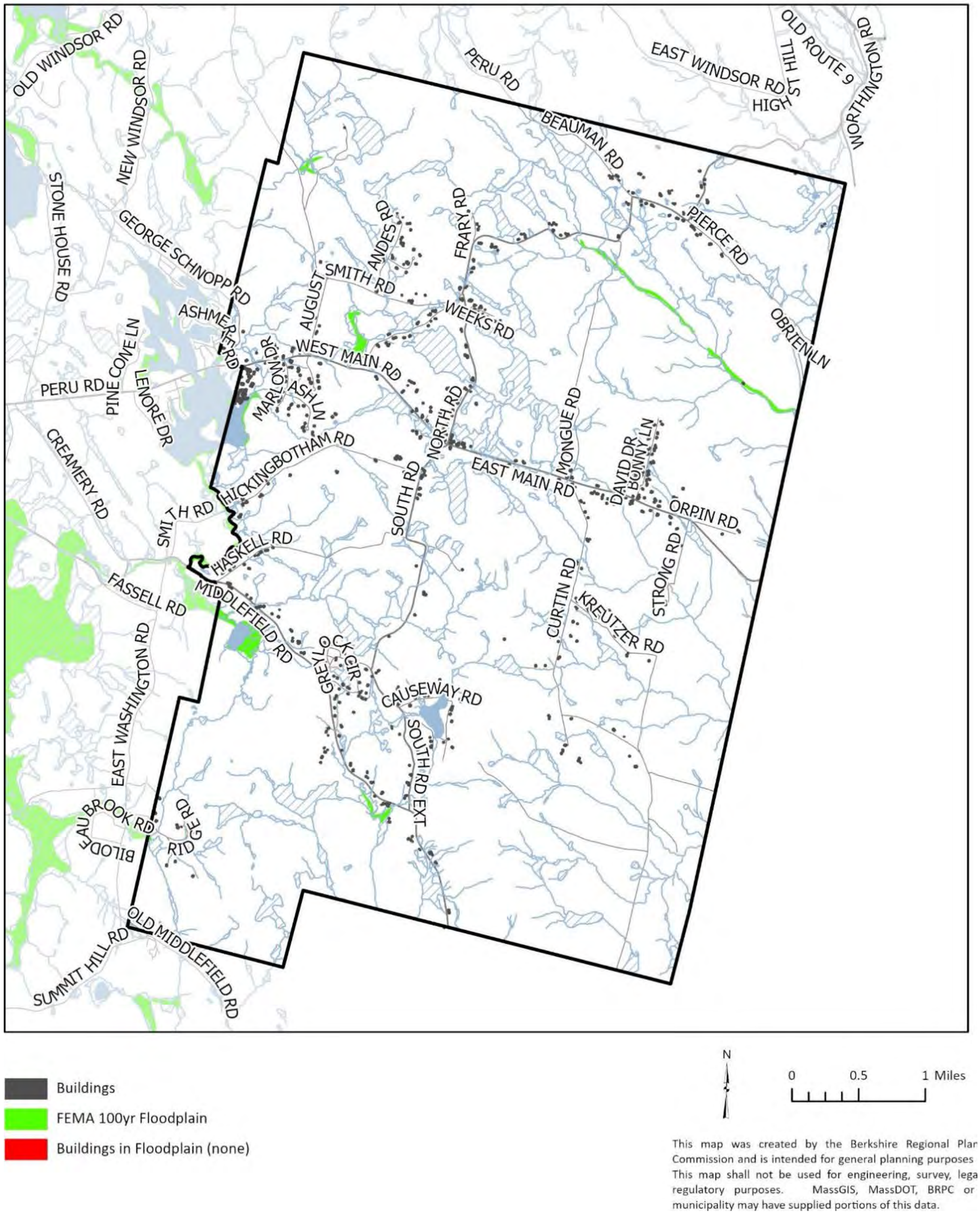
Bennett Brook carries high water levels in the fall when the DCR releases water at the Lake Ashmere dam to achieve a seasonal drawdown of the lake. This is to provide flood storage capacity and aid in control of nuisance aquatic plants. Although there has not been serious impacts of flooding during this process, improper operating procedures at the dam could send flood-level waters down Bennett Brook and threaten the integrity of Hickingbotham and Middlefield Roads, the latter of which is a main east-west travel corridor.

Other roads where stream or wetland crossings can flood are North, Beauman, and Pierce Roads. There are 13 stream/wetlands crossings along North Road, 11 of which the Town replaced several years ago. However, there is a need to replace the remaining culverts, which are deteriorating and are an increased flood risk. The road travels through the West Branch Westfield River watershed, which is a state-designated Outstanding Resource Watershed. Because of this the state permitting agencies are requiring that any new replacements meet the Massachusetts Stream Crossing Standards, which will require upsizing or open bottom culverts. Because the new designs increase the size, the required engineering, permitting and construction will substantially increase the cost. As such, the Town needs to identify grant funding to be able to afford the improvements. This is a high priority improvement project for the Town.

Another road improvement project with flood mitigation involves the full depth reconstruction that is needed for East Windsor Road. New culverts will need to be installed along the road length, and this provides an opportunity to upsize or install open bottom culverts for improved water flow and aquatic connectivity. If funding is limited, phasing the project may be needed, with culvert work as the first phase. This road is a major connector to Route 9 (a regional east-west commercial route) and has been used as a detour when accidents or other incidents close Route 9.

The location of Garnet Lake dam is shown on the map in Figure 3.3. If the dam were to overtop or fail, water would flow down Geer Brook and possibly flood Smith Road and Middlefield Road. A home along Geer Brook on Smith Road may also be impacted. Because the dam is of a low hazard, the owner is not required to develop inundation maps or emergency action plan to evaluate dam failure.

Figure 3. Town of Peru 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. Comparing MassGIS and assessor parcel data against the 1981 FIRM, there are no buildings within the 100-year floodplain in Peru. This analysis 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, it does not show the household on Hickingbotham Road that was stranded when the road washed out during T.S. Irene

The total number of injuries and casualties resulting from typical riverine flooding is generally limited due to advance weather forecasting, blockades, and warnings. The historical record from 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, occurring within two weeks of each other in March 2010. While six 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.

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)

By state law, dam owners are legally responsible for maintaining their dams, inspecting them on a regular basis and liable for damages and loss of life that occur as a result of a dam failure. High Hazard Dams such as Lake Ashmere must be inspected every two 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. 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 residents in the inundation area. The EAP must be filed with local and state emergency agencies. Low Hazard dams, such as Garnet Lake dam, must be inspected every 10 years, but are not required to have an EAP in place. In Massachusetts the Office of Dam Safety, within the Department of Conservation & Recreation (DCR), is the regulating authority that oversees dam safety. According to data received from DCR in 2004, the condition of Garnet Lake Dam was Fair when inspected in 2000, and newer, unverified data indicates that the dam was last inspected in 2009 but the dam's condition was not listed.

According to the contact list found in the Emergency Action Plan for the Lake Ashmere dam, there are 13 properties in Peru whose owners should be notified in the event of a dam failure. The properties are located along Hickingbotham, Haskell, and Middlefield Roads. Of these parcels, eight have homes and other structures on them, with a total assessed value of $1.1 million. A Camp Danbee parcel is also listed in the EAP, but none of its structures are located within the inundation area.

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, and populations without adequate warning are vulnerable to this hazard (MEMA & EOEEA, 2013). According to the EAP for the Lake Ashmere dam, the arrival time for flooding to occur at the Haskell Road / Middlefield Road intersection is approximately ½ hour, with peak flow levels at just less than one hour; Hickingbotham Road, which is upstream of this area, would be flooded more quickly.

Built Environment

Peru has few acres of land identified as the 100-year floodplain. A GIS analysis based on the of the FIRM flood hazard area maps indicates that of 132 acres of land within the floodplain in Peru, only 0.15 acres are developed, and these are roadways, which include 184 linear feet of road. (BRPC, 2020). There are no buildings in the 100-year floodplain in Peru.

The Town of Peru is not 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 MEMA data, there are no repetitive flood loss properties within the town (MEMA, 2017).

Regarding dam failures, all structures, critical facilities and roadways in the inundation zone are vulnerable to damage. Flood waters may potentially cut off evacuation routes, limit emergency access, and destroy power lines and communication infrastructure.

Bennett Brook is the outlet for Lake Ashmere. According to the EAP for Lake Ashmere, a failure of the lake's dam could result in flooding of roads and adjacent lands that are associated with the brook, including residential properties along Hickingbotham Road, Haskell Road and long sections of Middlefield Road in both Peru and Hinsdale.

As part of the Lake Ashmere dam EAP, an analysis was conducted to identify and list the residents and businesses that are located within the wet and fair weather inundation areas downstream of the dam in the towns of Peru, Hinsdale and Dalton. People within these inundation areas should be alerted and/or evacuated in the event that an emergency incident occurs at the dam. The listings were populated using ArcGIS10 data available on the MassGIS website to identify affected residences.

The EAP Resident's Contact List includes 13 parcels of land in Peru whose owners should be contacted in the event of a dam failure. Of those 13 parcels, eight contain residential buildings. As part of this hazard mitigation planning process, an analysis was conducted in an attempt to quantify the potential damages to those buildings if the dam were to have an abrupt, complete failure and destroy those buildings. For the purposes of this analysis, the total assessed value of the eight buildings and their contents were combined, with the contents of the buildings estimated to be 50% of the assessed value of the buildings. A summary of the damages is found in Table 3.10. It should be noted that this analysis is based solely on the EAP's Resident's Contact List and not on any detailed geospatial or engineering analysis of whether the buildings would be flooded and to what extent they would be flooded. It should also be noted that abrupt, complete dam failures are extremely rare. It is more likely that lighter levels of flooding due to dam failure would occur from damaged flashboards or equipment, leaks, or partial breaches that would be identified and fixed before a complete failure occurred.

Table 3.10. Potential Building Value Damages due to Complete Dam Failure, Lake Ashmere Dam

Type	Assessed Value of Buildings	Value of Contents (50% of building value)	Total
Residential	$1,107,500	$553,750	$1,661,250

Source: Lake Ashmere EAP and Peru Assessors Office, 2021.

Downstream in neighboring towns, Lake Ashmere dam's inundation area includes both Wahconah High School and Nessacus Middle School in Dalton, and injuries and/or casualties would significantly increase if a sudden dam failure were to occur when the schools are in session. The transportation routes at risk from this dam in Hinsdale include Middlefield and Buttermilk Roads and Route 8, the latter of which is a major regional transportation route for the towns of Hinsdale, Washington, Becket and beyond. In Dalton, Route 9 (major regional east-west route) and the Main Street bridge, Wahconah High School and the Dalton Water District office are also in the inundation area.

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. A severe flood event can threaten the functionality or structural integrity of the dams that are overtopped or fail.

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 T.S. 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.

Natural Environment

Flooding and saturated soils has the potential to affect the natural environment in several ways. Septic systems can flood, contaminating the surrounding areas, posing health risks, and damaging the environment. 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. Excessive sedimentation of stream and lake beds can disrupt aquatic life cycles by smothering aquatic life and fish eggs. 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 Japanese knotweed that readily spreads via broken plant fragments.

Fig. __ Sediment deposition into Lake Ashmere from unnamed tributary. The lake is immediately downstream of this site at Camp Danbee

Source: BRPC, 2011.

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.

Excessive sedimentation occurred at Lake Ashmere near Camp Danbee during T.S. Irene in 2011. The sediment was the result of natural but severe erosion of the unnamed streambed and bank and washed out soil and gravel from road drainage systems along West Main Road.

The sudden and potentially extreme volumes of water released during dam failures can result in ecological damage both upstream and downstream of the dam. River channels downstream of the dam can experience severe scouring, banks can experience erosion and mass wasting, and boulders can become dislodged and move downstream. Trees and other vegetation can become uprooted and add to the debris moved by floodwaters, potentially clogging and threatening the integrity of culverts and bridges. Upstream of the dam the former impoundment could become partially or completely dewatered, altering, and potentially destroying lacustrine aquatic habitat (MEMA, 2013.)

Economy

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. Fortunately, none of Peru's non-resident properties are located within the 100-year floodplain, but road impacts have occurred.

Dam failure at Lake Ashmere or Garnet Lake would likely cause the accumulation of downed trees and debris downstream, including blocking and/or damaging Middlefield Road, a main travel way.

Future Conditions

Based on data gathered from the Northeast Climate Science Center (NECSC), 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 1960's to 48.6 inches in the 2000's. According to projections from the NECSC, the county is projected to experience an additional 3.55 inches by the 2050's and 4.72 inches by the 2090's. (Northeast Climate Science Center, 2018)

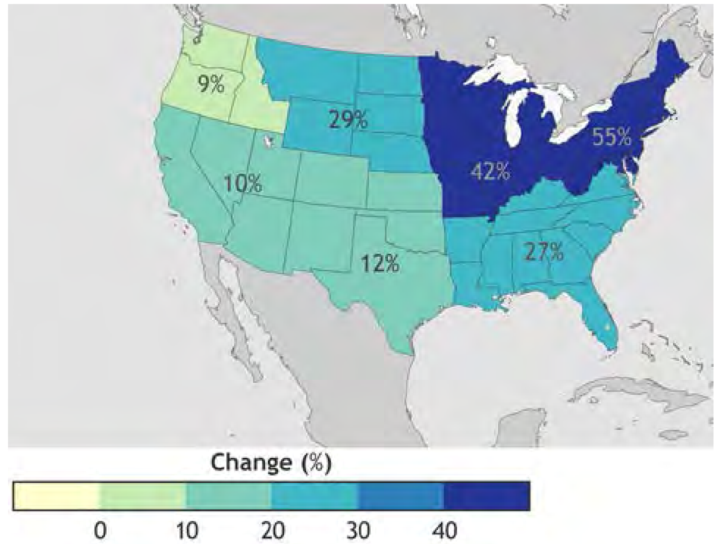
The scientific community agrees that climate change is altering the weather and precipitation patterns of the northeastern region of the U.S. The Intergovernmental Panel on Climate Change report of 2007 predicts temperature increases ranging from 2.5-5.0° C (36-41° F) over the next 100 years across the U.S., with the greatest increase in the northern states and during the winter months. More mid-winter cold/thaw weather pattern events could increase the risk of ice jams. Many studies agree that warmer temperatures late in the 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.

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).

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 map for Peru was developed in 1981, 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 Peru 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.

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.[9] 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. Increase in Precipitation Falling in Top 1% Extreme Precipitation Events 1958-2016



Source: NOAA Climate.gov, Data: NCA4

The Massachusetts Climate Change Projections report looked at the precipitation changes expected by greenhouse gas effects within the state's major watersheds. According to an upper-level scenario, the days per year with precipitation of more than one inch in the Housatonic River Watershed is predicted to increase from the baseline of six days per year to nine days by the 2050s, and to 10 days by the 2090s. The baseline reflects precipitation data 1971-2000. The upper scenario represents a 47% increase in these storms from the baseline by mid-century and a 66% increase by end of century.

Summer is currently season when there is the greatest chance for extreme precipitation events to occur, and summer is projected to continue to be the season of greatest chance and the season with the greatest increases in the number of days with extreme precipitation. Already observed in Massachusetts, the number of extreme precipitation events, those defined as more than two inches in one day, has increased since the the 1980s, with the greastest increase in the past decade (see Fig. 3.8)[10].

Fig. 3. Number of Extreme Precipitation Events of 2" or more in 1 Day

Source: https://statesummaries.ncics.org/ma

This trend has direct implications on the design of municipal infrastructure that can withstand extreme storm and flood events, indicating

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

[10] *https://statesummaries.ncics.org/ma*

that all future designs must be based on the most updated precipitation and stream gauge information available.

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.

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. Although climate change may not increase the probability of catastrophic dam failure, it may increase the probability of design failures that were based on outdated precipitation patterns (MEMA, 2013).

High Winds and Thunderstorms

Hazard Profile

High winds and thunderstorms occur outside of notable storm events, but still can cause significant damages. Peru, 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, hail that is one 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). 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.

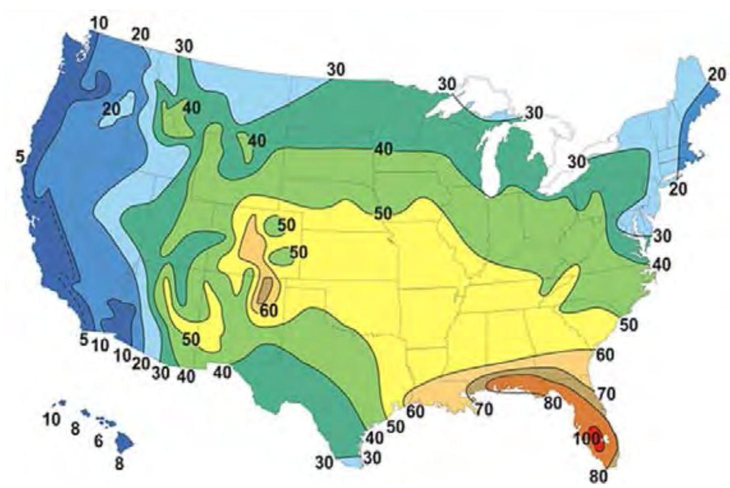
Geographic Areas Likely Impacted

All of Peru is vulnerable to high winds and thunderstorms that can cause extensive damage. Microbursts can also occur anywhere associated with thunderstorms.

Historic Data

It is difficult to define the number of other severe weather events experienced by Peru 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. An average thunderstorm is 15 miles across and lasts 30 minutes, although severe thunderstorms can be much larger and longer (MEMA, 2013).

Fig. 3. Annual Avg. Number of Thunderstorm Days in U.S.



Source: NOAA NWS, MEMA & EOEEA, 2018.

Microbursts occur throughout Berkshire County, downing trees, utility lines and sometimes causing damage to property. 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 __ show microburst damage in Cheshire, Berkshire County, in 2016.

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.[11]

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

On Sunday, June 1, 2016 an afternoon thunderstorm stalled for two hours over Lee and Stockbridge, flooding streets, basements and ground floors, including the ground floor of Stockbridge Town Hall. Stockbridge received almost 5" of rain while 4.5" fell at the Lee water treatment plant. Another inch of rain fell the next evening in another storm.[12]

A severe wind event took down several large pine trees on Peru Hill, off of Hickingbotham Road near the Tower. The fact that the trees were all lying down in the same direction indicated that it was likely a microburst instead of a tornado.

Vulnerability Assessment

People

The entire population of Peru 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. 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 isolation of these populations is a significant concern. Power outages may also result in inappropriate use of combustion heaters, cooking appliances

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

[12] *Lindsay, Dick, 6-1-16. "Weekend deluge swamps roads, homes in Stockbridge, Lee," Berkshire Eagle.*

and generators in indoor or poorly ventilated areas, leading to increased risks of carbon monoxide poisoning.

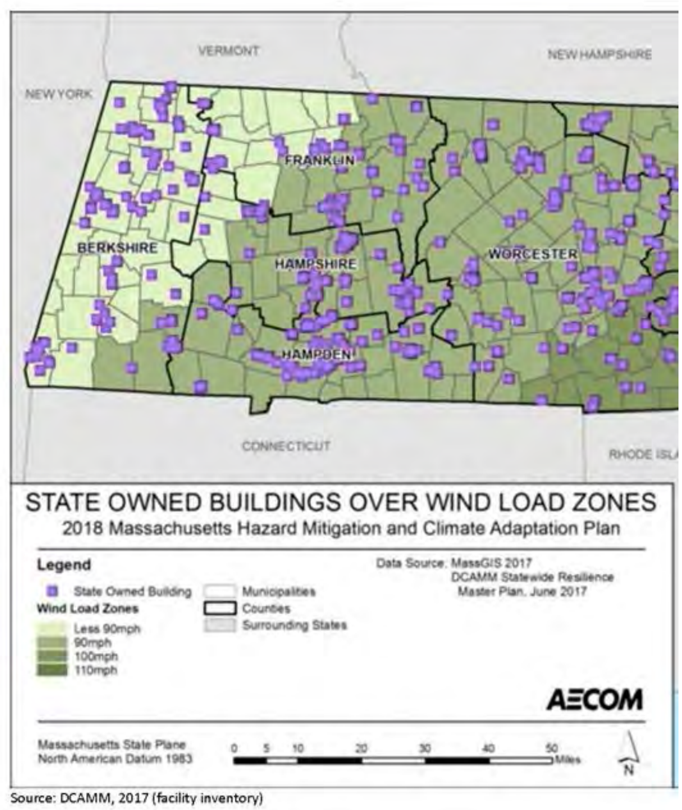
Both high winds and thunderstorms present potential safety impacts for individuals without access to shelter during these events. Extreme rainfall events can also affect raw water quality by increasing turbidity and bacteriological contaminants leading to gastrointestinal illness. Additionally, research 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 Peru is located in the second lowest load zone set at less than 90 mph (see Figure 3.23).

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).

Fig. 3.. Wind Load Zones for Massachusetts According to MA State Building Code



Source: MEMA & EOEEA, 2018.

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[13]. 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.

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

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 & Recreation (DCR) 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.

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 Peru is very 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 (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 Peru. 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. Although a wide-spread event has not impacted the Town in recent memory, for the purposes of this plan, the entire Town of Peru is at risk of drought. Nine residents who responded to the hazard mitigation public survey stated that their well has run dry in the past or that they know of neighbors' whose wells have run dry (9 out of 32 responses to this question = 28% positive response). The sites where residents' wells have run dry are not known.

Historic Data

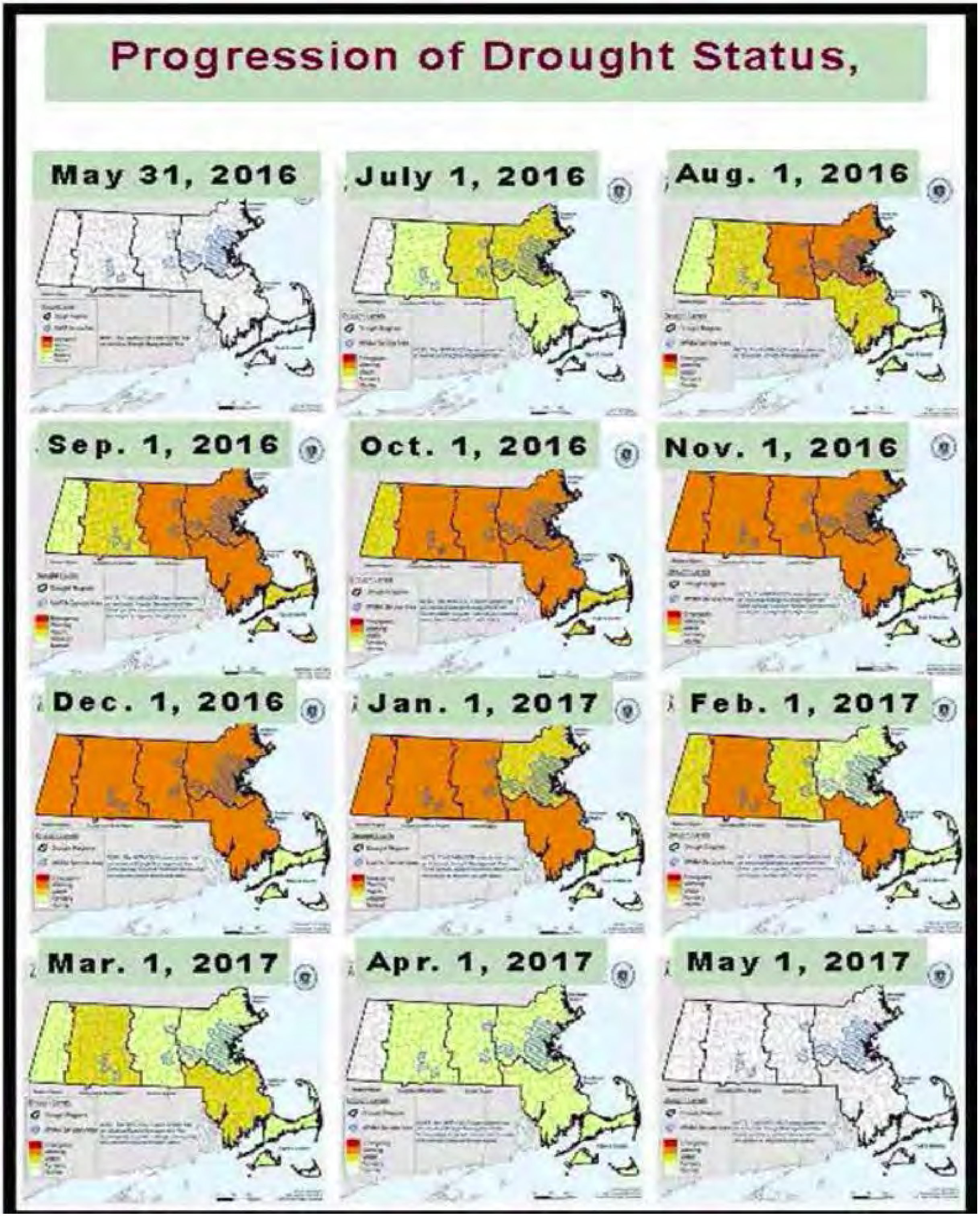
Massachusetts is relatively water-rich, with few documented drought occurrences. The most severe, state-wide droughts occurred in 1879-1883, 1908-1912, 1929-1932, 1939-1944, 1961-1969, 1980-1983, and 2016-2017. Several less-severe droughts occurred in 1999, 2001, 2002, 2007, 2008, 2010, 2014 and 2020. 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[14].

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. 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. 3.11) 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.[15] Refer to Figure 3.11 for the progression of the drought across the state.

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

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

Figure 3. Progression of the 2016-17 Drought



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

Vulnerability Assessment

People

The entire population of Peru 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, including Camp Danbee. 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 by a severe or prolonged drought. The Berkshire region has not suffered a severe, emergency level drought since the 1960s, and it is unclear how well Peru would fair during a prolonged drought given changes in population, water use, and precipitation patterns. More than a quarter of respondents to the hazard mitigation public survey stated that their well has run dry or that they knew fellow residents whose wells have run dry. All those respondents who cited dates of occurrence listed the past few years (2018-2020). The Town has in the past opened Town Hall for refilling jugs or provided bottled water for some residents whose wells temporarily ran dry.

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, structures and woodlots across Peru 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 we see occurring in Peru. This increases the devaluation of 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.

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 Peru is 87% forested, the risk of wildfire during drought conditions is a concern.

Invasive Species and Forest Pests

Hazard Profile

The Town of Peru 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 Peru 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. Lake Ashmere is a publicly accessible waterbody, 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 Peru 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 Peru, with the greatest risk along roadways and utility lines. Staff from the Massachusetts Department of Agriculture have verified the presence of giant hogweed along roads in the northwest corner of the Town.

Invasive aquatic plant species are found within Lake Ashmere. Although plant control management strategies are being undertaken, true and final eradication is unlikely given the easy public access to the lake via the public boat ramp and the many boats that visit the lake via private waterfront residences.

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. 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. [16]

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

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

weather events such as snow, ice, wind, tornado, frost, or hail (75,244 acres). Table 3.11 summarizes the most serious infestations facing Western Massachusetts forests.

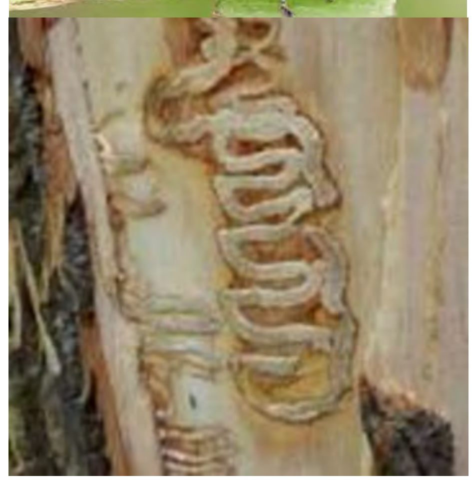
Table 3.11. Current Invasive and Nuisance Insect Threats to Peru Forests

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, including Peru in 2019. As of January 2021, EAB can be found in 169 communities throughout the state, as well as, all five other New England states. Peru has had to increase its tree management budget substantially to be able to keep up with taking down dead and dying ash trees along public roadways.

Fig. __Top: EAB Adult
Fig. __ Bottom: Damage done by EAB larvae under tree bark



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. ___. Hemlock Woolly Adelgid Infestation

Vulnerability Assessment

People

Giant hogweed Giant hogweed is a poisonous exotic plant. The sap of giant hogweed contains toxins that are activated by light (natural or artificial UV rays). Contact with giant hogweed sap, combined with exposure to light, can cause phytophotodermatitis, a serious skin inflammation. This can result in pain, skin lesions and blisters similar to very severe sunburns. Continued light exposure, heat and moisture (sweat or dew) can worsen the skin reaction. Healing of severe burn cases can take weeks or months and can leave extensive scarring. The sap can cause temporary or permanent blindness of it gets into the eyes. Breathing in sap particles from the air can cause respiratory problems. People most at risk from this plant are those who are conducting plant management activities and are not aware of the plant's toxicity. Town workers who mow or week-whack disturbed areas, such as along roadsides, are at greatest risk of these plants. Luckily, Peru highway crew members are aware of a few local populations of giant hogweed and are taking safety precautions around them. State officials have been alerted and will be safely removing the plants.

Aside from toxic species such as giant hogweed, 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

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 Figure __, where a line of several ash trees are dead and dying along Robinson Road in neighboring Hinsdale, MA, posing a risk to electricity lines and the travel way.

Fig. ___. EAB-infested trees along Robinson Road in neighboring Hinsdale MA in 2021. Dead trees (dead crowns) and dying trees pose a risk to the power lines and transportation.

Source: BRPC, 2021.

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).

In Peru, within the two short years that the EAB was first confirmed, the ash trees along local roadways have been decimated. The Town maintains a list of dying and dead roadside trees. Each year the Highway Department tries to prioritize the trees that need to be trimmed or taken down, partnering where possible with Eversource to reduce cost to the Town. Approximately six years ago the budget for roadside tree management was $5,000, but the last two years the Town has had to allocate $20,000 for this task. While some of the costs are due to the dying of trees damaged during successive ice or wind storms, or just from aging out, the significant cost increases have been largely due to the damage done to ash trees by the EAB.

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.[17] This includes all individuals working in outdoor recreation activities and tourism based on maintaining a natural landscape. This is especially important in Berkshire County, where the scenic beauty and outdoor recreational opportunities complement the region's international status as a cultural destination.

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. As a result, invasive species—which are often able to establish more rapidly following a disturbance—could have an increased probability of

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

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.
- 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).

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[18]. Data from several scientific sources indicate that 2011-2020 was the warmest decade recorded,[19] 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 Peru is somewhat protected from extreme heat by the Town's higher elevation. Temperatures here are often 4° to6°F cooler than the Berkshire County valley towns to the west and 6-8°F cooler than the towns in the Pioneer Valley to the east. 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.

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 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.

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

[19] *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*

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 (NE CASC), which is hosted by the University of Massachusetts, Amherst. NE CASC 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.

NE CASC 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). 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. The details for projections for mid-century and 2090s are outlined in Table 3.12.[20]

- Mean annual temperatures in Massachusetts 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.

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. If the temperature is 30°F, subtract the mean from 65 and the result is 30 HDD for that day.

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

Table 3.12. 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 Peru is exposed to the impacts of increased annual and extreme temperatures.

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, Peru has little experience with days when the air temperature exceeds 90°F, but that will soon change as we see an increase in the number of days with dangerous levels of heat. As seen in Figure 3.12, during the years 1960-2000, there were few if any days where the temperature was above 90°F in the Housatonic River Watershed.

During the baseline years 1971-2000 there was an average of 1.3 days per summer when the temperature exceeded 90°F.[21] 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 10 per summer by mid-century and to 19 by the 2090s. Under a high-greenhouse gas emissions scenario, the maximum number of days when the air temperature exceed 90°F could reach 26 days per year by mid-century and 62 days per year by the 2090s (NE CASC 2017)[22]. Peru is located at the upper elevation ridges that separate the Housatonic and Westfield River Watersheds. The Housatonic River Watershed was chosen for this analysis because the baseline year temperatures for this watershed are slightly cooler than the Westfield and more closely resemble what has been and is currently experienced in Peru during those years.

Fig. 3. Observed Pre-1960-2005 and Projected Higher Temperatures for the Housatonic River 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, and Peru has some of the highest elevations outside of the Mount Greylock complex. 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).

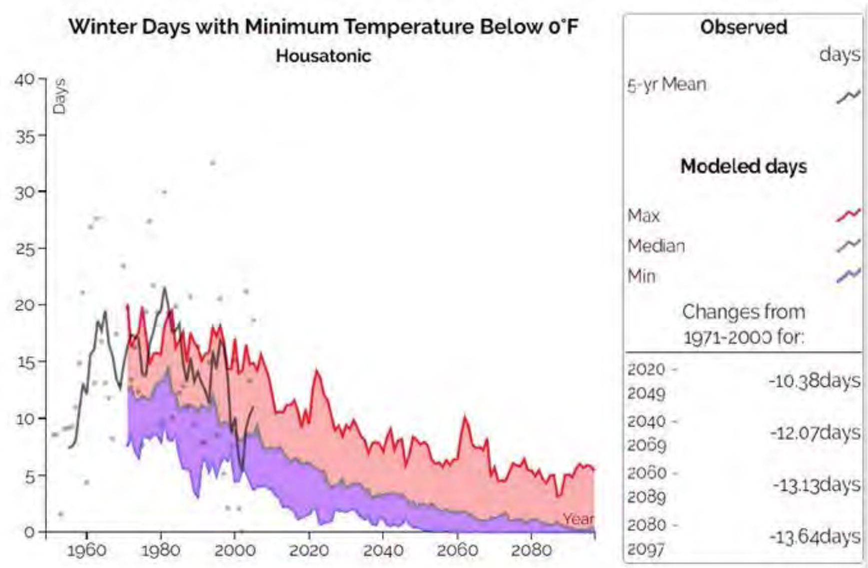
- Lanesborough, MA –28°F
- Great Barrington, MA –27°F
- Stockbridge, MA –24°F
- Pittsfield, MA -19°F

In the same manner that climate change will increase summer high temperatures, so too will it increase the lower winter temperatures.

[21] *MA Climate Change Projections by Basin report, 2017.*

[22] *https://resilientma.org/datagrapher/?c=Temp/basin/tx90/JJA/Housatonic/*

Fig. 3. Observed Pre-1960-2005 and Projected Lower Temperatures for the Housatonic River Watershed



Source: https://resilientma.org/datagrapher/?c=Temp/basin/tn0/DJF/Housatonic/

As illustrated in Figure 3.-, 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 4 days in 1960 and a high of 30 days in 1981. The baseline years of 1971-2000 averaged 15 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 only be one day where the temperature will fall that low.[23] This will bring some relief and reduce risk to people and buildings from extreme low temperatures. However, as described earlier in the Flood Risk Section of the plan, this change has implications for snow and ice management in the coming decades, with snows being heavier, snow melts more often and ice formation more often.

The temperature patterns have been projected by computer models for the entire Housatonic River Watershed in Massachusetts, including its highest and lowest elevations. While this watershed includes upper elevations at its headwater tributaries, such as those in Peru, the Housatonic River watershed also includes many square miles of lower elevation valley conditions, particularly in the southern portions of the watershed in Great Barrington and Sheffield. As such, the extreme winter temperatures for Peru – being at one of the highest elevations in the watershed – will likely be lower than those projected by the computer model, possibly significantly lower.

Vulnerability Assessment

People

All residents in the Town of Peru are vulnerable to the health effects of extreme temperatures, with those who work outside directly at a greater risk. According to the Centers for Disease Control and Prevention, populations most at risk to extreme heat and cold events include the following: (1) people over the age of 65, who are less able to withstand or regulate 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

[23] *https://resilientma.org/datagrapher/?c=Temp/basin/tx90/JJA/Housatonic/*

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. Berkshire County has a higher level of asthma-related emergency room visits than other parts of the state. 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.

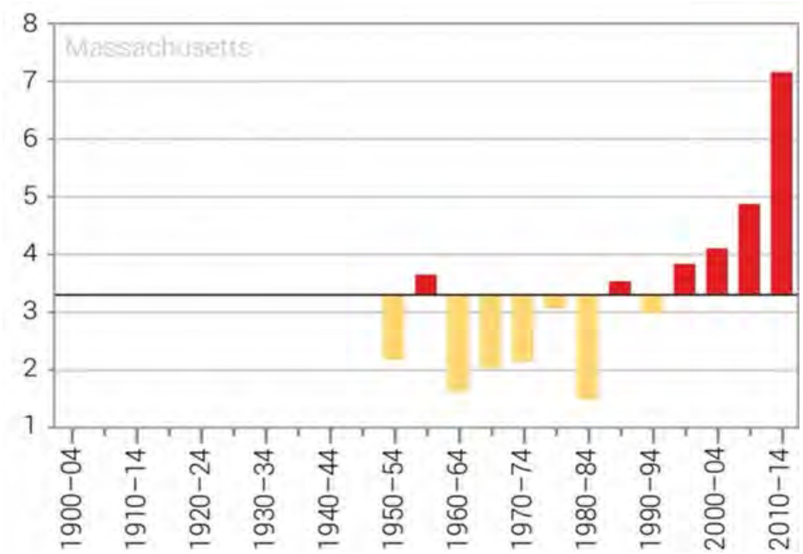
The NWS issues a Heat Advisory when the Heat Index is forecast to reach 100°-104°F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or more for two or more hours. The NWS Heat Index is based both on temperature and relative humidity and describes 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.

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. 3.14, 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. 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).

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).

Warmer annual winter temperatures are less consistent than in the past. Warm "false spring" periods have become more common. This results in more freeze/thaw events that begin earlier in late winter/early spring. In other words, the infamous New England "mud season" starts earlier and has more thaw events. The changes will drive up costs to maintain dirt roads and ensure safe passage for vehicles.

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 231 in the Housatonic River Watershed for the baseline years of 1971-2000. The summer CDDs are expected to increase by 73-205% (169 -473 degree-days) by mid-century, and by 104-403% (239-931 degree-days) by end of century[24]. 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.

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).

Economy

The agricultural industry is most directly at risk in terms of economic impact and damage due to extreme temperature and drought events. 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.

[24] *MA Climate Change Projections by Basin report, 2017.*

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. 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 Peru, there will be a 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. During a hot spell in 2020 the Town has opened the Town Hall to serve as a cooling shelter, but no one came to take advantage of the service.

Climate change is anticipated to be the second-greatest contributor to this 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.

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).

Tornadoes

Hazard Profile

Likely Severity

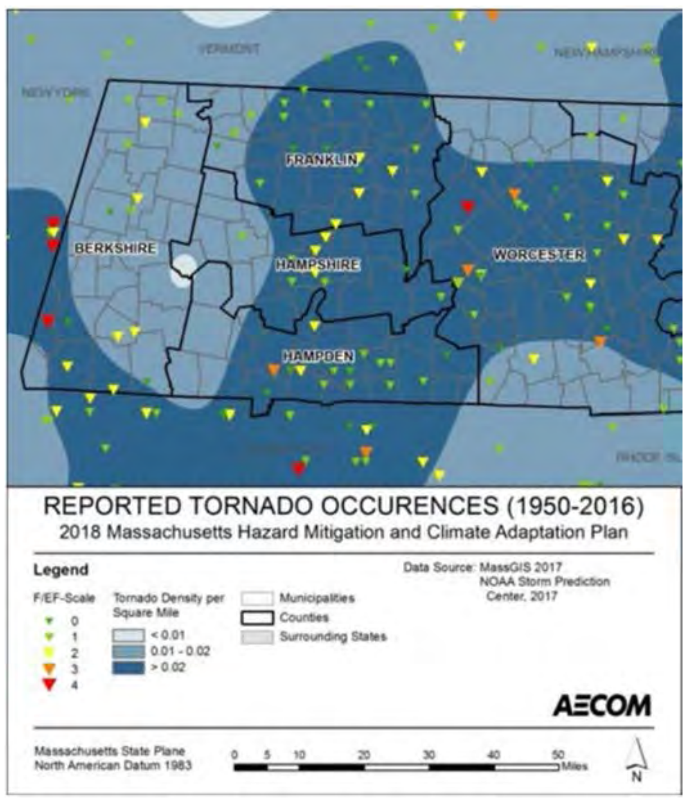
Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike damage could be significant, particularly if there is a home or other facility in its path. Many people could be displaced for an extended period of time; buildings could be damaged or destroyed; businesses 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.

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.

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).

Figure 3. Density of Reported Tornadoes per Square Mile



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

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. The most recent of these was in July 2014 when a tornado struck in Dalton. This averages to one tornado striking the county approximately every five 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 33 years. (NOAA, 2017).

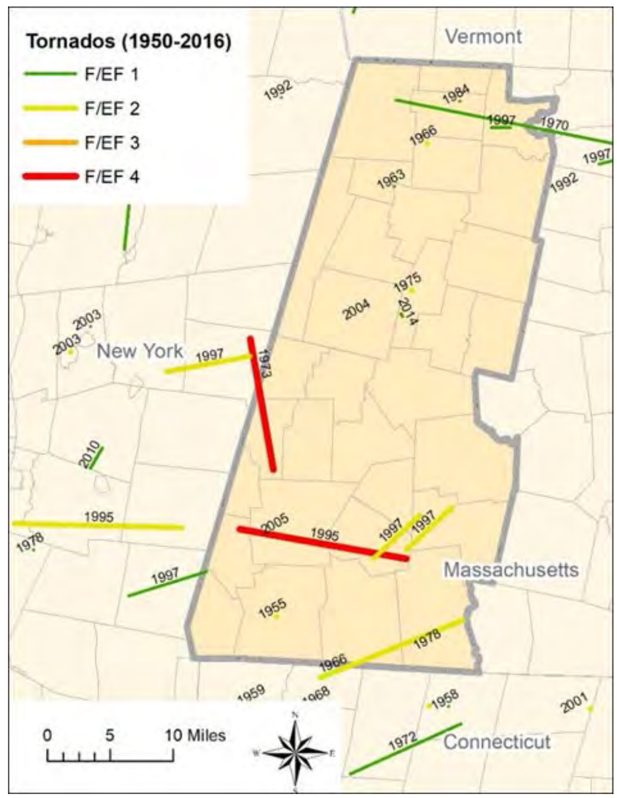
Geographic Areas Likely Impacted

While the area impacted by a tornado will be limited at the time of the event, anywhere in Peru is susceptible. Figure 3.16 shows where tornadoes density is greatest in Massachusetts through 2016.

Historic Data

The National Climatic Data Center reports data on tornado events and does so as far back as 1950. Of the 18 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 (MEMA & EOEEA, 2018).

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



Source: Midwest Regional Climate Center, 2018.

Although no tornadoes have struck Peru, Dalton has experienced two of them in recent decades. According to the *Dalton Multi-Hazard Mitigation Plan*, local Dalton residents remember a 1975 tornado event that landed on the Berkshire Bridge property, bounced across East Main Street, through Wahconah Country Club property and before heading towards Windsor. Minor damages were reported. In July 2014 an EF-1 tornado and microburst touched down in the Greenridge section of Dalton, causing downed trees and powerlines across the area, and temporarily closing local roads. The tornado caused structural damage on at least one home and cut a path through the woods behind Greenridge Park. A home on Norwich Drive sustained extensive damage, as the tornado lifted the roof off the house, shifted the chimney and ripped vents and siding. At this same house a large tree smashed through the back of the house and broke windows. Other local homeowners suffered minor damages (Dalton, 2018).

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). People who live in mobile homes are at greater risk of injury or death during a tornado, due to lighter construction and the lack of a basement in which to seek shelter. Approximately 73 housing units in Peru (17% of total units) are mobile homes. Power outages resulting from tornado or high winds can be life-threatening to those who are dependent on electricity for life support.

In Peru, warning systems are broadcast over television stations via satellite TV companies or via local or regional radio stations. Peru is located within the Albany satellite market, so its news and weather forecasts comes from local stations based in Albany, NY. Weather apps are available to download onto smart phones and tablets, but it is unknown how many residents subscribe to such apps. Summer, when tornadoes are most apt to form, 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.

People at Camp Danbee are more likely to be informed of potential tornado conditions and warnings, because staff are constantly monitoring radar and weather patterns of all kinds. Staff are trained on what to do when severe weather events are predicted. Additionally, staff are in frequent contact with their colleagues in their brother camp in the Berkshires, Camp Mah-kee-nac in Stockbridge. However, despite being informed and prepared, people at the camp 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 Peru 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 Peru and/or its neighboring towns, electricity could be out for several 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). The short warning time combined with the lack of a public warning system that could be widely transmitted to households in Peru increases the risk of people to tornadoes.

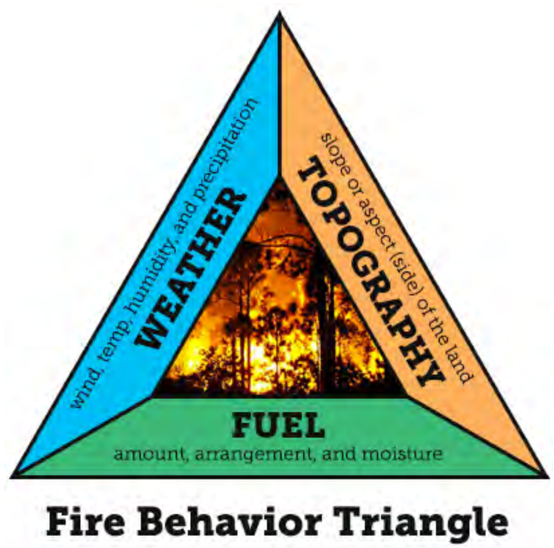
Wildfires

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

Given that Clarksburg is 87% forested, and that its neighboring communities are also heavily forested, the risk of wildfire is definitely present. The Town of Clarksburg has experienced Berkshire County's two largest fires, one in 2015 and one in 2021. The fire of 2021 is the largest in acreage to occur in the state since 1999, when the Tekoa Mountain fire in Russell burned 1,100 acres and claimed the life of a local firefighter.



Source: WeatherSTEM

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

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

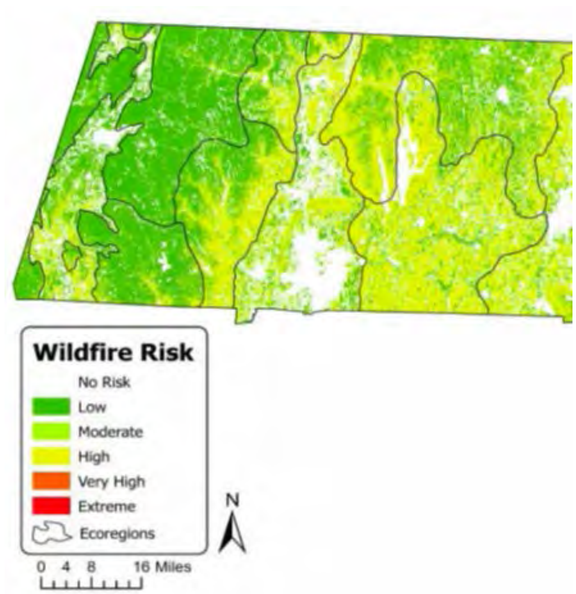
- Topography of a region or a local area influences the amount and moisture of fuel.
- Barriers such as highways and lakes can affect the spread of fire.
- Elevation and slope of landforms can influence fire behavior because fire spreads more easily uphill compared to downhill.

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. There is at least one notable wildfire that erupts in the Commonwealth each year. However, based on the frequency of past occurrences in the region, the probably of Peru being impacted is fairly 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.__, Peru 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.

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



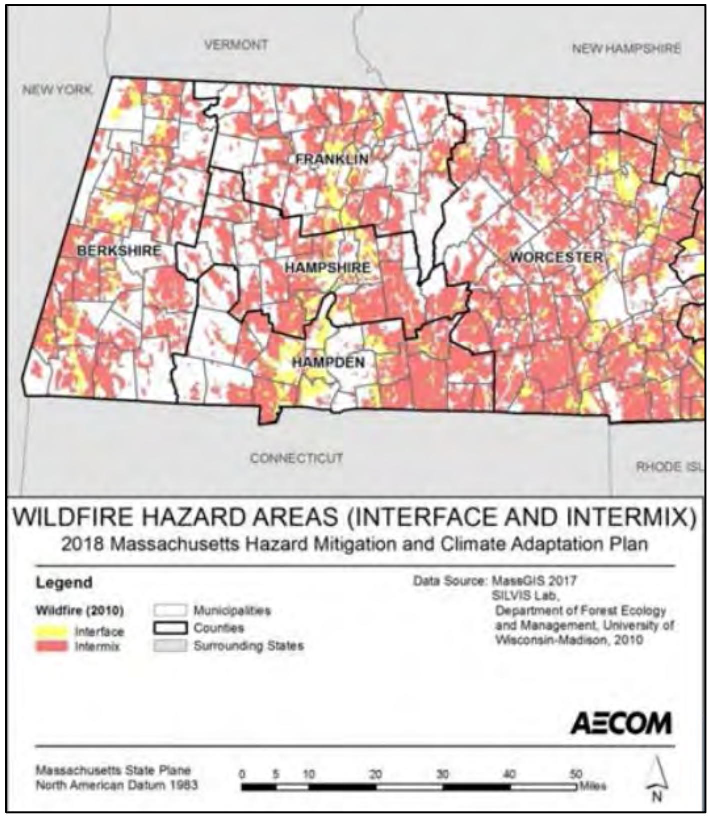
Source: Northeast Wildfire Risk Assessment Geospatial Working Group 2009

However, 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



Source: SHMCAP, 2018.

Peru 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 Peru 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. Given predictions for increasing temperature, evaporation, and short-term periods of drought, forest fire concerns are a growing concern in rural communities. 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. There are few of these tree communities in Peru. The SILVIS Lab at the University of Wisconsin-Madison Department of Forest Ecology and Management classifies exposure to wildlife hazard as “Interface” or “Intermix.” Intermix communities are those where housing and vegetation intermingle and where the area includes more than 50 percent vegetation and has a housing density greater than one house per 6.5 acres. 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 western portion of Peru lies within an Intermix area.

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.

Fig. 3.20. 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.

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. Fire fighting 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.[25]

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.

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

Source: iBerkshires, 5-17-21

The 2021 East Mountain fire started on Friday, May 14^{th} 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 16^{th} the fire had quadrupled to almost 800 acres, and by the time the fire was 90% contained on May 18^{th} it had consumed 950 acres of land, the majority in Clarksburg. 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 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.[26] 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

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

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

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 3.19 for these areas in Peru.

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.

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

Fig. __. 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.

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 invasive species. There are also risks related to hazardous material releases, where 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 in Peru and the region is projected to increase. 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).

- Without an increase in summer precipitation (greater than any predicted by climate models), future areas burned is very likely to increase.
- Infestation from insects is also a concern as it may affect forest health. Potential insect populations may increase with warmer temperatures and infested trees 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).

Hazard Profile

Likely Severity

The Town of Peru 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).[27]

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).[28] 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.

- 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.

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

- 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.[29]

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.

[29] 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

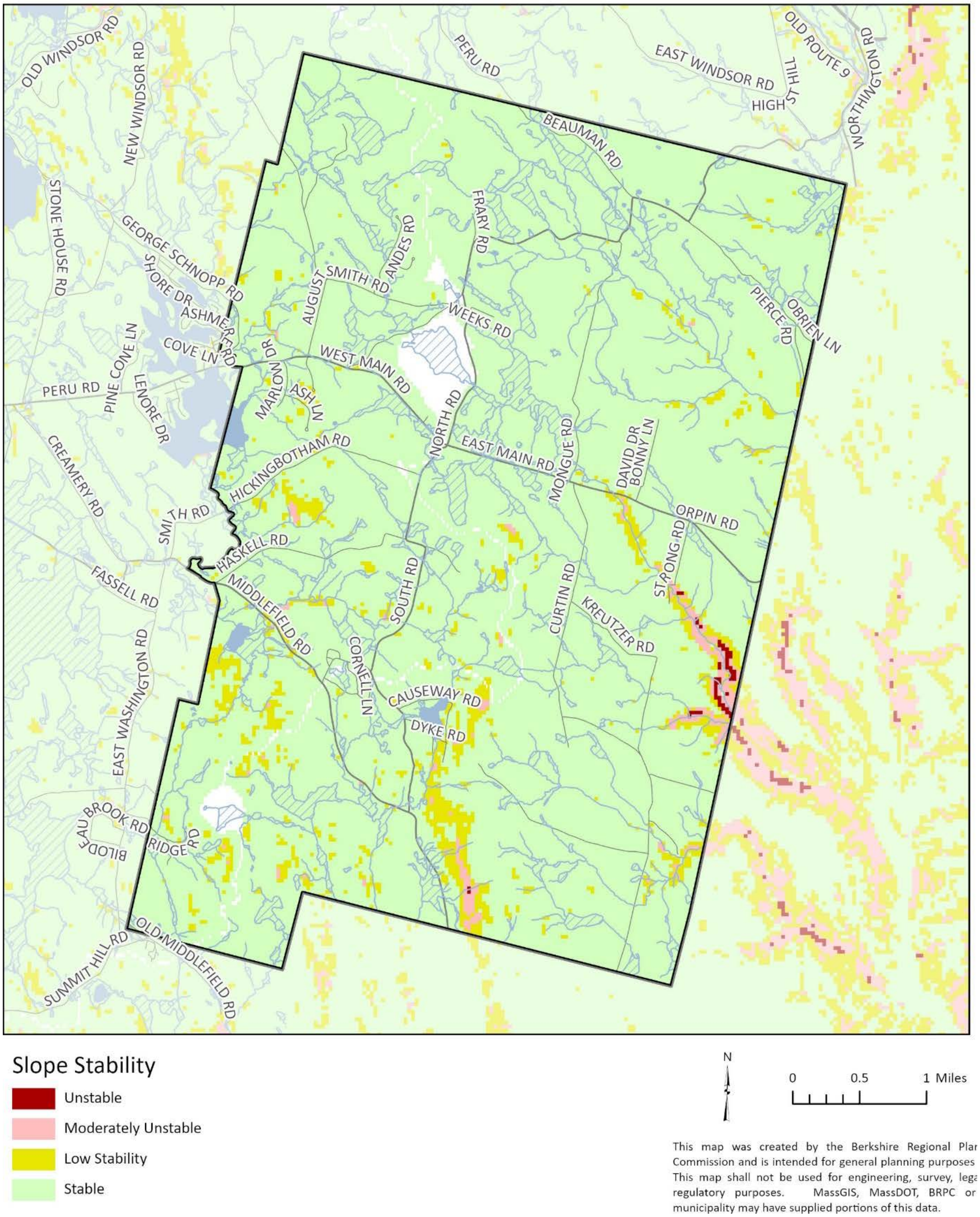
Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions (MEMA & EOEEA, 2018). Estimations of the potential severity of landslides are informed by previous occurrences as well as an examination of landslide susceptibility. 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).

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 Peru are illustrated in Figure 3.17, with corresponding map legend on the following page.

Figure 3. Slope Stability Map



Source: BRPC, 2021, MassGIS 2017.

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

[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]

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).

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. The underlying bedrock in Peru is granite and gneiss of the Berkshire Highlands, relatively hard materials that locally resist erosion. This creates the hilly landscape with deeply incised ravines. There are only a few areas of Peru in which Unstable slopes (seen as red areas in the map in Figure 3.) and Moderately Unstable slopes (seen as pink areas in the map) are found. The largest areas of Unstable lands are found along the steeply sloped ravines in which Fuller and Pierre Brooks flow southeast into Worthington. Moderately Unstable lands surround these areas. There is also a small section of Unstable lands along an unnamed brook in the very southern end of the Town. A few scattered areas of Moderately Unstable lands can be found along hills throughout Peru. In all, there 26 acres of land categories as Unstable (<1% of total) and 151 acres of land categorized as Moderately Unstable (1%) in various areas across Peru.

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 Route 2 in Savoy during T.S. Irene in 2011 (Figure __). The 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 bottom photo left). The landslide has a significant impact on norther Berkshire County communities because Route 2 is a major east-west transportation route in that region.

Fig. __. 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

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. No buildings are located in any Unstable land areas in Peru, while one building is located in a Moderately Unstable land area (located on East Main Road, west of Hilltop Road intersection). Using the ACS figure of 2.4 average persons per household in Peru, two to three people are potentially at risk from landslide in Peru.

Built Environment

There is one residential building in Peru within areas identified as Moderately Unstable slopes. According to data extracted from assessor parcel information, the value of this property is $37,700. There are no buildings located in areas identified as Unstable. Fortunately, there are no Unstable or Moderately Unstable lands near existing roadways or municipal buildings.

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.

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.

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

Source: BRPC, 1999.

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 Peru (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 3.13 describes the intensity and the equivalent Richter Scale rating.

Table 3.13. 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). More noticeable in Berkshire County was a 5.1 earthquake centered near Plattsburg in upstate New York on April 21, 2002, which shook homes throughout the region.

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 Peru 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).

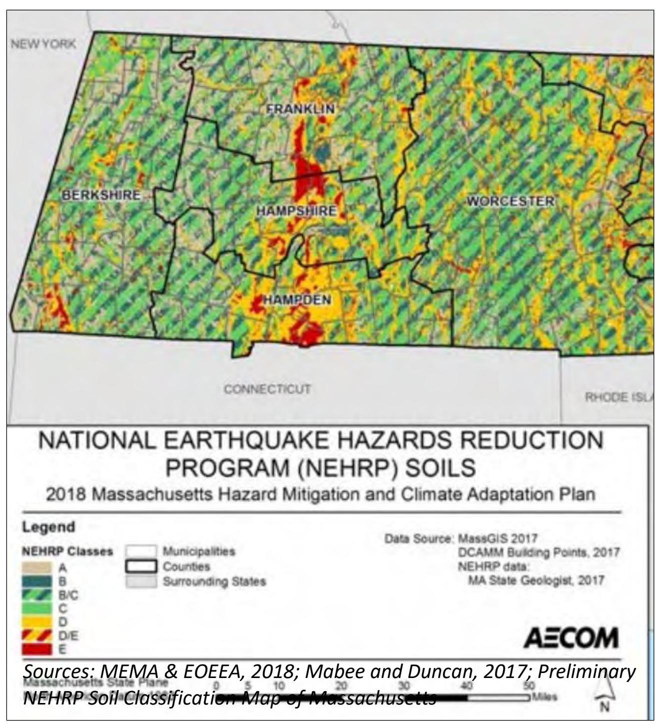
Geographic Areas Likely Impacted

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

Figure 3. NEHRP Soil Types in 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 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.[30] Clarksburg residents who participated in the development of this plan described the same impacts in their homes. 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 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 HMCAP* 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 3.14 shows the number of injuries and casualties expected for events in Berkshire County of varying severity (based on mean return periods) and for at various times of the day. Damages and loss due to liquefaction, landslide, or

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

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).

Table 3.14. Estimated Number of Injuries, Causalities and Sheltering Needs in Berkshire County based upon Mean Return Period

Mean Return Period (MRP)	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 3.15 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 3.15. Economic Loss Estimates, Hazus Probabilistic Scenarios

Economic Losses for Berkshire County	100-Year MRP	500-Year MRP	1,000-Year MRP	2,500-Year MRP
Building-Related Loss Estimates, Hazus Probabilistic Scenarios	$570,000	$25,660,000	$66,220,000	$200,810,000
Transportation and Utility Losses	$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 defined mission for the Town of Peru Hazard Mitigation and Climate Adaptation Plan is to identify risks, eliminate or reduce the loss of life, property, infrastructure and natural resources of the Town from disasters and climate change, and to develop sustainable cost-effective actions to mitigate those risks and the impacts of natural hazards. The Mitigation Strategy outlines how the Town of Peru intends to reduce potential losses identified in the Risk Assessment chapter. 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.

Hazard Mitigation Goals

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

1. Identify hazard risks throughout the Town and develop and implement sustainable, cost effective and environmentally-sound risk-reduction mitigation projects.
2. Protect the lives, health, safety and property of the citizens of Peru.
3. Protect public services, critical facilities, and infrastructure from loss of use during natural hazard events and potential damage from such events.
4. Actively pursue financial and technical support to implement the findings and recommended actions of this plan.
5. Involve stakeholders to enhance the local and regional capacity to mitigate, prepare for and respond to the impacts of natural hazards.
6. Integrate the risks and mitigation actions identified through this planning process into all plans for the town and ensure its consideration in all land use decisions.

National Flood Insurance Program (NFIP)

The Town of Peru is not a NFIP community. As part of the planning process in developing this hazard mitigation plan, the Peru Hazard Mitigation Planning Committee evaluated the benefits and costs of becoming a NFIP community. All property owners in communities that participate in the NFIP are able to purchase NFIP flood insurance, regardless of location in or out of the mapped flood hazard area. Homeowners and renters living in communities that do not participate in the NFIP and whose structures are found to be in the floodplain can be denied loans and/or affordable flood insurance coverage.

The Town received and reviewed guidance materials prepared by FEMA and MEMA about the program. According to the FEMA guide *Joining the National Flood Insurance Program, FEMA 496* (2019), to become eligible to enroll in the program, the Town of Peru would need to take these steps in order to submit an application package to FEMA.

1. Develop an application for Participation in the NFIP (FEMA Form 81-64): the Town needs to accomplish the following:

- Designate an official with overall responsibility for implementing the community's floodplain management program
- Set up a community repository for public inspection of flood maps
- Estimate land area, population, and number of structures in and outside flood-prone areas

2. Adopt a Resolution of Intent: this formally adopted resolution indicates an explicit desire to participate in the NFIP and a commitment to recognize flood hazards and carry out the objectives of the NFIP.
3. Adopt Floodplain Management Regulations: the Town must adopt and submit floodplain management regulations that meet or exceed the minimum floodplain management requirements of the NFIP. In Massachusetts this often translates into adoption of a floodplain overlay district.

MEMA has just recently drafted a model zoning bylaw that it is encouraging all communities in the Commonwealth to adopt. As stated in its model bylaw, the local floodplain overlay district is established as an overlay to all other districts. The model bylaw notes that the state already administers regulations that take care of many floodplain management requirements and concerns, i.e. the Wetlands Protection Act and Building Code. The model bylaw references these types of existing regulations to ensure that projects have been reviewed under the appropriate state regulations and that variances to the conditions of the bylaw do not erroneously allow variances to state requirements.

At this time, there are no documented structures within 100-year floodplain in the Town of Peru, and Town officials do not have any records of property owners sustaining damages or submitting insurance claims due to flooding. Town officials and the Planning Committee believe that the risk of constructing new buildings in Peru within the floodplain boundaries is extremely low given the existing protections and strictness of the Massachusetts Wetlands Protection Act and the Massachusetts Building Code, both of which reference FIRMs. However, Town officials and the Planning Committee acknowledge that future floodplain studies will likely result in newly-drawn floodplain boundaries, including the possibility that the boundaries may be expanded outward to include areas of existing development or that may be at risk of being developed in the future. If this situation occurs, where new floodplain boundaries are significantly expanded, then the Town of Peru should re-evaluate the benefits and costs of joining the NFIP.

Existing Protections

The Town of Peru is fortunate in having natural mitigative infrastructure in the contiguous forests and wetland resources that dominate the landscape. Peru's 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. Approximately 47% of these natural lands are permanently protected from development. 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[31]. 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

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

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 Peru has zoning in place to regulate development in the Town. The only land uses allowed by-right are those required under Massachusetts laws to be so. This includes single family homes, agricultural uses, religious or educational uses, and municipal/governmental uses. Two-family homes and home occupations are also allowed by-right. All other uses, such as small businesses and renewable energy projects, are allowed under the Special Permitting process. The Peru Zoning Board of Appeals is the Special Permit Granting Authority. Special Permit applications are forwarded to the Conservation Commission and Board of Health for their input. The Inspector of Buildings enforces the Town's zoning bylaws.

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. The Act is locally administered by the Peru 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 Peru as its minimum building standards. Local municipal building inspectors must be certified by the state to be eligible for the position.

The Massachusetts DCR completed extensive repairs to the Lake Ashmere dam in 2010 and has updated its EAP. The dam has a low-level outlet control valve that can be accessed to reduce water levels and/or pressure. Flow over the top of the dam is controlled by stoplogs. According to the EAP of 2013, DCR staff are responsible for flow and control of water over the dam, but no formal operations and maintenance manual exists to provide guidance. The lake is drawn down 28-32 inches each autumn to increase storage capacity. The drawdown occurs slowly and over a long period of time to reduce downstream impacts. Although no flooding of property or roads in Peru have resulted from the release of water during drawdown operations, Town officials are not notified of when water releases will occur. Better communication between DCR staff and Town officials is warranted. If a severe autumn rain event or tropical storm were to occur at the same time that water was being released from the lake, flooding could flood or damage Middlefield Road, a main artery.

The Peru Highway Department is a small but dedicated crew of three staff, working under challenging financial constraints to maintain the road system throughout the Town. Staff frequently inspect culverts and bridges to ensure that they are clear of debris. The Highway Superintendent works in the field with his crew and is aware of road conditions. There are several areas where upsizing culverts should be undertaken, but outside funding is needed to bring them up to state stream crossing standards. Sites along North Road are examples of where this is needed. Additionally, Town officials believe that the box culvert on Bennet Brook on the Peru/Hinsdale border should be upsized as part of the reconstruction of that section of road.

The Department actively pursues funding to control beaver activity that impacts roadways. Beavers were trapped out at sites along Middlefield Road, but new populations are inevitable. Beaver deceivers were placed along Beauman and Pierce Roads with funding from Mass. Society for the Prevention of Cruelty to Animals (MSPCA), and similar controls will be installed on Hickingbotham Road with additional MSPCA funding.

The Department 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 Peru in receiving priority state highway funding. 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. The needed culvert replacements on North Road are a high priority, while the upsizing of the box culvert on the Peru/Hinsdale town line should also be upsized to reduce risk.

The Highway Department has a long history of monitoring and trimming or taking down trees that threaten utility lines or safe travel. The Department maintains a list of dead, dying or damages trees and proactively trims or takes down the most dangerous each year. Eversource conducts work in Peru approximately every four years or so, and the Department communicates with the utility company to take advantage of their crews and gain maximum efficiency and cost reductions for the Town. There has been a dramatic increase in the number of dead and dying ash trees along the roadways due to the emerald ash borer, and this has forced the department to significantly increase its tree control budget. Whereas this budget was approximately $5,000 six years ago, the Town is now requesting a budget of $20,000 for this work.

The Town Hall, which also serves as the Town's Shelter, has kitchen facilities and has a backup power generator. The shelter was set up for two days as a 24-hour service during the Ice Storm of 2008, and local residents provided it with warm food. Some residents and utility crews visited the shelter during the day, but no one stayed there overnight as all those without electricity sheltered in place or stayed with friends or relatives within the region.

The Peru Fire Department is an all-volunteer organization, including the Chief and Officers. The Fire Station, built in 2012, is approximately 4,000 square feet in size and is equipped with a backup generator. Its open layout and size provide the Town with extra room for emergency operations and is the reason that it is the Town's Alternate EOC. It is commonly used for Town gatherings when large indoor space is needed. The Department has a long history of applying for and securing loans and grants for its equipment needs. A significant grant from FEMA enabled the fire department to purchase a new 3,000-gallon tanker truck and pumper, a major success for such a small town. That grant paid 90% of the cost of the vehicle, with the remaining 10% paid with local funds. Most recently the department has pursued grant funds for newer, lighter self-contained breathing apparatus and upgraded wildlife suppression.

Public safety services are provided through the Peru Police Department, which currently employs a Chief and four officers. An officer is on call 24 hours a day, with additional coverage provided by the Massachusetts State Police. All members of the department are certified by the Massachusetts Municipal Police Training Committee. Officers are dispatched through the regional center at the Berkshire County Sheriff's office. The Peru Police Department is a signatory member of several county and statewide mutual aid agreements.

The Town is fortunate that Camp Danbee has taken great strides in emergency preparedness planning and exercise. The camp's owner, CampGroup, LLC, retained the services of Fire Storm, a professional safety and security firm, to develop Emergency Response Plans (ERP) for each of its camps, four of which are located in Berkshire County. The plan outlines and lists emergency response personnel, their roles and responsibilities, and provides detailed response protocols for a variety of emergencies, including natural disasters, lost children and active shooters. A clear call-down list has been created, along with narrative scripts that staff can refer to during an emergency. A copy of the ERP has been provided to the Town and an updated call-down list is provided each spring to the Town. Emergency response trainings and drills are conducted each year with staff before campers arrive. In the past, Peru first responders have not been involved in any of these exercises, but given the high number of people and children at this facility, greater Town/Camp Danbee communication could be beneficial for both partners.

Camp Danbee is equipped with two large generators that will keep the water and sewer pumps working in the event of a prolonged electricity outage. If evacuations, sheltering or other support is needed, other camps in the CampGroup family, in Becket, Pittsfield or Stockbridge, can provide it. As standard protocol, the camp always has at least three days worth of dry food on site.

Strengths and Challenges

As part of the hazard mitigation planning process, the Town conducted a self-evaluation of its policies, regulations, operations and emergency preparedness. The Town used as its guide the Capability Assessment Worksheet tool found within FEMA's *Local Mitigation Planning Workbook* of 2013. Additionally, one-on-one interviews were held with key Town officials, department heads and first responders.

One of the main strengths of the Town is the independent spirit and resilience of its residents. Winters are generally harsher and longer here than in the valley towns below, and wind and ice damages are generally more severe. Services such as stores, fuels or medical care are many miles away, and those who live here are generally equipped to shelter in place if necessary. Also, residents here have a willingness to work together during emergency situations. The population of the Town is small enough that people know their neighbors. First responders and neighbors are generally aware of where the small number of vulnerable residents live, such as the elderly or those with medical conditions, and they check in on them during severe storms or when electricity is out. There is, however, no formal list of vulnerable residents or formal protocols to check in on them.

Although the Town and its residents are resilient in the face of routine severe storms, true resiliency was shown during the Ice Storm of 2008. This was the event that isolated wide swaths of the Town and its residents, testing the Town's ability to respond to a Town-wide emergency situation. All town roads suffered from downed trees, limbs and power lines, with most completely closed down for safety. Town crews, volunteers and citizens worked together with chainsaws to open passageways, with crews working non-stop for four days. Neighbors checked on neighbors, helped each other cut branches and start generators, and clear debris from driveways and property. Even with that effort some side roads remained impassible for almost a week, and many residents lost power for longer than a week. The prolonged power outages during T.S. Irene have prompted the regional utility companies to improve the integrity and build resiliency into their power grid systems. Communications and cooperation between Eversource and the Town of Peru have improved.

Although the Peru Fire Department is an all-volunteer company, it has been successful in securing grant funds to replace aging vehicles and equipment. It regularly submits applications for PPE and other equipment, including forest fire suppression gear. Its most rewarding grant was an almost $200,000 award from FEMA approximately 18 years ago for a 3,000-gallon tanker truck and pumper.

Due to its rural nature, Berkshire County is a region where small towns routinely share experiences, resources and services. Formal mutual aid agreements for first responders are in place, providing regional services beyond the capacity of a small town such as Peru. In the case of fire response, mutual aid is commonly used, and helps to create good working relationships between firefighters. The Town is a member of the Central Berkshire Regional Emergency Planning Committee (REPC), which provides shared and coordinated resources amongst its rural membership, including shared training opportunities, supplies and coordinated grant writing. Safety and disaster drills are conducted at the regional school district through a state police initiative.

Camp Danbee is an accredited overnight camp that has engaged in emergency response planning under the guidance of a professional safety and security firm. Additionally, having three brother camps in the region with which staff interact often and professionally is an added strength for all four of the camps. Peru Fire Department personnel are familiar with the facilities on camp, because they inspect every buildings for working fire alarms and some buildings for working fire suppression systems. However, improved emergency response coordination between the camp and the Town, including face-to-face annual exercises or drills, would reinforce good working relationships.

One of the Town's greatest challenges is drawing and retaining volunteers for town offices and committees, and for the fire department. Decreasing volunteerism in fire and ambulance companies is a common issue across the region and the U.S., due to a variety of trends, among them:

- Our increasing elderly population: this increases demands for emergency response.
- Our volunteers are aging out: many current volunteers are retiring from their volunteer fire and ambulance positions.
- Economic trends: two-income families are the norm, leaving less free time for volunteerism.
- Increased trainings: there are ever-greater demands for achieving and maintaining fire and medical training and certification, a burden for those with limited time to volunteer.

- Social trends: the able-bodied population of today is generally less interested in volunteer service.

Retaining seasoned and experienced volunteers within the fire department is particularly concerning. The decrease in volunteerism leads to longer response times for medical and fire calls. Because most volunteers work out of Town, it is difficult to get one or two people to respond to a fire call during the day. Peru's neighbors are also small hilltowns, all of whom have volunteer fire departments that also struggle to pull together a crew to respond to mutual aid. In past years Peru was fortunate that highway crew members were volunteer firemen and were close by to respond, but this is no longer the case. As a result, it may take 45 minutes for an ambulance or fire crew to respond to a call in Peru. To address this issue, some other rural regions in the state, including southern Berkshire towns, have created regional ambulance squads that hire and retain paid, full-time crews.

The Town of Peru also struggles to draw and retain police officers to cover all shifts. Staff turnovers are common, with the Town frequently losing personnel to larger, full-time agencies that offer better pay and benefits than Peru can provide. The department's most serious current need is funding to help officers complete the training mandated by the state's new police reform legislation. This includes hundreds of hours of additional training that is so far unfunded by the state. These changes will also make it more difficult for the Town to attract new candidates in the future.

The every-increasing demands for training and certification of fire and police leaves little time to plan and hold local table-top or field exercises for local first responders. This lack of coordinated, cross-discipline emergency response exercises could lead to miscommunications and breakdown of incident command structure in the event of a large-scale natural hazard response.

The regional dispatch center continues to use an outdated communication system. This, together with existence of a few "dead zones" within Town, can make radio communication unreliable, putting residents and first responders at risk and increasing emergency response times.

Because the Town has such a small tax base, pulling together funding for large, costly projects is difficult and often takes years to secure. As climate change is expected to increase the frequency and intensity of severe storm events, it will be important for the Town to be able to prepare for and maximize its competitiveness for regional, state and local funding sources.

The Town of Peru is too small to employ a technical staff (e.g. Community Planner, Civil Engineer, etc.) and turns to Berkshire Regional Planning Commission for technical assistance in a variety of disciplines, including data collection, zoning and energy planning, public health and grant writing. Local engineering firms and other technical advisors are hired as needed.

The Town of Peru has developed few formal planning documents or protocols. It has not drafted a master plan, economic development plan, or future land use strategy and map. This hazard mitigation plan is its first attempt at looking comprehensively at natural hazard mitigation, emergency response capabilities and climate change adaptation. The Town does not have local "Safe Growth" policies or regulations in place to steer development away from hazard areas, but strict state regulations effectively serve this purpose regarding wetland, river and floodplain resource areas. As noted above, the Town expects to revisit the issue of developing floodplain overlay zoning when new flood studies and/or FIRMS are drafted for Peru.

Prioritizing Actions

Actions are categorized within primary *Mitigation Types*:

- Local plans and regulations
- Structural projects
- Education, preparedness and response
- Natural resource protection

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

Benefit explains what the action mitigates or how it to increase resilience.

Implementation Responsibility will reflect 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 is listed at Short, Long, and Ongoing to reflect the timeframe identified for projects through the MVP Community Resilience Building process. A project that has been identified as short term is one that can and needs to be implemented immediately. These projects are likely to have a favorable benefit-cost outcome, have the political and community support necessary, and are practicable. Long term projects still require multiple steps before implementation, including studies, engineering, and gaining community support. 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.

Cost 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 and Funding for each action are known or potential technical assistance, materials and funding for the type of project identified.

Table 4.1 provides a roadmap for the Town of Peru to increase resiliency and will be updated with the new plan in five years.

Table 4.1. Mitigation Action Plan for the Town of Peru

Mitigation Type	Description of Action	Benefit	Implementation Responsibility	Priority / Timeframe / Cost	Resources / Funding
Structural Projects	Continue upsizing culverts and bridges where feasible; pursue funding for upgrades on North Road, Hickingbotham Road, Middlefield Road; upsize along East Windsor in prep for reconstruction of road	Reduce flooding and damage of roads and adjacent properties	Highway Dept., Selectboard	High / Ongoing / High	DOT Small Bridges; DER Culvert Replacement Municipal Assistance; Chapter 90; Town Funds
Structural Projects	Continue to employ beaver control methods where feasible, focusing on Hickingbotham, Curtin and Pierce Roads; also where beavers may move to in the future	Maintain safe public transportation and emergency response routes	Highway Dept., Selectboard, Town Administrator	High / Ongoing / Low	MSPCA Grant Fund; Ch. 90; Town funds
Local plans and regulations	Work with MEMA to stay updated on the progress of developing a new FIRM for Peru; if existing structures or land reasonably expected to be developed are found to be within newly-drawn floodplain boundaries, evaluate the pros/ cons of joining NFIP	Provide affordable flood insurance for homeowners if they find their homes are within re-drawn FIRM boundaries; keep new development out of flood-risk areas	Planning Board, Selectboard	High / Ongoing / NA	None needed at this time
Education, Preparedness, Response	Increase information sharing between DCR Lake Ashmere dam operations and the Town	Reduce potential for injury or damages to landowners and town infrastructure from dam releases	Emergency Management Director (EMD), Highway Dept., Police Dept., Fire Dept.	High / Short / NA	None needed at this time
Education, Preparedness, Response	Investigate a public emergency communication system, possibly joining a neighboring town for cost effectiveness and efficiency	Improve/expand ways to alert residents about hazardous weather conditions or impending disasters	EMD, Selectboard, Town Meeting	Medium / Long term / Low	None needed at this time; Town Meeting will likely need to approve funds to establish system
Education, Preparedness, Response	Investigate the feasibility of establishing a regional ambulance squad that could serve the central Berkshire hilltown region	Improve medical emergency response time	EMD, Police Dept., Fire Dept.	Medium / Long term / Low	MEMA for guidance; Town Meeting will likely need to approve funds to establish program

Mitigation Type	Description of Action	Benefit	Implementation Responsibility	Priority / Timeframe / Cost	Resources / Funding
Education, Preparedness, Response	Increase efforts to hold cross-discipline emergency preparedness trainings, drills or exercises, possibly in coordination with Central Berkshire REPC	Improve coordination and response to emergencies and disasters; reduce risk and impacts to people, property and infrastructure	EMD, Police Dept., Fire Dept.	Medium / Long term / Low	MEMA, REPC
Education, Preparedness, Response	Improve annual communication with Camp Danbee; consider ways to join in emergency trainings or drills at the site; consider having Hinsdale first responders also join this effort	Improve coordination and response; reduce risk to children, staff and first responders during incidents	EMD, Police Dept., Fire Dept.	Medium / Long term / Low	None needed
Education, Preparedness, Response	Consider creating incident command protocols in emergency management; ensure redundancy	Ensure clear incident commend system and response for more effective coverage	EMD, Police Dept., Fire Dept.	Medium / Long term / Low	MEMA guidance
Local Plans and Regulations	Review the Hazard Mitigation & Climate Adaptation Plan bi-annually; update as needed or conditions change; update plan in 5 years	Adapt to changing conditions and reduce overall risk; improve chances of implementation of actions	EMD, Selectboard, Planning Board, Police Dept., Fire Dept.	Medium / Ongoing / Low	None needed at this time; FEMA funding to update plan

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 Peru 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 Peru 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 Peru will officially review needed updates for the plan on an annual basis. Specifically, the Hazard Mitigation 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.

Bi-annual review is scheduled to occur once this HMCAP has been approved by FEMA. Under the leadership of the Emergency Management Director and the Town Administrator, the Town 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 Peru, the Hazard Mitigation Planning Committee began building a network of interested residents that can enhance the next update. While the Hazard Mitigation Plan must be updated every five years, Peru will begin the process of organizing and identifying funding for the plan update 1.5 years before this plan expires. 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 Peru including comprehensive plan updates, transportation plans, and zoning changes.

The final adopted HMCAP will be made publicly available on the Town of Peru website for reference and comment. Any regional plans developed by BRPC or the Commonwealth should refer to the publicly available Peru 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 FEMA 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

Major References:

Berkshire Regional Planning Commission (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.

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.

Mass. Natural Heritage & Endangered Species Program, 2012. *BioMap2, Conserving the Biodiversity of Massachusetts in a Changing World, Peru*, Westborough, MA.

Resilient MA Climate Change Clearinghouse for the Commonwealth, resilientma.org, 2021.

APPENDICES:

APPENDIX A: Public Survey Results

Q1 What street do you live on in Peru?

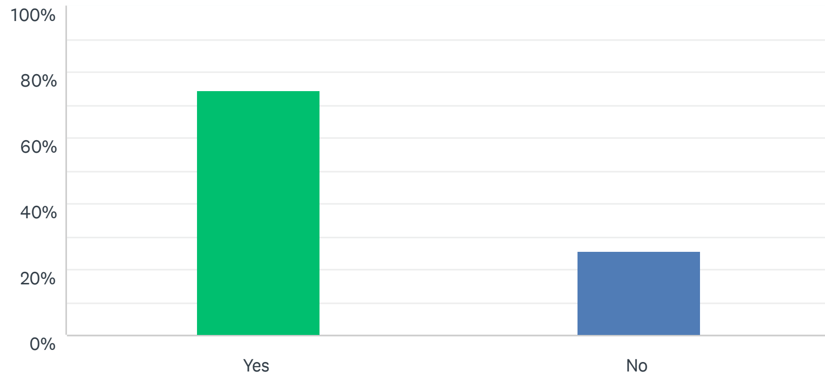
Answered: 41 Skipped: 1

#	RESPONSES	DATE
1	Ash Lane	5/21/2021 9:44 PM
2	78 E. Main Rd	5/8/2021 4:20 PM
3	Middlefield	5/8/2021 9:10 AM
4	8 ash lane	5/5/2021 10:17 PM
5	North	5/5/2021 6:53 PM
6	South Road	5/5/2021 1:18 PM
7	Curtin	5/5/2021 12:35 PM
8	51 Middlefield Road	5/4/2021 9:22 AM
9	Marlow Drive	5/3/2021 2:15 PM
10	Garnet Mountain Lane	5/3/2021 1:36 PM
11	North Road	5/3/2021 11:18 AM
12	Middlefield Road	5/2/2021 8:53 PM
13	Marlow Drive	5/2/2021 1:02 PM
14	Andes Rd.	5/2/2021 9:07 AM
15	16 Ash Lane	5/1/2021 8:25 PM
16	West Main Rd.	5/1/2021 6:13 PM
17	Hickingbotham Rd	5/1/2021 4:12 PM
18	18 Bonny Lane	5/1/2021 3:36 PM
19	Lafayette Dr	5/1/2021 1:34 PM
20	Pierce Road	5/1/2021 1:11 PM
21	26 east windsor rd	5/1/2021 12:08 PM
22	Spruce Dr.	5/1/2021 11:35 AM
23	7 Marlow Drive	5/1/2021 11:34 AM
24	7 Gentian Hill Rd	4/20/2021 3:49 PM
25	North road	4/9/2021 4:54 PM
26	West Main Rd.	4/5/2021 3:33 PM
27	Curtin Rd	4/4/2021 10:19 AM
28	8 baumann rd	4/2/2021 9:56 PM
29	South Road	4/2/2021 7:15 PM
30	South Rd	4/2/2021 10:52 AM
31	Curtin	4/2/2021 3:25 AM
32	Andes Rd	4/1/2021 9:19 PM
33	Middlefield rd	4/1/2021 8:34 PM
34	Middlefield	4/1/2021 8:28 PM
35	East Windsor Road	4/1/2021 8:16 PM
36	Ash Ln	4/1/2021 8:12 PM
37	Middlefield Rd	4/1/2021 7:05 PM
38	Garnet mountain lane	4/1/2021 6:48 PM
39	East Main Road	3/29/2021 11:47 AM
40	Route 143	3/28/2021 4:50 PM

41	3 East Main Road, Suite 100	3/26/2021 3:01 PM

Q2 Have you witnessed severe natural hazards or disasters in Peru?

Answered: 39 Skipped: 3



ANSWER CHOICES	RESPONSES	
Yes	74.36%	29
No	25.64%	10
TOTAL		39

Q3 If yes to Question 2, when and where did the events occur? Please be as specific as possible to help town officials understand when and where these events occurred.

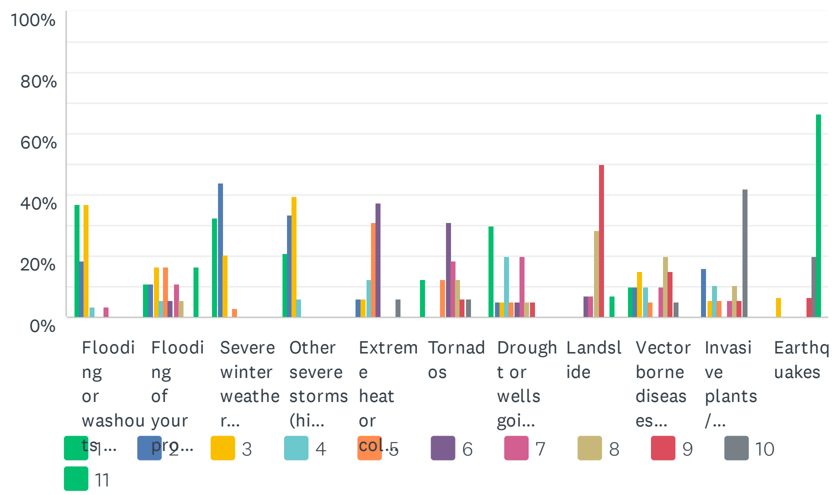
Answered: 29 Skipped: 13

#	RESPONSES	DATE
1	Severe ice storm around 2008 that knocked out power for days.	5/8/2021 4:20 PM
2	ICE STORM 2008? WHEN MOST RESIDENTS LOST POWER FOR DAYS. RECURRING HIGH WINDS. HEAVY RAINS AND SNOW MELT EVERY SPRING CAUSING ROAD WASHOUT ESPECIALLY ON OUR ROAD,	5/5/2021 10:17 PM
3	Hurricane irene and ice storm	5/5/2021 6:53 PM
4	Culvert washouts on Rte 143, Hickingbotham Rd washout, 2011	5/5/2021 1:18 PM
5	Snow storms and heavy rain wash out property on Marlow DR due to storm drain flooding property and snow being piled up at end of street	5/3/2021 2:15 PM
6	Late March 2021, high winds blew several trees down on neighbor's properties. Late April, heavy rains damaged gravel road. August 2020, my well ran dry.	5/3/2021 1:36 PM
7	Skyline trail causeway that connects to Rt. 8 floods frequently	5/2/2021 8:53 PM
8	2009 or 2010 severe Ice storm, power loss and major tree damage town wide	5/2/2021 1:02 PM
9	Severe ice storm. Not sure 2008 maybe. Lost power for 8 days. Town wide outage.	5/2/2021 9:07 AM
10	Hurricane Irene caused flooding on our land because of a faulty road drainage system, washing out our small bridge across our brook and washed out our driveway, causing 2-3 ft. deep ruts washing the gravel into our back yard. It took weeks to clean up our front and backyard, and we had to have our driveway re-done. We have had some torrential rain storms the last 20 years that have washed out our driveway also.	5/1/2021 8:25 PM
11	Don't know what year… road washed out.	5/1/2021 4:12 PM
12	Property line abuts wildlife management area. Much tree damage from winter precipitation and extremely high winds. Flooding in already moist woodland, allows trees to uproot and tip over. Many are quite old and large.	5/1/2021 3:36 PM
13	Hurricane Irene impacted our street and others in town: Rt 143 and Hickingbotham. The ice storm if 2008	5/1/2021 1:34 PM
14	E Windsor Rd.....road surface needs replacing	5/1/2021 1:11 PM
15	high groundwater 2011	5/1/2021 12:08 PM
16	1970's , 1980's, 1990.s, a number of blizzards with electricity out for extended periods of time. Even today, in the 2020's we have had some issues with heavy snow. At 2000 ft. in elevation, snow and wind is and will be a major issue. Gravel roads are especially prone to issues, such as washouts or blockages in the spring. It would be nice to have blacktopped roads where gravel/dirt/ mud is now. When one considers the amount of money spent repairing these roads, blacktopping, although expensive, would it not be cheaper in the long run? We do average between 9 and 10 feet of snow each year.	5/1/2021 11:35 AM
17	Ice storms, tropical storms and severe thunderstorms	4/20/2021 3:49 PM
18	Flooding at 27 North road =berrys and goyetts	4/9/2021 4:54 PM
19	Ice storms. High winds, thaw and freeze with lots of water runoff	4/4/2021 10:19 AM
20	Ice storm	4/2/2021 7:15 PM
21	severe ice storm - lost power for days- 2008	4/2/2021 10:52 AM
22	In different areas of peru. Trees fall and take out power lines all the time on the really high windy days. Maybe cutting the dead trees back would help with that a little. Or reinforced lines even if possible. Mud season is a big issue to on dirt roads. The ruts get so large that people lose control of their vehicles and end up off road.	4/1/2021 9:19 PM
23	Hurricane sandy washed out our newly paved road. There was about a 5 foot gap between the driveway and the road.	4/1/2021 8:34 PM
24	Ice storm 2006	4/1/2021 8:28 PM
25	Destruction caused by ice storms, hurricanes and Nor'easters	4/1/2021 8:16 PM

26	On my street when the new road was being built. I think it was during Irene. The road washed out and couldn't get out of my driveway. The road has been fixed since then.	4/1/2021 7:05 PM
27	Last summer towards the end. Trees down over roads. Power out.	4/1/2021 6:48 PM
28	Hurricane Irene 2008 Ice Storm Several Blizzards	3/29/2021 11:47 AM
29	All over Peru	3/28/2021 4:50 PM

Q4 What natural hazards concern you the most when you are in Peru? Choose and rank the top three hazards, by placing a number 1, 2 or 3 next to the top hazards. Place a 1 next to the hazard of greatest concern to you, 2 next to your second greatest concern, and 3 next to your third greatest concern.

Answered: 40 Skipped: 2



	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Flooding or washouts of roads	37.04% 10	18.52% 5	37.04% 10	3.70% 1	0.00% 0	0.00% 0	3.70% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	27
Flooding of your property	11.11% 2	11.11% 2	16.67% 3	5.56% 1	16.67% 3	5.56% 1	11.11% 2	5.56% 1	0.00% 0	0.00% 0	16.67% 3	18
Severe winter weather (snow, blizzards, ice storms)	32.35% 11	44.12% 15	20.59% 7	0.00% 0	2.94% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	34
Other severe storms (high winds, thunderstorms, hurricanes/tropical storms)	21.21% 7	33.33% 11	39.39% 13	6.06% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	33
Extreme heat or cold events	0.00% 0	6.25% 1	6.25% 1	12.50% 2	31.25% 5	37.50% 6	0.00% 0	0.00% 0	0.00% 0	6.25% 1	0.00% 0	16
Tornados	12.50% 2	0.00% 0	0.00% 0	0.00% 0	12.50% 2	31.25% 5	18.75% 3	12.50% 2	6.25% 1	6.25% 1	0.00% 0	16
Drought or wells going dry	30.00% 6	5.00% 1	5.00% 1	20.00% 4	5.00% 1	5.00% 1	20.00% 4	5.00% 1	5.00% 1	0.00% 0	0.00% 0	20
Landslide	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	7.14% 1	7.14% 1	28.57% 4	50.00% 7	0.00% 0	7.14% 1	14
Vector borne diseases (rodents, ticks, mosquitos, etc.)	10.00% 2	10.00% 2	15.00% 3	10.00% 2	5.00% 1	0.00% 0	10.00% 2	20.00% 4	15.00% 3	5.00% 1	0.00% 0	20
Invasive plants / animals	0.00% 0	15.79% 3	5.26% 1	10.53% 2	5.26% 1	0.00% 0	5.26% 1	10.53% 2	5.26% 1	42.11% 8	0.00% 0	19
Earthquakes	0.00% 0	0.00% 0	6.67% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	6.67% 1	20.00% 3	66.67% 10	15

Q5 What are your greatest concerns about the hazards that you ranked in Question 5? Choose and rank the top three hazard impacts, with 1 being of greatest concern, 2 the next greatest concern, and 3 the next concern.

Answered: 40 Skipped: 2

	1	2	3	4	5	6	7	TOTAL	SCORE
Not being informed of impending disasters	14.29% 3	23.81% 5	19.05% 4	19.05% 4	9.52% 2	9.52% 2	4.76% 1	21	4.67
Injury or loss of life	62.96% 17	3.70% 1	25.93% 7	0.00% 0	3.70% 1	3.70% 1	0.00% 0	27	6.11
Loss of property	20.00% 5	20.00% 5	40.00% 10	8.00% 2	12.00% 3	0.00% 0	0.00% 0	25	5.28
Loss of electricity	33.33% 11	45.45% 15	18.18% 6	3.03% 1	0.00% 0	0.00% 0	0.00% 0	33	6.09
Becoming isolated during a storm due to road washout or loss or loss of communication	12.50% 4	37.50% 12	21.88% 7	12.50% 4	15.63% 5	0.00% 0	0.00% 0	32	5.19
Loss of work due to isolation	0.00% 0	12.50% 2	12.50% 2	0.00% 0	12.50% 2	62.50% 10	0.00% 0	16	3.00
Other	0.00% 0	0.00% 0	26.67% 4	6.67% 1	0.00% 0	0.00% 0	66.67% 10	15	2.27

Q6 If you listed "Other" in Question 6 as a top three hazard impact of concern, please describe what your concern is.

Answered: 11 Skipped: 31

#	RESPONSES	DATE
1	sickness from ticks, or contaminated water	5/8/2021 4:20 PM
2	None	5/8/2021 9:10 AM
3	Not having any control of it. such as the ash bore invasion killing all of our ash trees	5/5/2021 10:17 PM
4	None	5/5/2021 6:53 PM
5	flooding of property from storm drain snow piling at end of road causes wash out of property into brook from runoff	5/3/2021 2:15 PM
6	Na	5/2/2021 8:53 PM
7	Frost heave damage between driveways and town road.	5/1/2021 3:36 PM
8	n/a	4/20/2021 3:49 PM
9	Getting emergency vehicles to sites for assistance	4/9/2021 4:54 PM
10	Lack of resources for most at risk residents. Need to be sure there is a “command center” where residents can go for shelter if necessary.	4/2/2021 10:52 AM
11	The tree damage.	4/1/2021 9:19 PM

Q7 Are there areas of Peru that you believe are most at risk from any of the above hazards? If so, please provide additional information below.

Answered: 17 Skipped: 25

#	RESPONSES	DATE
1	yes	5/8/2021 4:20 PM
2	Low line areas	5/8/2021 9:10 AM
3	Can't answer the question because I don't drive around town looking for hazardous conditions.	5/5/2021 10:17 PM
4	The tower looses power that is used for communication all over the state and cell phones. Flooding by 29 north rd Baumann rd flooding	5/5/2021 6:53 PM
5	Loss of power throughout entire town due to severe wind storms and ice storms. Contamination of wells due to excessive use of salt on the roads throughout the winter.	5/5/2021 1:18 PM
6	Yes end road Marlow drive	5/3/2021 2:15 PM
7	Yes, loss of power. We lost power a lot last year (5-6 times) for a significant amount of time.	5/2/2021 8:53 PM
8	Pretty much the entire town. East Windsor Rd, and Curtain Rd. come too mind having issues.	5/2/2021 9:07 AM
9	Tree damage, forest and yard flooding.	5/1/2021 3:36 PM
10	Andes Rd., Spruce Dr., Curtin Rd., other dirt rds.	5/1/2021 11:35 AM
11	All are at risk	5/1/2021 11:34 AM
12	no	4/20/2021 3:49 PM
13	Low lying areas and areas near rivers or lakes	4/9/2021 4:54 PM
14	East Windsor Rd.	4/2/2021 7:15 PM
15	Non enforcement of board of health issues such as non conforming wells/septic that potentially can contaminate other properties.	4/2/2021 10:52 AM
16	Areas between Rte 143 and East Windsor Road where storm water drainage is inadequate, mis-directed or uses ineffective management techniques to efficiently enable it to flow to wetland areas of East Windsor Road.	4/1/2021 8:16 PM
17	Some of the unpaved roads	4/1/2021 8:12 PM

Q8 Has your well ever run dry? Or do you know of wells in your area running dry? If so, in the box below please provide information on when and for how long this occurred?

Answered: 32 Skipped: 10

#	RESPONSES	DATE
1	2 times	5/8/2021 4:20 PM
2	No	5/8/2021 9:10 AM
3	Luckily no	5/5/2021 10:17 PM
4	Not mine but others	5/5/2021 6:53 PM
5	My well has run dry. Can take up to a day to recover.	5/5/2021 1:18 PM
6	No	5/5/2021 12:35 PM
7	No	5/3/2021 2:15 PM
8	August 2020; well ran dry, recovered extremely slowly (had to use bottled water, avoid flushing toilet, limit bathing for a week).	5/3/2021 1:36 PM
9	No	5/3/2021 11:18 AM
10	No, but we replaced our well pump fall 2020 and it running dry was a concern/ potential issue.that	5/2/2021 8:53 PM
11	No	5/2/2021 1:02 PM
12	NO	5/2/2021 9:07 AM
13	Never	5/1/2021 8:25 PM
14	No well problems	5/1/2021 3:36 PM
15	Some have in town. ? 2018 summer drought	5/1/2021 1:34 PM
16	Yes…We have a spring fed well…2019	5/1/2021 1:11 PM
17	NO	5/1/2021 11:35 AM
18	Yes, our well ran dry last year. Well had to be fracked to restore water.	5/1/2021 11:34 AM
19	no	4/20/2021 3:49 PM
20	No. But has been low. I have an artesian. Neighbors have gone dry	4/9/2021 4:54 PM
21	No	4/4/2021 10:19 AM
22	413	4/2/2021 9:56 PM
23	No	4/2/2021 7:15 PM
24	No	4/2/2021 10:52 AM
25	No	4/2/2021 3:25 AM
26	N/A	4/1/2021 9:19 PM
27	Several of our neighbors wells went dry a few years ago	4/1/2021 8:34 PM
28	Water level always low. Hydro fracture about every 5 years.	4/1/2021 8:28 PM
29	Never ran dry.	4/1/2021 8:16 PM
30	No	4/1/2021 8:12 PM
31	no	3/29/2021 11:47 AM
32	No	3/28/2021 4:50 PM

APPENDIX B: PUBLIC PARTICIPATION DOCUMENTATION.

Natural Hazard Mitigation and Climate Adaptation Plan

Town of Peru
June 14, 2021

What is Hazard Mitigation?

- Natural hazards pose a risk to people, property and the environment
- Examples: floods, hurricanes, tornadoes, drought, heat waves
- Identify activities that can be done to mitigate the hazards *before* they occur
- Mitigation: *pro-active*, rather than reactive; action taken to solve a problem on a *permanent, long-term basis*
- Mitigation Plan a requirement for eligibility for some FEMA funds

What Risks Are We Evaluating?

11 Main Hazards Evaluated 3 Top Hazards Identified
Severe Winter Events (Ice Storm, Blizzard, Nor'easter)
Flooding (Dam Failure, Ice Jam, Beaver Activity)
Hurricane & Tropical Storm
High Wind & Thunderstorm
Drought
Invasive Species / Pests
Wildfire
Annual & Extreme Temperature Changes
Landslide, Tornado, Earthquake
Cyber Attacks

Ice Storm Dec. 2008

- Loss of electricity for 1+ million customers; some for more than 2 weeks
- In Peru: 4 days of non-stop chainsaws; a week to clear all roads; weeks for full cleanup
- FEMA obligates >$32 million in Mass.
  - State costs >$7 million
  - Municipal costs >$5 million
  - National Grid claims damages of >$30 million
  - Small businesses without electricity "lose tens of millions of dollars"

T.S. Irene 2011

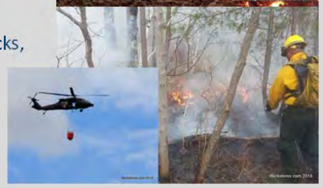
- 3"-9" in 12-hour period + high winds
- 500,000+ MA residents w/out electricity
- In Peru: damages to Hickingbotham & Middlefield Roads; flooding of Smith, Beauman, Marlow
- Dubbed the "costliest Category 1 storm" ($15.8 billion in damages in U.S.)
- $35 million in damages in Berk. Co.; $23 million alone for Mohawk Trail
- Permanent loss of The Spruces, Wmstn.

Don't take Water for Granted

- Warmer temps. = drought cycles due to more evaporation rates
- Less groundwater recharge
- Downpours = more runoff = less base flow and groundwater recharge
- Berkshires got off lightly 2016-17

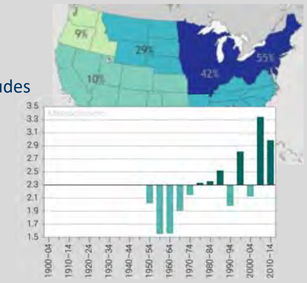
Berkshire County Forest Fires

- Clarksburg, April 2015 – record for county – 272 acres
- Clarksburg, May 2021 – new record – 950+ acres
- Bad News: sites inaccessible to trucks, tankers; helicopters win the battles
- Good News: no buildings nearby
- Experience gained



Observed Number of Extreme Precipitation Events

- 55% increase 1958-2016 in heavy rain/snow events – more downpours
- 55% increase in heavy precipitation includes 9-year drought
- 30% increase in precipitation events >2” in 1 day (see right)
- >2”/day = flooding, especially if rain on snow/frozen ground



https://statesummaries.ncics.org/ma

Winter Weather Changes

Cycles of cold and warm will increase, alter risks

- **More rain-on-snow events** = Increased runoff, risk of winter floods and ice jams
- **More Ice Storms** = 2008: >1 million w/out power; several smaller ice events in recent years
- **Less snowpack** = less groundwater recharge
- **Loss of snow insulation** = risk of freeze/thaw = increased risk of frozen pipes, drains
- **Dryer spring soils** = more fire risk

Will Climate Change Effect Hazards and Human Health?

Already we see altered weather patterns:

- More frequent and more intense precipitation; damages and repairs more costly
- Longer growing season, more airborne allergens
- More heat waves (>90°F); more in spring and fall
- Warmer winters with heavier snow and more ice
- Higher survival rates for pests (ticks, mosquitos, forest pests)
- Increased risk for algae blooms on lakes/ponds (recent ex. = Stockbridge, Pittsfield)

Are you ready for power outages?

Observed: household summer peak demand up 3-fold from 1960-2000

The energy sector‘s 3 major climate change concerns:

- Flooding (increased downpours, flooding in low lying areas)
- Extreme events (hurricanes, snow, ice);
- Increased temperature (AC demand surge, heat damage to distribution system, controlled brownouts)

Are you prepared to open warming or cooling shelters?

Public Survey Results

- 41 surveys completed – **and it’s still open!**
- Respondents from across Town
- Hazard cited most often: Ice Storm 2008 (46% directly list it)
- Hurricane Irene 2011 second most listed event
- Road washouts
- Tree damages

Public Survey Results

Rankings: what natural hazards concern residents the most

1. Severe winter weather
2. Others (hurricanes, high winds, thunderstorms)
3. Flooding or washout of roads

Rankings: why residents are concerned about hazards

1. Loss of electricity - #1 by a large margin
2. Injury or loss of life
3. Being isolated (washed out roads or communication)

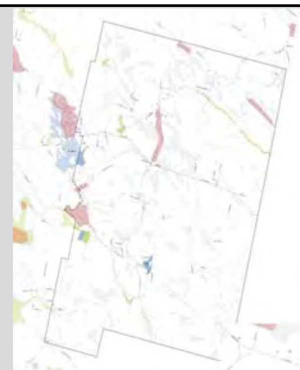
Flooding

Good News: 0 homes in 100-year floodplain; few road miles in FP

Bad News: main connector roads at risk

Flooding of key connectors

- Hickingbotham Road – rain, dam releases
- Middlefield Road – rain, beavers
- North Road – rain
- East Windsor Road – rain



Natural Hazards Themes

Flooding of roads

- Need to up-size some culverts, but high cost is barrier
- Timing and coordination: Lake Ashmere dam water releases in fall
- Resident concerns about washouts and isolation

Widespread tree damage: from storms, emerald ash borer

Emergency Preparedness

- Concern for loss of electricity and communications

Main Recommended Actions

Pursue road improvements with flooding in mind:

- Advocate for upsizing of box culvert on Middlefield Rd.
- Continue culvert improvements along North Road; pursue grant options to cover costs
- Continue beaver control measures and funding options

Mitigation Example: Dingle Rd., Worthington

Double box culvert washed out 2003
New crossing survived T.S. Irene 2011

Mitigation Example: Benton Hill Rd., Becket

3 culvert bridge replacements in 7 years

New full span bridge reduces risk of repeated failures

Major Recommended Actions

- Continue tree trimming/removal of roadside trees
- Look for updates to FEMA floodplain maps
- Consider a town-wide emergency notification system

  Towns with systems: Middlefield, Hinsdale, Dalton, Cummington, Clarksburg, Monterey, New Marlborough

- Remain active in the Central REPC to take advantage of regional preparedness trainings, exercises and services

Now it's Your Turn!

Help town officials, first responders and fellow residents prioritize the most important actions

Seeking Public Comments

- **Fill out the survey if you haven't done so - through June 25th at https://www.surveymonkey.com/r/PeruHM**
- **Provide comments about tonight's presentation**
- **Review / comment on the Draft Hazard Mitigation and Climate Adaptation Plan when it's posted June 30 – July 20, 2021**
- **Send comments to: lauren@berkshireplanning.org or to any of your Selectmen**