PUBLIC REVIEW DRAFT

Town of Buckland Hazard Mitigation Plan

Adopted by the Buckland Select Board on
XX, XX

Prepared by

Buckland Hazard Mitigation Committee

and

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Acknowledgements

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

Heather Butler, Buckland Town Administrator
Steven Daby, Buckland Highway Department
Barry DelCastilho, Buckland Select Board
Andrea Donlon, Buckland Planning Board
Terry Estes, Buckland Board of Health
Marti Ferguson, Buckland Board of Health
Dan Fleuriel, Superintendent, Shelburne Falls Wastewater Facility
Herb Guyette, Buckland Emergency Management Director and Buckland Fire Chief
Thomas H. Heinig, Buckland Conservation Commission
James T. Hicks, Buckland Chief of Police
Rebekah McDermott, Shelburne Falls Fire District Water Superintendent
Michael D. Norach, Buckland Energy Committee
Margaret Olin, Buckland Energy Committee
Brian Summer, Buckland Energy Committee

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Cover Photo: Conway Street Flooding During Tropical Storm Irene, 2011. Photo courtesy of *The Recorder.*

Contents

1 PLANNING PROCESS

1.1 INTRODUCTION

The Federal Emergency Management Agency (FEMA) and the Massachusetts Emergency Management Agency (MEMA) define Hazard Mitigation as any sustained action taken to reduce or eliminate long- term risk to people and property from natural hazards such as flooding, storms, high winds, hurricanes, wildfires, earthquakes, etc. Mitigation efforts undertaken by communities will help to minimize damages to buildings and infrastructure, such as water supplies, sewers, and utility transmission lines, as well as natural, cultural and historic resources.

Planning efforts, like the one undertaken by the Town of Buckland, make mitigation a proactive process. Pre-disaster planning emphasizes actions that can be taken before a natural disaster occurs. Future property damage and loss of life can be reduced or prevented by a mitigation program that addresses the unique geography, demography, economy, and land use of a community within the context of each of the specific potential natural hazards that may threaten a community.

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

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

1.2 HAZARD MITIGATION COMMITTEE

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

- Heather Butler, Buckland Town Administrator
- Steven Daby, Buckland Highway Department
- Barry DelCastilho, Buckland Select Board

- Andrea Donlon, Buckland Planning Board
- Terry Estes, Buckland Board of Health
- Marti Ferguson, Buckland Board of Health
- Dan Fleuriel, Superintendent, Shelburne Falls Wastewater Facility
- Herb Guyette, Buckland Emergency Management Director and Buckland Fire Chief
- Thomas H. Heinig, Buckland Conservation Commission
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- Michael D. Norach, Buckland Energy Committee
- Margaret Olin, Buckland Energy Committee
- Brian Summer, Buckland Energy Committee

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

- Hosting a Community Resilience Building workshop with local and regional stakeholders who identified Buckland's key natural and man-made hazard vulnerabilities and strengths and proposed actions to build infrastructural, social, and environmental resilience to climate change.
- Reviewing and incorporating existing plans and other information including changes in development in the years since the Town's previous Hazard Mitigation planning process.
- Updating the natural hazards that may impact the community from the previous plan.
- Conducting a Vulnerability/Risk Assessment to identify the infrastructure and populations at the highest risk for being damaged by the identified natural hazards, particularly flooding.
- Identifying and assessing the policies, programs, and regulations the community is currently implementing to protect against future disaster damages.
- Identifying deficiencies in the current Hazard Mitigation strategies and establishing goals for updating, revising or adopting new strategies.
- Adopting and implementing the final updated Hazard Mitigation Plan.

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

Meetings

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

Law and were open to the public.

March 28, 2018
Held a Community Resilience Building workshop as part of Buckland's Municipal Vulnerability Preparedness (MVP) designation process. The objectives of the workshop were to:

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

July 9, 2019
Work group meeting included hazard mitigation planning overview, overview of hazards and climate change stressors, and completion of the risk assessment by discussing Buckland's risk to each hazard based on the location, extent, probability, and severity. Review of the draft Critical Facilities and Infrastructure map.

August 12, 2019
Work group reviewed the first draft of Section 2: Local Profile and Planning Context, and the first draft of Section 3: Hazard Identification and Risk Assessment and the results of the risk analysis completed at the previous meeting.

October 9, 2019
Work group reviewed second drafts of Section 2: Local Profile and Planning Context and Section 3: Hazard Identification and Risk Assessment.

December 18, 2019
Work group reviewed the first draft of the Hazard Mitigation Action Plan.

January 28, 2020
Work group reviewed the second draft of the Hazard Mitigation Action Plan and planned for the public forum and public review period.

February 13, 2020
Buckland Town Administrator and FRCOG Senior Planner met to finalize the Action Plan and forum date.

April 7, 2020

A public forum was held to present the plan and solicit feedback on priority action items. Comments were incorporated into the final plan.

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

1.3 PARTICIPATION BY STAKEHOLDERS

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

Local and Regional Agencies Involved in Hazard Mitigation Activities

In the Spring of 2018, Buckland held a Community Resiliency Building workshop as part of the Massachusett's Municipal Vulnerability Preparedness (MVP) designation program. The workshop was critical to enabling participants to think about and engage across different sectors. Members of the Board of Selectmen, Highway, Fire, and Police Departments, water and wastewater districts, the Emergency Management Director, and Great River Hydro, all came together to determine the most threatening hazards to the Town of Buckland and to agree upon high priorities and actions to address them. The results of the workshop are documented in the Town of Buckland's *MVP Resiliency Plan*, and were integrated into this Hazard Mitigation Plan update process. The Franklin Regional Council of Governments (FRCOG), the regional planning agency for Buckland and all 26 towns in Franklin County, facilitated the workshop.

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

- Developing the Sustainable Franklin County Plan, which advocates for sustainable land use throughout the region and consideration of the impact of flooding and other natural hazards on development.
- Developing and implementing the Franklin County Comprehensive Economic Development Strategy, which includes goals and strategies to build the region's economic resilience.

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

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

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

Agencies that Have the Authority to Regulate Development

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

Participation by the Public, Businesses, and Neighboring Communities

The plan update and public meetings were advertised on the Town website, and were posted at the Town Hall and at other designated public notice buildings. A copy of the draft plan was available to the public at the Town Hall and on the Town website at https://www.town.buckland.ma.us/. A public forum was held on April 7, 2020, and provided an opportunity for the public and other stakeholders to provide input on the mitigation strategies and to prioritize action items. Invitations were sent to Town boards, committees, and departments, and to all neighboring communities, inviting them to the public forum and to review the plan and provide comments. The public forum and subsequent comment period was advertised via a press release in the Greenfield Recorder and on the Town website. The final public Comment Period was held from **[date]** through **[date].** (See Appendix A, Public Participation Process, for copies of all press releases and stakeholder letters mailed to solicit comments on the draft Plan). Comments were reviewed by the Committee and incorporated into the final plan as appropriate.

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

- 2010 Buckland Open Space and Recreation Plan
- 2018 Town of Buckland MVP Resiliency Plan
- 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan
- 2018 High Risk Stream Crossings in Buckland, MA: A Resource for Assessing Risk and Improving Resiliency
- Resilient MA Climate Change Clearinghouse for the Commonwealth
- Additional data sources cited in footnotes throughout this Plan

2 Local Profile and Planning Context

2.1 COMMUNITY SETTING

Buckland is situated along the Deerfield River in the western central part of Franklin County. As with many other Franklin County towns, the proximity of the river played a major role in the development of the town. Buckland is strongly linked with the neighboring Town of Shelburne through the shared village of Shelburne Falls, which straddles the river between the two towns.

Shelburne Falls was once known as 'Salmon Falls' and was an important Native American fishing ground prior to European settlement of the area in the mid-1700s. The falls were an attraction to the Native Americans and early inhabitants as a supply of fresh salmon. The 64-foot falls prevented the fish from traveling further upstream. The falls later provided an excellent power source, allowing the village to develop into a major manufacturing center during the mid-1800s. While most settlers established farms in the outlying regions of Buckland and Shelburne, Shelburne Falls continued to be the site of the most productive salmon fishing in Massachusetts until the early 1800s.

Conflicts with Native Americans caused the town to be sporadically settled until around 1769. The town was incorporated in 1779. During the Federal period, there was an increase in use of the river for sawmills and gristmills, but farming remained dominant. In the early industrial period, the town saw a dramatic increase in manufacturing, especially with the expansion and success of the Lamson & Goodnow Company. Most industrial building was done on the Buckland side of the river, as the Shelburne side was nearly built out by the time that major industry began to spring up. The location of the railroad on the Buckland side of the river was also a factor in the location of industry.

The Great Depression and rise of the automobile are seen as factors in the decline in industry in Shelburne Falls and the subsequent decline in the growth and development of the adjacent residential village. Overall, the loss of manufacturing jobs in the region led to a drop in population and stagnation in the development of the village. In 2015, Lamson and Goodnow sold its buildings in Buckland and moved its manufacturing business to Westfield. Also in 2015, Mayhew Steel closed its Buckland manufacturing business to consolidate operations in Turners Falls. While manufacturing jobs have declined, in recent years the town has attracted artists, craftspeople, and tourism (see Current Development Trends on the next page).

Population Characteristics

According to the 2010 U.S. Census, there are 1,902 residents in Buckland (a 4% decrease since 2000). As of 2017, Buckland's total population is estimated to be 1,927 (a 1% increase since 2010).[1]

Environmental Justice Populations

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

- Block group whose annual median household income is equal to or less than 65 percent of the statewide median ($62,072 in 2010); or
- 25% or more of the residents identifying as minority; or
- 25% or more of households having no one over the age of 14 who speaks English only or very well - Limited English Proficiency (LEP)

According to these criteria, the Town of Buckland does not currently have any environmental justice populations based on race, income, or language proficiency. Approximately 93% of the Town's population is White, while the next largest racial group is Asian at 4% of the total population. While household incomes do not meet the definition for environmental justice populations, the annual median household income in Buckland ($50,899) is low compared to the county ($57,307) and State ($74,167) median household incomes in 2017. According to the latest U.S. Census's American Community Survey, there are no households that have Limited English Proficiency (LEP).

Current Development Trends

Buckland is about 19.75 square miles and is approximately 81 percent forested, according to 2005 Franklin County land use data. Preservation of farmland and the rural nature of the town are very important to Buckland's residents. According to the 2010 Buckland Open Space and Recreation Plan Survey, residents rated the loss of farmland and the loss of open space as the top threats to the rural character of their town. According to the same survey, the residents also rated lack of economic growth as one of the top four threats to the Town's sense of community.

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

A total of 51 building permits were issued in Buckland for new housing units between 2000 and 2019. The number of permits issued per year has fluctuated from a low of zero (2013, 2015, 2017, 2018) to a high of 10 in 2004 and 2005. Overall, building permit activity has declined since 2008, reflecting the economic recession and slowdown in the housing market nationwide during the late 2000s and early 2010s. Roughly half of the new units created in the last 15 years were located within the village of Shelburne Falls (on the Buckland side) or just outside of the village. The other half were spread out along existing roads in town. While many of the permits are for new single family homes, nine building permits were issued to convert an existing building into a housing unit, either by converting a single family home to a two family home (four permits), adding an apartment to a garage or barn (three permits), or converting commercial space to apartments (two permits). Almost all of these conversions took place in the village, showing a trend for housing infill through the creative modification of the existing building stock.[2]

With the loss of the Lamson and Goodnow manufacturing businesses in 2015, ownership of the mill buildings in the village has changed. The new owner has converted some of the buildings into workspace for small businesses, craftspeople, and artists. The former Mayhew Steel site is now owned by the Town and is used as the Town Highway Garage.

The Town of Buckland has cable television and broadband service provided by Comcast. In 2018, a project through the Massachusetts Broadband Extension Project was completed that extended access to Comcast service to at least 96% percent of the households in the town. Previous to this project, Buckland was consider an underserved community in terms of broadband access. In addition to Comcast, the MassBroadband 123 middle-mile fiber network travels through the Town of Buckland, with connections at seven Community Anchor Institutions, such as at libraries, and public safety locations. The buildout of broadband service in Buckland and the region may have implications for future development, as more people will have the ability to work from home in rural areas of Buckland.

The Town of Buckland has a Floodplain Overlay District. The underlying permitted uses are allowed, however, as long as they meet the requirements of the Section VII of the Zoning Bylaws as well as those of the Massachusetts State Building Code. See the Appendix of this document for wording of the Bylaws. Some changes to the Floodplain Overlay District Bylaws recommended in 2005 have not yet been acted upon. They include limiting new development within the 100-year floodplain and adding flood prevention and protecting the integrity of the Floodplain as stated purposes of the Floodplain Overlay District.

[2] Building permit information excerpted from the *2016 Buckland Housing Plan*.

Some of the recent change in use at the Lamson and Goodnow factory buildings is located in the 100-year floodplain. However, these buildings have been in use for manufacturing for over a century, so this change is not necessarily increasing the community's vulnerability to flooding, but altering who is at risk. The new use of the buildings for small businesses and artist spaces places these businesses more at risk, as opposed to the cutlery business that had operated out of the structures for decades.

The lack of digital floodplain maps limits the analysis that can be done to determine an increase or decrease in vulnerability from recent development. FRCOG staff reviewed 2019 aerial photography and 2016 MassGIS Land Use/Land Cover data relative to the 100-year floodplain. The number of acres of floodplain and the number of structures are the same as for the 2005 Land Use data, although direct comparisons between the two data sets cannot be made due to differences in mapping methods.

National Flood Insurance Program Status

Buckland is a participating member of the National Flood Insurance Program. Currently there are 13 flood insurance policies in effect in Buckland, for a total insurance value of $2,657,600. Since 1978, eight losses have been paid in Buckland, for a total of $248,502. The town does not have any repetitive loss properties. Buckland's floodplain map is from 1980.[3] In 2018, the Federal Emergency Management Agency (FEMA) initiated a 5-year process to update the floodplain maps for Franklin County towns.

Roads and Highways

Running parallel to Clesson Brook is the Town of Buckland's principal roadway, Ashfield Road, also known as Route 112. This is a north-south byway linking Buckland with Ashfield and Franklin County to the south. To the south, Route 112 extends to Goshen and connects the town to Route 9, another primary east-west corridor, with connections to Northampton and Interstate 91, the major north-south highway. To the north, this roadway provides a northern corridor through Colrain to Vermont. Along the northeastern corner of town, Route 2 provides a major east-west highway, which intersects in Greenfield with Interstate 91, the primary north-south route for western Massachusetts.

About five miles (10 percent) of Buckland's roads are gravel. The town has a total of forty-nine

[3] National Flood Insurance Program (NFIP) Statistics as of December 18, 2018.

miles of roads.[4] Gravel roads throughout the Town were identified as an area of concern in the 2018 Buckland Municipal Vulnerability Preparedness (MVP) Plan because they are especially vulnerable to washouts caused by flooding and severe storm hazards described by the report. Similarly, culverts and bridges are an area of concern because of their distinct vulnerability to these hazards and the crippling impact on the town when roads and bridges become impassable due to damage from storms. After the extensive damage caused from Tropical Storm Irene in 2011, many culverts were repaired or replaced in Buckland. However, according to the MVP Plan, culverts on South Street, Nilman Road, Pine and Birch Streets, Elm Street and Charlemont Road, and the bridge on Apple Valley Road, are areas that remain at risk or in disrepair.

Buckland residents living on Apple Valley Road are confined to one mode of egress and are vulnerable if the bridge on the road were to fail or be washed out. The Town successfully applied for funding through the Massachusetts Small Bridge Program to replace the bridge. The project is due to be complete in 2020. In addition, culverts on South Street are being replaced as part of a larger infrastructure project in this area funded through the Federal Transportation Improvement Program.

Rail

Freight rail service in Buckland is owned by Pan Am Southern. The MVP report details the rails as a concern for the Town in several locations, especially in parts of town where they are less than 200 feet from homes and other structures, and where a hazardous spill triggered by a derailment would be especially harmful. These locations include the new highway garage, the Buckland Recreation Area, several railroad crossings, including the Elm Street crossing near the Elm Street neighborhood where residents lack evacuation options. Railroad ties stacked along the tracks in Buckland pose a serious fire hazard. Sparks from passing trains periodically cause brush fires along the tracks, and could ignite the ties. In June 2017, multiple fire departments in the county responded to a fire in Northfield where an estimate 1,500 ties were ignited next to the railroad tracks.[5]

Public Transportation

The Franklin Regional Transit Authority (FRTA) schedules a regular bus route with four busses a day, Monday through Friday, between Greenfield, Shelburne Falls, Buckland, and Charlemont.

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[4] 2017 MassDOT Road Inventory File.
[5] "Multiple towns respond to fire on railroad ties in Northfield." The Recorder newspaper, June 13, 2017.

However, stops in Buckland are limited to three stops at Mohawk Trail Regional School. Otherwise, residents of Buckland can access the bus at the Charlemont Park and ride on Route 2, or at the Arms Library on the Shelburne side of Shelburne Falls. FRTA also provides on-demand transportation for the elderly and people with disabilities with scheduling done through the Shelburne Falls Senior Center.

Public Drinking Water Supply

The Shelburne Falls Fire District was established in 1912, and provides water supply to approximately 2,200 persons within the village of Shelburne Falls, on both the Buckland and Shelburne side. The District has two active wells, and an emergency supply in the Fox Brook Reservoir. The wells are located between 120 and 165 feet from the banks of the North River in the Town of Colrain. The well field flooded during Tropical Storm Irene in 2011, and the District lost power for 3 days. The Fire District received a Hazard Mitigation grant in 2013 to move the electrical controls to a new building out of the flood plain. The project was completed in 2018.

Farmland on the west side of the North River is protected through the Agricultural Preservation Restriction Program. Fox Brook Reservoir has a surface area of approximately 3 acres and a total storage capacity of 12 million gallons. In 2009, the Fire District served the residents, commercial businesses, and industries with 61.7 million gallons of drinking water, with an average annual daily withdrawal of 169,088 gallons. The registered withdrawal for the system is 310,000 gallons per day. Approximately half of the water consumed in 2009 was by Buckland residents and businesses and half by Shelburne's. The Shelburne Falls Fire District has a delineated Zone II Recharge Area and received a Source Water Assessment and Protection (SWAP) Report from the DEP in 2003.

Drinking Water supplied by the District crosses the Deerfield River in a conduit on the Bridge of Flowers. Flood waters from Hurricane Irene in 2011 reached the deck of the Bridge of Flowers, damaging the bridge. Though the water main remained intact, damage from a flood event could cut off water service to the village where residents do not have private wells. Infrastructural repairs and reinforcement may be needed for the Bridge. Possible temporary or permanent backup connections could also be explored for the Iron Bridge or the Route 2 Bridge. A Cost/Benefit Analysis is needed to better understand backup water supply options.

The Fox Brook Reservoir in Colrain serves as an emergency back-up water supply, and there are also two 500,000 gallon water tanks that store approximately 6 days of back-up supply. The District also has a backup propane generator allowing it to pump 130,000 gallons/day for up to one week. The 2010 Buckland Open Space and Recreation Plan recommends that the towns of

Buckland and Shelburne work to identify any aquifers and potential water supply sources within their own town boundaries to ensure protection of the local water supply. The Fire District is exploring locating a water source on the Buckland side of the Deerfield River, which would provide additional resiliency for Buckland in the event that the water main over the Bridge of Flowers is compromised.

Residents living outside of the village of Shelburne Falls rely on private wells for drinking water. When power outages occur, these residents may lose access to drinking water. During prolonged power outages, the Buckland Fire Station serves as a location for residents to fill containers to use for drinking water. During times of drought, some wells may dry up, necessitating the drilling of a new well.

Sewer Service

Sewage disposal in Buckland is primarily by private systems, except for the buildings and homes in a small part of town known as the "Shelburne Falls" district of Buckland. These homes and businesses utilize the Shelburne Falls Waste Water Facility, a shared sewage treatment facility that also covers part of Shelburne. The effectiveness of the private systems is variable and depends on topography, water table, and soils. Dependence on private sewage disposal requires that housing be restricted to soils and slopes that can reasonably be expected to handle on-site sewage systems. Soil types are critical for determining this capacity, and many soils in Buckland are wet, are shallow to bedrock, or are coarse and stony which provide very little filtration to septic leachate since water passes through coarse soils very quickly. While not precluding development in Buckland, the density and total amount of new development in the near future will in large part be determined by the soils and their ability to pass percolation tests.

The Shelburne Falls Wastewater District provides municipal sewage treatment to the village of Shelburne Falls. The plant has a total design capacity to treat .25 million gallons of wastewater per day, and currently treats roughly .17 million gallons per day (approximately 70 percent of design capacity over a five year period from 2014-2018). The district is focusing its efforts on reducing inflow and infiltration to lower the number of gallons of groundwater and stormwater treated by the plant. Groundwater infiltrates through cracks in the pipes, adding significantly to the amount of fluids the plant must treat. The amount of flow processed by the treatment plant annually is directly proportional to the amount of precipitation (snow and rain) in a year. For example, in 2017 and 2018, the plant operated at 79% and 97% of design capacity, respectively, due to high amounts of precipitation during those years. In contrast, in 2015 and 2016, the plant operated at 54% and 56% of design capacity, due to average or lower than average precipitation in those years.

The collection system is over 100 years old. The Town of Buckland has applied for and received grants over the last 20 years to replace deteriorating pipes with new piping that will reduce the amount of infiltration into the system. In addition to I&I from groundwater, the system receives additional flow from residential sump pumps and roof drains. The Wastewater District is working to disconnect these sources from the collection system, but would like to do more outreach to residents and potentially establish a funding source to help residents disconnect. According to the Superintendent, the treatment plant and pump station are situated in a way that protects them from riverine flooding. The facilities, however, are vulnerable to a Harriman Dam failure.

The flooding hazards facing the Town's drinking water also threaten wastewater infrastructure from the Shelburne Falls district of Buckland. A sewer line from homes and businesses on the Shelburne side of the river crosses the Deerfield River on the Iron Bridge. A hazard event that damages the Iron Bridge and sewer main could cut off sewer service to this part of the Town, and the damaged sewer line could potentially contaminate flood waters. The pumping station on the Shelburne side of the river has a shut-off valve to keep sewage from flowing into the river. The pump station is also served by a back-up diesel generator.

Schools

Schools in Buckland include Buckland-Shelburne Elementary School located on the Shelburne side of Shelburne Falls, and the Mohawk Trail Regional School located in Buckland.

Emergency Shelters and Critical Facilities

The Mohawk Trail Regional School on Route 112 in Buckland serves as a regional emergency shelter. Participants at the 2018 MVP planning workshop raised concerns about low-income residents who live in the downtown area of Buckland having limited options for sheltering, should they have to evacuate their homes. There is no shelter in the downtown area of Buckland. The regional shelter is about 2/10 of a mile from the potentially hazardous rail line and is within the Harriman Dam inundation area. Participants at the workshop discussed the possibility of the Mary Lyon Church, which is not located near any known hazards, serving as a shelter; however, there are some modifications that would need to be made to the church facilities, including purchasing and installing a generator and installing ADA accessible bathrooms.

It is important for communities to determine which areas or specific populations in their community may need special attention in times of an emergency. In addition to the infrastructure previously described, these critical facilities are identified on the 2020 Critical Facilities and Infrastructure Map.

A community's critical facilities include important municipal structures (i.e., town hall), emergency service structures (i.e., municipal public safety complex, shelters, and medical centers), and locations of populations that may need special assistance (i.e., nursing homes, day cares, schools, prisons) and major employers or other areas where there is a dense concentration of people. The following facilities in Buckland were identified by the Hazard Mitigation Planning Committee as either public venues, special institutions, critical infrastructure, or shelters:

- Buckland Town Hall
- Mohawk Trail Regional School
- Buckland Police Station
- Upper Buckland Fire Station
- Shelburne Falls Fire District Station
- Highway Department Town Garage
- Wastewater Treatment Plant
- Buckland Public Library
- Buckland Recreation Center

Natural Resources

The town is situated in the Berkshire Hills. According to 2005 land use data, approximately 7.8 percent of the town is agricultural land - down from 9.2 percent in 1999. This agricultural land is mostly located along the Clesson Brook Valley and in the Deerfield River floodplain. The land is rugged, with high upland hills and steep slopes and is predominantly forested. The prime farmland soils of the town have contributed to its economy throughout its history.

Buckland is located in the Northern Hardwoods Region (USDA, 1992). This forest type commonly occurs up to an elevation of 2,500 ft. above sea level and prefers fertile, loamy soils and good moisture conditions. In New England, the Northern Hardwoods can be found in Massachusetts in the glacial till soils west of the Connecticut River and in small portions of Maine and Connecticut, as well as most of the forested areas in New Hampshire and Vermont. The predominant species of the Northern Hardwoods are American beech (Fagus grandifolia), yellow birch (Betula alleghaniensis) and sugar maple (Acer saccharum). Associated species include red maple (Acer rubrum), white ash (Fraxinus americana), eastern hemlock (Tsuga canadensis), paper birch (Betula papyrifera), quaking and big tooth aspen (Populus tremuloides and P. grandidentata), eastern white pine (Pinus strobus), red spruce (Picea rubens) and red oak (Quercus rubra).

Buckland contains areas in the eastern part of Town identified by the Harvard Forest as forested in the 1830s that may not ever have been tilled, placing them in a category of Primary Forest with greater biodiversity value than forest with soils that have been tilled over time. Native biodiversity unique to these areas typically includes soil fauna and flora, microorganisms and plants that produce primarily vegetatively, as well as species of wildflowers not common in other areas. Harvard Forest has GIS maps available showing primary forests by town. (Harvard Forest, 2002, 1830 Map Project).

Large blocks of contiguous forestland such as those in Buckland are important resources for several reasons. Large blocks of forest provide clean water, air, and healthy wildlife populations. They represent an area with a low degree of fragmentation that can support wildlife species that require a certain amount of deep forest cover separate from people's daily activities. Forests help mitigate flooding by slowing and absorbing stormwater, and are critical in mitigating future climate change through sequestering and storing carbon.

Buckland lies in the Deerfield River Watershed, a part of the larger Connecticut River Watershed. Clesson Brook and Clark Brook are important sub-watersheds within the town. Buckland has approximately twelve acres covered by wetlands, which are fed by nearby brooks and rivers. The town also has a fairly substantial amount of open water within its borders (approximately 132 acres). The Connecticut and Deerfield rivers are supportive of recreational use.

Cultural and Historic Resources

The importance of integrating cultural resource and historic property considerations into hazard mitigation planning is demonstrated by disasters that have occurred in recent years, such as the Northridge earthquake in California, Hurricane Katrina in New Orleans, or floods in the Midwest. The effects of a disaster can be extensive—from human casualty to property and crop damage to the disruption of governmental, social, and economic activity. Often not measured, however, are the possibly devastating impacts of disasters on historic properties and cultural resources. Historic structures, artwork, monuments, family heirlooms, and historic documents are often irreplaceable, and may be lost forever in a disaster if not considered in the mitigation planning process. The loss of these resources is all the more painful and ironic considering how often residents rely on their presence after a disaster, to reinforce connections with neighbors and the larger community, and to seek comfort in the aftermath of a disaster.[6]

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

Cultural and historic resources help define the character of a community and reflect its past. These resources may be vulnerable to natural hazards due to their location in a potential hazard area, such as a river corridor, or because of old or unstable structures.

Table 2-1: Significant Structures and Sites within the Buckland Historic District

Name of Feature	Date	Location	MHC Form #
Sash, door, and blind factory	1863	State St., east of split with North St.	156
Shelburne Falls Fire House	1869	#4 and # 6 State Street	157
Shelburne Falls Business District	Late 1860's to early 1900's	Ashfield Street and State Street	31-37 +903
Methodist Episcopal Church (now Buckland Town Hall)	1877	17 State Street	155
Odd Fellows Building	1877	On corner of State and Clement Streets	153
Buckland – Shelburne Iron Bridge	1890	Bridge Street	904
Potter Grain Company	1894	Off of Ashfield Street, west of Shelburne Falls	158
Newell Block	1895	On State St, opposite the Truss Bridge	154
Methodist Episcopal Church	1906	On corner of State and Clement Streets	152
Bridge of Flowers (1929 Flowers added)	1908 Const.	Across Deerfield River, State - Water Streets	903

Source: Compiled from Massachusetts Historical Commission Inventory forms and the Massachusetts Cultural Resource Information System (MACRIS) database.

The Massachusetts Cultural Resource Information System (MACRIS) The Shelburne Falls

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

National Historic District (NHD) encompasses 26 acres in the village center business district spanning both Buckland and Shelburne. The commercial core of the Shelburne Falls NHD, located one-half mile from Route 2, contains many contributing commercial, civic, and religious buildings located primarily to the north and south of Bridge Street in Shelburne and on State Street in Buckland. Within the NHD are the Glacial Potholes located in the Deerfield River, just south of the dam and falls.

Table 2-2: Significant Structures and Sites within the Buckland Historic District

Name of Feature	Date	Location	MHC Form #
No. 2 East Buckland, Cemetery	1804 - 1876	Old County Rd. (abandoned)	801
East Buckland Cemetery	1849 - Present	Buckland Road	802
Upper City Cemetery	1841	Old Apple Valley Road	804
Mary Lyon birth place, bronze plaque on a rock	1887	East Buckland Road	901
Mary Lyon's first school, bronze plaque on quartz boulder	1968	Walker Road	902
Boston and Maine Railroad Trestle	1885	Old Conway Road, approx. 300 meters northwest of Gardner Falls Hydro Facility	905
Gardner Falls Station Power House, Canal and Dam	1904	Gardner Falls Station Road	159, 906, 907
Glacial Pothole	unknown	North Street, near feature # 13	909
Residence	1800	South Street	160
Home of Lois Buell	pre 1800	Off of Old Goodnough Road	151
Salt Box Home	1880	Off of Stone Road	150
F. R. Bray Farm	1820	On West side of Bray Road	148
Residence	1840	Stone Road	149
The Elmer Place	1876	Off of Bray Road, north of Stone Road	147
The Drake Place	1780	On Bray Road 100 yards north of Ashfield	146
The Nilman House	1846	Off of Nilman Road	145
The Johnson House	1896	East Buckland Road	144
The Bellows Place	1810	East Buckland Road	143
Hog Hollow Schoolhouse	1800	Hog Hollow Road	142
Purinton House	1852	Hog Hollow Road	141
Goddard Place (Porter House)	1812	Hog Hollow Road	140
The Hartwell House (Schneider Dog Pound)	not available	Hawley Road	138
The Rood Place	1830	Hawley Road	137
The Cranson Place	1700	Hawley Road	136
The Sanderson Ruddock Place	1800	Dodge Road	135
The Dodge Place	1805	Dodge Road	134

Table 2-2: Significant Structures and Sites within the Buckland Historic District			
Name of Feature	Date	Location	MHC Form #
The Orta Kenney Place	1750	Hawley Road	133
Residence	1780	Hawley Road	132
The Ward Place	1790	Hawley Road	131
High Street School House	1850	Hawley Road	130
Auge Place	1880	Hawley Road	129
Scott House	1830	Hawley Road	127
The Hartwell House	1790	Hawley Road	126
The Lily Place (H. L. Dea. Warfield House)	1830	Martin Road	115
The Wood House	1810	Ashfield Road	121
Hathaway Place	1750	Hawley Road	122
District No. 5 Schoolhouse	1829	Hawley Road, Buckland Four Corners	123
The Kenney Place (Enos Pomeroy House)	1750	Hawley Road	124
Enoch Wells Place	1814	Hawley Road	125
Residence	1871	85 North Street	2
Freighter's Inn	c. 1800	124 North Street	1
Residence	1800	South Street	43
Braehead Farm	1795	88 Elm Street, near intersection of Homestead Avenue	42
Residence, Salt Box	1795	65 Elm Street, near intersection of Laurel Road	41
Residence, Greek Revival	1830	41 Elm Street	40
Residence	1850	Bray Road, just south of Ashfield Street	38
Residence	1815	Elm Street, on corner of Birch Road	39
The Lanfair Estate	1830	26 Walker Road	37
Residence	1850	9 Kendrick Road	36
Residence, Cape	1875	79 Ashfield Street	35
Parsonage for Catholic Church	1870	Monroe Avenue on corner of Ashfield Street	34
Crittenden School	after Dec. 6, 1919	Ashfield Street, near intersection with Franklin Street	33
E. B. Sherwin House	1830	50 - 52 Ashfield Street, on corner of School Street	32
Slattery House	1830	49 School Street	31
Nathaniel Lamson House	1850	39 Green Street	30
The Spencer Woodward House	1790	Rand Road, opposite the high school	52
Patch Farm	1785	Crittenden Hill Road, near intersection with	53

Table 2-2: Significant Structures and Sites within the Buckland Historic District			
Name of Feature	**Date**	**Location**	**MHC Form #**
		Rand Road	
The Luther Dunnell House	1840	Ashfield Road	54
Pine Brook Farm	1809	Ashfield Road, near intersection with Rand Road	55
The Gould Place	1875	Woodward Road, near intersection with Ashfield Road	56
Boehmer's Mill	1810	Ashfield Road and Woodward Road	57
The Lightning Splitter	1900	Ashfield Road, on corner of Depot Road	58
Bert Shaw's House	1830	Depot Road, near corner of Ashfield Rd	59
William Taylor House	Pre - 1800's	Dunbar Road	60
Dunbar House	1776	Dunbar Road	61
Burdick Place	1796	Laurel Road	62
The Otis Field House	1790	Purinton Road	63
The Sweet Place	1890	Laurel Road	64
Residence	1850	Purinton Road (Mowry's)	65
Goodnow Farm	1860	Purinton Road	66
Scott's Dairy	1780	Ashfield Road	67
Cooper's Shop	Pre - 1800	Ashfield Road, opposite Purinton Road	68
The Silas Trowbridge Place	1829	Ashfield Road, opposite Purinton Road	69
Enos Taylor House	Pre - 1800's	Ashfield Road, just north of intersection with Purinton Road	70
The Buckland Post Office	1819	Ashfield Rd, at intersection of Depot Rd	71
Koonchaug Farm	1800	Avery Road	82
Keach Place	pre - 1793	Charlemont Road	81
The Ward Place	1858	Charlemont Road	80
The Manard Place	1812	Charlemont Road	79

Source: Compiled from Massachusetts Historical Commission Inventory forms and the Massachusetts Cultural Resource Information System (MACRIS) database.

The various historic structures and sites within the NHD have been compiled from the Massachusetts Historical Commission (MHC) inventory and the Massachusetts Cultural Resource Information System (MACRIS)[7] database. The table includes the name of the feature, the date of origin, and its location. The tables also include a form number, assigned by the MHC. The form numbers were recorded from the individual MHC historical inventories. MACRIS properties are cited in Table 2-2. Designation on the MACRIS database does not provide any protective measures for the historic resources but designated sites may qualify for

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

federal and state funding if damaged during a natural or manmade hazard.

Buildings of historic and/or cultural interest identified by the Committee as lying in the flood include all the buildings listed in Table 2-1, excluding the Potter Grain Company. Many of the more than 80 buildings and sites listed in Table 2-2 – as well as other buildings and sites not yet identified – may also be located in the floodplain. An Action Item for this plan should include compiling the inventory and mapping all the buildings and sites to make a determination as to which may be at most risk for flooding or other hazards.

The Downtown area of Buckland was recognized as an area of concern in the Town's Municipal Vulnerability Preparedness (MVP) report due to its proximity to the Deerfield River and the flood risk brought on by severe storms or dam failures. These events have the potential to impact human safety, especially elderly and isolated residents living downtown. Buildings and critical infrastructure are also at risk, including the two bridges that cross the Deerfield River and connect Buckland and Shelburne. The Iron Bridge and the Bridge of Flowers both suffered damage from Hurricane Irene in 2011. As a safety protocol, the Iron Bridge was closed until state inspectors could evaluate if there were structural damages. It took several weeks for the bridge to be repaired and reopened, first to pedestrians, and then to vehicle traffic, but with a lower weight limit than prior to the storm. Downtown businesses were flooded, and a quilt shop washed away. Many businesses shut down for several months after the storm.

2.2 IMPACTS OF CLIMATE CHANGE

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

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

Rising Temperatures

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

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

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

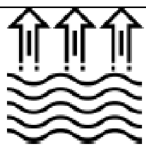
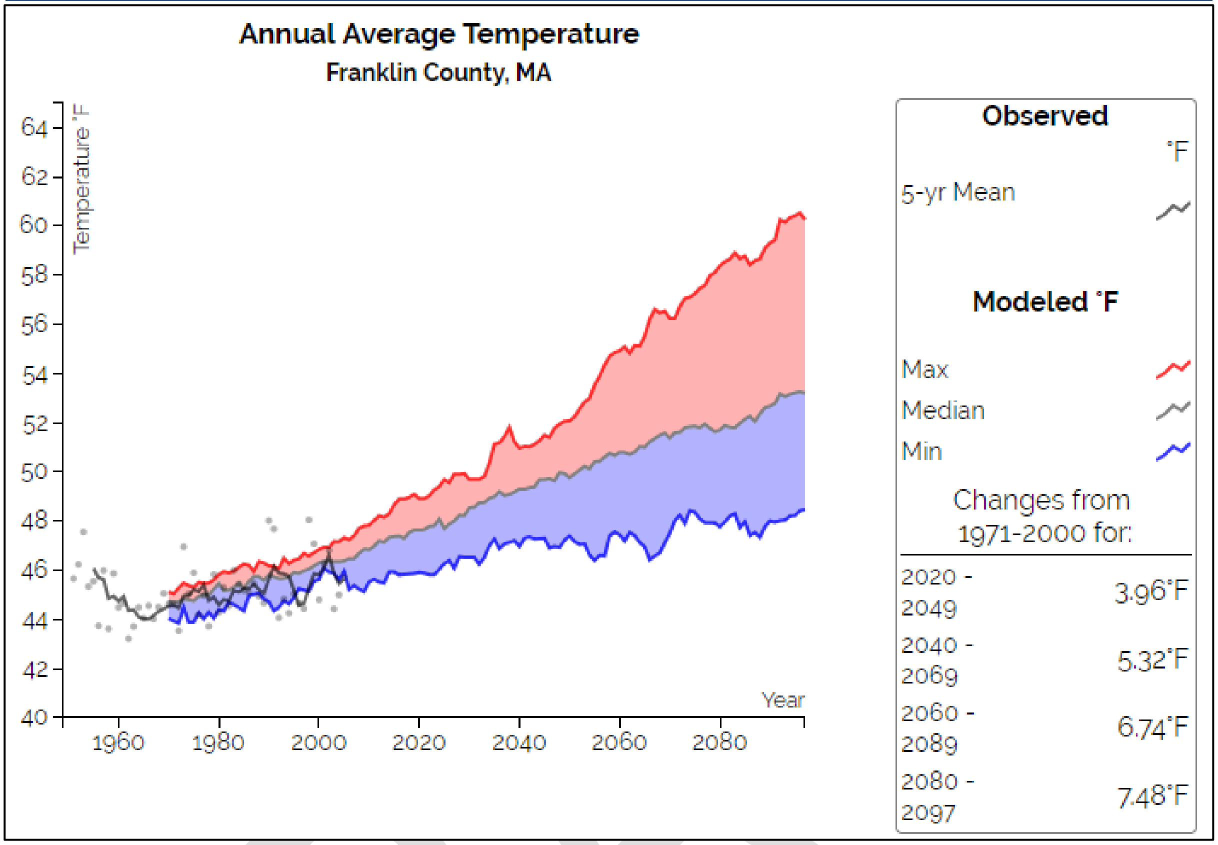
Primary Climate Change Interaction	Natural Hazard	Other Climate Change Interactions	Representative Climate Change Impacts
 Changes in Precipitation	Inland Flooding	Extreme Weather	Flash flooding, urban flooding, drainage system impacts (natural and human-made), lack of groundwater recharge, impacts to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

Figure 2-2: Projected Annual Average Temperature

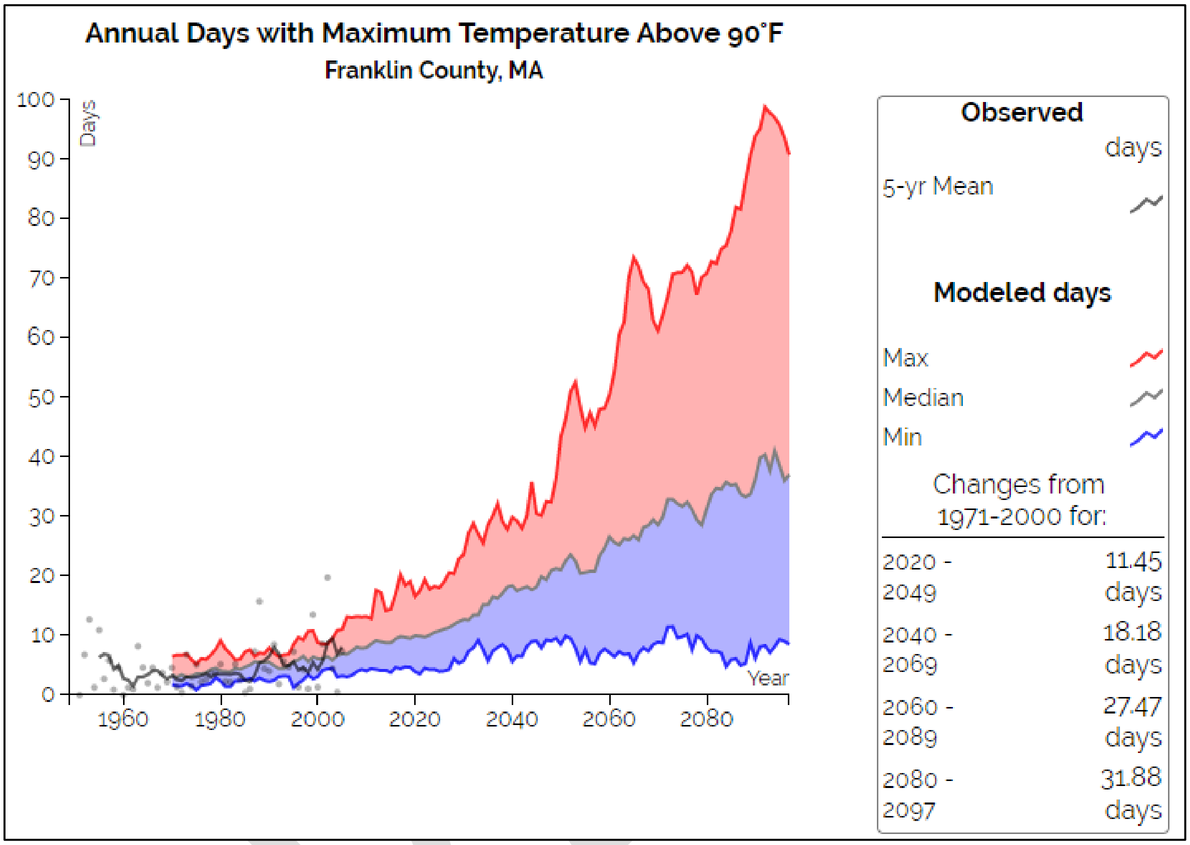


Source: Resilient MA, 2018

Winter temperatures are projected to increase at a greater rate than spring, summer, or fall. Currently Franklin County experiences an average of 169 days per year with a minimum temperature below freezing (32°F). The number of days per year with daily minimum temperatures below freezing is projected to decrease anywhere from 13 to 40 days by the 2050s, and by 15 to as many as 82 days (down to 87 days total) by the 2090s.

Although minimum temperatures are projected to increase at a greater rate than maximum temperatures in all seasons, significant increases in maximum temperatures are anticipated, particularly under a higher GHG emissions scenario. Figure 2-3 displays the projected increase in the number of days per year over 90°F. The number of days per year with daily maximum temperatures over 90°F is projected to increase by 18 days by the 2050s, and by 32 days by the end of the century (for a total of 36 days over 90°F), compared to the average observed range from 1971 to 2000 of 4 days per year. Under a high emissions scenario, however, there could be as many as 100 days with a maximum temperature above 90°F by the end of the century.

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



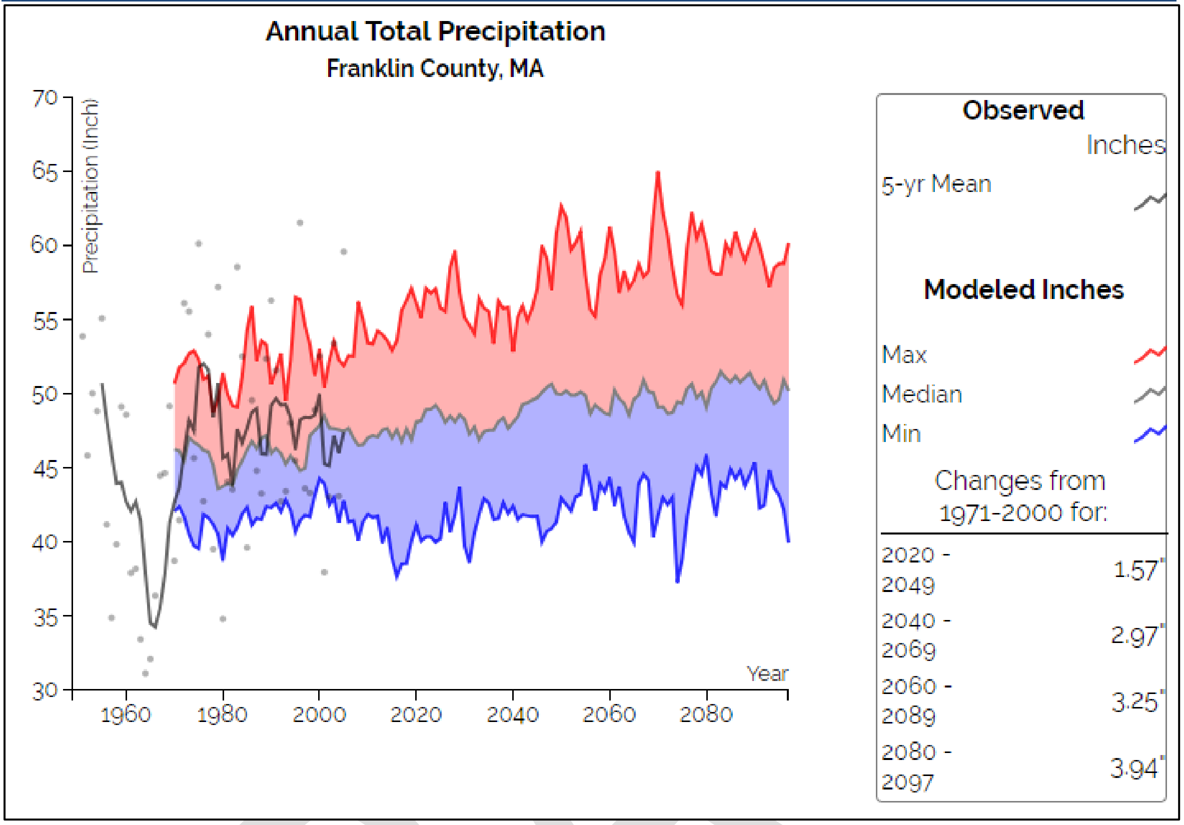
Source: Resilient MA, 2018

Changes in Precipitation

Changes in the amount, frequency, and timing of precipitation—including both rainfall and snowfall—are occurring across the globe as temperatures rise and other climate patterns shift in response. Precipitation is expected to increase over this century in Franklin County. Total annual precipitation is projected to increase by 3 inches by mid-century, and by 4 inches by the end of this century (see Figure 2-4). This will result in up to 52 inches of rain per year, compared to the 1971-2001 average annual precipitation rate of 48 inches per year in Franklin County. Precipitation during winter and spring is expected to increase, while precipitation during summer and fall is expected to decrease over this century. In general precipitation projections are more uncertain than temperature projections.[8]

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

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



Source: Resilient MA, 2018

Extreme Weather

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

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

3 HAZARD IDENTIFICATION AND RISK ASSESSMENT

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

The Hazard Mitigation Committee referred to the *Massachusetts State Hazard Mitigation and Climate Adaptation Plan* (September 2018) as a starting point for determining the relevant hazards in Buckland. The table below illustrates a comparison between the relevant hazards in the State plan and in Buckland's plan.

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

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

Table 3-1: Comparison of Hazards in the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, Buckland Hazard Mitigation Plan, and Buckland MVP Resiliency Plan		
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2018)	**Town of Buckland Relevance**	**MVP Resiliency Plan Top Priority Hazard**
Tsunami	NO	
Average/Extreme Temperatures	YES	
Wildfires	YES	
Invasive Species	YES	
Hurricanes/Tropical Storms	YES	Severe Rain Events
Severe Winter Storm	YES	Severe Snow Events
Tornadoes	YES	
Other Severe Weather	YES	Railroad Derailment / Hazardous Spills
Earthquake	YES	

3.1 NATURAL HAZARD RISK ASSESSMENT METHODOLOGY

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

Hazard Description

The natural hazards identified for Buckland are: flooding, severe winter storms and snow events, hurricanes/tropical storms, severe thunderstorms/wind/microbursts, tornados, dam failure, earthquakes, landslides, average/extreme temperatures, drought, wildfire, and invasive species. Railroad derailments resulting in hazardous spills is a top hazard in Buckland, though it is a Manmade rather than a natural hazard, and will be discussed in more detail in the Manmade Hazard section of the plan. Many of these hazards result in similar impacts to a community. For example, hurricanes, tornados and severe snowstorms may cause wind-related damage.

Location

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

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

Extent

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

Previous Occurrences

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

Probability of Future Events

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

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

Impact

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

Table 3-4: Impacts Rating Scale	
Classification	**Magnitude of Multiple Impacts**
Catastrophic	Multiple deaths and injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of facilities for 30 days or more.
Critical	Multiple injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 week.

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

Vulnerability

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

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

The ranking is qualitative and is based, in part, on local knowledge of past experiences with each type of hazard, review of available data, and the work of the Committee. The size and impacts of a natural hazard can be unpredictable. However, many of the mitigation strategies currently in place and many of those proposed for implementation can be applied to the expected natural hazards, regardless of their unpredictability.

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

* Extreme temperatures refers to the projected increase, over the next century, in the number of days per year with temperature greater than 90 degrees and the decrease in the number of days per year below 32 degrees. Extreme high and low temperatures and rapid shifts between warm and cold weather are also considered a temperature and climate change related hazard.

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

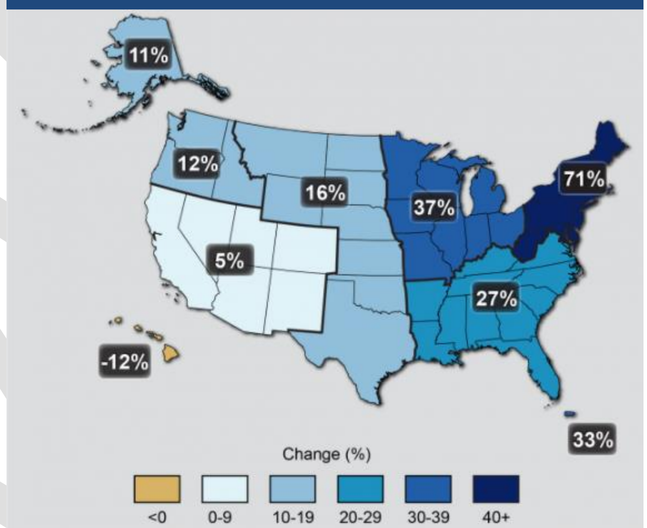
3.3 FLOODING

Potential Effects of Climate Change

In Massachusetts, annual precipitation amounts have increased at a rate of over 1 inch per decade since the late 1800s, and are projected to continue to increase largely due to more intense precipitation events. The Northeast has experienced a greater increase in extreme precipitation events than the rest of the U.S. in the past several decades (Figure 3-2). Although overall precipitation is expected to increase as the climate warms, it will occur more in heavy, short intervals, with a greater potential for dry, drought conditions in between.

Observed annual precipitation in Massachusetts for the last three decades was 47 inches. Total annual precipitation in Massachusetts is expected to increase between 2% to 13% by 2050, or by roughly 1 to 6 inches. In the Deerfield River Watershed, where Buckland is located, annual precipitation has averaged around 48 inches in recent decades. By 2050, the annual average could remain relatively the same (but occur in more heavy, short intervals) or increase by up to 18 inches a year. In general precipitation projections are more uncertain than temperature projections.[9]

Figure 3-2: Observed Change in Very Heavy Precipitation



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

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

[9] http://resilientma.org/.

Figure 3-3: Effects of Climate Change on Flooding

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

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

Hazard Description

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

Riverine Flooding

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

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

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

Fluvial Erosion

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

Fluvial erosion hazard (FEH) zones are mapped areas along rivers and streams that are susceptible to bank erosion caused by flash flooding. Any area within a mapped FEH zone is considered susceptible to bank erosion during a single severe flood or after many years of slow channel migration. As noted above, while the areas of the FEH zones often overlap with areas mapped within the 100-year floodplain on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) or Flood Hazard Boundary Maps (FHBMs), the FIRMs or FHBMs only show areas that are likely to be inundated by floodwaters that overtop the riverbanks during a severe flood. However, much flood-related property damage and injuries is the result of bank erosion that can undermine roads, bridges, building foundations and other infrastructure. Consequently, FEH zones are sometimes outside of the 100-year floodplain shown on FIRMs or FHBMs. FEH zones can be mapped using fluvial geomorphic assessment data as well as historic data on past flood events. Both the FIRMs and FEH maps should be used in concert to understand and avoid both inundation and erosion hazards, respectively.[10]

Urban Drainage Flooding

Urban drainage flooding entails floods caused by increased water runoff due to urban

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

development and drainage systems that are not capable of conveying high flows. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. They make use of a closed conveyance system that channels water away from an urban area to surrounding streams, bypassing natural processes of water infiltration into the ground, groundwater storage, and evapotranspiration (plant water uptake and respiration). Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding can occur more quickly and reach greater depths than if there were no urban development at all. In urban areas, basement, roadway, and infrastructure flooding can result in significant damage due to poor or insufficient stormwater drainage.

Ground Failures

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

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

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

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

Ice Jam

An ice jam is an accumulation of ice that acts as a natural dam and restricts the flow of a body of water. There are two types of ice jams: a freeze-up jam and a breakup jam. A freeze-up jam usually occurs in early winter to midwinter during extremely cold weather when super-cooled water and ice formations extend to nearly the entire depth of the river channel. This type of jam can act as a dam and begin to back up the flowing water behind it. The second type, a breakup jam, forms as a result of the breakup of the ice cover at ice-out, causing large pieces of ice to move downstream, potentially piling up at culverts, around bridge abutments, and at curves in river channels. Breakup ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding upstream of the obstruction. The Ice Jam Database, maintained by the Ice Engineering Group at the U.S. Army Corps of Engineers (USACE) Cold Regions Research and Engineering Laboratory currently consists of more than 18,000 records from across the U.S.

Dam Failure

A dam is an artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water. There are two primary types of dam failure: catastrophic failure, characterized by the sudden, rapid, and uncontrolled release of impounded water, or design failure, which occurs as a result of minor overflow events. Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur as a result of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for 34 percent of all dam failures in the U.S.

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

Additional Causes of Flooding

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

Floodplains

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

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

Location

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

In Buckland, the 100-year floodplain covers about 691 acres, or approximately five percent of the town. The majority of the land zones in and around the flood plain is zoned Rural Residential with an estimated 32.37 acres of residential use. Estimates also include 7.68 acres of commercial, public/institutional use which is 35% of the total industrial land use in town.. Additionally, the Deerfield River runs through Buckland's town center. The Buckland Town Hall, Police Station, Fire Department, and wastewater treatment plant are all located in or close to the town center and the 100-year floodplain. The highest population density of residents and businesses is also located within the center and susceptible to damage from 100 year floods. The town's primary shelter, the Mohawk Trail Regional High School, and a number of the towns primary evacuation routes are located in or very close to the floodplain. There are no FEMA flood control structures in town.

The majority of 100-year floodplain in Buckland is along Clesson and Clark brooks and on the Deerfield River. These waterways are the most prone to flooding and the majority of flood related damages to the town have historically been from these sources. In addition to these primary features, there are additional streams, brooks, and water features that pose a flood risk.

Committee members identified the following areas as being prone to flooding:

- **Buckland Recreation Area**: This area adjacent to the Clesson Brook has had chronic issues with flooding and riverbank erosion. In the 2010 Buckland Open Space and Recreation Plan, an action item was listed to "follow up on work already done to secure funding to address stream bank erosion at Buckland Recreation Area." Due to extreme damage within the Clesson Brook watershed from Hurricane Irene in 2011, bank stabilization work was postponed. The recreation area access road and parking lot were located close to the stream banks and vulnerable to flooding. Relocation of these facilities outside of the 200-foot river buffer zone is complete, and will help protect water quality by reducing the amount of runoff from these impervious surfaces entering the brook.

- **South Street Culvert:** This culvert for Bray Brook chronically floods and requires periodic repairs. This culvert will be replaced as part of a larger infrastructure project funded through the Federal Transportation Improvement Program (TIP). The project is currently under design and is due for completion in the next few years.

- **Other Culverts in Town:** According to the 2018 MVP Plan, major culverts on Nilman Road, Elm Street and Charlemont Road are in need of repair. These culverts are too expensive for the Town to repair and too large for the State's Culvert Replacement Municipal Assistance Grant Program. Many culverts along Clesson Brook Road in Buckland were replaced after Tropical Storm Irene, but other culverts in town have been identified as having "High" to "Medium" risk of failure through the MassDOT Stream Crossing Study for the Deerfield River Watershed.[11] These culverts pose a future risk to transportation and emergency response and should be prioritized for replacement with right-sized infrastructure to anticipate future rain events.

- **Route 112:** The road runs adjacent to Clesson Brook for most of its length through Buckland and a considerable portion of this major roadway lies in the floodplain. Sections of the road have experienced fluvial erosion, culvert damage, and washouts in the past and it continues to be at risk from flood events. During Irene, a section of Route 112 was undercut by the brook and washed out. Several telephone poles were damaged by flooding and caused power outages in the area.

  Several areas of Clesson Brook are still experiencing severe erosion that threatens roads and bridges. As part of the Deerfield River Watershed Based Plan in 2017, the mass slope failure just upstream of the Route 112 Bridge near the Buckland Recreation Area was assessed for possible stabilization measures. According to the Plan, "A 38-feet high mass failure (landslide in glacial deposits) immediately upstream of the Route 112 stream crossing threatens the bridge and contributes a significant volume of sediment to Clesson Brook. Sediment from Clesson Brook and other tributaries deposited in the Deerfield River contributes to the formation of large gravel bars and represents increased hazards to bridges, roads and other infrastructure." The Plan recommends several bank stabilization measures for this area.[12]

- **Farmland along Clesson Brook**: Also situated along Clesson Brook are working farms which lost valuable farmland soils to washouts and erosion during Irene. These areas continue to be at risk for erosion, according to the 2018 Buckland MVP Plan. Some landowners and farmers may have added berms to protect their land after Irene, but this may cause greater flooding downstream.

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[11] MassDOT Stream Crossing Explorer: http://sce.ecosheds.org/

[12] *A Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed*. Franklin Regional Council of Governments, 2017. https://frcog.org/publication/view/deerfield-river-watershed-based-resiliency-plan/

- **Apple Valley Road Bridge:** Scouring is impacting the abutments of this bridge, which is planned to be replaced through the Small Bridge Program in 2020. Residents on this road only have one exit and would be isolated if the bridge were to fail.

- **Nilman Road Bridge:** This bridge is in need of replacement. If it were to fail, an entire neighborhood would be isolated. Design has been completed and the Town is seeking funding for construction.

- **Old Hawley Road:** A bridge on this road is now impassable due to damage from Hurricane Irene in 2011, limiting access to one outlet. This causes a significant delay for emergency services wanting to reach residents on the other side of the bridge.

- **Conway Street:** Conway Street in the village periodically floods during heavy rain events. Properties along the street were flooded during Hurricane Irene.

- **Ice jams on the Deerfield River:** The Committee reports that ice jams are a problem upstream of Buckland, in the town of Charlemont, where they can cause flooding on Route 2. Ice jams have not been an issue in the Buckland section of the river in recent years.

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

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

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

Extent

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

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

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

Flash Floods

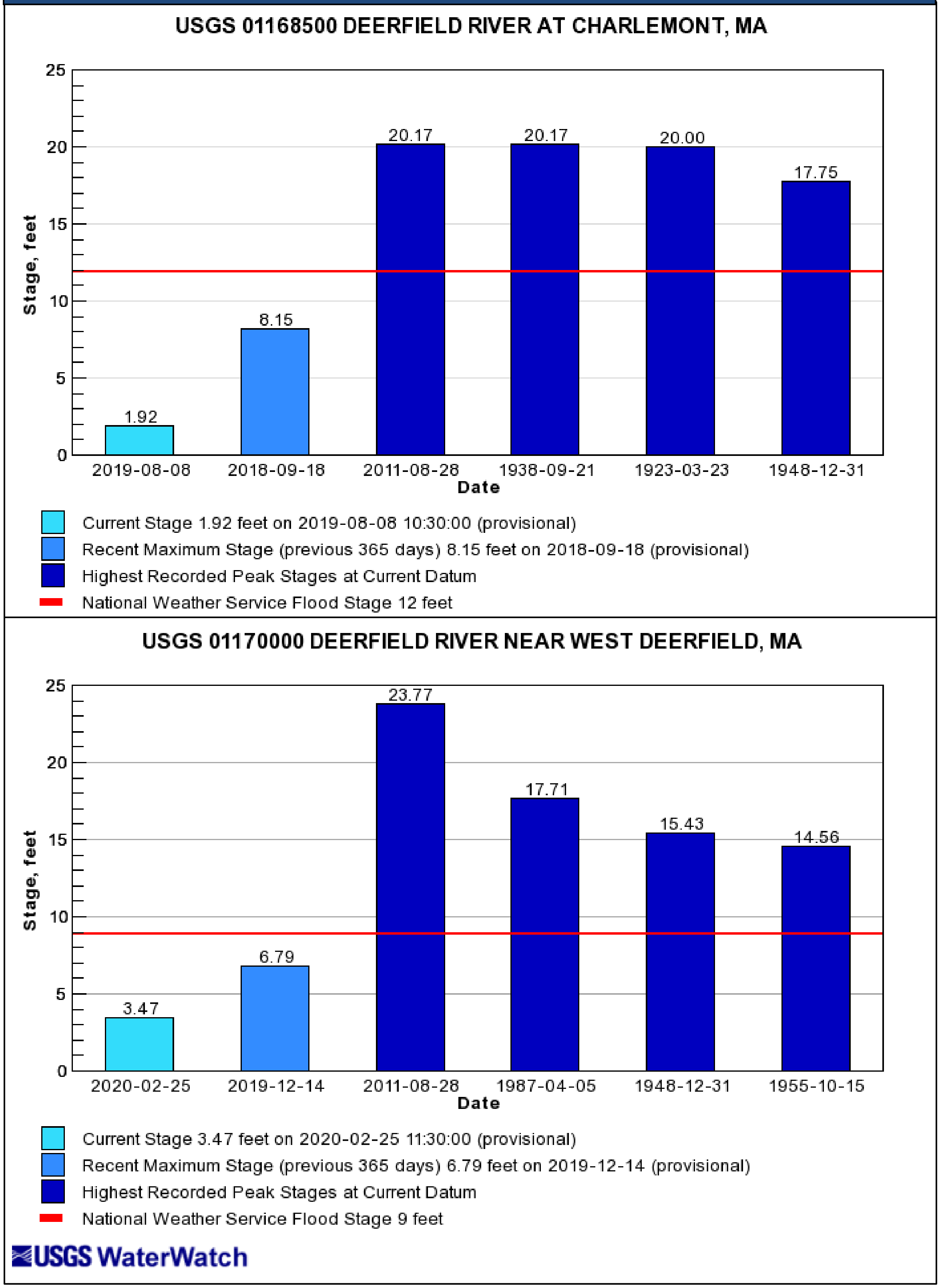
Flash floods are the product of heavy, localized precipitation in a short time period over a given location. Flash flooding events typically occur within minutes or hours after a period of heavy precipitation, after a dam or levee failure, or from a sudden release of water from an ice jam. Most often, flash flooding is the result of a slow-moving thunderstorm or the heavy rains from a hurricane. In rural areas, flash flooding often occurs when small streams spill over their banks. However, in urbanized areas, flash flooding is often the result of clogged storm drains (leaves and other debris) and the higher amount of impervious surface area (roadways, parking lots, roof tops).

General Floods

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

Flood flows in Massachusetts are measured at numerous USGS stream gauges. The gauges operate routinely, but particular care is taken to measure flows during flood events to calibrate the stage-discharge relationships at each location and to document actual flood conditions. In the aftermath of a flood event, the USGS will typically determine the recurrence interval of the event using data from a gauge's period of historical record. Figure 3-4 shows the four highest recorded Flood events on the Deerfield River at points upstream and downstream from Buckland, compared to the current stage and the highest flow event in the past year. There are no stream gauges located in Buckland.

Figure 3-4: Highest Recorded Flood Events on the Deerfield River near Buckland



Source: USGS WaterWatch https://waterwatch.usgs.gov/index.php?id=flood

The 100-Year Flood

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

The extent of flooding associated with a 1 percent annual probability of occurrence (the base flood or 100-year flood) is called the 100-year floodplain, which is used as the regulatory boundary by many agencies. Also referred to as the Special Flood Hazard Area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. This extent generally includes both the stream channel and the flood fringe, which is the stream-adjacent area that will be inundated during a 100-year (or 1 percent annual chance) flood event but does not effectively convey floodwaters.

The 500-Year Flood

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

Secondary Hazards

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

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

Previous Occurrences

The average annual precipitation for Buckland and surrounding areas in western Massachusetts is 48 inches. Between 1996 and 2017, 17 flash floods have been reported in Franklin County (Table 3-6), resulting in $3,245,000 in property damages.

Table 3-6: Previous Occurrences of Flash Floods in Franklin County

Year	# of Flash Flood Events	Annual Property Damage	Annual Crop Damage
1996	4	$1,800,000	$0
1998	1	$75,000	$0
2000	1	$0	$0
2003	1	$10,000	$0
2004	1	$10,000	$0
2005	3	$1,235,000	$0
2013	3	$65,000	$0
2014	2	$50,000	$0
2017	1	$0	$0
Total	**17**	**$3,245,000**	**$0**

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

From 1996 to 2018, 44 flood events were reported in Franklin County, resulting in total property damages worth $25,582,000 (Table 3-7). The bulk of these damages ($22,275,000) were from Tropical Storm Irene in August, 2011.

Table 3-7: Previous Occurrences of Floods in Franklin County

Year	# of Flood Events	Annual Property Damage	Annual Crop Damage
1996	7	$0	$0
1998	3	$0	$0
2001	1	$0	$0
2004	1	$0	$0
2005	2	$2,600,000	$0

Table 3-7: Previous Occurrences of Floods in Franklin County			
Year	**# of Flood Events**	**Annual Property Damage**	**Annual Crop Damage**
2007	1	$250,000	$0
2008	3	$38,000	$0
2010	1	$150,000	$0
2011	8	$22,375,000	$0
2012	2	$0	$0
2015	10	$31,000	$0
2017	1	$1,000	$0
2018	4	$137,000	$0
Total	**44**	**$25,582,000**	**$0**

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

Buckland was significantly impacted by Irene with damage to residential and commercial properties throughout town. Some agricultural land adjacent to rivers and streams were permanently lost when banks eroded. In addition to private property damage, many under road culverts failed, taking the road above with them, and significant portions of roads adjacent to streams and rivers were lost to fluvial erosion.

While many culverts in town have been replaced in the past decade, participants of the 2018 MVP workshop identified that there are remaining "at risk" culverts throughout the town. There are three major culverts identified as critical priority in Buckland's MVP: Nilman Road, Elm Street, and Charlemont Road. Failure of these culverts threatens to cut off communities and important infrastructure during emergencies. Unfortunately, these culverts are too large to be eligible under the State's Culvert Replacement Municipal Assistance Grant Program, but are too expensive for the Town to fund itself.

Table 3-8: Significant Flooding Events in Buckland			
Date	**Location**	**Type**	**Recorded Property Damages**
2011	Significant damage to multiple properties within the 100 year floodplain	Tropical Storm; Hurricane Irene	Check town records
2013	Bray Road	Flooding caused an oil tank to spill	Not available
2015	March Road on the Buckland / Ashfield town line.	Heavy Rain	None reported through NOAA

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

Probability of Future Events

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

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

Of all the regions in the United States, the Northeast has seen the most dramatic increase in the intensity of rainfall events. The U.S. National Climate Assessment reports that between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events). Climate projections for Massachusetts, developed by the University of Massachusetts, suggest that the frequency of high-intensity rainfall events will continue to trend upward, and the result will be an increased risk of flooding. Specifically, the annual frequency of downpours releasing more than two inches of rain per day in Massachusetts may climb from less than 1 day per year to approximately 0.9-1.5 days by 2100. Events which release over one inch during a day could climb to as high as 8-11 days per year by 2100. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure. While the coastal areas in Massachusetts will experience the greatest increase in high-intensity rainfall days, some level of increase will occur in every area of Massachusetts, including Buckland.[13]

Impact

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

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

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

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

The impact of a flood event could be critical in Buckland, with more than 25% of property in the affected area damaged or destroyed, and possible shutdown of facilities (roads, bridges, critical facilities) for more than one week.

The Sherman and Harriman Dams, owned and operated by Great River Hydro, are large hydro-electric dams located Deerfield River upstream from Buckland. Failure of these dams presents a catastrophic flooding impact to Buckland, and is discussed in more detail in the Dam Failure section.

Vulnerability

Society

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

Of Buckland's's total acreage, 691 acres lie within the 100-year floodplain. According to 2005 MassGIS Land Use data there are 45 dwellings located in the floodplain (Table 3-9). Using this number and Buckland's's estimated average household size, it is estimated that one-hundred and six people, or 5.5% of Bucklands's total population, resisde in the floodplain.

Table 3-9: Estimated Buckland Population Exposed to a 1 Percent Flood Event

Total Population	# of Dwelling Units in Flood Hazard Area	Average # of People Per Household	Estimated Population in Flood Hazard Area	% of Total Population in Flood Hazard Area
1,927	45	2.35	106	5.5%

Source: 2013-2017 American Community Survey Five-Year Estimates; 2005 MassGIS Land Use data.

Vulnerable Populations

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

Table 3-10 estimates the number of vulnerable populations and households in Buckland. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Buckland residents during a flood event.

Table 3-10: Estimated Vulnerable Populations in Buckland		
Vulnerable Population Category	**Number**	**Percent of Total Population***
Population Age 65 Years and Over	470	24%
Population with a Disability	216	11%
Population who Speak English Less than "Very Well"	12	0.6%
Vulnerable Household Category	**Number**	**Percent of Total Households***
Low Income Households (annual income less than $35,000)	291	33%
Householder Age 65 Years and Over Living Alone	139	16%
Households Without Access to a Vehicle	29	3%

*Total population = 1,927; Total households = 935

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

Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

The 2018 Buckland MVP Community Building workshop participants identified the following population groups that may be particularly vulnerable to flooding events and need additional assistance:

- **Low-income households in the village**: Participants raised concerns about low-income residents who live in the downtown area of Buckland and who may have limited options for sheltering, should they have to evacuate their homes. There is no shelter in the downtown area of Buckland, which is in the floodplain. The regional shelter at the Mohawk Regional High School is about 2/10 of a mile from the potentially hazardous rail and the Deerfield River. Participants discussed the possibility of the Mary Lyons Church, which is not located near any known hazards, serving as a shelter however there are some modifications that would need to be made to the church facilities in order for this to happen, including purchasing and installing a generator and installing ADA accessible bathrooms.

- **Isolation of other residents**: There are areas of Town where residents might become cut off in the event of flooding, road closures and other events. There is a bridge on Apple Valley Road which is in need of repair and which, if closed, would cut off access to some homes in the area.

  Residents near the Elm Street railroad crossing could also be vulnerable should there be a derailment or other issue with a train which would necessitate residents' evacuation. There is currently no secondary evacuation route to direct residents away from the railroad in the event of a rail emergency and toward Bray Road. Access to Bray Road would have to be on foot over rough terrain.

  There are some residents without landlines, with poor or no cell phone coverage and/or no broadband. In 2018, a project through the Massachusetts Broadband Extension Project was completed that extended access to Comcast service to at least 96% percent of the households in the town, but there are still some isolated homes that are not served by broadband. Additionally, not all have signed up for Reverse 9-1-1, so reaching all residents in the event of a widespread emergency is very difficult.

Health Impacts

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

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

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

Flood events can also have significant impacts after the initial event has passed. For example, flooded areas that do not drain properly can become breeding grounds for mosquitos, which can transmit vector-borne diseases. Exposure to mosquitos may also increase if individuals are outside of their homes for longer than usual as a result of power outages or other flood-related conditions. Finally, the growth of mold inside buildings is often widespread after a flood. Investigations following Hurricane Katrina and Superstorm Sandy found mold in the walls of many water-damaged homes and buildings. Mold can result in allergic reactions and can exacerbate existing respiratory diseases, including asthma (CDC, 2004). Property damage and displacement of homes and businesses can lead to loss of livelihood and long-term mental stress for those facing relocation. Individuals may develop post-traumatic stress, anxiety, and depression following major flooding events (Neria et al., 2008).

<u>Economic Impacts</u>

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

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

Infrastructure

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

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

Buckland's key bridges and roadways on Route 112 and Route 2 are located within the flood plain. Flood damage to these critical roadways can disrupt the established evacuation routes from town and the ability of residents to reach emergency shelters or receive emergency support after a flood event.

The Town Hall and emergency services, Fire, Police, and EMS, have their departments within the dam inundation area and close to the floodplain. The 2018 Buckland MVP recommended that determining alternate sites for Town Hall and Police operations during extreme flood events was a top priority. Part of this recommendation should include planning and assessment for the possible redesign and/or retrofitting the two facilities, as well as evaluating the feasibility of relocating facilities outside of the flood hazard area.

In addition to critical infrastructure, there are at least six facilities containing hazardous materials in the dam inundation area and adjacent to the floodplain. Residents residing in the floodplain around and downstream of these facilities are at an increased public health and life safety risk during a major flood event. Environmental and economic impacts caused by flood damage to these facilities can be significant as well. Buckland is also at risk from hazardous materials (including potentially toxic debris from manmade structures) being brought down stream during a flood. The Committee reported that large propane tanks and other hazardous materials were confirmed to be carried down the Deerfield River during Irene and left in the Buckland floodplain after the high waters receded.

Table 3-11 shows the amount of commercial, industrial, and public/institutional land uses located in town and within the floodplain. Roughly one acre of commercial land uses lie within the floodplain, accounting for 4.9 percent of commercial land uses in town. Roughly an acre of public and institutional land is within the hazard for a total of 5.3 percent of the total public and institution land in Buckland. Five of the fifteen total acres of industrial land use is within the flood hazard acre accounting for a significant 35% of total industrial land use in town.

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

Land Use	Total acres in Town	Acres in Flood Hazard Area	% of total acres in Flood Hazard Area
Commercial	24.4	1.2	4.9%
Industrial	15.0	5.3	35.4%
Public/Institutional	22.5	1.2	5.3%

Source: 2005 MassGIS Land Use data.

2019 assessed building values were collected from the Buckland Assessors Office for all significant structures partially or completely located in the floodplain in Buckland. Table 3-12 lists those structures and estimated 2019 value.

Table 3-12: Total Building Value in Flood Hazard Area			
Structure	**Building Structure Value**	**Other Value**	**Total Building Value**
Gardner Falls Hydro Electric Plant, Gardner Falls Road	$2,460,900	$354,100	$2,815,000
Former Lamson and Goodnow factory buildings, Conway Street	$462,800	$101,000	$563,800
Lamson and Goodnow Retail Store, 45 Conway Street	$317,300	$83,300	$400,600
TransCanada Hydro, Conway Street	$9,974,100	$379,900	$10,354,000
TransCanada Hydro, Creamery Avenue	$8,969,300	$108,700	$9,078,000
Suburban Propane, 30 Conway Street	$178,200	$179,000	$357,200
Shelburne Falls Fire Station, 121 State Street, Shelburne Falls	$66,400	$553,400	$619,800
Total	**$22,429,000**	**$1,206,000**	**$24,188,400**

Source: 2019 Buckland Assessors data.

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

Table 3-13: NFIP Policies, Claims, and Repetitive Loss Statistics for Buckland						
Number of Housing Units (2017 Estimates)	**Number of Policies in Force**	**Percent of Housing Units**	**Total Insurance in Force**	**Number of Paid Losses**	**Total Losses Paid**	**Number of Repetitive Loss Properties**
935	13	0.3%	$2,657,600	8	$248,502	0

Source: National Flood Insurance Program (NFIP), FEMA Region I; U.S. Census Bureau 2013-2017 American Community Survey Five-Year Estimates.

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

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

Agriculture

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

Energy

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

Public Health

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

Public Safety

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

<u>Transportation</u>

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

<u>Water Infrastructure</u>

Stormwater drainage systems and culverts that are not sized to accommodate larger storms are likely to experience flood damage as extreme precipitation events increase (resilient MA, 2018). Both culverts that are currently undersized and culverts that are appropriately sized may be overwhelmed by larger storms. Gravity-fed water and wastewater infrastructure that is located in low lying areas near rivers and reservoirs may experience increased risks. Combined sewer overflows may increase with climate change, resulting in water quality degradation and public health risks (resilient MA, 2018).

Environment

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

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

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

Vulnerability Summary

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

Flood Hazard Problem Statements
• Much of Buckland's Critical Infrastructure(CI), including Fire, Police, EMS, and the Town Hall, are adjacent to the floodplain. Continuity of Operations Plans should be written for all CI in town that focuses on how to maintain these important services during a major flood event.
• While the chances are low, a failure of the Sherman, Harriman, or Bear Swamp high hazard dams would cause catastrophic damage to Buckland. The Dam Failure section of this plan provides more detail on this hazard.
• Route 2 and Route 112 are primary roads for the region and primary evacuation routes for Buckland residents. Both are within the floodplain and at risk from flooding.
• The Nilman Road, Elm Street, Pine/Birch Street, and Charlemont Road culverts are at a "critical" risk from flooding. Failure of these culverts threatens to cut off communities and important infrastructure during emergencies.
• Old Hawley Road Bridge is impassible from past flood damage. This causes a significant delay for emergency services wanting to reach residents on the other side of the bridge.
• The Mohawk Trail Regional High School, the designated emergency shelter for Buckland, may not be accessible to all residents during a flood event, and is located within the dam inundation zone. An alternative shelter should be identified for flooding.
• The Town's wastewater treatment plan lies adjacent to the floodplain. The plant is elevated 25' above the riverbank and is not considered to be at risk from flooding. However, its access road on South Street has two culverts that are at high risk to flood damage. Damage to these culverts would cut all access to the wastewater treatment plant.
• The water main and sewer main that cross the Deerfield River are vulnerable to damage from flooding events.
• There are areas of Town where residents might become cut off in the event of flooding, road closures and other events. The bridge on Apple Valley Road is in need of repair; if closed, some homes would become inaccessible.
• Since Tropical Storm Irene in 2011, several areas of Clesson Brook are still experiencing severe erosion that threatens roads and bridges.

3.4 SEVERE SNOWSTORMS / ICE STORMS

Potential Effects of Climate Change

Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase annually by as much as 0.4-3.9 inches (an increase of 4-35%), but by the end of the century most of this precipitation is likely to fall as rain instead of snow. There are many human and environmental impacts that could result from this change including reduced snow cover for winter recreation and tourism, less spring snow melt to replenish aquifers and lower spring river flows for aquatic ecosystems. Figure 3-5 show potential effects of climate change on severe winter storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Figure 3-5: Effects of Climate Change on Severe Winter Storms

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

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

Hazard Description

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

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

Ice Storms

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

Ice pellets are another form of freezing precipitation, formed when snowflakes melt into raindrops as they pass through a thin layer of warmer air. The raindrops then refreeze into particles of ice when they fall into a layer of subfreezing air near the surface of the earth. Finally, sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. The difference between sleet and hail is that sleet is a wintertime phenomenon whereas hail falls from convective clouds (usually thunderstorms), often during the warm spring and summer months.

Nor'easters

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

Nor'easters are among winter's most ferocious storms. These winter weather events are notorious for producing heavy snow, rain, and oversized waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. These storms occur most often in late fall and early winter. The storm radius is often as much as 100 miles, and nor'easters often sit stationary for several days, affecting multiple tide cycles and causing extended heavy precipitation. Sustained wind speeds of 20 to 40 mph are common during a nor'easter, with short-term wind speeds gusting up to 50 to 60 mph. Nor'easters are commonly accompanied with a storm surge equal to or greater than 2.0 feet.

Nor'easters begin as strong areas of low pressure either in the Gulf of Mexico or off the East Coast in the Atlantic Ocean. The low will then either move up the East Coast into New England and the Atlantic provinces of Canada, or out to sea. The level of damage in a strong hurricane is often more severe than a nor'easter, but historically Massachusetts has suffered more damage from nor'easters because of the greater frequency of these coastal storms (one or two per year). The comparison of hurricanes to nor'easters reveals that the duration of high surge and winds in a hurricane is 6 to 12 hours, while a nor'easter's duration can be from 12 hours to 3 days.

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

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

Location

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

The entire town of Buckland is susceptible to severe snowstorms and ice storms. Because these storms occur regionally, they impact the entire town. As a result, the location of occurrence is "large," with over 50 percent of land area affected. However, the steep elevation changes in town results in different impacts during winter storms. For instance, it is common for the higher elevations of town to have snow and ice while the lower section of town receives rain. In addition, residents in the higher elevations are also more isolated and experience longer and more frequent power outages.

Extent

Since 2005, the Regional Snowfall Index (RSI) has become the descriptor of choice for measuring winter events that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale system from 1 to 5 as depicted in Table 3-13. The RSI is similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes, except that it includes an additional variable: population. The RSI is based on the spatial extent of the storm, the amount of snowfall, and population.

The RSI is a regional index. Each of the six climate regions (identified by the NOAA National Centers for Environmental Information) in the eastern two-thirds of the nation has a separate index. The RSI incorporated region-specific parameters and thresholds for calculating the index. The RSI is important because, with it, a storm event and its societal impacts can be assessed within the context of a region’s historical events. Snowfall thresholds in Massachusetts (in the Northeast region) are 4, 10, 20, and 30 inches of snowfall, while thresholds in the Southeast U.S. are 2, 5, 10, and 15 inches.

Table 3-14: Regional Snowfall Index Categories

Category	RSI Value	Description
1	1—3	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Source: NOAA National Climatic Data Center

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

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

Source: NOAA National Climatic Data Center

Previous Occurrences

New England generally experiences at least one or two severe winter storms each year with varying degrees of severity. Severe winter storms typically occur during January and February; however, they can occur from late September through late April. According to NOAA's National Climatic Data Center, there have been 80 heavy snow events in Franklin County since 1996, resulting in $15,440,000 in damages; 29 winter storm events since 2002, resulting in $1,170,000 in damages; and two ice storms have resulted in damages of $3,150,000.

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

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

Buckland did not suffer as devastating a blow from this ice storm as some of its neighboring Franklin County towns at higher elevations. However, the Town tallied 137 downed trees or hanging limbs from the storm. All told, 50 miles of streets and right-of-ways required repair or clearing and power outages ranged from 1-5 days, depending upon location in town. Anecdotal reports included property damage such as garages and decks crushed by trees as well as water damage due frozen pipes in those structures that lost power. There were numerous car accidents and reports of dirt roads washed out, but no reports of injuries. The Town submitted $15,864 in costs related to this ice storm to MEMA.

Based on data available from the National Oceanic and Atmospheric Administration, there are 210 winter storms since 1900 that have registered on the RSI scale. Of these, approximately 18 storms resulted in snow falls in all or parts of Franklin County of at least 10 inches. These storms are listed in Table 3-16, in order of their RSI severity.

Table 3-16: High-Impact Snowstorms in Franklin County, 1958 - 2018

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

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

The Hazard Mitigation Committee noted that Buckland has not experienced severe impacts from a winter storm in recent years. The most recent storm that caused damage in town was the November 2014 "Thanksgiving" storm that brought down tree limbs and wires in isolated areas of town. The Committee expressed concern over changing precipitation in the winter, with more ice than snow becoming common. Ice can cause greater tree damage that can take out power lines, damage structures, and block roadways.

During the 2018 Municipal Vulnerability Preparedness (MVP) community workshop, heavy snow events were identified as a top hazard, due to the potential for downed trees and power lines, widespread power outages and some residents being cut off from the rest of the Town due to road closures. Even though most people in Buckland are used to heavy snow, such events can still have broad and significant impacts on the Town.

Probability of Future Events

Based upon the availability of records for Franklin County, the likelihood that a severe snow storm will hit Buckland in any given year is "Moderate," or a 2 to 25 percent probability in any given year.

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

Impact

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

The impact of an event would be "minor," with only minor property damage and temporary shutdown of facilities.

Vulnerability

Society

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

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

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

<u>Vulnerable Populations</u>

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

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

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

Table 3-17: Estimated Vulnerable Populations in Buckland

Vulnerable Population Category	Number	Percent of Total Population (1,927)
Population Age 65 Years and Over	470	24%
Population with a Disability	216	11%
Population who Speak English Less than "Very Well"	12	1%
Vulnerable Household Category	**Number**	**Percent of Total Households (873)**
Low Income Households (annual income less than $35,000)	291	33%
Householder Age 65 Years and Over Living Alone	139	16%
Households Without Access to a Vehicle	29	3%

Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Participants at the 2018 MVP community workshop identified vulnerable populations in Buckland at risk to impacts from severe winter weather or other hazard events, including:

- Low-income residents who lack transportation to access the emergency shelter at the Mohawk Trail Regional School on Route 112.
- Some areas of town could be isolated if roads are closed, particularly on Apple Valley Road where a bridge is in need of repair.

- Residents that live near the freight rail line in town are vulnerable to the impacts of a train derailment due to severe winter weather.
- Some residents do not have landlines, and may have poor or no cell phone coverage and/or no broadband. Additionally, not all have signed up for Reverse 9-1-1, so reaching all residents in the event of a widespread emergency is very difficult.

Health Impacts

Cold weather, which is a component of a severe winter storm, increases the risk of hypothermia and frostbite. Exposure to cold conditions can also exacerbate pre-existing respiratory and cardiovascular conditions. In addition to temperature-related dangers, however, severe winter storms also present other potential health impacts. For example, individuals may use generators in their homes if the power goes out or may use the heat system in their cars if they become trapped by snow. Without proper ventilation, both of these activities can result in carbon monoxide buildup that can be fatal. Loss of power can also lead to hypothermia. After Hurricane Sandy, the number of cases of cold exposure in New York City was three times greater than the same time period in previous years.[14] Driving during severe snow and ice conditions can also be very dangerous, as roads become slick and drivers can lose control of their vehicle. During and after winter storms, roads may be littered with debris, presenting a danger to drivers. Health impacts on people include the inability to travel to receive needed medical services and isolation in their homes. Additionally, natural gas-fueled furnaces, water heaters, and clothes dryers, and even automobile exhaust pipes, may become blocked by snow and ice, which can lead to carbon monoxide poisoning.

Economic Impacts

The entire building stock inventory in Buckland is exposed to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames rather than building content. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communication and power networks can be disrupted for days while utility companies work to repair the extensive damage.

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

[14] Fink, 2012

loss of business functions, and loss of income for many individuals during business closures, also impact the local economy.

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

Infrastructure

All infrastructure and other elements of the built environment in Buckland are exposed to the severe winter weather hazard. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and after a severe winter event. Disruptions to key public services such as electricity, transportation, schools, and health care may become more common.[15] Table 3-18 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a severe winter storm.

Table 3-18: Estimated Potential Loss by Tax Classification in Buckland

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$174,715,480	$1,747,155	$8,735,774	$17,471,548
Open Space	$0	$0	$0	$0
Commercial	$9,988,100	$99,881	$499,405	$998,810
Industrial	$22,786,300	$227,863	$1,139,315	$2,278,630
Total	**$207,489,880**	**$2,074,899**	**$10,374,494**	**$20,748,988**

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

Agriculture

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

Energy

Severe weather can cause power outages from trees that fall during heavy snow and strong wind events. Severe ice events can take down transmission and distribution lines. The severe

[15] Resilient MA 2018

weather can impair a utility's ability to rapidly repair and recover the system.

Public Health

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

Public Safety

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

Transportation

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

Water Infrastructure

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

Environment

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

Vulnerability Summary

Based on the above assessment, Buckland faces a "medium" vulnerability from severe snow storms and ice storms. Severe Winter Storms / Ice Storms occur frequently in Buckland. However, the severity of impact is typically minor. The following problem statements summarize Buckland's areas of greatest concern regarding severe winter storms.

Severe Winter Storm Hazard Problem Statements
• Buckland residents who rely on private wells for water are at risk during prolonged power outages.
• The designated emergency shelter at the Mohawk Trail Regional School may not be accessible to residents who lack access to transportation. An alternative shelter location could be designated in the village, where residents could walk to access the shelter if needed.
• The water main and sewer main that cross the Deerfield River are vulnerable to damage from winter storm-related flooding or ice jams.
• There are areas of town where residents might become isolated if roads, bridges, or culverts were blocked or damaged. Key areas of concern include a bridge on Apple Valley Road, and culverts on Nilman Road, Pine/Birch Street, Elm Street, and Charlemont Road.
• Train derailment and the potential for hazardous material spills during a severe winter storm is a concern given the history of derailments in town and the close proximity of the Deerfield River, Route 2, and homes to the rail line.
• Communication with some residents during emergencies can be challenging due to lack of landlines, cell and/or broadband coverage. Not all residents have signed up for Reverse 911.
• The change in elevation between different sections of town leads to different winter storm impacts. Higher elevations tend to get more snow, while lower elevations may receive more rain or ice.

3.5 HURRICANES / TROPICAL STORMS

Potential Effects of Climate Change

A 2017 U.S. Climate Science Special Report noted that there has been an upward trend in North Atlantic hurricane activity since 1970. The report forecasts that future hurricanes formed in the North Atlantic will drop more rain and may have higher wind speeds. This is because a warmer atmosphere will hold more water, and hurricanes are efficient at wringing water out of the atmosphere and dumping it on land. When extreme storms like Tropical Storm Irene travel over inland areas, they may release large quantities of precipitation and cause rivers to overtop their banks. Irene dumped more than 10 inches of rain in western Massachusetts. Buildings floated downriver in Shelburne Falls, flooded highways were closed, and 400,000 utility customers lost power (resilient MA, 2018). Figure 3-6 displays the potential effects of climate change on hurricanes and tropical storms from the Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Figure 3-6: Effects of Climate Change on Hurricanes and Tropical Storms

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

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

Hazard Description

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

Tropical systems customarily come from a southerly direction and when they accelerate up the

East Coast of the U.S., most take on a distinct appearance that is different from a typical hurricane. Instead of having a perfectly concentric storm with heavy rain blowing from one direction, then the calm eye, then the heavy rain blowing from the opposite direction, our storms (as viewed from satellite and radar) take on an almost winter-storm-like appearance. Although rain is often limited in the areas south and east of the track of the storm, these areas can experience the worst winds and storm surge. Dangerous flooding occurs most often to the north and west of the track of the storm. An additional threat associated with a tropical system making landfall is the possibility of tornado generation. Tornadoes would generally occur in the outer bands to the north and east of the storm, a few hours to as much as 15 hours prior to landfall.

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

Tropical Storms

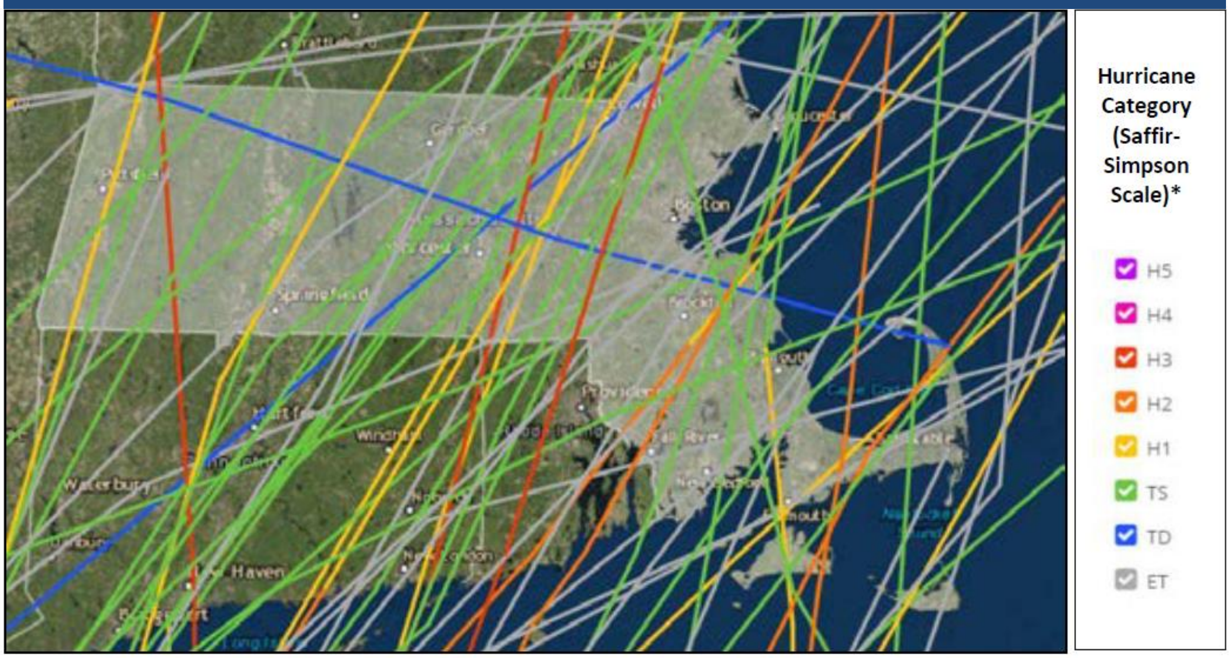
A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as a tropical storm versus a hurricane). Tropical storms strengthen when water evaporated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

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

Location

Because of the hazard's regional nature, all of Buckland is at risk from hurricanes and tropical storms, with a "medium" location of occurrence with the potential for 10 to 50 percent of land area affected. Ridge tops are more susceptible to wind damage. Inland areas, especially those in floodplains, are also at risk for flooding from heavy rain and wind damage. The majority of the damage following hurricanes and tropical storms often results from residual wind damage and inland flooding, as was demonstrated during recent tropical storms.

Figure 3-7: Historical Hurricane Paths within 65 Miles of Massachusetts



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

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2017. According to this resource, over the time frame tracked, 63 events categorized as an extra-tropical storm or higher occurred within 65 nautical miles of Massachusetts. The tracks of these storms are shown in Figure 3-7. As this figure shows, the paths of these storms vary across the Commonwealth, but are more likely to occur toward the coast. An unnamed hurricane was recorded as passing through Buckland in September of 1945. According to the Committee, there have been no other hurricanes in Buckland since then.

Extent

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

Table 3-19: Saffir-Simpson Scale

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

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

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Serious power outages can also be associated with these types of events. After Hurricane Irene passed through the region as a tropical storm in late August 2011, many areas of the Commonwealth were without power for more than 5 days.

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

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

Previous Occurrences

According to NOAA’s Historical Hurricane Tracker tool, 63 hurricane or tropical storm events have occurred in the vicinity of Massachusetts between 1842 and 2016. The Commonwealth was impacted by tropical storms Jose and Phillipe in 2017. Therefore, there is an average of one storm every other year or 0.5 storms per year. Storms severe enough to receive FEMA disaster declarations, however, are far rarer, occurring every 9 years on average. The Commonwealth has not been impacted by any Category 4 or 5 hurricanes; however, Category 3 storms have historically caused widespread flooding. Winds have caused sufficient damage to impair the ability of individuals to remain in their homes.

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

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

Probability of Future Events

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

Buckland's location in western Massachusetts reduces the risk of extremely high winds that are associated with hurricanes, although it can experience some high wind events. Based upon past occurrences, Buckland has a "moderate" probability, or between a 2 percent and 25 percent chance, of experiencing a hurricane or tropical storm event in a given year.

Impact

A major hurricane or tropical storm occurrence could critically impact the Town, with potential multiple injuries to citizens possible and with a potential of more than 25% of property damaged or destroyed.

Vulnerability

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

Society

Vulnerable Populations

Among the exposed populations, the most vulnerable include people with low socioeconomic status, people over the age of 65, people with medical needs, and those with low English language fluency. For example, people with low socioeconomic status are likely to consider the economic impacts of evacuation when deciding whether or not to evacuate. Individuals with medical needs may have trouble evacuating and accessing needed medical care while displaced. Those who have low English language fluency may not receive or understand the warnings to evacuate. During and after an event, rescue workers and utility workers are

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

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. Structures built before the building code was enacted in 1970 may be more likely to sustain damage from winds associated with a hurricanes or tropical storms. Mobile homes may also be more susceptible to wind damage.

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

Table 3-20: Estimated Vulnerable Populations in Buckland

Vulnerable Population Category	**Number**	**Percent of Total Population (1,927)**
Population Age 65 Years and Over	470	24%
Population with a Disability	216	11%
Population who Speak English Less than "Very Well"	12	1%
Vulnerable Household Category	**Number**	**Percent of Total Households (873)**
Low Income Households (annual income less than $35,000)	291	33%
Householder Age 65 Years and Over Living Alone	139	16%
Households Without Access to a Vehicle	29	3%
Home Built Prior to 1970	550	59%
Living in a Mobile Home	17	2%

Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Participants at the 2018 MVP community workshop identified vulnerable populations in Buckland at risk to impacts from hurricanes, tropical storms, or other hazard events, including:

- Low-income residents who lack transportation to access the emergency shelter at the Mohawk Trail Regional School on Route 112.

- Some areas of town could be isolated if roads are closed, particularly on Apple Valley Road where a bridge is in need of repair.
- Residents that live near the freight rail line in town are vulnerable to the impacts of a train derailment due to severe weather.
- Some residents do not have landlines, and may have poor or no cell phone coverage and/or no broadband. Additionally, not all have signed up for Reverse 9-1-1, so reaching all residents in the event of a widespread emergency is very difficult.

Health Impacts

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

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

Economic Impacts

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

Infrastructure

Hurricanes and tropical storms could critically impact the Town, with a potential of more than 25% of property in affected area damaged or destroyed. Residential and commercial buildings built along rivers may be vulnerable to severe damage. Potential structural damage to the facilities themselves may include damage to roofs and building frames. These facilities may not be fully operational if workers are unable to travel to ensure continuity of operations prior and

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

after a severe winter event. Table 3-21 identifies the assessed value of all residential, open space, commercial, and industrial land uses in Town, and the losses that would result from 1%, 5%, and 10% damage to this inventory as a result of a hurricane or tropical storm.

Table 3-21: Estimated Potential Loss by Tax Classification

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$174,715,480	$1,747,155	$8,735,774	$17,471,548
Open Space	$0	$0	$0	$0
Commercial	$9,988,100	$99,881	$499,405	$998,810
Industrial	$22,786,300	$227,863	$1,139,315	$2,278,630
Total	**$207,489,880**	**$2,074,899**	**$10,374,494**	**$20,748,988**

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

Energy

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

Public Health

Combined sewer overflows associated with heavy rainfall can release contaminants, chemicals, and pathogens directly into the environment and into water systems. If a mass outbreak of waterborne illness were to occur, hospitals and medical providers may lack the capacity to treat patients.

Public Safety

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

Transportation

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

[18] Resilient MA 2018.

Water and Wastewater Infrastructure

Wastewater treatment centers may face elevated risks of damage and destruction from hurricanes (resilient MA, 2018). Heavy rains can lead to contamination of well water and can release contaminants from septic systems (DPH, 2014). Buckland estimates that 60% of their residents use private wells and septic systems and 40% use the public water and sewer system. Heavy rainfall can also overburden stormwater systems, drinking water supplies, and sewage systems.

Environment

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

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

Vulnerability Summary

Based on the above analysis, Buckland faces a high vulnerability from hurricanes and tropical storms. The Vulnerability Assessment revealed an occurrence could critically impact the Town, with potential multiple injuries to citizens possible and with a potential of more than 25% of property in affected area damaged or destroyed. The following problem statements summarize Buckland’s greatest areas of concern regarding hurricanes and tropical storms.

Hurricane / Tropical Storm Hazard Problem Statements
• An estimated 59% of homes in Buckland were built prior to the first State building code in 1975, making them potentially more vulnerable to damages from high winds associated with a hurricane or tropical storm. Mobile homes, making up 2% of homes in town, are also vulnerable.
• Buckland residents who rely on private wells for water are at risk during prolonged power outages.
• The designated emergency shelter at the Mohawk Trail Regional School may not be accessible to residents who lack access to transportation. An alternative shelter location could be designated in the village, where residents could walk to access the shelter if needed.
• The water main and sewer main that cross the Deerfield River are vulnerable to damage from hurricane or tropical storm-related flooding. Approximately 60% of Buckland residents are served by the public water and sewer service.
• There are areas of town where residents might become isolated if roads, bridges, or culverts were blocked or damaged. Key areas of concern include a bridge on Apple Valley Road, and culverts on Nilman Road, Elm Street, and Charlemont Road.
• Train derailment and the potential for hazardous material spills during a hurricane or tropical storm is a concern given the history of derailments in town and the close proximity of the Deerfield River, Route 2, and homes to the rail line.
• Communication with some residents during emergencies can be challenging due to lack of landlines, cell and/or broadband coverage. Not all residents have signed up for Reverse 911.

3.6 SEVERE THUNDERSTORMS / WIND / MICROBURSTS

Potential Effects of Climate Change

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

Figure 3-8: Effects of Climate Change on Severe Thunderstorms, Wind, and Microbursts

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

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

Hazard Description

A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave, known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size. Tornadoes can also be generated during these events. According to the National Weather Service, a thunderstorm is classified as "severe" when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado.

Every thunderstorm has an updraft (rising air) and a downdraft (sinking air). Sometimes strong downdrafts known as downbursts can cause tremendous wind damage that is similar to that of

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

a tornado. A small (less than 2.5 mile path) downburst is known as a "microburst" and a larger downburst is called a "macro-burst." An organized, fast-moving line of microbursts traveling across large areas is known as a "derecho." These occasionally occur in Massachusetts. Winds exceeding 100 mph have been measured from downbursts in Massachusetts.

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

Location

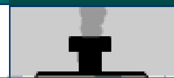
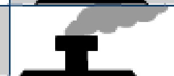
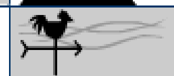
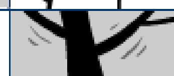
The entire town of Buckland is at risk for severe thunderstorms, wind and microbursts, which have the potential to impact anywhere from 10% – 50% of property in the town.

Extent

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

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

Figure 3-9: Beaufort Wind Scale

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

Source: Developed in 1805 by Sir Francis Beaufort

Buckland is susceptible to high winds from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms and tornadoes, and nor'easters. Sometimes, wind gusts of only 40 to 45 mph can cause scattered power outages from downed trees and wires. This is especially true after periods of prolonged drought or excessive rainfall, since both are situations that can weaken the root systems and make them more susceptible to the winds' effects. Winds measuring less than 30 mph are not considered to be hazardous under most circumstances. Wind speeds in a hurricane are measured using the Saffir-Simpson scale. Another scale developed for measuring wind is the Beaufort wind scale (see Figure 3-9).

Previous Occurrences

Since 1996, a total of 13 high wind events occurred in Franklin County (Table 3-22), causing a total of $288,000 in property damages. High winds are defined by the National Weather Service as sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration. The probability of future high wind events is expected to increase as a result of climate projections for the state that suggest a greater occurrence of severe weather events in the future.

Table 3-22: High Wind Events in Franklin County

Year	# of High Wind Events	Annual Property Damage	Annual Crop Damage
1996	2	$0	$0
1999	1	$0	$0
2003	2	$130,000	$0
2004	1	$30,000	$0
2005	1	$10,000	$0
2006	3	$68,000	$0
2011	1	$15,000	$0
2013	2	$35,000	$0
Total	**13**	**$288,000**	**$0**

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

Thunderstorm winds are defined by the National Weather Service as winds arising from convection (occurring within 30 minutes of lightning being observed or detected) with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage. Buckland has experienced six (6) thunderstorm wind events since 1994 (Table 3-23). These storms resulted in downed trees and wires and caused a total of $48,000 in property damage. An additional hazard are older electrical transformers that contain PCBs. When these fall or are otherwise damaged from a storm, they can leak hazardous material. The power company is responsible for assessing and cleaning up the site, and provides the Town with a report of each incident. According to the Committee, in the past 5 years, there have been six incidences of older transformers being damaged.

Table 3-23: Thunderstorm Wind Events in Buckland			
Event Date	**Property Damage**	**Crop Damage**	**Event Narrative**
5/31/1998	$0	$0	Trees downed by strong winds
7/29/2006	$15,000	$0	A severe thunderstorm brought down a tree onto a transformer in Buckland
8/3/2007	$0	$0	Trees down
5/26/2010	$20,000	$0	Trees and wires were downed throughout portions of Buckland, leaving large parts of town without power.
5/29/2013	$8,000	$0	Trees were downed in Shelburne Falls on Route 2 at State Street
10/7/2013	$5,000	$0	A tree and wires on Monroe Avenue were downed by thunderstorm winds.
Total	**$48,000**	**$0**	

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

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

Table 3-24: Lightning Events in Franklin County			
Year	**# of Lightning Events**	**Annual Property Damage**	**Annual Crop Damage**
1997	1	$3,000	$0
2001	1	$20,000	$0
2002	1	$15,000	$0
2004	1	$35,000	$0
2005	1	$50,000	$0
2008	1	$10,000	$0
2010	2	$25,000	$0
2012	1	$500,000	$0
2013	4	$49,000	$0
2014	3	$93,000	$0
2018	6	$35,500	$0
Total	**22**	**$835,500**	**$0**

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

Two lightning events in Buckland caused a total of $18,000 in property damages since 2002. In both cases, a tree struck by lightning fell onto a nearby house (Table 3-25).

Table 3-25: Lightning Events in Buckland			
Event Date	**Property Damage**	**Crop Damage**	**Event Narrative**
8/14/2002	$15,000	$0	Lightning struck a large tree in Buckland, causing a portion of it to fall onto a nearby home.
7/28/2014	$3,000	$0	Lightning struck a tree, felling it onto a nearby house.
Total	**$18,000**	**$0**	

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

A total of 42 hail events have been reported in Franklin County since 1998 (Table 3-26). Property damage was only recorded for one event, in the amount of $5,000. One hail event in 2008 resulted in $50,000 in crop damages. Pea to marble size hail fell in a swath from Colrain to Shelburne damaging apple and peach orchards. An estimated 45 acres of apples and two to three acres of peaches were damaged by the hail.

Table 3-26: Hail Events in Franklin County			
Year	**# of Hail Events**	**Annual Property Damage**	**Annual Crop Damage**
1998	4	$0	$0
2000	1	$0	$0
2001	1	$0	$0
2003	1	$0	$0
2004	2	$0	$0
2005	3	$5,000	$0
2007	5	$0	$0
2008	7	$0	$50,000
2009	2	$0	$0
2010	4	$0	$0
2011	4	$0	$0
2012	1	$0	$0
2013	3	$0	$0
2017	3	$0	$0
2018	1	$0	$0
Total	**42**	**$5,000**	**$50,000**

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

Probability of Future Events

According to the National Weather Service, Massachusetts experiences between 20 to 30 thunderstorm days each year. Based on past occurrences, there is a “very high” probability

(50% - 100% chance) of a severe thunderstorm or winds affecting the town in a given year. Climate change is expected to increase the frequency and intensity of thunderstorms and other severe weather.

Impact

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

Vulnerability

Society

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

<u>Vulnerable Populations</u>

Socially vulnerable populations are most susceptible to severe weather based on a number of factors, including their physical and financial ability to react or respond during a hazard, and the location and construction quality of their housing. In general, vulnerable populations include people over the age of 65, the elderly living alone, people with low socioeconomic status, people with low English language fluency, people with limited mobility or a life-threatening illness, and people who lack transportation or are living in areas that are isolated from major roads. The isolation of these populations is a significant concern. Structures built before the building code was enacted in 1975 may be more likely to sustain damage from winds associated with a hurricanes or tropical storms. Mobile homes may also be more susceptible to wind damage.

Table 3-27 estimates the number of vulnerable populations and households in Buckland. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Buckland residents during a severe weather event.

Table 3-27: Estimated Vulnerable Populations in Buckland

Vulnerable Population Category	**Number**	**Percent of Total Population (1,927)**
Population Age 65 Years and Over	470	24%
Population with a Disability	216	11%
Population who Speak English Less than "Very Well"	12	1%
Vulnerable Household Category	**Number**	**Percent of Total Households (873)**
Low Income Households (annual income less than $35,000)	291	33%
Householder Age 65 Years and Over Living Alone	139	16%
Households Without Access to a Vehicle	29	3%
Home Built Prior to 1975	550	59%
Living in a Mobile Home	17	2%

Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Participants at the 2018 MVP community workshop identified vulnerable populations in Buckland at risk to impacts from severe thunderstorms, wind, microbursts, or other hazard events, including:

- Low-income residents who lack transportation to access the emergency shelter at the Mohawk Trail Regional School on Route 112.
- Some areas of town could be isolated if roads are closed, particularly on Apple Valley Road where a bridge is in need of repair.
- Residents that live near the freight rail line in town are vulnerable to the impacts of a train derailment due to severe weather.
- Some residents do not have landlines, and may have poor or no cell phone coverage and/or no broadband. Additionally, not all have signed up for Reverse 9-1-1, so reaching all residents in the event of a widespread emergency is very difficult.

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

Health Impacts

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

Economic Impacts

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

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

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry

[20] (Andrews, 2012).

buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

Infrastructure

Damage to buildings is dependent upon several factors, including wind speed, storm duration, path of the storm track, and building construction. According to the Hazus wind model,[21] direct wind-induced damage (wind pressures and windborne debris) to buildings is dependent upon the performance of components and cladding, including the roof covering (shingles, tiles, membrane), roof sheathing (typically wood-frame construction only), windows, and doors, and is modeled as such. Structural wall failures can occur for masonry and wood-frame walls, and uplift of whole roof systems can occur due to failures at the roof/wall connections. Foundation failures (i.e., sliding, overturning, and uplift) can potentially take place in manufactured homes.

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

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

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

Table 3-27: Estimated Potential Loss by Tax Classification				
Tax Classification	**Total Assessed Value FY2019**	**1% Damage Loss Estimate**	**5% Damage Loss Estimate**	**10% Damage Loss Estimate**
Residential	$174,715,480	$1,747,155	$8,735,774	$17,471,548
Open Space	$0	$0	$0	$0
Commercial	$9,988,100	$99,881	$499,405	$998,810
Industrial	$22,786,300	$227,863	$1,139,315	$2,278,630
Total	**$207,489,880**	**$2,074,899**	**$10,374,494**	**$20,748,988**

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

Agriculture

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

Energy

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

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

Public Safety

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

Transportation

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

Water & Wastewater Infrastructure

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

Environment

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

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

Vulnerability Summary

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

Severe Thunderstorm / Wind Hazard Problem Statements
• An estimated 59% of homes in Buckland were built prior to the first State building code in 1975, making them potentially more vulnerable to damages from high winds associated with a thunderstorm, microburst, or high wind event. Mobile homes, making up 2% of homes in town, are also vulnerable.
• Buckland residents who rely on private wells for water are at risk during prolonged power outages.
• The designated emergency shelter at the Mohawk Trail Regional School may not be accessible to residents who lack access to transportation. An alternative shelter location could be designated in the village, where residents could walk to access the shelter if needed.
• There are areas of town where residents might become isolated if roads, bridges, or culverts were blocked or damaged. Key areas of concern include a bridge on Apple Valley Road, and culverts on Nilman Road, Pine/Birch Street, Elm Street, and Charlemont Road.
• Train derailment and the potential for hazardous material spills during a thunderstorm, microburst, or high wind event is a concern given the history of derailments in town and the close proximity of the Deerfield River, Route 2, and homes to the rail line.
• Communication with some residents during emergencies can be challenging due to lack of landlines, cell and/or broadband coverage. Not all residents have signed up for Reverse 911.
• Older electrical transformers contain PCBs and become a hazard when damaged by storms. On average one transformer is damaged in Buckland each year.

3.7 TORNADOES

Potential Impacts of Climate Change

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

Figure 3-10: Impacts of Climate Change on Tornadoes

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

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

Hazard Description

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

The following are common factors in tornado formation:

- Very strong winds in the middle and upper levels of the atmosphere
- Clockwise turning of the wind with height (i.e., from southeast at the surface to west aloft)
- Increasing wind speed in the lowest 10,000 feet of the atmosphere (i.e., 20 mph at the surface and 50 mph at 7,000 feet)
- Very warm, moist air near the ground, with unusually cooler air aloft
- A forcing mechanism such as a cold front or leftover weather boundary from previous shower or thunderstorm activity

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

A tornadic waterspout is a rapidly rotating column of air extending from the cloud base (typically a cumulonimbus thunderstorm) to a water surface, such as a bay or the ocean. They can be formed in the same way as regular tornadoes, or can form on a clear day with the right amount of instability and wind shear. Tornadic waterspouts can have wind speeds of 60 to 100 mph, but since they do not move very far, they can often be navigated around. They can become a threat to land if they drift onshore.

Location

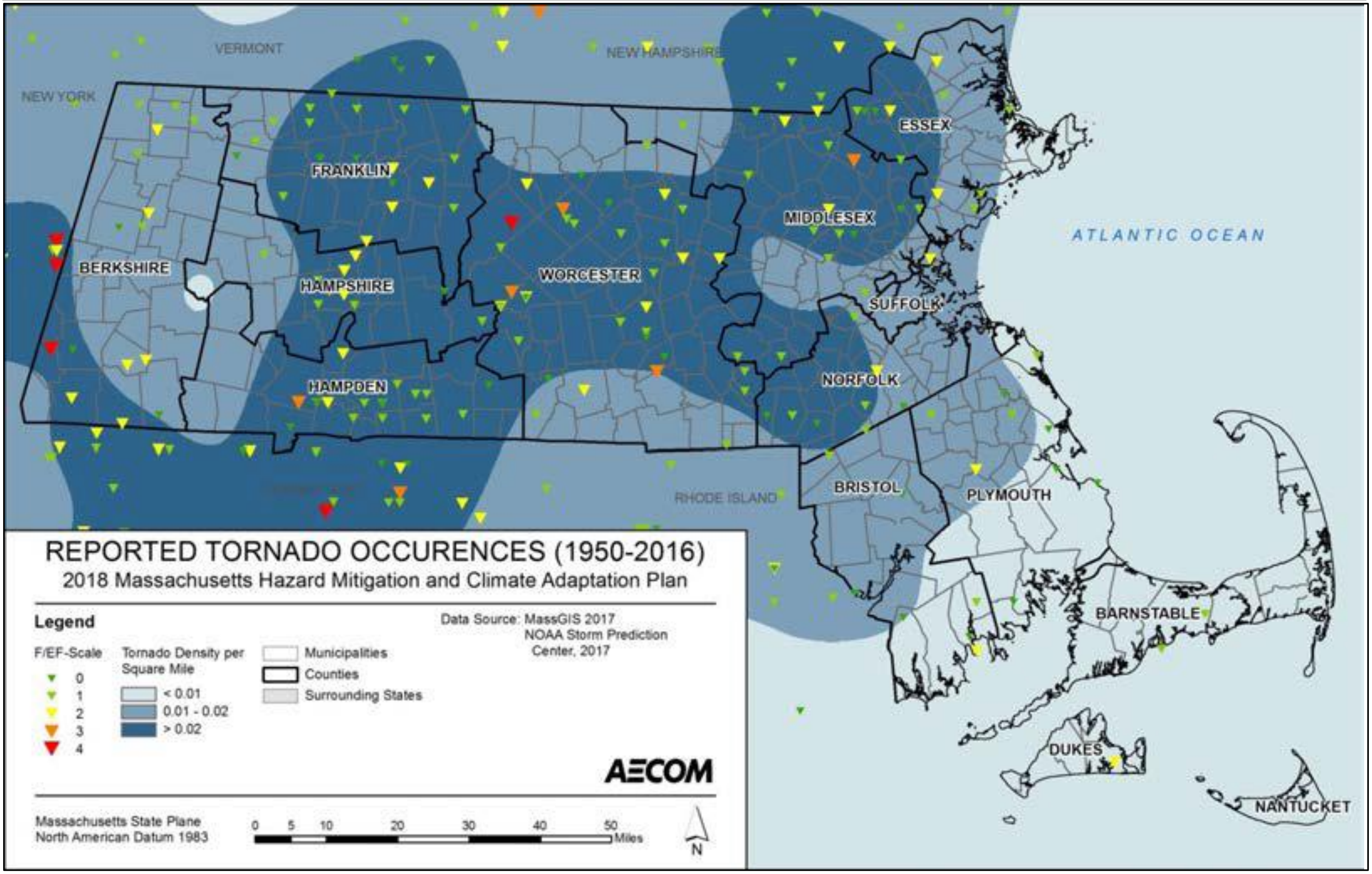
Figure 3-11 illustrates the reported tornado occurrences, based on all-time initial touchdown locations across the Commonwealth as documented in the NOAA NCDC Storm Events Database. ArcGIS was used to calculate an average score per square mile. The analysis indicated that the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts, and includes Buckland and much of Franklin County. Tornadoes are rated as having an Area of Occurrence of “Isolated.” If a tornado were to occur in Buckland, it could impact less than 10% of the town.

According to the Committee, the area of town along Route 112 is more tornado-prone, because it is more open and less hilly than the rest of the town.

Extent

The NWS rates tornadoes using the Enhanced Fujita scale (EF scale), which does not directly measure wind speed but rather the amount of damage created. This scale derives 3-second gusts estimated at the point of damage based on the assignment of 1 out of 8 degrees of damage to a range of different structure types. These estimates vary with height and exposure. This method is considerably more sophisticated than the original Fujita scale, and it allows surveyors to create more precise assessments of tornado severity. Figure 3-12 provides guidance from NOAA about the impacts of a storm with each rating.

Figure 3-11: Density of Reported Tornadoes per Square Mile



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

Figure 3-12: Enhanced Fujita Scale & Guide to Tornado Severity

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

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

Previous Occurrences

High wind speeds, hail, and debris generated by tornadoes can result in loss of life, downed trees and power lines, and damage to structures and other personal property (cars, etc.). Since the 1950s, there have been over twenty tornadoes in Franklin County. In the last two decades, five tornadoes have been reported in Franklin County, in the towns of Heath, Charlemont, Wendell, New Salem, and Conway (Table 3-28). The February 2017 tornado in the center of Conway was the most destructive, impacting forests and causing major property damage to several homes, barns, and a church that subsequently had to be torn down. Miraculously, no deaths or serious injuries were reported.

Table 3-28: Tornado Events in Franklin County				
Date	**Severity**	**Property Damage**	**Crop Damage**	**Event Narrative**
7/3/1997	F1	$50,000	$0	A tornado touched down just west of Number Nine Road in Heath and then skipped along a path which ended about a mile into northwest Colrain. Many large trees were uprooted or snapped at their mid levels. A silo was destroyed and part of the roof of an attached barn was peeled back. A hay tractor was flipped over with its wheels in the air. Doors to a garage were blown in and the roof was partially ripped off. The tornado affected mostly wooded terrain and did extensive tree damage when it passed through a state forest. The path width was up to 100 yards. There were no injuries.
7/3/1997	F1	$50,000	$0	A tornado touched down in the eastern part of Charlemont and travelled east causing damage to a campground. Fifteen trailers were damaged from falling trees and flying debris. Two of the trailers were severely damaged and one was destroyed with seven trees falling on top of it. Eyewitnesses reported rotation in the clouds and debris. The tornado then moved through the higher terrain of the Catamount State Forest. The path was discontinuous and ranged in width from 50 to 100 yards. The tornado path ended in the Copeland Hills section of Colrain. There were no direct injuries reported.
7/11/2006	F2	$200,000	$0	Brief F2 touchdown in Wendell
9/1/2013	EF0	$0	$0	A Massachusetts Department of Conservation and Recreation employee observed a waterspout on Quabbin Reservoir in New Salem, MA. He was able to snap two pictures of the storm, one showing a funnel and another showing the funnel extended down to the water. The waterspout was very short lived, never hit land, and did no damage and injured no people. Winds aloft were not conducive for tornadic

Table 3-28: Tornado Events in Franklin County				
Date	Severity	Property Damage	Crop Damage	Event Narrative
				development, but the environment was unstable and a surface front was moving through the region.
2/25/2017	EF1	$400,000	$0	This tornado touched down at 7:23 pm on Main Poland Road in western Conway, Massachusetts. The path width started at 50 yards, with a sharp gradient evident of damage versus no damage. Large sections of forest had thick pine trees snapped at mid-tree. Numerous power lines were downed along the path into downtown Conway. The path width grew, reaching a maximum width of 200 yards near the town hall. Several houses were severely damaged on Whately Road, southeast of the town hall. Roofs were blown off, and in one case the side walls of a house were missing with the interior of the house exposed. On Hill View Road a large barn collapsed. One injury occurred when a tree landed on a house on South Deerfield Road east of town. That was where the visible damage path ended.

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

Probability of Future Events

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

Impact

Tornadoes are potentially the most dangerous of local storms. If a major tornado were to strike in the populated areas of Buckland, damage could be widespread. Fatalities could be high; many people could be displaced for an extended period of time; buildings could be damaged or destroyed; businesses could be forced to close for an extended period of time or even permanently; and routine services, such as telephone or power, could be disrupted. Because Buckland is largely forested and sparsely inhabited, the severity of impact of a tornado event is likely "Limited," with more than 10% of property in the affected area damaged or destroyed.

Vulnerability

Society

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

<u>Vulnerable Populations</u>

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

An estimated 550 housing units in Buckland, or 59% of all housing units in town, were built prior to the 1970s when the first building code went into effect in Massachusetts. An estimated 17 mobile homes are located in Buckland, accounting for 2% of the total housing stock.[22] Table 3-29 estimates the number of vulnerable populations and households in Buckland. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Buckland residents during a tornado event.

Table 3-29: Estimated Vulnerable Populations in Buckland		
Vulnerable Population Category	**Number**	**Percent of Total Population (1,927)**
Population Age 65 Years and Over	470	24%
Population with a Disability	216	11%
Population who Speak English Less than "Very Well"	12	1%

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

Table 3-29: Estimated Vulnerable Populations in Buckland		
Vulnerable Household Category	**Number**	**Percent of Total Households (873)**
Low Income Households (annual income less than $35,000)	291	33%
Householder Age 65 Years and Over Living Alone	139	16%
Households Without Access to a Vehicle	29	3%
Home Built Prior to 1975	550	59%
Living in a Mobile Home	17	2%

Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Participants at the 2018 MVP community workshop identified vulnerable populations in Buckland at risk to impacts from tornadoes or other hazard events, including:

- Low-income residents who lack transportation to access the emergency shelter at the Mohawk Trail Regional School on Route 112.
- Some areas of town could be isolated if roads are closed, particularly on Apple Valley Road where a bridge is in need of repair.
- Residents that live near the freight rail line in town are vulnerable to the impacts of a train derailment due to a tornado.
- Some residents do not have landlines, and may have poor or no cell phone coverage and/or no broadband. Additionally, not all have signed up for Reverse 9-1-1, so reaching all residents in the event of a widespread emergency is very difficult.

Health Impacts

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

Economic Impacts

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

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

Infrastructure

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

Table 3-30: Estimated Potential Loss by Tax Classification in Buckland

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$174,715,480	$1,747,155	$8,735,774	$17,471,548
Open Space	$0	$0	$0	$0
Commercial	$9,988,100	$99,881	$499,405	$998,810
Industrial	$22,786,300	$227,863	$1,139,315	$2,278,630
Total	**$207,489,880**	**$2,074,899**	**$10,374,494**	**$20,748,988**

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

Agriculture

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

Energy

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

Public Safety

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

Transportation

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

Water & Wastewater Infrastructure

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

Environment

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

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

Vulnerability Summary

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

Tornado Hazard Problem Statements
• An estimated 59% of homes in Buckland were built prior to the first State building code in 1975, making them potentially more vulnerable to damages from high winds associated with a tornado. Mobile homes, making up 2% of homes in town, are also vulnerable.
• Buckland residents who rely on private wells for water are at risk during prolonged power outages.
• The designated emergency shelter at the Mohawk Trail Regional School may not be accessible to residents who lack access to transportation. An alternative shelter location could be designated in the village, where residents could walk to access the shelter if needed.
• The water main and sewer main that cross the Deerfield River are vulnerable to damage from a tornado.
• There are areas of town where residents might become isolated if roads, bridges, or culverts were blocked or damaged. Key areas of concern include a bridge on Apple Valley Road, and culverts on Nilman Road, Elm Street, and Charlemont Road.
• Train derailment and the potential for hazardous material spills caused by a tornado is a concern given the history of derailments in town and the close proximity of the Deerfield River, Route 2, and homes to the rail line.
• Communication with some residents during emergencies can be challenging due to lack of landlines, cell and/or broadband coverage. Not all residents have signed up for Reverse 911.
• Residents are not familiar with the tornado alert system or how to protect themselves during this type of weather event. This lack of familiarity increases the risk of harm to residents.

3.8 WILDFIRE

Potential Impacts of Climate Change

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Periods of hot, dry weather create the highest fire risk. Therefore, the predicted increase in average and extreme temperatures in the Commonwealth may intensify wildfire danger by warming and drying out vegetation. A recent study published in *the Proceedings of the National Academy of Sciences* found that climate change has likely been a significant contributor to the expansion of wildfires in the western U.S., which have nearly doubled in extent in the past three decades.[23] Another study found that the frequency of lightning strikes—an occasional cause of wildfires—could increase by approximately 12 percent for every degree Celsius of warming.[24] Finally, the year-round increase in temperatures is likely to expand the duration of the fire season.

Climate change is also interacting with existing stressors to forests, making them more vulnerable to wildfire. Drought, invasive species, and extreme weather events, all can lead to more dead, downed, or dying trees, increasing the fire load in a forest.

Figure 3-13: Impacts of Climate Change on Wildfires

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

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

Hazard Description

A wildfire can be defined as any non-structure fire that occurs in vegetative wildland that contains grass, shrub, leaf litter, and forested tree fuels. Wildfires in Massachusetts are caused by natural events, human activity, or prescribed fire. Wildfires often begin unnoticed but spread

[23] Abatzoglou and Williams, 2016
[24] Romps et al., 2014

quickly, igniting brush, trees, and potentially homes. The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire danger is the highest. Drought, snowpack level, and local weather conditions can impact the length of the fire season.

Fire Ecology and Wildfire Behavior

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

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

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

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

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

Fire is also used extensively as a land management tool to replicate natural fire cycles, and it has been used to accomplish both fire-dependent ecosystem restoration and hazard fuel mitigation objectives on federal, state, municipal, and private lands in Massachusetts since the 1980s. for example, over the past 16 years, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) has used a combination of tree harvesting, shrub mowing, and prescribed burning to benefit rare species and to reduce the risk of a catastrophic wildfire in the Montague Plains Wildlife Management Area, a rare pitch pine-scrub oak forest in Montague. Approximately 880 acres have been treated since 2004 to restore woodland and shrubland habitats. MassWildlife has cooperative agreements with the Department of Conservation and Recreation and the Town of Montague Conservation Commission to restore sandplain habitats on their inholdings within the plains, and works closely with local fire departments and the DCR Bureau of Fire Control to ensure that firefighters have adequate access in the event of a wildfire and are familiar with the changes in vegetation and fuels resulting from habitat management activities.[25]

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

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

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

Location

The ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface. The SILVIS Lab at the University of Wisconsin-Madison Department of Forest Ecology and Management classifies exposure to wildlife hazard as "interface" or "intermix." Intermix communities are those where housing and vegetation intermingle and where the area includes more than 50 percent vegetation and has a housing density greater than one house per 16 hectares (approximately 6.5 acres). Interface communities are defined as those in the vicinity of contiguous vegetation, with more than one house per 40 acres and less than 50 percent vegetation, and within 1.5 miles of an area of more than 500 hectares (approximately 202 acres) that is more than 75 percent vegetated. These areas are shown in Figure 3-14. Inventoried assets (population, building stock, and critical facilities) were overlaid with these data to determine potential exposure and impacts related to this hazard. Buckland has several areas of "intermix" zones within town.

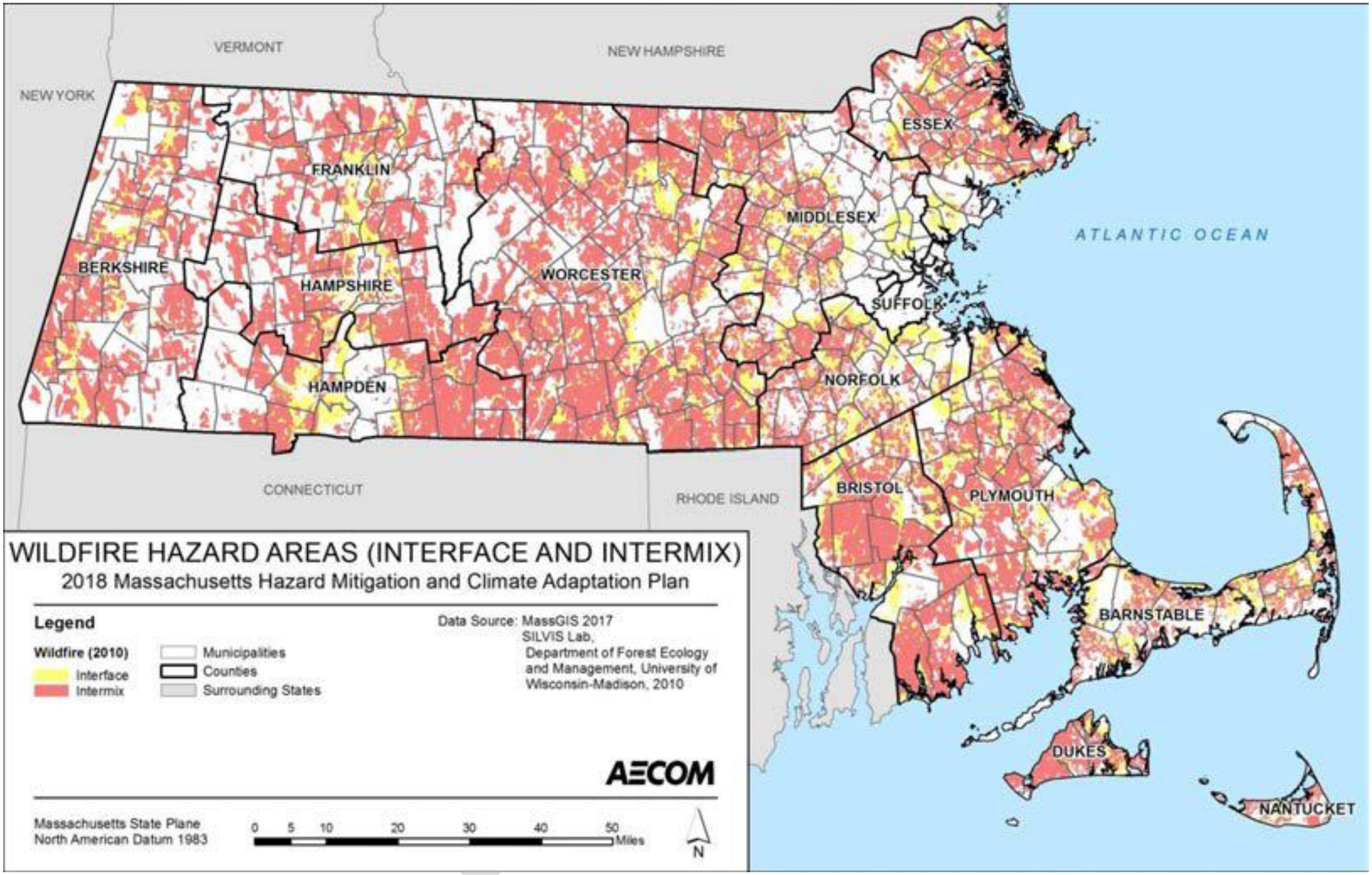
The Northeast Wildfire Risk Assessment Geospatial Work Group completed a geospatial analysis of fire risk in the 20-state U.S. Forest Service Northeastern Area. The assessment is comprised of three components—fuels, wildland-urban interface, and topography (slope and aspect)—that are combined using a weighted overlay to identify wildfire-prone areas where hazard mitigation practices would be most effective. Figure 3-15 illustrates the areas identified for the Commonwealth. Buckland mostly falls within the "High" wildfire risk area. The entire town of Buckland, which is approximately 81% forested, is at risk for wildfire. The location of occurrence is typically "isolated," with a fire affecting less than 10% of the town.

Early detection of wildfires is a key part of the Bureau's overall effort. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols assist cities and towns in prevention efforts and allow for the quick deployment of mobile equipment for suppression of fires during their initial stage. Buckland can tell Shelburne Control to refrain from issuing burn permits during times of high fire risk or when the Town is lacking staff capacity to address a wildfire. Figure 3-16 displays the Bureau's fire control districts and fire towers in Massachusetts. In Buckland, firefighting in rural areas is a concern, according to the Committee, because of lack of access to water and staff capacity.

Additionally, the freight rail line and surrounding area is vulnerable to brush fires started by sparks from passing trains. The Committee noted that numerous stockpiles of old railroad ties are now located along the tracks in town, and are a major fire concern. In June 2017, multiple fire departments responded to a fire in Northfield where an estimate 1,500 ties were ignited next to the railroad tracks.[26]

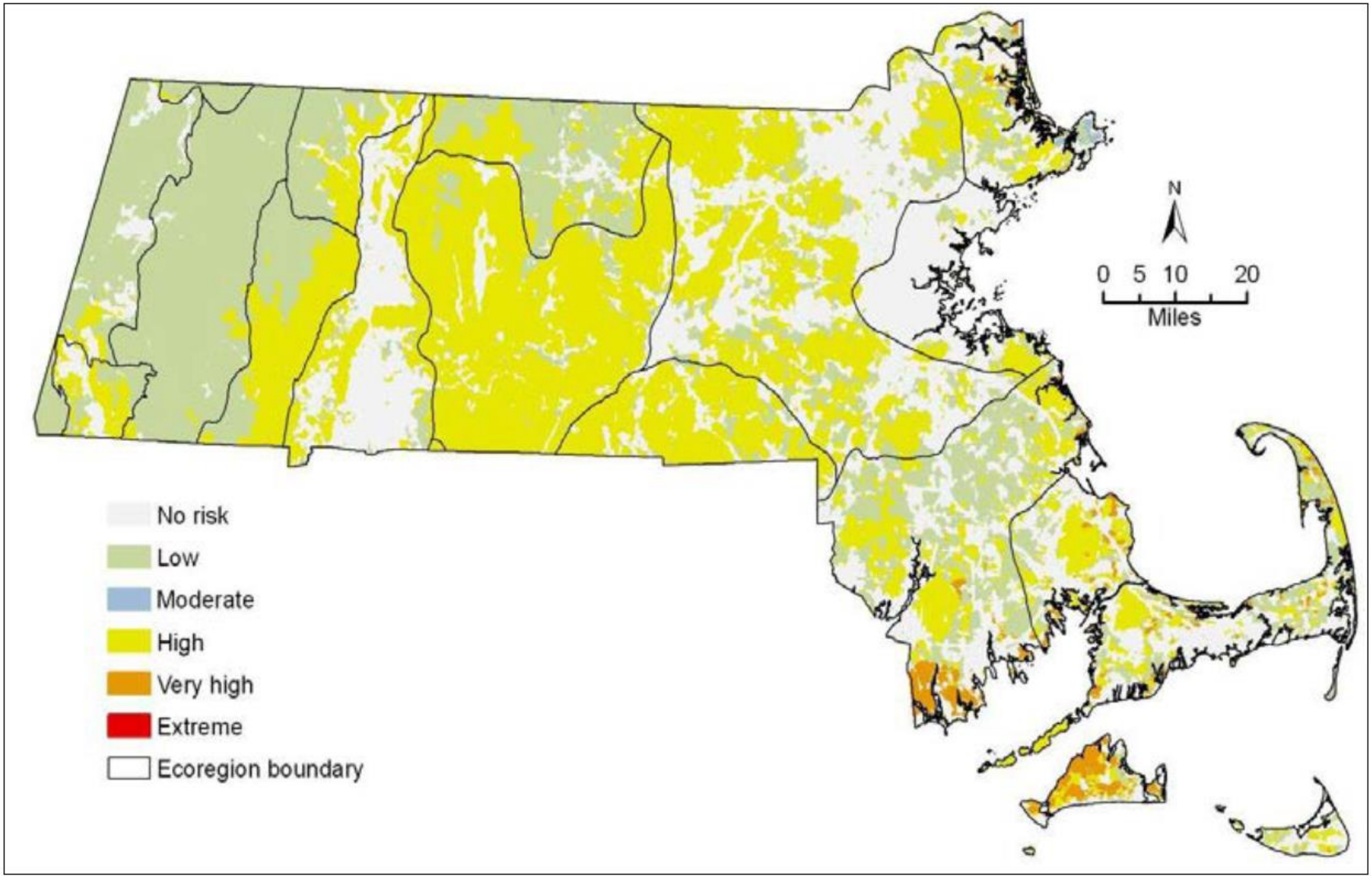
[26] "Multiple towns respond to fire on railroad ties in Northfield." The Recorder newspaper, June 13, 2017.

Figure 3-14: Wildland-Urban Interface and Intermix for the Commonwealth of Massachusetts



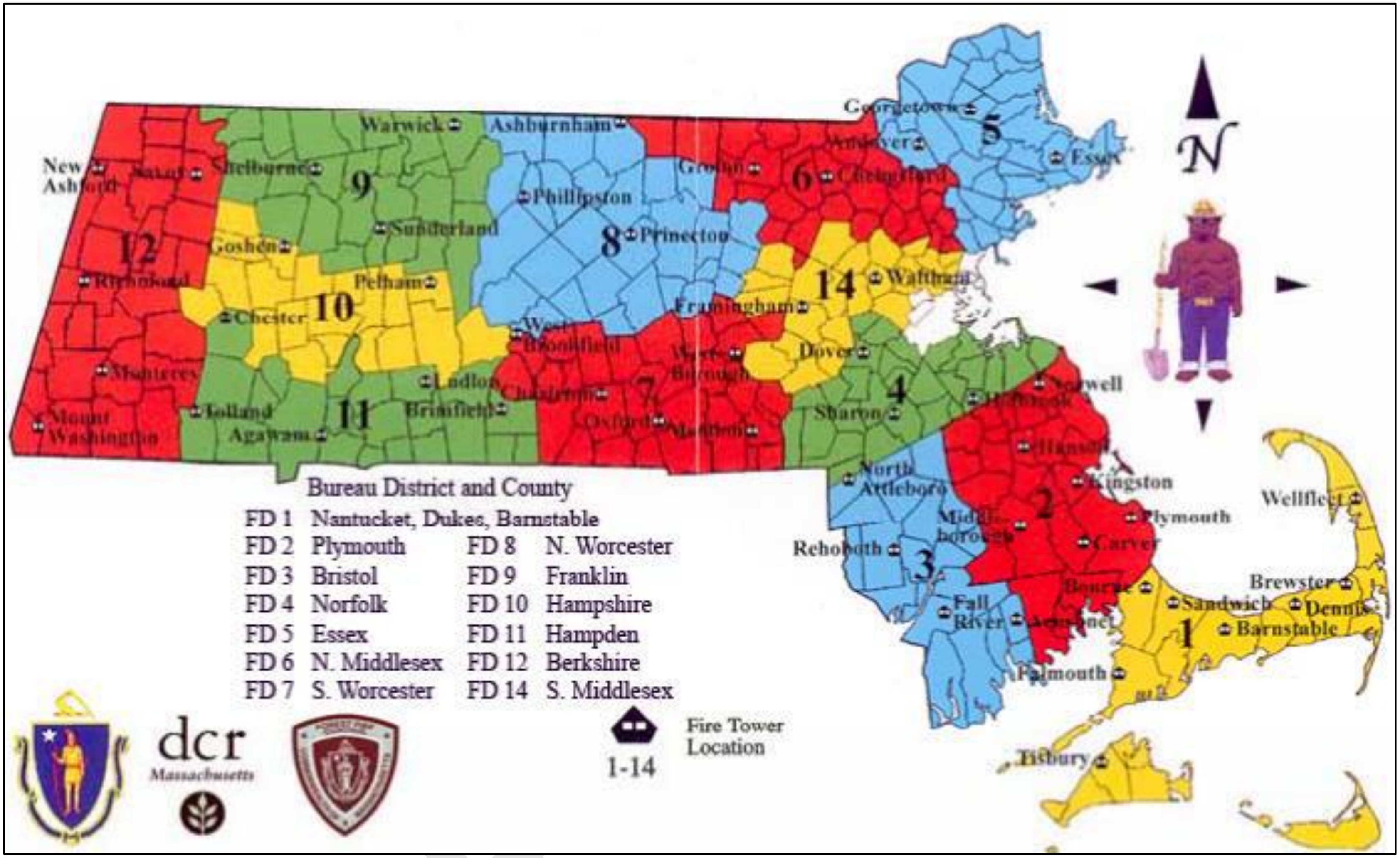
Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan. September 2018

Figure 3-15: Wildfire Risk Areas for the Commonwealth of Massachusetts



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

Figure 3-16: Massachusetts Bureau of Forest Fire Control Districts and Tower Network



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

Extent

The National Wildfire Coordinating Group defines seven classes of wildfires:

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

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

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

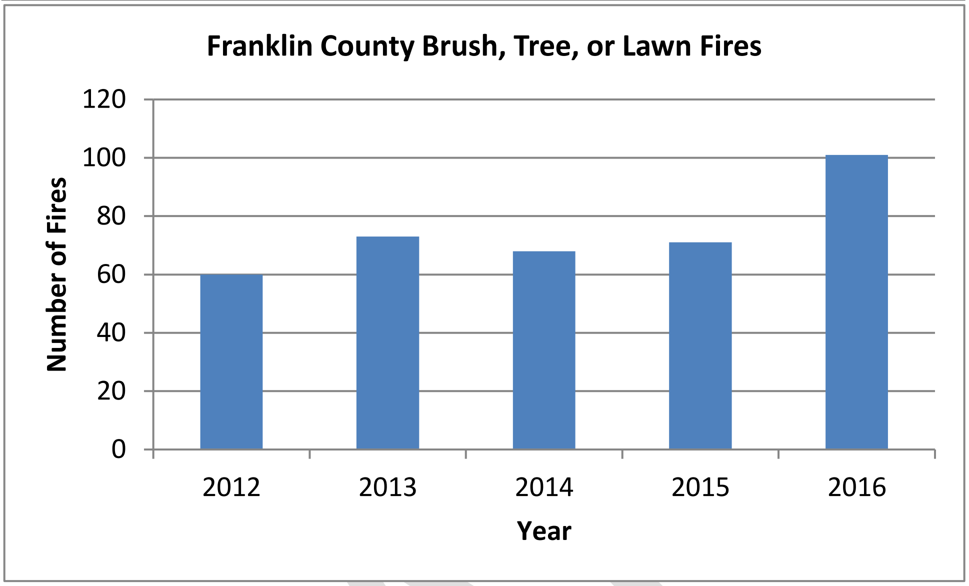
Previous Occurrences

In the last five years (2012 – 2016) Franklin County has averaged 75 brush, tree, or lawn fires a year, with the highest reported number of fires occurring in 2016 (Figure 3-17). During 2016,

[27] (NPS, n.d.).

Franklin County and Massachusetts experienced one of the worst droughts in the last 50 years.

Figure 3-17: Outdoor Vegetation Fires in Franklin County 2012 - 2016



Source: Massachusetts Fire Incident Reporting System County Profiles.

Buckland is heavily forested and therefore vulnerable to wildfires. A wildfire approximately 15 years ago burned 16 acres on East Buckland Road in town. An abnormally dry spring that year raised wildfire risk across the area. Firefighting resources were depleted because departments were fighting brush fires throughout the region.

Probability of Future Events

It is difficult to predict the likelihood of wildfires in a probabilistic manner because a number of factors affect fire potential and because some conditions (e.g., ongoing land use development patterns, location, and fuel sources) exert changing pressure on the wildland-urban interface zone. However, based on the frequency of past occurrences, Buckland has a “Moderate” probability (2% to 25% chance) that it will experience a wildfire in a given year.

Impact

Unfragmented and heavily forested areas of Buckland are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. The greatest impact in Buckland from a wildfire is to the natural environment. Overall, the impact on Buckland from a wildfire is likely "limited," with more than 10% of property in the affected area damaged or destroyed.

Vulnerability

Society

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

<u>Vulnerable Populations</u>

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

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

Table 3-31: Estimated Vulnerable Populations in Buckland		
Vulnerable Population Category	**Number**	**Percent of Total Population (1,927)**
Population Age 65 Years and Over	470	24%
Population with a Disability	216	11%

Table 3-31: Estimated Vulnerable Populations in Buckland		
Population who Speak English Less than "Very Well"	12	1%
Vulnerable Household Category	**Number**	**Percent of Total Households (873)**
Low Income Households (annual income less than $35,000)	291	33%
Householder Age 65 Years and Over Living Alone	139	16%
Households Without Access to a Vehicle	29	3%
Home Built Prior to 1975	550	59%
Living in a Mobile Home	17	2%

Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Health Impacts

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

Economic Impacts

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

Infrastructure

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

Table 3-32: Estimated Potential Loss by Tax Classification in Buckland

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$174,715,480	$1,747,155	$8,735,774	$17,471,548
Open Space	$0	$0	$0	$0
Commercial	$9,988,100	$99,881	$499,405	$998,810
Industrial	$22,786,300	$227,863	$1,139,315	$2,278,630
Total	**$207,489,880**	**$2,074,899**	**$10,374,494**	**$20,748,988**

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

Agriculture

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

Energy

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

Public Health

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

Public Safety

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

Transportation

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

Water Infrastructure

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

Environment

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

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

Vulnerability Summary

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

Wildfire Hazard Problem Statements
• Most residents in Buckland live within or adjacent to heavily forested areas.
• Areas adjacent to the freight rail line in Buckland are vulnerable to wildfire; sparks from passing trains have ignited fires in the past. Old rail ties stored next to the tracks pose a serious fire hazard.
• A lack of access to forested areas and water/manpower for firefighting purposes in rural Buckland is a concern.
• Most towns in the region rely on volunteer fire departments and mutual aid to assist in firefighting; during dry spells or drought, firefighting resources in Buckland and surrounding towns can be strained if multiple wildfires break out at the same time.
• Communication with some residents during emergencies can be challenging due to lack of landlines, cell and/or broadband coverage. Not all residents have signed up for Reverse 911.

3.9 EARTHQUAKES

Potential Impacts of Climate Change

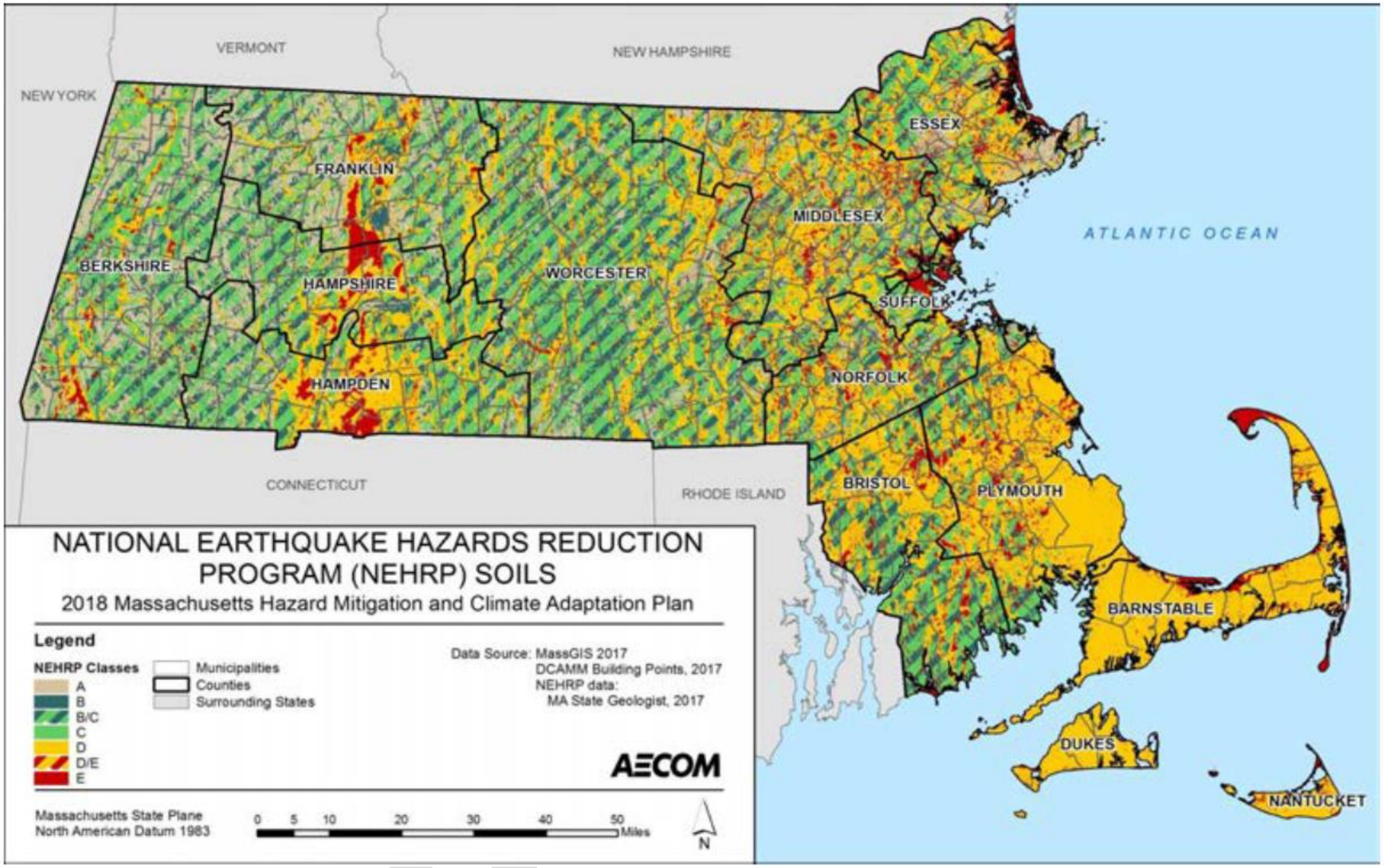
The State Hazard Mitigation and Climate Adaptation Plan does not identify any effects of climate change on the earthquake hazard in Massachusetts.

Hazard Description

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

Ground shaking is the primary cause of earthquake damage to man-made structures. This damage can be increased due to the fact that soft soils amplify ground shaking. A contributor to site amplification is the velocity at which the rock or soil transmits shear waves (S waves). The National Earthquake Hazards Reduction Program (NEHRP) developed five soil classifications, which are defined by their S-wave velocity, that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. These soil types are shown in Figure 3-14.

Figure 3-18: National Earthquake Hazards Reduction Program Soil Types in Massachusetts



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

Location

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

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

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

Extent

The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. The focal depth of an earthquake is the depth from the surface to the region where the earthquake's energy originates (the focus). Earthquakes with focal depths up to about 43.5 miles are classified as shallow. Earthquakes with focal depths of 43.5 to 186 miles are classified as intermediate. The focus of deep earthquakes may reach depths of more than 435 miles. The focus of most earthquakes is concentrated in the upper 20 miles of the Earth's crust. The depth to the Earth's core is about 3,960 miles, so even the deepest earthquakes originate in relatively shallow parts of the Earth's interior. The epicenter of an earthquake is the point on the Earth's surface directly above the focus.

[28] (USGS, 2012).

Seismic waves are the vibrations from earthquakes that travel through the Earth and are recorded on instruments called seismographs. The magnitude or extent of an earthquake is a measured value of the amplitude of the seismic waves. The Richter magnitude scale (Richter scale) was developed in 1932 as a mathematical device to compare the sizes of earthquakes. The Richter scale is the most widely known scale for measuring earthquake magnitude. It has no upper limit and is not used to express damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, can have the same magnitude as an earthquake in a remote area that causes no damage.

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

Table 3-33: Richter Scale Magnitudes and Effects

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

Source: US Federal Emergency Management Agency

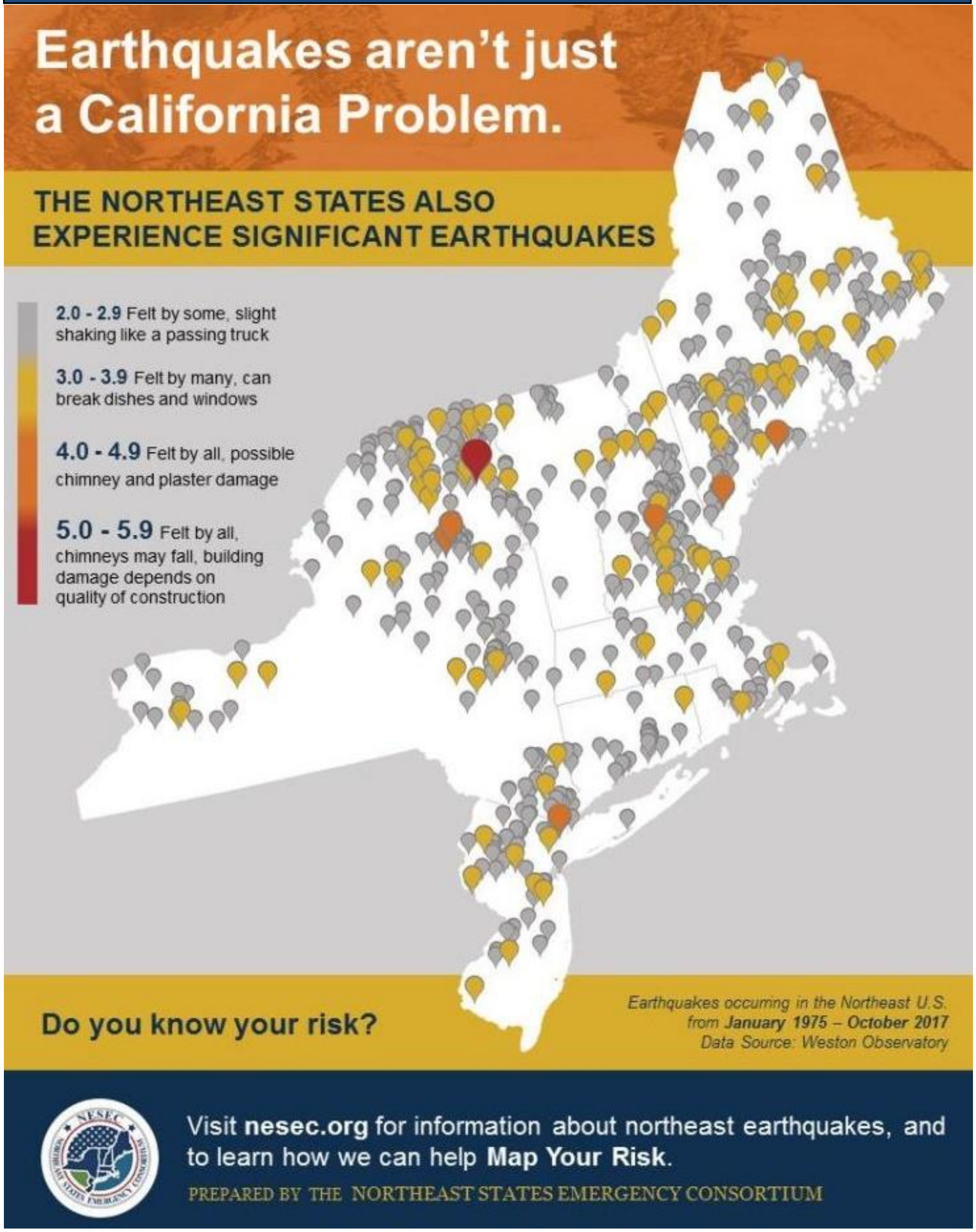
Table 3-34: Modified Mercalli Intensity Scale for and Effects			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
I	Instrumental	Detected only on seismographs.	
II	Feeble	Some people feel it.	< 4.2
III	Slight	Felt by people resting; like a truck rumbling by.	
IV	Moderate	Felt by people walking.	
V	Slightly Strong	Sleepers awake; church bells ring.	< 4.8
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves.	< 5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls.	< 6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged.	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open.	< 6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread.	< 7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards.	< 8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves.	> 8.1

Source: US Federal Emergency Management Agency

Previous Occurrences

Although it is well documented that the zone of greatest seismic activity in the U.S. is along the Pacific Coast in Alaska and California, in the New England area, an average of six earthquakes are felt each year (Figure 3-19). Damaging earthquakes have taken place historically in New England (Table 3-35). According to the Weston Observatory Earthquake Catalog, 6,470 earthquakes have occurred in New England and adjacent areas. However, only 35 of these events were considered significant. The most recent earthquakes in the region that could have affected the Town of Buckland are shown in Figure 3-19. There is no record of any damage to the Town of Buckland as a result of these earthquakes.

Figure 3-19: Earthquakes Occurring in the Northeast from 1975 - 2017



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

Table 3-35: Northeast States Record of Historic Earthquakes

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

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

Probability of Future Events

Earthquakes cannot be predicted and may occur at any time. However, a 1994 report by the USGS, based on a meeting of experts at the Massachusetts Institute of Technology, provides an overall probability of occurrence. Earthquakes above magnitude 5.0 have the potential for causing damage near their epicenters, and larger magnitude earthquakes have the potential for causing damage over larger areas. This report found that the probability of a magnitude 5.0 or greater earthquake centered somewhere in New England in a 10-year period is about 10 percent to 15 percent. This probability rises to about 41 percent to 56 percent for a 50-year period. The last earthquake with a magnitude above 5.0 that was centered in New England took place in the Ossipee Mountains of New Hampshire in 1940. Based on past events, Buckland has "Very Low" probability, or less than 1% chance in a given year, of being impacted by an earthquake.

Impact

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

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

Vulnerability

Society

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

Vulnerable Populations

The populations most vulnerable to an earthquake event include people over the age of 65 (24% of Buckland’s population) and those living below the poverty level (10.8% of Buckland’s population). These socially vulnerable populations are most susceptible, based on a number of factors, including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the inability to be self-sustaining after an incident due to a limited ability to stockpile supplies. Residents living in homes built prior to the 1970s when the State building code first went into effect, and residents living in mobile homes, are also more vulnerable to earthquakes. An estimated 550 housing units in Buckland, or 59% of all housing units in town, were built prior to the 1970s. An estimated 17 mobile homes are located in Buckland, accounting for 2% of the total housing stock.[29]

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risks for earthquakes. High-Hazard hydro-electric dams upstream of Shelburne include the Harriman Dam in Vermont, and the Bear Swamp Pumped Storage facility in Rowe. Dam release and dam failure were identified by Town officials

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

as a specific area of concern during the town's Municipal Vulnerability Preparedness Community Building Workshop in 2018, and is discussed in more detail in the Dam Failure section.

Health Impacts

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

Economic Impacts

Earthquakes also have impacts on the economy, including loss of business functions, damage to inventories, relocation costs, wage losses, and rental losses due to the repair or replacement of buildings. Lifeline-related losses include the direct repair cost for transportation and utility systems. Additionally, economic losses include the business interruption losses associated with the inability to operate a business due to the damage sustained during the earthquake as well as temporary living expenses for those displaced.

Infrastructure

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

Table 3-36: Estimated Potential Loss by Tax Classification in Buckland

Tax Classification	Total Assessed Value FY2019	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Residential	$174,715,480	$1,747,155	$8,735,774	$17,471,548
Open Space	$0	$0	$0	$0
Commercial	$9,988,100	$99,881	$499,405	$998,810
Industrial	$22,786,300	$227,863	$1,139,315	$2,278,630
Total	**$207,489,880**	**$2,074,899**	**$10,374,494**	**$20,748,988**

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

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

Agriculture

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

Energy

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

Public Health

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

Public Safety

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

Transportation

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

Water and Wastewater Infrastructure

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

Environment

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

Vulnerability Summary

Based on this analysis, Buckland has a "Medium" vulnerability to earthquakes. The following problem statements summarize Buckland’s areas of greatest concern regarding earthquakes.

Earthquake Hazard Problem Statements
• An estimated 59% of homes in Buckland were built prior to the first State building code in 1975, making them potentially more vulnerable to earthquakes. Mobile homes, making up 2% of homes in town, are also vulnerable.
• Buckland residents who rely on private wells for water are at risk during prolonged power outages.
• The designated emergency shelter at the Mohawk Trail Regional School is located within the dam inundation zone. An alternative shelter location outside of the dam inundation zone and that was constructed under current State building code seismic standards should be identified for use after an earthquake.
• The water main and sewer main that cross the Deerfield River are vulnerable to damage from an earthquake.
• There are areas of town where residents might become isolated if roads or bridges are damaged.
• Train derailment and the potential for hazardous material spills caused by an earthquake is a concern given the close proximity of the Deerfield River, Route 2, and homes to the rail line.
• Damage from an earthquake to the High Hazard dams upstream of Buckland is a major concern.
• Communication with some residents during emergencies can be challenging due to lack of landlines, cell and/or broadband coverage. Not all residents have signed up for Reverse 911.

3.10 DAM FAILURE

Potential Impacts of Climate Change

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

Hazard Description

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

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

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

Extent

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

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

- *High Hazard*: Dams located where failure or improper operation will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways, or railroads.
- *Significant Hazard*: Dams located where failure or improper operation may cause loss of life and damage to homes, industrial or commercial facilities, secondary highways or railroads or cause interruption of use or service of relatively important facilities.
- *Low Hazard*: Dams located where failure or improper operation may cause minimal property damage to others. Loss of life is not expected.

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

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

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

Location

According to the MA DCR Office of Dam Safety, there are eight dams located within Buckland, six of which are under the jurisdiction of the Federal Energy Regulatory Commission (FERC). The Deerfield #4 Dam and the Deerfield #3 Dam are owned by Great River Hydro and are categorized as high hazard. The Gardner Falls-Main Dam is categorized as a significant hazard dam, and the Gardner Falls Diversion is a low hazard dam. Both are owned by Hull Street Energy and operated by Ware River Hydro. The Great River Hydro Forebay #3, Forebay #4 and are all categorized as low hazard. The Hillman Ice Pond Dam is not FERC licensed and is categorized as a low hazard dam.

Of particular note are the upstream projects on the Deerfield River owned by Great River Hydro and Brookfield Power, and licensed by FERC. These projects include the Somerset Dam, the Harriman Dam, and the Sherman Dam, owner by Great River Hydro, and the Fife Brook Dam and the Bear Swamp Upper Reservoir, owned by Brookfield Power, all of which are classified as high hazard dams. The Emergency Action Plans for these projects include a series of inundation maps for each dam which illustrate potential flooding conditions for downstream areas including portions of Buckland and adjacent to the Deerfield and Connecticut rivers. A catastrophic failure of any one of these high hazard dams would likely result in the cascading failure of all the downstream dams (both high and low hazard dams), resulting in widespread flooding of downstream areas in a matter of hours.

For example, on a sunny day (no additional precipitation added to released water) or Probable Maximum Flood (worst case scenario) conditions, water from a catastrophic failure of the Harriman Dam would reach Route 112 in Buckland (31 miles from the dam) in roughly 2 hours. The dam inundation area, the area likely to flood from the failure of one or more High Hazard dams on the Deerfield River, is identified on the Critical Infrastructure and Facilities map. Inundation maps for the Harriman Dam extend from the dam downstream to Holyoke, roughly 86 miles away.

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

Put in simplest terms, if the Harriman Dam fails under worst case conditions, every dam downstream of it on the Deerfield River will most likely fail as the water released by the Harriman Dam reaches it. During such an event, the river is expected to rise approximately 72 feet, sending an estimated 675 million gallons of water rapidly downstream. This would occur with very little warning or preparation time. There would be the potential for incalculable property damage and significant loss of life in every town on the Deerfield River from Monroe to Holyoke. Therefore, emergency responders should review inundation areas and identify possible evacuation routes as well as familiarize themselves with the contents of the Harriman Dam Emergency Action Plan.

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

The 100-year flood plain covers about four percent, or roughly 551 acres of the town, including an estimated 32 acres of developed residential land. An inundation area due to dam failure would cover substantially more acreage. Emergency responders should review inundation areas and identify possible evacuation routes.

The Committee identified significant beaver dams in Buckland:

- Nilman Road: Beaver dam on Hog Hollow Brook with an approximate 10-acre impoundment.
- East Buckland Road: A breached beaver dam is located on the Clark Brook.
- Dodge Road: A breached beaver dam is located off Dodge Road.

Previous Occurrences

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

Probability of Future Events

Currently the frequency of dam failures is “Very Low” with a less than 1 percent chance of a dam failing in any given year.

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

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

Impact

A dam failure in Buckland is likely to have a catastrophic impact, with multiple deaths and injuries possible, more than 50% of property in the affected area damaged or destroyed, and a possible complete shutdown of facilities for 30 days or more.

Vulnerability

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

Society

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

In Buckland, areas most vulnerable to the impacts of a dam failure include: the northwestern end of Charlemont Road; Purinton Road, Dunbar Road, Depot Road, Ashfield Road (Route 112), and Woodward Road; and areas in the village along State Street and Conway Street. Critical facilities within the dam inundation area include bridges on Route 2, Mohawk Trail Regional School, which is also the identified emergency shelter for Buckland, Town Hall, the Fire Station, the Police Station, bridges over the Deerfield River, the water and sewer mains on the Bridge of Flowers and the Iron Bridge, and the wastewater treatment facility. Flooding from a High Hazard dam failure was identified as a key area of concern during the 2018 Municipal Vulnerability Preparedness Community Building workshop in Buckland.

Economic Impacts

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

Infrastructure

Structures that lie in the inundation area of each of the dams in Buckland are vulnerable to a dam failure. Buildings located within the floodplain are also vulnerable to dam failure in Buckland. Table 3-12 in the Flooding section provides the 2018 assessed building values for significant structures partially or completely located in the floodplain in Buckland. Together these buildings are valued at $24,188,400.

Environment

Examples of environmental impacts from a dam failure include:

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

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

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

Vulnerability Summary

Due to the presence of the High Hazard hydro-electric dams upstream of Buckland on the Deerfield River, a dam failure could have a catastrophic impact on portions of Buckland. However, the likelihood of a catastrophic dam failure is low. Overall, the Town has a "Medium" vulnerability from dam or levee failure.

Dam Failure Hazard Problem Statements
• A failure of one of the High Hazard dams on the Deerfield River would result in catastrophic flooding in Buckland and the village of Shelburne Falls. Residents would have less than 2 hours to evacuate.
• The owner of the High Hazard dams on the Deerfield River maintain an emergency notification flowchart to notify emergency officials of a dam failure; however, communication that is more robust is needed between owners of the dams and the Town. In addition, a public notification plan is needed for a High Hazard dam failure event, and education about what to do in the event of a High Hazard dam failure.
• Critical facilities, including Buckland's designated emergency shelter, the Mohawk Trail Regional School, and the Town Hall, Fire Station, Police Station, and wastewater treatment plant, are located within the High Hazard dam inundation area.
• The water main and sewer main that cross the Deerfield River are vulnerable to damage from a dam failure or dam release.
• Hazardous material spills from facilities or transportation routes, including the railroad and hazardous facilities upstream of Buckland within the dam inundation area, is a major concern.

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

3.11 DROUGHT

Potential Impacts of Climate Change

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

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

Figure 3-20: Impacts of Climate Change on Drought

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

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

Hazard Description

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

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

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

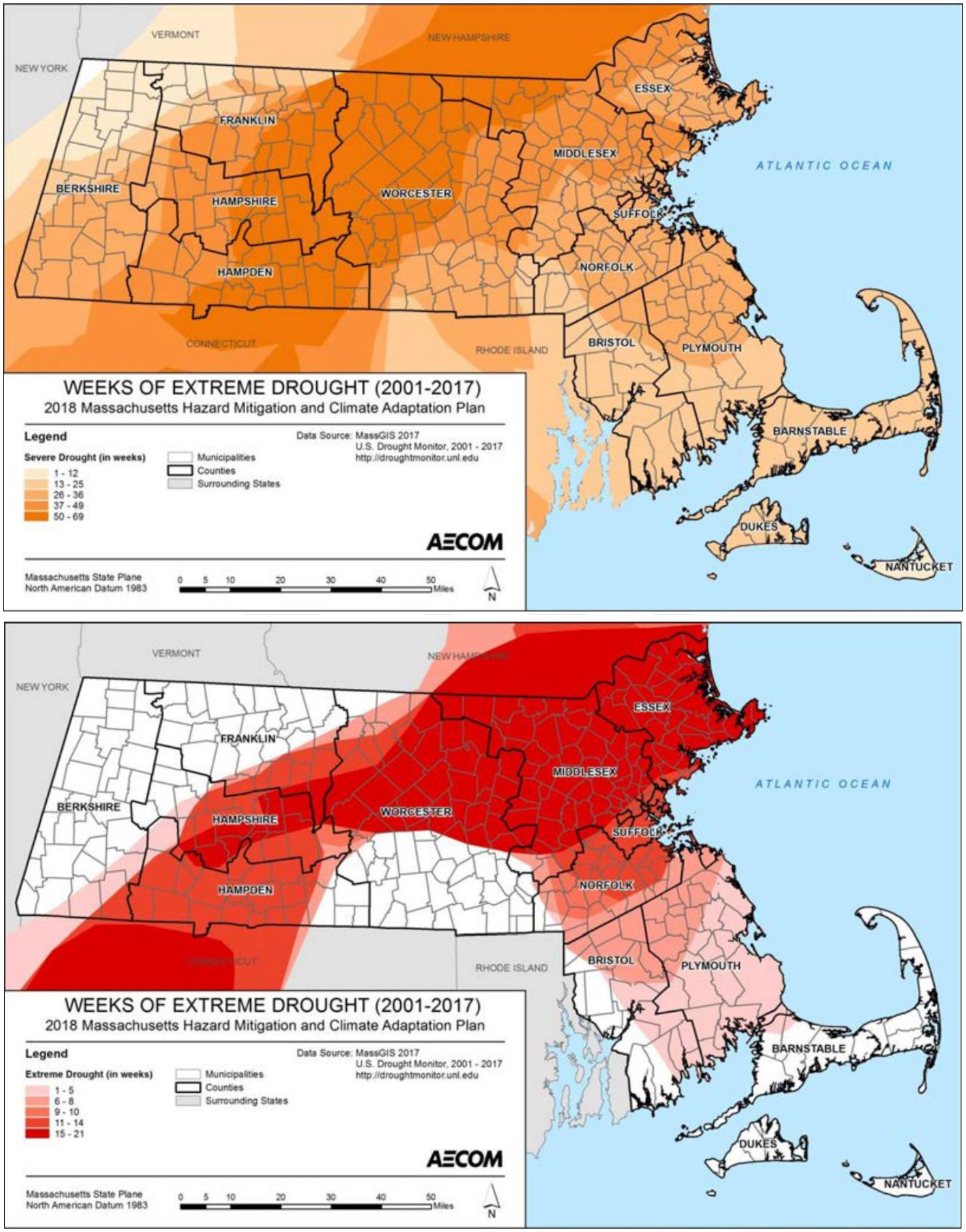
Highly urbanized areas with traditional stormwater drainage systems tend to result in higher peak flood levels during rainfall events and rapid decline of groundwater levels during periods of low precipitation. Thus, the hydrology in these areas becomes more extreme during floods and droughts.[32] The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

Location

Buckland falls just outside of a region in Massachusetts that is more prone to severe and extreme drought based on the number of weeks these areas experienced drought conditions from 2001-2017 (Figure 3-21). Because of this hazard’s regional nature, a drought would impact the entire town, resulting in a “large” location of occurrence, or more than 50 percent of total land area affected.

[32] ERG and Horsley Witten Group, 2017

Figure 3-21: Areas Experiencing Severe or Extreme Drought, 2001 - 2017



Source: U.S. Drought Monitor, 2017, as presented in the *2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan.*

Extent

The severity of a drought would determine the scale of the event and would vary among town residents depending on whether the residents' water supply is derived from a private well or the public water system. The majority of residents in the village of Shelburne Falls are served by the public water supply, which draws water from two wells located adjacent to the North River in Colrain. The remaining residents depend on private wells for water. Massachusetts' wells are permitted according to their ability to meet demand for 180 days at maximum capacity with no recharge; if these conditions extended beyond the thresholds that determine supply capacity the damage from a drought could be widespread due to depleted groundwater supplies.

The U.S. Drought Monitor categorizes drought on a D0-D4 scale as shown below.

Table 3-36: U.S. Drought Monitor		
Classification	**Category**	**Description**
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies

Source: U.S. Drought Monitor, as presented in the *2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan.*

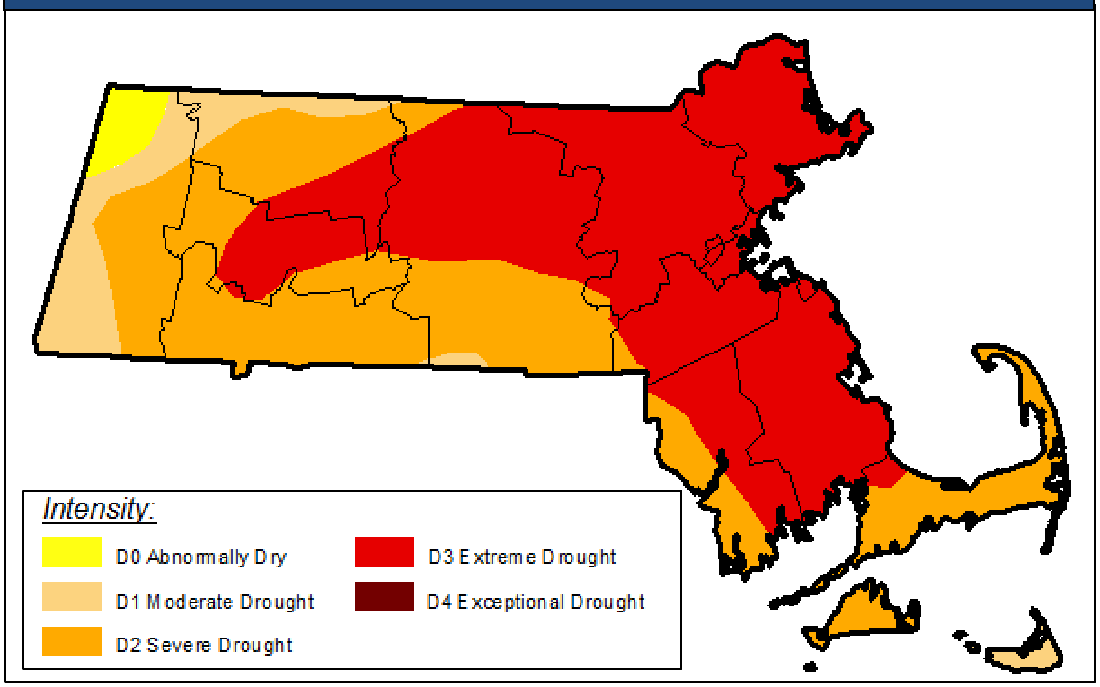
Previous Occurrences

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

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

By September 2016, 78% of Franklin County was categorized as "severe drought" (D2) or higher and 26% of the County was categorized as "extreme drought" (D3) (Figure 3-22).[33] By May 2017, the entire Commonwealth had returned to "normal" due to wetter-than-normal conditions in the spring of 2017.

Figure 3-22: Drought Conditions in Massachusetts on September 20, 2016



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

According to the Committee, during the 2016 drought, some private wells in town dried out, and people using springs for water were particularly vulnerable. Agricultural operations in town were impacted, and firefighting capabilities in the rural area of town was a concern due to low surface water levels. The public water supply was not affected by the drought, although the

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

Shelburne Falls Fire District is required to implement water restrictions when the North River falls below a certain level.

Probability of Future Events

According to the 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan, on a monthly basis over the 162-year period of record from 1850 to 2012, there is a 2% chance of being in a drought warning level. As noted previously, rising temperatures and changes in precipitation due to climate change could increase the frequency of episodic droughts, like the one experienced across the Commonwealth in the summer of 2016. In Buckland, the Committee identified the probability of future droughts as “High,” with a 25% - 50% chance of occurring in a given year.

Impact

Due to the water richness of western Massachusetts, Buckland is unlikely to be adversely affected by anything other than a major, extended drought. The major impact to residents would be private wells running dry or being contaminated du e to low water levels. Farmers could be impacted economically by the extended lack of water. Drought may increase the probability of a wildfire occurring. The prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly prone to ignition as long as the drought persists. As a result, the impact of a drought would be “limited” with the potential for more than 10% of property damage in the affected area.

Firefighting capabilities could be compromised in a drought if aquifers, fire ponds, or rivers used for pumping water are low. In particular, rural Buckland is more at risk during drought conditions, where the ability of the Fire Department to pump adequate water could be compromised.

Vulnerability

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

Society

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

Vulnerable Populations

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. Public water supplies (PWS) provide water for both of these services and may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The Massachusetts Department of Environmental Protection (DEP) requires all PWS to maintain an emergency preparedness plan. The Shelburne Falls Fire District serves residents and businesses in the Shelburne Falls area of Town. The District has two water storage tanks – one on the Buckland side of the village, and one on the Shelburne side - that provide up to 6 days of back-up water. The District is interested in establishing a second water source on the Buckland side of the Deerfield River, to provide additional back-up capacity and redundancy. Drought has not been a concern for the public water supply in the past.

Other parts of Buckland, or roughly 40% of residents, are served by private wells. Residential well owners are as vulnerable as their ability to find an alternate short- or long-term water supply (i.e. install a new well) or temporarily relocate in the event their well runs dry.

Health Impacts

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

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

Economic Impacts

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

Infrastructure

Agriculture

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

Water and Wastewater Infrastructure

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

Environment

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

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

[34] Clark et al., 2016

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

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

Vulnerability Summary

Based on the above assessment, Buckland has a "High" vulnerability to drought. While such a drought would require water saving measures to be implemented, there would be no foreseeable damage to structures or loss of life resulting from the hazard. The following problem statements summarize Buckland's areas of greatest concern regarding droughts.

Drought Hazard Problem Statements
• The Shelburne Falls Fire District is interested in establishing a new water supply source on the Buckland side of Shelburne Falls, which would provide additional back-up supply. Currently the District stores roughly 6 days of back-up water in two water tanks.
• Roughly 40% of Buckland residents are served by private wells or springs and are vulnerable to loss of drinking water during a severe drought.
• Buckland's forests make up approximately 81% of the town and are vulnerable to extended drought, which could also increase the risk to other hazards including wildfire and pests.
• A drought could compromise firefighting efforts, particularly in rural Buckland where the Fire Department relies on surface water resources.

3.12 LANDSLIDES

Potential Impacts of Climate Change

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

Figure 3-23: Impacts of Climate Change on Landslides

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

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

Hazard Description

The term landslide includes a wide range of ground movements, such as rock falls, deep failure of slopes, and shallow debris flows. The most common types of landslides in Massachusetts include translational debris slides, rotational slides, and debris flows. Most of these events are caused by a combination of unfavorable geologic conditions (silty clay or clay layers contained in glaciomarine, glaciolacustrine, or thick till deposits), steep slopes, and/or excessive wetness leading to excess pore pressures in the subsurface. Historical landslide data for the Commonwealth suggests that most landslides are preceded by two or more months of higher than normal precipitation, followed by a single, high-intensity rainfall of several inches or more.[35] This precipitation can cause slopes to become saturated.

Landslides associated with slope saturation occur predominantly in areas with steep slopes underlain by glacial till or bedrock. Bedrock is relatively impermeable relative to the unconsolidated material that overlies it. Similarly, glacial till is less permeable than the soil that forms above it. Thus, there is a permeability contrast between the overlying soil and the underlying, and less permeable, unweathered till and/or bedrock. Water accumulates on this less permeable layer, increasing the pore pressure at the interface. This interface becomes a plane of weakness. If conditions are favorable, failure will occur.[36]

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

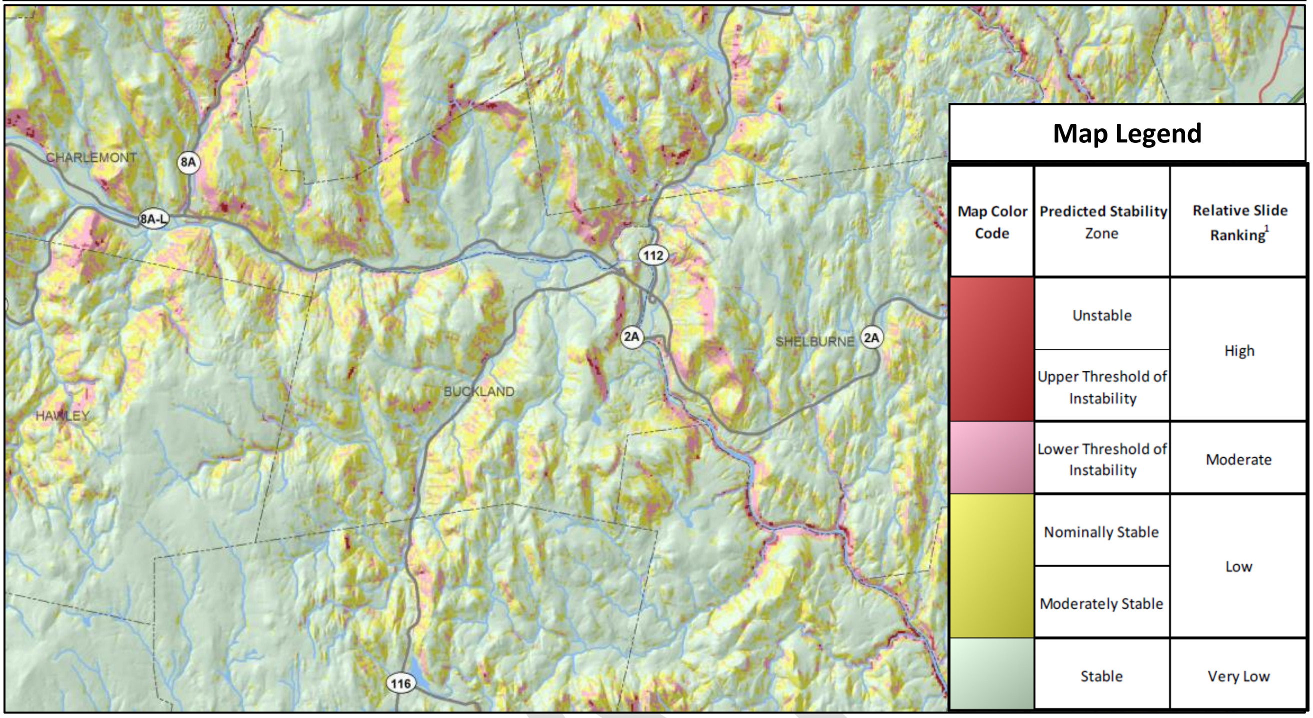
- vibrations from machinery or traffic;
- blasting;
- earthwork which alters the shape of a slope, or which imposes new loads on an existing slope;
- in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock; and
- construction, agricultural or forestry activities (logging)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

Location

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

[35] Mabee and Duncan, 2013
[36] Mabee, 2010

Figure 3-24: Slope Stability Map, Buckland and Surrounding Towns



Source: Massachusetts Geologic Survey and UMass Amherst, 2013

Buckland has areas in town with high and moderate landslide rankings. These areas are shown in Figure 3-24 and are mostly located along the steep ridges in town that run north-south. In particular, the slopes to the west of the village of Shelburne Falls are identified as having moderate to high landslide rankings. There are also slopes running along ridges in the northeast section of town with high and moderate landslide rankings.

In Buckland, no significant landslide issues were identified by the Committee. There is, however, potential for a landslide in the area behind North Street where houses back up against a steep hill and where there has been some minor landslide issues. Erosion is potentially an issue in Buckland along any stream or river corridor. Clesson Brook Road and Route 112 are vulnerable, and were impacted significantly during Tropical Storm Irene in 2011. During Irene, a portion of Route 112 caved in, damaging the road and telephone poles and resulting in loss of power. Situated near Clesson Brook, the Buckland Recreation Area and the riverbanks along Clesson Brook have been subject to erosion since Tropical Storm Irene. Also situated along Clesson Brook are working farms which lost valuable farmland soils to washouts and erosion during Irene. These areas continue to be at risk for erosion.

Extent

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

Previous Occurrences

No significant landslide events have been observed in Buckland. The Committee evaluated the potential area of occurrence to be isolated (less than 10% of the Town).

Probability of Future Events

In general, landslides are most likely during periods of higher than average rainfall. The ground must be saturated prior to the onset of a major storm for a significant landslide to occur. Increasing heavy precipitation events will increase the risk of landslides in Buckland. There is a "very low" probability, or less than 1% chance, of a landslide happening in the next year.

Impact

Homes located on lots with significant slopes (i.e., 10% or greater), or that are located at the bottom of steep slopes, are at greater risk of impacts from landslides. The impact of a landslide in Buckland would likely be "minor" with less than 10% of property in the affected area damaged or destroyed.

Vulnerability

Society

<u>Vulnerable Populations</u>

Populations who rely on potentially impacted roads for vital transportation needs are considered to be particularly vulnerable to this hazard. In Buckland, many residents may be vulnerable to landslides due to the fact that many homes are built on property below steep slopes, and also because Buckland has limited alternative routes for accessing homes if certain roads were blocked or damaged by a landslide.

Health Impacts

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.

Economic Impacts

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

Infrastructure

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

Agriculture

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.

Energy

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

Public Health

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

Public Safety

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

Transportation

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

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

Water and Wastewater Infrastructure

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

Environment

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

Vulnerability Summary

Based on the above assessment, Buckland has a hazard index rating of “Low” for landslides. The following problem statements summarize Buckland’s areas of greatest concern regarding landslides.

Landslide Hazard Problem Statements
• The steep slopes above the village of Shelburne Falls and along the north-south ridges in town are vulnerable to landslides, as identified on the Slope Stability Map.
• Erosion continues to be an issue along the Clesson Brook, impacting farmland, roads, and the Buckland Recreation Area.
• There are areas of town where residents might become isolated if roads or bridges are damaged or blocked from a landslide.
• A stretch of the Deerfield River upstream of the Gardner Falls Dam on the Shelburne side is prone to landslides and erosion.

3.13 EXTREME TEMPERATURES

Potential Impacts of Climate Change

Beyond the overall warming trend associated with global warming and climate change, Buckland will experience increasing days of extreme heat in the future. Generally, extreme heat is considered to be over 90 degrees Fahrenheit (°F), because at temperatures above that threshold, heat-related illnesses and mortality show a marked increase. The average summer across the Commonwealth during the years between 1971 and 2000 included 4 days over 90°F. Climate scientists project that by mid-century, the state could have a climate that resembles that of southern states today, with between 10-28 days over 90°F. By the end of the century, extreme heat could occur between 13-56 days during summer, depending on how successful we are in reducing greenhouse gas emissions.[37]

Figure 3-25: Impacts of Climate Change on Extreme Temperatures

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

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

Hazard Description

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

Massachusetts has four seasons with several defining factors, and temperature is one of the most significant. Extreme temperatures can be defined as those that are far outside the normal

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

ranges. The average highs and lows of the hottest and coolest months in Franklin County (using Greenfield data as a proxy) are provided in Table 3-37.

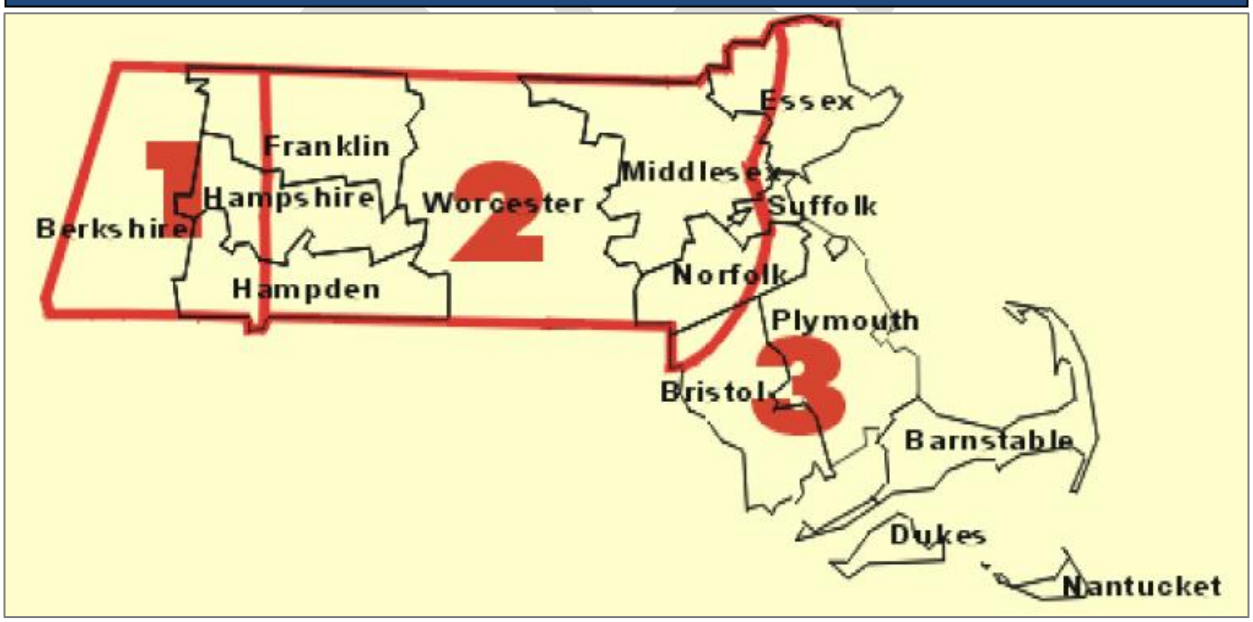
Table 3-37: Annual Average High and Low Temperatures (Greenfield)		
	July (Hottest Month)	**January (Coldest Month)**
Average High (°F)	81°	33°
Average Low (°F)	57°	12°

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

Location

According to the NOAA, Massachusetts is made up of three climate divisions: Western, Central, and Coastal, as shown in Figure 3-26. Average annual temperatures vary slightly over the divisions, with annual average temperatures of around 46°F in the Western division (area labeled “1” in the figure), 49°F in the Central division (area labeled “2” in the figure) and 50°F in the Coastal division (area labeled “3” in the figure). Buckland falls between the Central and Western climate division.

Figure 3-26: Climate Divisions in Massachusetts



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

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

Extent

The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop. The National Weather Service (NWS) issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to –15°F to –24°F for at least three hours, based on sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to –25°F or colder for at least three hours. On November 1, 2001, the NWS implemented a Wind Chill Temperature Index designed to more accurately calculate how cold air feels on human skin. Figure 3-27 shows the Wind Chill Temperature Index.

Figure 3-27: National Weather Service Wind Chill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

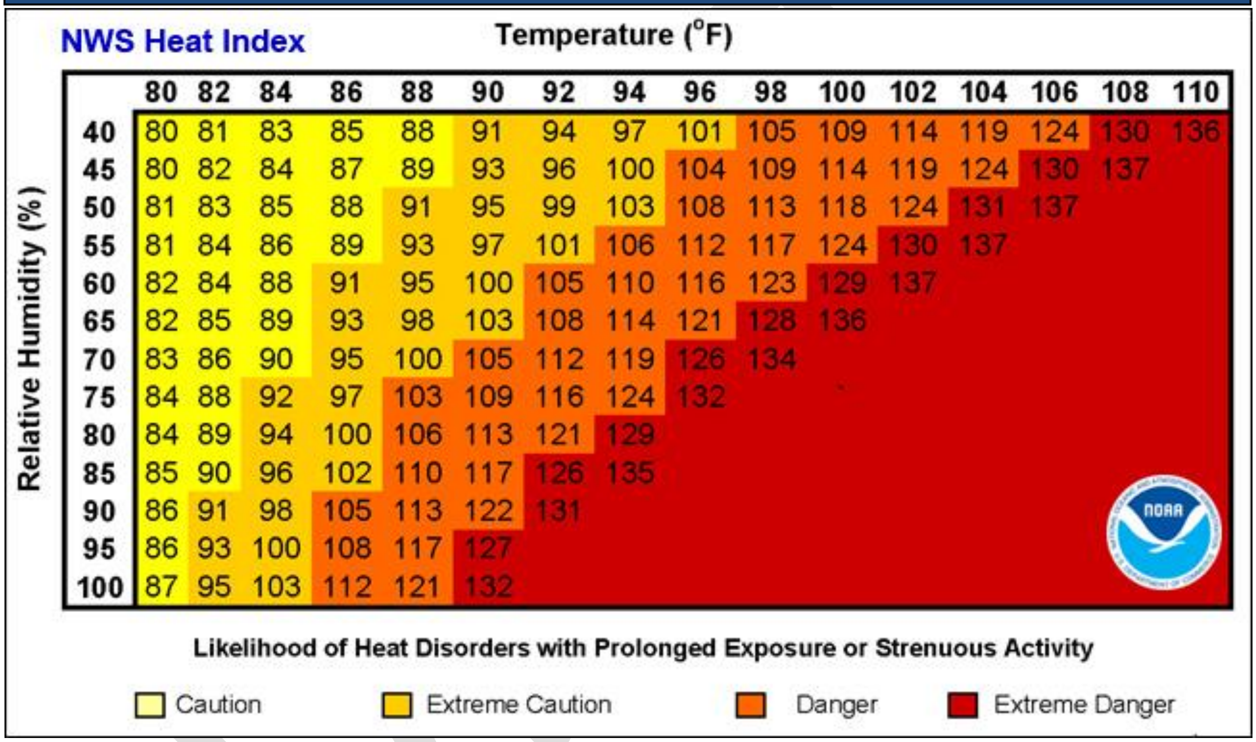
$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T = Air Temperature (°F) V = Wind Speed (mph) *Effective 11/01/01*

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

The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for two or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for two or more hours. The NWS Heat Index is based both on temperature and relative humidity, and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a person to lose heat to their environment. The relationship between these variables and the levels at which the NWS considers various health hazards to become relevant are shown in Figure 3-28. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. In addition, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts.

Figure 3-28: National Weather Service Heat Index


NWS Heat Index

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution Extreme Caution Danger Extreme Danger

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

Previous Occurrences

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

In February 2015, a series of snowstorms piled nearly 60 inches on the city of Boston in 3 weeks and caused recurrent blizzards across eastern Massachusetts. While Buckland and western Massachusetts was not impacted as much from the snow, temperature gauges across the

Commonwealth measured extreme cold, with wind chills as low as -31°F. Wind chills as low as 28 below zero were recorded at the Orange Municipal Airport.

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

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

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

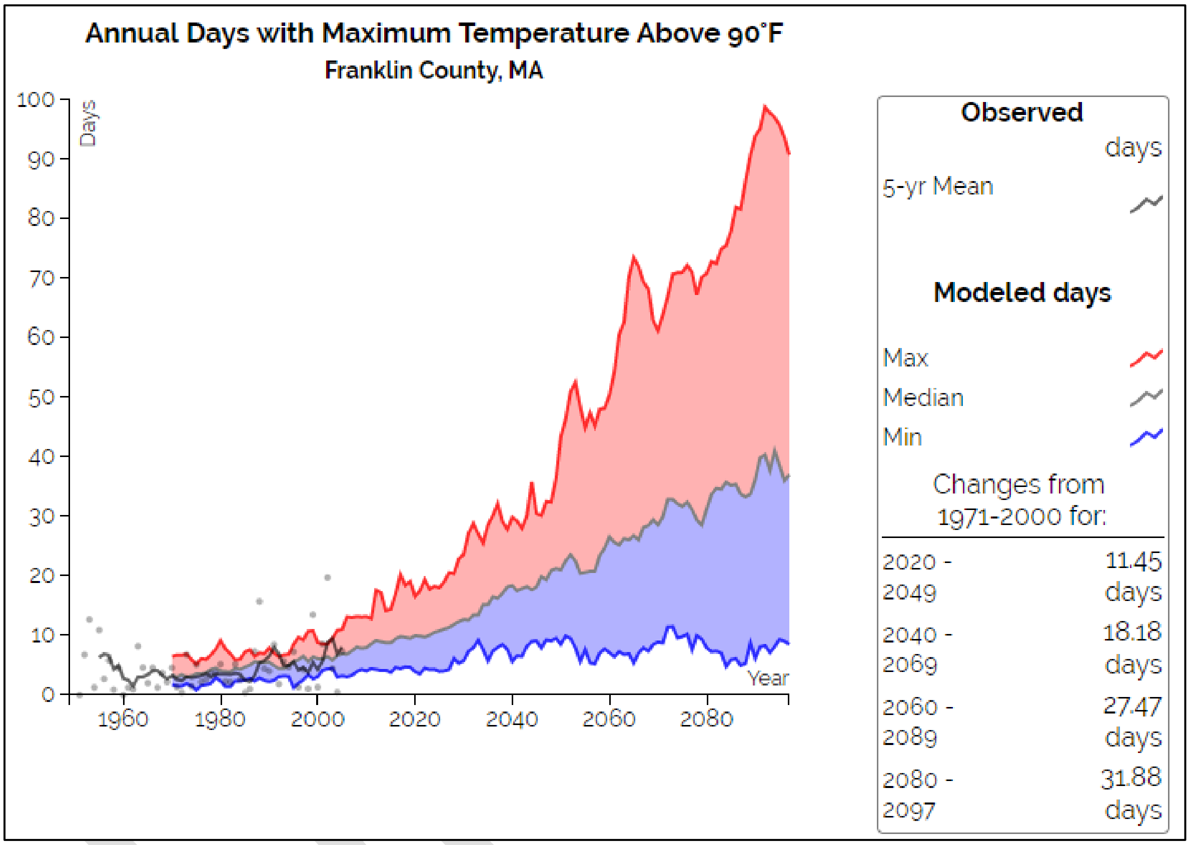
Probability of Future Events

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

The average, maximum, and minimum temperatures in Franklin County are likely to increase significantly over the next century (resilient MA, 2018). This gradual change will put long-term stress on a variety of social and natural systems, and will exacerbate the influence of discrete events. Significant increases in maximum temperatures are anticipated, particularly under a higher GHG emissions scenario. Figure 3-29 displays the projected increase in the number of days per year over 90°F. The number of days per year with daily maximum temperatures over

90°F is projected to increase by 18 days by the 2050s, and by 32 days by the end of the century (for a total of 36 days over 90°F), compared to the average observed range from 1971 to 2000 of 4 days per year. Under a high emissions scenario, however, there could be as many as 100 days with a maximum temperature above 90°F by the end of the century.

Figure 3-29: Projected Annual Days with a Maximum Temperature Above 90°F



Source: resilient MA, 2018.

Impact

Extreme Cold

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

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

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

Extreme Heat

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

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

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

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

Society

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

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

Table 3-38 estimates the number of vulnerable populations and households in Buckland. Individuals and households may fall into multiple categories, so the numbers should not be added. Rather, the table provides Town officials and emergency response personnel with information to help plan for responding to the needs of Buckland residents during an extreme temperature event.

Table 3-38: Estimated Vulnerable Populations in Buckland		
Vulnerable Population Category	**Number**	**Percent of Total Population (1,927)**
Population Age 65 Years and Over	470	24%
Population with a Disability	216	11%
Population who Speak English Less than "Very Well"	12	1%
Vulnerable Household Category	**Number**	**Percent of Total Households (873)**

Table 3-38: Estimated Vulnerable Populations in Buckland		
Low Income Households (annual income less than $35,000)	291	33%
Householder Age 65 Years and Over Living Alone	139	16%
Households Without Access to a Vehicle	29	3%
Home Built Prior to 1975	550	59%
Living in a Mobile Home	17	2%

Note: Individuals and households may be counted under multiple categories.
Source: U.S. Census American Community Survey 2013-2017 Five-Year Estimates.

Health Impacts

When people are exposed to extreme heat, they can suffer from potentially deadly illnesses, such as heat exhaustion and heat stroke. Heat is the leading weather-related killer in the U.S., even though most heat-related deaths are preventable through outreach and intervention. A study of heat-related deaths across Massachusetts estimated that when the temperature rises above the 85th percentile (hot: 85-86°F), 90th percentile (very hot: 87-89°F) and 95th percentile (extremely hot: 89-92°F) there are between five and seven excess deaths per day in Massachusetts. These estimates were higher for communities with high percentages of African American residents and elderly residents on days exceeding the 85th percentile.[38] A 2013 study of heart disease patients in Worcester, MA, found that extreme heat (high temperature greater than the 95th percentile) in the 2 days before a heart attack resulted in an estimated 44 percent increase in mortality. Living in poverty appeared to increase this effect.[39] In 2015, researchers analyzed Medicare records for adults over the age of 65 who were living in New England from 2000 to 2008. They found that a rise in summer mean temperatures of 1°C resulted in a 1 percent rise in the mortality rate due to an increase in the number and intensity of heat events.[40]

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

[38] Hattis et al., 2011)
[39] Madrigano et al., 2013
[40] (Shi et al., 2015).

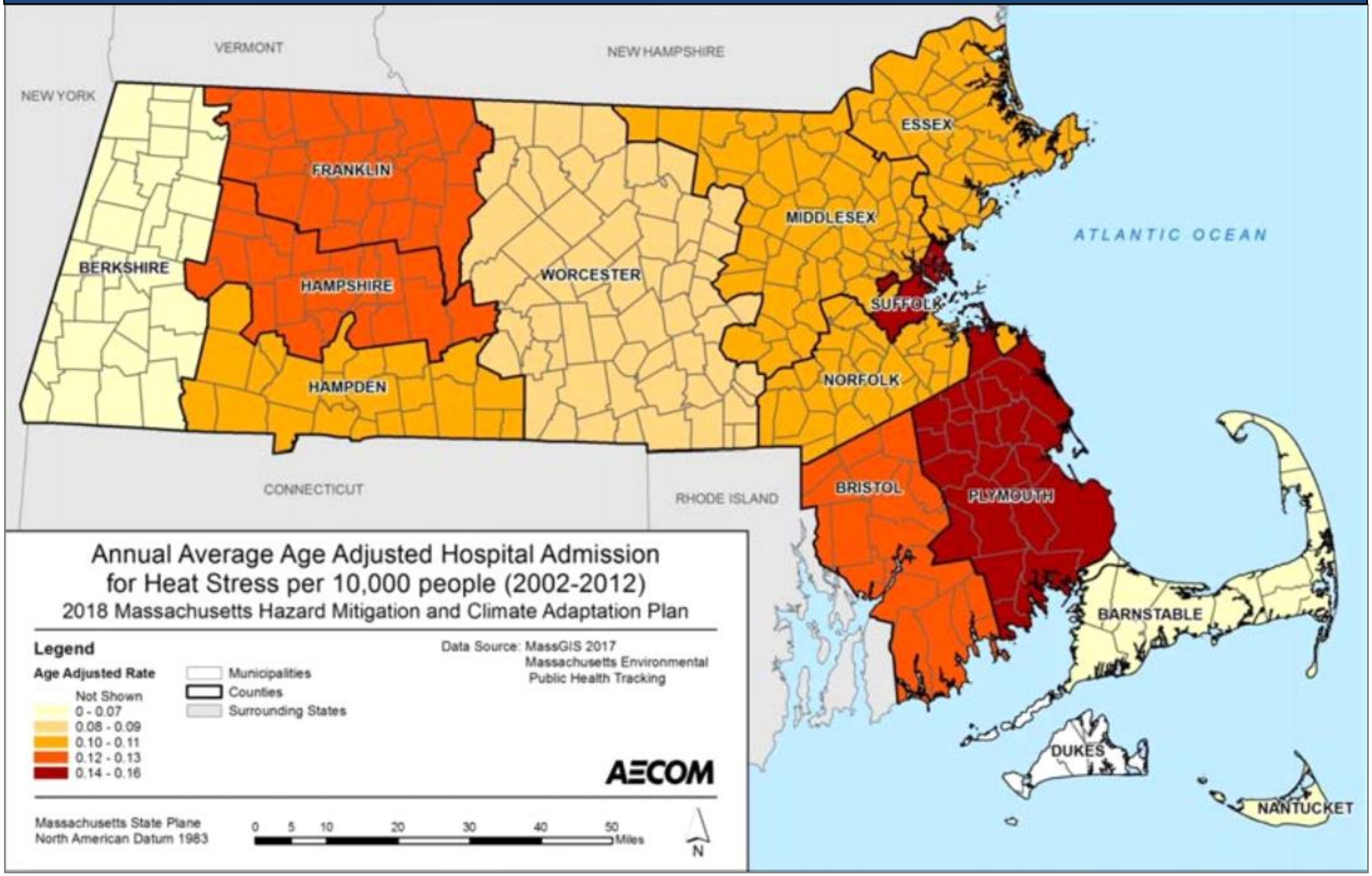
Massachusetts has a very high prevalence of asthma: approximately 1 out of every 11 people in the state currently has asthma. In Massachusetts, poor air quality often accompanies heat events, as increased heat increases the conversion of ozone precursors in fossil fuel combustion emissions to ozone. Particulate pollution may also accompany hot weather, as the weather patterns that bring heat waves to the region may carry pollution from other areas of the continent. Poor air quality can negatively affect respiratory and cardiovascular systems, and can exacerbate asthma and trigger heart attacks.

The rate of hospital admissions for heat stress under existing conditions is shown in Figure 3-30. Between 2002 and 2012, the annual average age-adjusted rate of hospital admission for heat stress was highest in Plymouth and Suffolk Counties. Franklin County ranked among the second highest rate of 0.12-0.13 admissions per 10,000 people. As displayed in Figure 3-31, Franklin County experienced the highest annual average age-adjusted hospital admissions for heart attacks (4.29 to 4.17 per 10,000 people) during this period, along with Plymouth, Bristol, and Berkshire Counties. Hamden County had the highest annual average age emergency department visits due to asthma (see Figure 3-32), while Franklin County's rate was statistically significantly lower.

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

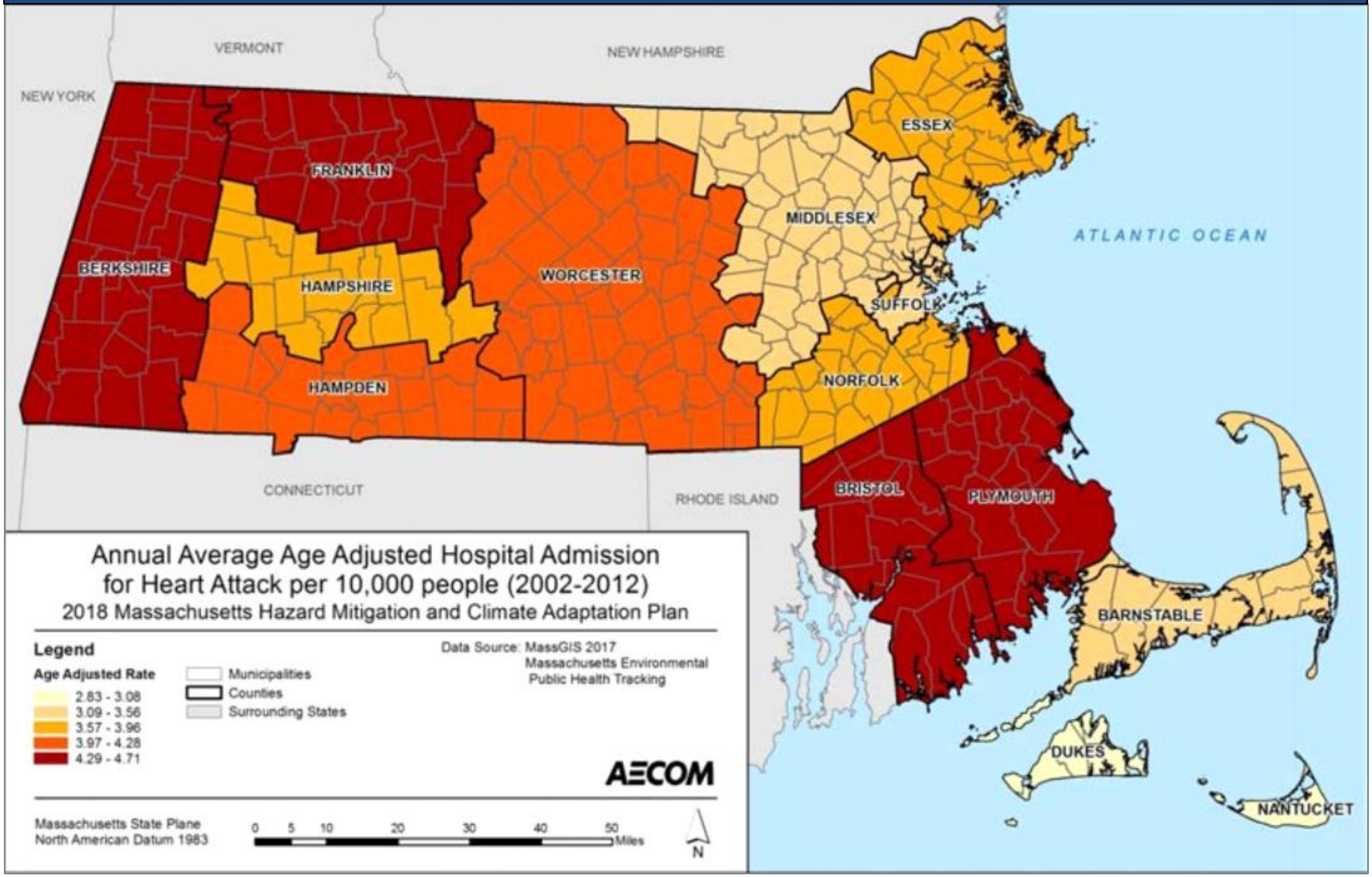
Cold-weather events can also have significant health impacts. The most immediate of these impacts are cold-related injuries, such as frostbite and hypothermia, which can become fatal if exposure to cold temperatures is prolonged. Similar to the impacts of hot weather that have already been described,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

Figure 3-30: Rates of Heat Stress-Related Hospitalization by County



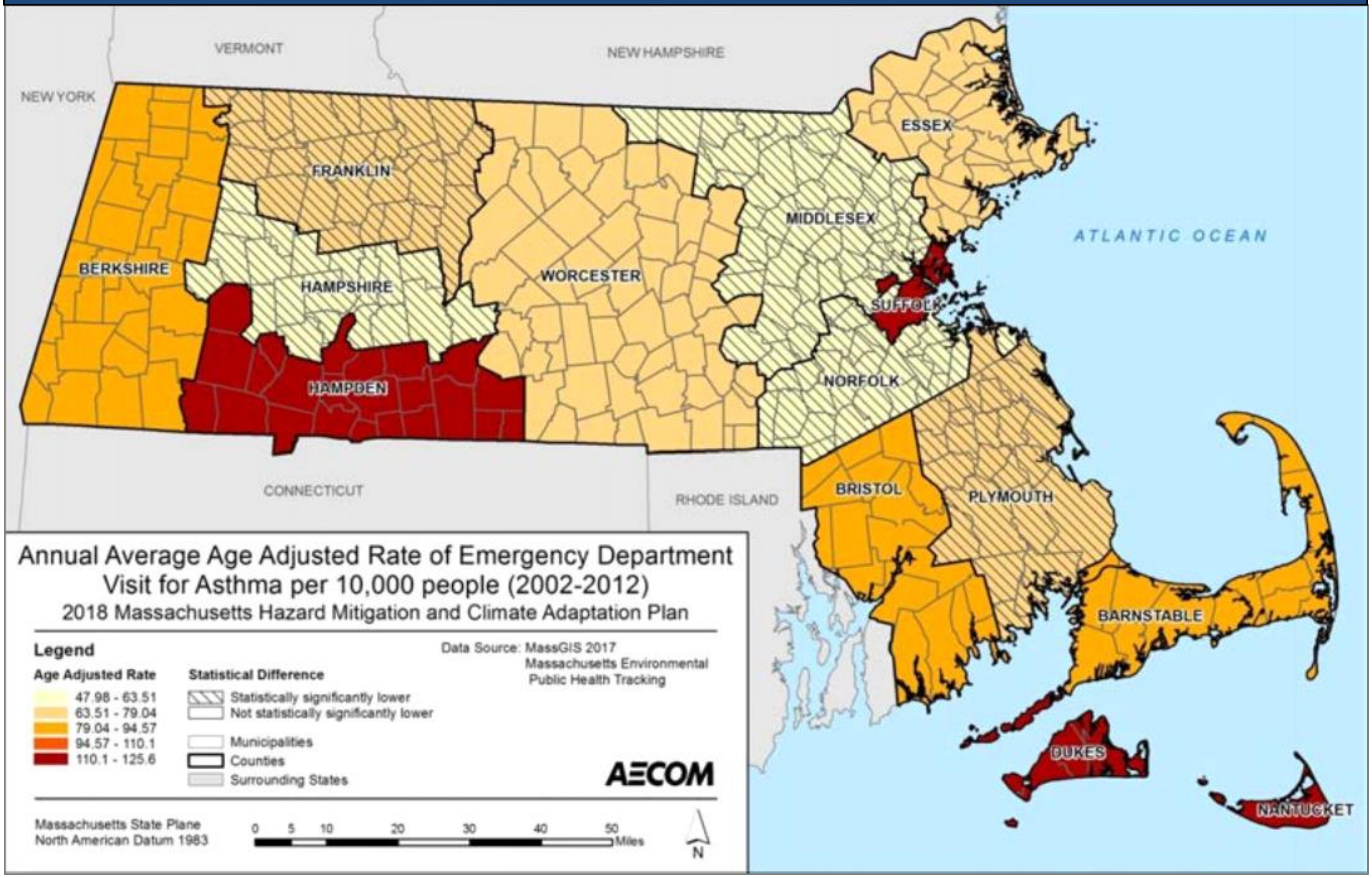
Source: Massachusetts Hazard Mitigation and Climate Adaptation Plan, September 2018.

Figure 3-31: Rates of Hospital Admissions for Heart Attacks by County



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

Figure 3-32: Rates of Emergency Department Visits Due to Asthma by County



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

<u>Economic Impacts</u>

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

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

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

Infrastructure

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

Agriculture

Above average, below average, and extreme temperatures are likely to impact crops—such as apples, peaches, and maple syrup—that rely on specific temperature regimes. Unseasonably warm temperatures in early spring that are followed by freezing temperatures can result in crop loss of fruit-bearing trees. Increasing heat stress days (above 90°F) may stress livestock and some crops. More pest pressure from insects, diseases and weeds may harm crops and cause farms to increase pesticide use. Farmers may have the opportunity to introduce new crops that are viable under warmer conditions and longer growing seasons; however, a transition such as this may be costly.[41]

Energy

In addition to increasing demand for heating and cooling, periods of both hot and cold weather can stress energy infrastructure. Electricity consumption during summer may reach three times the average consumption rate of the period between 1960 and 2000; more than 25 percent of this consumption may be attributable to climate change.[42] In addition to affecting consumption rates, high temperatures can also reduce the thermal efficiency of electricity generation.

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

Transportation

Extreme heat has potential impacts on the design and operation of the transportation system. Impacts on the design include the instability of materials, particularly pavement, exposed to high temperatures over longer periods of time, which can cause buckling and lead to increased failures.[43] High heat can cause pavement to soften and expand, creating ruts, potholes, and jarring, and placing additional stress on bridge joints. Extreme heat may cause heat stress in materials such as asphalt and increase the frequency of repairs and replacements. Roads are also vulnerable to rapid freeze and thaw cycles, which may cause damage to road surfaces. An increase in freeze and thaw cycles can also damage bridge expansion joints.[44]

Railroad tracks can expand in extreme heat, causing the track to "kink" and derail trains. Higher

[41] Resilient MA: http://resilientma.org/sectors/agriculture. Accessed March 4, 2019.
[42] EOEEA, 2011
[43] MassDOT, 2017
[44] Resilient MA: http://resilientma.org/sectors/transportation. Accessed March 4, 2019.

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

Operations are vulnerable to heat waves and associated power outages that affect electrical power supply to rail operations and to supporting ancillary assets for highway operations, such as electronic signing. Increased heat also impacts transportation workers, the viability of vegetation in rights-of-way, and vehicle washing or maintenance schedules.[45] Hot weather increases the likelihood that cars may overheat during hot weather, and also increases the deterioration rate of tires.

Water Infrastructure

Extreme temperatures do not pose as great a threat to water infrastructure as flood-related hazards, but changes in temperature can impact water infrastructure. For example, extreme heat that drives increases in air-conditioning demand can trigger power outages that disrupt water and wastewater treatment.[46] Hotter temperatures will also likely result in increased outdoor water consumption. Combined with other climate impacts such as an increase in surface water evapotranspiration, changing precipitation patterns, and groundwater recharge rates, increased water demand may challenge the capacity of water supplies and providers. Extreme heat can damage aboveground infrastructure such as tanks, reservoirs, and pump stations. Warmer temperatures can also lead to corrosion, water main breaks, and inflow and infiltration into water supplies.[47] Extreme heat is likely to result in increased drought conditions, and this has significant implications for water infrastructure, as discussed in the Drought Section.

Extreme cold can freeze pipes, causing them to burst. This can then lead to flooding and mold inside buildings when frozen pipes thaw.

Environment

There are numerous ways in which changing temperatures will impact the natural environment.

45 MassDOT, 2017

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

47 (Jha and Pathak, 2016).

Because the species that exist in a given area have adapted to survive within a specific temperature range, extreme temperature events can place significant stress both on individual species and the ecosystems in which they function. High-elevation spruce-fir forests, forested boreal swamp, and higher-elevation northern hardwoods are likely to be highly vulnerable to climate change. Higher summer temperatures will disrupt wetland hydrology. Paired with a higher incidence and severity of droughts, high temperatures and evapotranspiration rates could lead to habitat loss and wetlands drying out.[48] Individual extreme weather events usually have a limited long-term impact on natural systems, although unusual frost events occurring after plants begin to bloom in the spring can cause significant damage. However, the impact on natural resources of changing average temperatures and the changing frequency of extreme climate events is likely to be massive and widespread.

One significant impact of increasing temperatures may be the northern migration of plants and animals. Over time, shifting habitat may result in a geographic mismatch between the location of conservation land and the location of critical habitats and species the conserved land was designed to protect. One specific way in which average temperatures influence plant behavior is through changes in phenology, the pattern of seasonal life events in plants and animals. A recent study by the National Park Service found that of 276 parks studied, three-quarters are experiencing earlier spring conditions, as defined by the first greening of trees and first bloom of flowers, and half are experiencing an “extreme” early spring that exceeds 95% of historical conditions.[49] These changing seasonal cues can lead to ecological mismatches, as plants and animals that rely on each other for ecosystem services become “out of sync.” For example, migratory birds that rely on specific food sources at specific times may reach their destinations before or after the species they feed on arrive or are in season. Additionally, invasive species tend to have more flexible phenologies than their native counterparts; therefore, shifting seasons may increase the competitiveness of present and introduced invasive species.

Wild plants and animals are also migrating away from their current habitats in search of the cooler temperatures to which they are accustomed. This is particularly pertinent for ecosystems that (like many in the northeastern U.S.) lie on the border between two biome types. For example, an examination of the Green Mountains of Vermont found a 299- to 390-foot upslope shift in the boundary between northern hardwoods and boreal forests between 1964 and 2004.[50] Such a shift is hugely significant for the species that live in this ecosystem as well as for forestry companies or others who rely on the continued presence of these natural resources. Massachusetts ecosystems that are expected to be particularly vulnerable to

[48] (MCCS and DFW, 2010).
[49] (NPS, 2016).
[50] USGRP, 2014

warming temperatures include:

- Coldwater streams and fisheries
- Vernal pools
- Spruce-fir forests
- Northern hardwood (Maple-Beech-Birch) forests, which are economically important due to their role in sugar production
- Hemlock forests, particularly those with the hemlock wooly adelgid
- Urban forests, which will experience extra impacts due to the urban heat island effect

Additional impacts of warming temperatures include the increased survival and grazing damage of white-tailed deer, increased invasion rates of invasive plants, and increased survival and productivity of insect pests, which cause damage to forests.[51] As temperature increases, the length of the growing season will also increase.

Vulnerability Summary

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

Extreme Temperature Hazard Problem Statements
• Buckland does not have a formal plan for opening a warming or cooling center during extreme temperature events.
• The public water and sewer infrastructure is vulnerable to extreme cold, which has caused pipes to burst in the past.
• Extreme temperature changes during spring and fall can negatively affect crops.
• The potential for extreme heat to cause a train derailment and possible hazardous material spill is a concern given the close proximity of the Deerfield River, Route 2, and homes to the rail line.

[51] MCCS and DFW, 2010)

3.14 INVASIVE SPECIES

Potential Impacts of Climate Change

A warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. This northward trend is already well documented, and is expected to accelerate in the future. Another way in which climate change may increase the frequency of natural species threat is through the possibility of climate refugees. As populations move to escape increasingly inhospitable climates, they are likely to bring along products, food, and livestock that could introduce novel (and potentially invasive) species to the areas in which they settle.

Extreme winter temperatures are also critical limiting factors for many forest pests, and warming is expected to increase their survival and lead to expansions and outbreaks. For example, in Massachusetts, it's likely that winter temperatures have been limiting the impact of hemlock wooly adelgid (Adelges tsugae), as many infested forest stands are surviving while in more southerly ranges there is near complete mortality from this pest. But the adelgid has already expanded its range with warming winter temperatures and is likely to have increased survival and higher reproductive rates in the northern portion of its range as temperatures warm, likely leading to more significant impacts on forests.[52]

Figure 3-33: Impacts of Climate Change on Invasive Species

Potential Effects of Climate Change		
	RISING TEMPERATURES ➔ WARMING CLIMATE	A warming climate may place stress on colder-weather species, while allowing non-native species accustomed to warmer climates to spread northward.
	RISING TEMPERATURES AND CHANGES IN PRECIPITATION ➔ ECOSYSTEM STRESS	Changes in precipitation and temperature combine to create new stresses for Massachusetts' unique ecosystems. For example, intense rainfall in urbanized areas can cause pollutants on roads and parking lots to get washed into nearby rivers and lakes, reducing habitat quality. As rainfall and snowfall patterns change, certain habitats and species that have specific physiological requirements may be affected. The stresses experienced by native ecosystems as a result of these changes may increase the chances of a successful invasion of non-native species.

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

Hazard Description

"Invasives" are species recently introduced to new ecosystems that cause or are likely to cause

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

significant harm to the environment, economy, or human health. Invasives compete with native plants and wildlife for resources, disrupt beneficial relationships, spread disease, cause direct mortality, and can significantly alter ecosystem function. Some of the more common invasives in Massachusetts may already be familiar - problematic invasive plants include purple loosestrife (Lythrum salicaria), Japanese barberry (Berberis thunbergi), glossy buckthorn (Frangula alnus), multiflora rose (Rosa multiflora), Japanese knotweed (Fallopia japonica), garlic mustard (Alliaria petiolata) and black locust (Robinia pseudoacacia). Invasive animals include forest pests such as the hemlock woolly adelgid (Adelgis tsugae), Asian longhorn beetle (Anoplophora glabripennis), and the emerald ash borer (Agrilus planipennis). The zebra mussel (Dreissena polymorpha) is a particularly detrimental aquatic invasive species that has recently been detected in Western Massachusetts.[53] Spotted lanternfly (*Lycorma delicatula*) is an invasive insect first detected in Pennsylvania in 2014. It causes damage to trees and other woody plants by feeding on their sap. While the primary host plant is the invasive tree-of-heaven, researchers have found that it also targets grapevines, hops, and fruit trees, giving it the potential to become a serious agricultural pest.[54] It has not yet been detected in Massachusetts.

The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by the Massachusetts Executive Office of Energy and Environmental Affairs to provide recommendations to the Commonwealth to manage invasive species. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self- sustaining populations and becoming dominant and/or disruptive to those systems." These species have biological traits that provide them with competitive advantages over native species, particularly because in a new habitat they are not restricted by the biological controls of their native habitat. As a result, these invasive species can monopolize natural communities, displacing many native species and causing widespread economic and environmental damage. MIPAG recognized 69 plant species as "Invasive," "Likely Invasive," or "Potentially Invasive."

Massachusetts has a variety of laws and regulations in place that attempt to mitigate the impacts of these species. The Massachusetts Department of Agricultural Resources (MDAR) maintains a list of prohibited plants for the state, which includes federally noxious weeds as

[53] MassWildlife Climate Action Tool: http://climateactiontool.org/content/invasive-plants-and-animals. Accessed March 4, 2019.
[54] Massachusetts Department of Agricultural Resources website: https://www.mass.gov/spotted-lanternfly. Accessed January 14, 2020.

well as invasive plants recommended by MIPAG and approved for listing by MDAR. Species on the MDAR list are regulated with prohibitions on importation, propagation, purchase, and sale in the Commonwealth. Additionally, the Massachusetts Wetlands Protection Act (310 CMR 10.00) includes language requiring all activities covered by the Act to account for, and take steps to prevent, the introduction or propagation of invasive species.

In 2000, Massachusetts passed an Aquatic Invasive Species Management Plan, making the Commonwealth eligible for federal funds to support and implement the plan through the federal Aquatic Nuisance Prevention and Control Act. MassDEP is part of the Northeast Aquatic Nuisance Species Panel, which was established under the federal Aquatic Nuisance Species Task Force. This panel allows managers and researchers to exchange information and coordinate efforts on the management of aquatic invasive species. The Commonwealth also has several resources pertaining to terrestrial invasive species, such as the Massachusetts Introduced Pest Outreach Project, although a strategic management plan has not yet been prepared for these species.

Code of Massachusetts Regulation (CMR) 330 CMR 6.0(d) requires any seed mix containing restricted noxious weeds to specify the name and number per pound on the seed label. Regulation 339 CMR 9.0 restricts the transport of currant or gooseberry species in an attempt to prevent the spread of white pine blister rust. There are also a number of state laws pertaining to invasive species. Chapters 128, 130, and 132 of Part I of the General Laws of the state include language addressing water chestnuts, green crabs, the Asian longhorn beetle, and a number of other species. These laws also include language allowing orchards and gardens to be surveyed for invasive species and for quarantines to be put into effect at any time.

Identification and monitoring is an important element in mitigating impacts from invasive species. The Outsmart Invasive Species project is a collaboration between the University of Massachusetts Amherst, the Massachusetts Department of Conservation and Recreation (MA DCR) and the Center for Invasive Species and Ecosystem Health at the University of Georgia. The goal of the project is to strengthen ongoing invasive-species monitoring efforts in Massachusetts by enlisting help from citizens. The web- and smartphone-based approach enables volunteers to identify and collect data on invasive species in their own time, with little or no hands-on training. By taking advantage of the increasing number of people equipped with iPhone or digital camera/web technology, this approach will expand the scope of invasive-species monitoring, in an effort to help control outbreaks of new or emergent invasive species that threaten our environment.[55]

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

Location

The damage rendered by invasive species is significant. The massive scope of this hazard means that the entire Town of Buckland may experience impacts from these species. Furthermore, the ability of invasive species to travel far distances (either via natural mechanisms or accidental human interference) allows these species to propagate rapidly over a large geographic area. Similarly, in open freshwater ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations (by boats, for example).

According to the Committee, invasive species of concern in Buckland include Bittersweet, which has the ability to take down large trees, and Japanese knotweed, which crowds out native species along riverbanks and is not as effective for erosion control. Other invasive species present in Buckland include Japanese barberry and Multi-flora rose.

Extent

Invasive species are a widespread problem in Massachusetts and throughout the country. The geographic extent of invasive species varies greatly depending on the species in question and other factors, including habitat and the range of the species. Some (such as the gypsy moth) are nearly controlled, whereas others, such as the zebra mussel, are currently adversely impacting ecosystems throughout the Commonwealth. Invasive species can be measured through monitoring and recording observances.

Previous Occurrences

The terrestrial and freshwater species listed on the MIPAG website as "Invasive" (last updated April 2016) are identified in Table 3-39. The table also includes details on the nature of the ecological and economic challenges presented by each species as well as information on where the species has been detected in Massachusetts. Twenty-one of the invasive species on the list have been observed in Buckland since 2010.

Table 3-39: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Buckland**
Acer platanoides L. (**Norway maple**)	A tree occurring in all regions of the state in upland and wetland habitats, and especially common in woodlands with colluvial soils. It grows in full sun to full shade. Escapes from cultivation; can form dense stands; out-competes native vegetation, including sugar maple; dispersed by water, wind and vehicles.	Y
Aegopodium podagraria L. (**Bishop's goutweed; bishop's weed; goutweed**)	A perennial herb occurring in all regions of the state in uplands and wetlands. Grows in full sun to full shade. Escapes from cultivation; spreads aggressively by roots; forms dense colonies in flood plains.	Y
Ailanthus altissima (P. Miller) Swingle (**Tree of heaven**)	This tree occurs in all regions of the state in upland, wetland, & coastal habitats. Grows in full sun to full shade. Spreads aggressively from root suckers, especially in disturbed areas.	N
Alliaria petiolata (Bieb.) Cavara & Grande (**Garlic mustard**)	A biennial herb occurring in all regions of the state in uplands. Grows in full sun to full shade. Spreads aggressively by seed, especially in wooded areas.	Y
Berberis thunbergii DC. (**Japanese barberry**)	A shrub occurring in all regions of the state in open and wooded uplands and wetlands. Grows in full sun to full shade. Escaping from cultivation; spread by birds; forms dense stands.	Y
Cabomba caroliniana A.Gray (**Carolina fanwort; fanwort**)	A perennial herb occurring in all regions of the state in aquatic habitats. Common in the aquarium trade; chokes waterways.	N
Celastrus orbiculatus Thunb. (**Oriental bittersweet; Asian or Asiatic bittersweet**)	A perennial vine occurring in all regions of the state in uplands. Grows in full sun to partial shade. Escaping from cultivation; berries spread by birds and humans; overwhelms and kills vegetation.	Y
Cynanchum louiseae Kartesz & Gandhi (**Black swallow-wort, Louise's swallow-wort**)	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to partial shade. Forms dense stands, out-competing native species: deadly to Monarch butterflies.	Y
Elaeagnus umbellata Thunb. (**Autumn olive**)	A shrub occurring in uplands in all regions of the state. Grows in full sun. Escaping from cultivation; berries spread by birds; aggressive in open areas; has the ability to change soil.	Y

Table 3-39: Invasive Plants Occurring in Western Massachusetts

Species (Common Name)	Notes on Occurrence and Impact	Observed in Buckland
Euonymus alatus (Thunb.) Sieb. (**Winged euonymus; Burning bush**)	A shrub occurring in all regions of the state and capable of germinating prolifically in many different habitats. It grows in full sun to full shade. Escaping from cultivation and can form dense thickets and dominate the understory; seeds are dispersed by birds.	Y
Euphorbia esula L. (**Leafy spurge; wolf's milk**)	A perennial herb occurring in all regions of the state in grasslands and coastal habitats. Grows in full sun. An aggressive herbaceous perennial and a notable problem in western USA.	ND
Frangula alnus P. Mill. (**European buckthorn; glossy buckthorn**)	Shrub or tree occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Produces fruit throughout the growing season; grows in multiple habitats; forms thickets.	Y
Hesperis matronalis L. (**Dame's rocket**)	A biennial and perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Spreads by seed; can form dense stands, particularly in flood plains.	Y
Iris pseudacorus L. (**Yellow iris**)	A perennial herb occurring in all regions of the state in wetland habitats, primarily in flood plains. Grows in full sun to partial shade. Out-competes native plant communities.	Y
Lonicera japonica Thunb. (**Japanese honeysuckle**)	A perennial vine occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Rapidly growing, dense stands climb and overwhelm native vegetation; produces many seeds that are bird dispersed; more common in southeastern Massachusetts.	N
Lonicera morrowii A.Gray (**Morrow's honeysuckle**)	A shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	Y
Lonicera x bella Zabel [*morrowii* x *tatarica*] (**Bell's honeysuckle**)	This shrub occurs in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade. Part of a confusing hybrid complex of nonnative honeysuckles commonly planted and escaping from cultivation via bird dispersal.	Y

Table 3-39: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Buckland**
Lysimachia nummularia L. (**Creeping jenny; moneywort**)	A perennial herb occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Escaping from cultivation; problematic in flood plains, forests and wetlands; forms dense mats.	Y
Lythrum salicaria L. (**Purple loosestrife**)	A perennial herb or subshrub occurring in all regions of the state in upland and wetland habitats. Grows in full sun to partial shade. Escaping from cultivation; overtakes wetlands; high seed production and longevity.	Y
Myriophyllum heterophyllum Michx. (**Variable water-milfoil; Two-leaved water-milfoil**)	A perennial herb occurring in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	N
Myriophyllum spicatum L. (**Eurasian or European water-milfoil; spike water-milfoil**)	A perennial herb found in all regions of the state in aquatic habitats. Chokes waterways, spread by humans and possibly birds.	N
Phalaris arundinacea L. (**Reed canary-grass**)	This perennial grass occurs in all regions of the state in wetlands and open uplands. Grows in full sun to partial shade. Can form huge colonies and overwhelm wetlands; flourishes in disturbed areas; native and introduced strains; common in agricultural settings and in forage crops.	Y
Phragmites australis (Cav.) Trin. ex Steud. subsp. australis (**Common reed**)	A perennial grass (USDA lists as subshrub, shrub) found in all regions of the state. Grows in upland and wetland habitats in full sun to full shade. Overwhelms wetlands forming huge, dense stands; flourishes in disturbed areas; native and introduced strains.	Y
Polygonum cuspidatum Sieb. & Zucc. (**Japanese knotweed; Japanese or Mexican Bamboo**)	A perennial herbaceous subshrub or shrub occurring in all regions of the state in upland, wetland, and coastal habitats. Grows in full sun to full shade, but hardier in full sun. Spreads vegetatively and by seed; forms dense thickets.	Y
Polygonum perfoliatum L. (**Mile-a-minute vine or weed; Asiatic tearthumb**)	This annual herbaceous vine is currently known to exist in several counties in MA, and has also has been found in RI and CT. Habitats include streamside, fields, and road edges in full sun to partial shade. Highly aggressive; bird and human dispersed.	N

Table 3-39: Invasive Plants Occurring in Western Massachusetts		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Buckland**
Potamogeton crispus L. (**Crisped pondweed; curly pondweed**)	A perennial herb occurring in all regions of the state in aquatic habitats. Forms dense mats in the spring and persists vegetatively.	N
Ranunculus ficaria L. (**Lesser celandine; fig buttercup**)	A perennial herb occurring on stream banks, and in lowland and uplands woods in all regions of the state. Grows in full sun to full shade. Propagates vegetatively and by seed; forms dense stands especially in riparian woodlands; an ephemeral that outcompetes native spring wildflowers.	N
Rhamnus cathartica L. (**Common buckthorn**)	A shrub or tree occurring in all regions of the state in upland and wetland habitats. Grows in full sun to full shade. Produces fruit in fall; grows in multiple habitats; forms dense thickets.	Y
Robinia pseudoacacia L. (**Black locust**)	A tree that occurs in all regions of the state in upland habitats. Grows in full sun to full shade. While the species is native to central portions of Eastern North America, it is not indigenous to Massachusetts. It has been planted throughout the state since the 1700's and is now widely naturalized. It behaves as an invasive species in areas with sandy soils.	Y
Rosa multiflora Thunb. (**Multiflora rose**)	A perennial vine or shrub occurring in all regions of the state in upland, wetland and coastal habitats. Grows in full sun to full shade. Forms impenetrable thorny thickets that can overwhelm other vegetation; bird dispersed.	Y
Trapa natans L. (**Water-chestnut**)	An annual herb occurring in the western, central, and eastern regions of the state in aquatic habitats. Forms dense floating mats on water.	N
MIPAG "Likely Invasive" Plants observed near Buckland		
Species (Common Name)	**Notes on Occurrence and Impact**	**Observed in Buckland**
Microstegium vimineum (Trin.) A. Camus (**Japanese stilt grass; Nepalese browntop**)	An annual grass occurring in the western region of the state in upland and wetland habitats. Grows in full sun to full shade. Forms dense stands; currently localized in the lower Connecticut River Valley; spreads in flood plains. In the Mid-Atlantic states it has been found to be very dominating and detrimental to forest ecosystems, preventing regeneration of small-seeded trees. Conway, MA has a concerted program to keep it from spreading, which could serve as a model for Buckland and other towns.	ND

Anthriscus sylvestris (L.) Hoffmann (**Wild chervil**)	A biennial or short-lived perennial herb with a few reported sites in minimally managed habitats scattered across the state. It occurs in old fields, wetlands, roadsides and proliferates in floodplain soils. Grows in full sun to partial shade. It has a very long taproot and is reported to be spreading in Vermont and Connecticut, and in Colrain, MA. It is concerning for farmers because it serves as a host for the parsnip yellow fleck virus that infects carrots, celery, and parsnips. It spreads quickly in hayfields and can cause molding in hay because it takes a long time to dry. It is unpalatable to livestock when mature. Difficult to control because of deep taproot.	ND
Cynanchum rossicum (Kleopov) Borhidi (**European swallow-wort; pale swallow-wort**)	A perennial herb occurring in the western region of the state in upland habitats. Grows in full sun to partial shade. Forms dense stands; found primarily in the lower Connecticut River Valley.	N

Source: Massachusetts Invasive Plant Advisory Group, https://www.massnrc.org/mipag/invasive.htm, and Franklin County Flora Group, 2019.

Although there are less clear-cut criteria for invasive fauna, there are a number of animals that have disrupted natural systems and inflicted economic damage on the Commonwealth, and may impact Buckland (Table 3-40). One invasive species, the Zebra mussel, was first documented in Massachusetts in Laurel Lake in Lee (Berkshire County, Housatonic River watershed) in 2009. Invasive fungi are also included in this table. Because of the rapidly evolving nature of the invasive species hazard, this list is not considered exhaustive.

Table 3-40: Invasive Animal and Fungi Species in Massachusetts

Species (Common Name)	**Notes on Occurrence and Impact**
Terrestrial Species	
Lymantria dispar dispar (**Gypsy moth** (insect))	This species was imported to Massachusetts for silk production, but escaped captivity in the 1860s. It is now found throughout the Commonwealth and has spread to parts of the Midwest. This species is considered a serious defoliator of oaks and other forest and urban trees; however, biological controls have been fairly successful against it.
Ophiostoma ulmi, Ophiostoma himal-ulmi, Ophiostoma novo-ulmi (**Dutch elm disease** (fungus))	In the 1930s, this disease arrived in Cleveland, Ohio, on infected elm logs imported from Europe. A more virulent strain arrived in the 1940s. The American elm originally ranged in all states east of Rockies, and elms were once the nation's most popular urban street tree. However, the trees have now largely disappeared from both urban and forested landscapes. It is estimated that "Dutch" elm disease has killed more than 100 million trees.
Adelges tsugae (**Hemlock woolly adelgid** (insect))	This species was introduced accidentally around 1924 and is now found from Maine to Georgia, including all of Massachusetts. It has caused up to 90% mortality in eastern hemlock species, which are important for shading trout streams and provide habitat for about 90 species of birds and mammals. It has been documented in about one-third of Massachusetts cities and towns and threatens the state's extensive Eastern Hemlock groves.
Cryphonectria parasitica (**Chestnut blight** (fungus))	This fungus was first detected in New York City in 1904. By 1926, the disease had devastated chestnuts from Maine to Alabama. Chestnuts once made up one-fourth to one-half of eastern U.S. forests, and the tree was prized for its durable wood and as a food for humans, livestock, and wildlife. Today, only stump sprouts from killed trees remain.
Anoplophora glabripennis (**Asian long-horned beetle**)	This species was discovered in Worcester in 2008. The beetle rapidly infested trees in the area, resulting in the removal of nearly 30,000 infected or high-risk trees in just 3 years.
Cronartium ribicola (**White pine blister rust** (fungus))	This fungus is an aggressive and non-native pathogen that was introduced into eastern North America in 1909. Both the pine and plants in the Ribes genus (gooseberries and currants) must be present in order for the disease to complete its life cycle. The rust threatens any pines within a quarter-mile radius from infected Ribes.

Lycorma delicatula (**Spotted lanternfly– SLF** (insect))	First detected in Pennsylvania (PA) in 2014. At the writing of this plan, this rapidly spreading pest has only been found as dead individuals in MA. This pest is a high alert species that the USDA calls potentially the most destructive pest in 150 years. In PA it has caused destruction of grape, apple, hops, and hardwoods. Can breed on Tree of heaven (also invasive), which should be removed from the region to slow the spread of SLF.
Agrilus planipennis (**Emerald Ash Borer** (insect))	This small, invasive beetle is devastating to all ash tree species in MA. It is currently present in ten MA counties and continues to spread rapidly. This beetle kills Ash trees within a few years of arrival. The entire state of MA is under quarantine. Ash should not be moved (firewood, green wood products, nursery stock, or any plant materials from Ash stock). Three biocontrol species have been released in MA, the larval parasitoids Tetrastichus planipennisi and Spathius galinae and the egg parasitoid Oobius agrili. All biocontrol species are thoroughly researched prior to introduction into the ecosystem to avoid any negative impacts. The biocontrols appear to be a promising tool against the emerald ash borer.
Operophtera brumata (**Winter moth** (insect))	This caterpillar of most deciduous trees appears under control in eastern MA from an introduced fly biocontrol agent. Moths have been detected as far west as Turners Falls. They are a danger to fruits (apples and blueberries) and maple trees (syrup production) but will eat other plants as well.
Beech Bark Disease (insect and fungus)	Beech bark disease (BBD) has killed millions of American beech (Fagus grandifolia) throughout New England and has drastically altered northern hardwood forests, of which beech is a primary tree species. BBD is a disease-insect complex that involves both native and non-native scale insects (Cryptococcus fagisuga and Xylococculus betulae) and two species of the fungal pathogen Neonectria (N. ditissima and N. faginata).
Aquatic Species	
Dreissena polymorpha (**Zebra mussel**)	The first documented occurrence of zebra mussels in a Massachusetts water body occurred in Laurel Lake in July 2009. Zebra mussels can significantly alter the ecology of a water body and attach themselves to boats hulls and propellers, dock pilings, water intake pipes and aquatic animals. They are voracious eaters that can filter up to a liter of water a day per individual. This consumption can deprive young fish of crucial nutrients.

Source: Chase et al., 1997; Pederson et al., 2005, CZM, 2013, 2014; Defenders of Wildlife; Gulf of Maine; EOEEA, 2013a, 2013b; as presented in the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

Probability of Future Events

Because the presence of invasive species is ongoing rather than a series of discrete events, it is difficult to quantify the frequency of these occurrences. However, increased rates of global trade and travel have created many new pathways for the dispersion of exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plants species in the U.S. were originally imported as ornamentals.

More generally, a warming climate may place stress on colder-weather species while allowing non-native species accustomed to warmer climates to spread northward. The impacts of invasive species and climate change is discussed in more detail below.

Impact

The impacts of invasive species may interact with those of climate change, magnifying the negative impacts of both threats. Furthermore, due to the very traits that make them successful at establishing in new environments, invasives may be favored by climate change. These traits include tolerance to a broad range of environmental conditions, ability to disperse or travel long distances, ability to compete efficiently for resources, greater ability to respond to changes in the environment with changes in physical characteristics (phenotypic plasticity), high reproductive rates, and shorter times to maturity.

To become an invasive species, the species must first be transported to a new region, colonize and become established, and then spread across the new landscape. Climate change may impact each stage of this process. Globally, climate change may increase the introduction of invasive species by changing transport patterns (if new shipping routes open up), or by increasing the survival of invasives during transport. New ornamental species may be introduced to Massachusetts to take advantage of an expanded growing season as temperatures warm. Aquatic invasives may survive in ships' ballast waters with warmer temperatures. Extreme weather events or altered circulation patterns due to climate change could also allow the dispersal of invasive species to new regions via transportation of seeds, larvae and small animals.

Species may shift their ranges north as the climate warms and be successful in regions they previously had not colonized. Invasives may also be able to spread more rapidly in response to climate change, given their high dispersal rates and fast generation times. These faster moving species may be at a competitive advantage if they can move into new areas before their native competitors.

Here in the Northeast, warming conditions may be particularly concerning for some invasives because species ranges in temperate regions are often limited by extreme cold temperatures or snowfall. There is concern that aquatic species, such as hydrilla (Hydrilla verticillata) and water hyacinth (Eichhornia crassipes), may be able to survive and overwinter in Massachusetts with increased temperatures and reduced snowfall. Nutria (Myocastor coypus), large, non-native, semi-aquatic rodents that are currently established in Maryland and Delaware, are likely to move north with warming temperatures - perhaps as far as Massachusetts.

Extreme winter temperatures are also critical limiting factors for many forest pests, and warming is expected to increase their survival and lead to expansions and outbreaks. For example, in Massachusetts, it's likely that winter temperatures have been limiting the impact of hemlock wooly adelgid (Adelges tsugae), as many infested forest stands are surviving while in more southerly ranges there is near complete mortality from this pest. But the adelgid has already expanded its range with warming winter temperatures and is likely to have increased survival and higher reproductive rates in the northern portion of its range as temperatures warm, likely leading to more significant impacts on forests.

Invasive species are often able to thrive or take advantage of areas of high or fluctuating resource availability such as those found in disturbed environments. For example, for invasive plants, insect outbreaks or storms often free up space in the forest allowing light to penetrate and nutrients and moisture balances to change, allowing invasive plants to move in. Climate change is likely to create these types of opportunities through increased disturbances such as storms and floods, coastal erosion and sea level rise.

Invasives may also be better able to respond to changing environmental conditions that free up resources or create opportunities. For example, greater plasticity in response to their environment may allow some invasive plants to respond faster to increases in spring temperature than native plants. These invasives are able to leaf-out earlier in warmer years, taking up available space, nutrients, and sunlight, and achieving a competitive advantage against native species. Increased carbon dioxide in the atmosphere may also benefit some weedy plant species, allowing them to compete for other resources (like water) more effectively than their native counterparts.

Species roles may change as the climate changes, further complicating the management and policy response. As species ranges shift and existing inter-species relationships are broken, there is the potential that some species, including native species, may become pests because the interspecies interactions (e.g., predation, herbivory) that used to keep their population numbers in check are no longer functional.[56]

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

Once established, invasive species often escape notice for years or decades. Introduced species that initially escaped many decades ago are only now being recognized as invasives. Because these species can occur anywhere (on public or private property), new invasive species often escape notice until they are widespread and eradication is impractical. As a result, early and coordinated action between public and private landholders is critical to preventing widespread damage from an invasive species.

Vulnerability

Because plant and animal life is so abundant in Buckland, the entire town is considered to be exposed to the invasive species hazard. Areas with high amounts of plant or animal life may be at higher risk of exposure to invasive species than less vegetated areas; however, invasive species can disrupt ecosystems of all kinds.

Society

The majority of invasive species do not have direct impacts on human well-being; however, as described in the following subsections, there are some health impacts associated with invasive species.

Vulnerable Populations

Invasive species rarely result in direct impacts on humans, but sensitive people may be vulnerable to specific species that may be present in the state in the future. These include people with compromised immune systems, children under the age of 5, people over the age of 65, and pregnant women. Those who rely on natural systems for their livelihood or mental and emotional well-being are more likely to experience negative repercussions from the expansion of invasive species.

Health Impacts

Of particular concern to human health are species like the Asian tiger mosquito (Aedes albopictus). This invasive mosquito, originally from southeast and subtropical Asia has moved through the Eastern U.S. and has recently arrived in Massachusetts. Capable of spreading West Nile Virus, Equine Encephalitis, and numerous other tropical diseases, this aggressive mosquito is likely range-limited by cold winter temperatures, suitable landscape conditions (it prefers urban areas), and variation in moisture. As winter temperatures increase, the species is likely to become more prevalent in Massachusetts and throughout the Northeast, increasing the risk of serious illness for residents in summer months.[57]

Additional invasive species have negative impacts on human health. The Tree of Heaven (Ailanthus altissima)) produces powerful allelochemicals that prevent the reproduction of other species and can cause allergic reactions in humans. Similarly, due to its voracious consumption, the zebra mussel accumulates aquatic toxins, such as polychlorinated biphenyls or polyaromatic hydrocarbons, in their tissues at a rapid rate. When other organisms consume these mussels, the toxins can accumulate, resulting in potential human health impacts if humans consume these animals.

Loss of urban tree canopy from invasive species and pests can lead to higher summertime temperatures and greater vulnerability to extreme temperatures. Health impacts from extreme heat exposure is discussed in the Extreme Temperature section.

Economic Impacts

Economic impacts include the cost to control invasive species on public and private land. Individuals who are particularly vulnerable to the economic impacts of this hazard include all groups who depend on existing ecosystems in Buckland for their economic success. This includes all individuals working in forestry and agriculture-related fields, as well as those whose livelihoods depend on outdoor recreation activities such as hunting, hiking, or aquatic sports. Businesses catering to visitors who come to a town for outdoor recreation opportunities can also suffer from loss of business. Additionally, homeowners whose properties are adjacent to vegetated areas or waterbodies experiencing decline from an invasive species outbreak could experience decreases in property value.

Infrastructure

The entire town of Buckland is considered exposed to this hazard; however, the built environment is not expected to be impacted by invasive species to the degree that the natural environment is. Buildings are not likely to be directly impacted by invasive species. Amenities such as outdoor recreational areas that depend on biodiversity and ecosystem health may be impacted by invasive species. Facilities that rely on biodiversity or the health of surrounding ecosystems, such as outdoor recreation areas or agricultural/forestry operations, could be more vulnerable to impacts from invasive species.

Agriculture

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

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 negatively impact the small farm economy which is already struggling to remain viable. Farms may be forced to adapt their cultivation and land management practices, which is likely to include increased pesticide usage to control tenacious invasives, such as Japanese knotweed, for which manual control is untenable. 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.

Negative impacts of invasive species on forestry products include concern for the future of maple syrup production, based on observed stress in maple stands or "sugar bush" in recent years. Stressors on forestry and timber stands involve the impacts on tree health from invasive pests like the wooly adelgid and emerald ash borer, as well as invasive plants, like oriental bittersweet and Japanese barberry, which can take over many acres of land, destroy the habitat for native wildlife, and involve extensive costs to mitigate.

Public Health

An increase in species not typically found in Massachusetts could expose populations to vector-borne disease. A major outbreak could exceed the capacity of hospitals and medical providers to care for patients.

Transportation

Water transportation may be subject to increased inspections, cleanings, and costs that result from the threat and spread of invasive species. Species such as zebra mussels can damage aquatic infrastructure and vessels.

Water Infrastructure

Water storage facilities may be impacted by zebra mussels. Invasive species may lead to reduced water quality, which has implications for the drinking water supplies and the cost of treatment.

Environment

Buckland is 81% forested, and is therefore vulnerable to invasive species impacts to forests. Invasive plants can out-compete native vegetation through rapid growth and prolific seed production. Increased amounts of invasive plants can reduce plant diversity by dominating forests. When invasive plants dominate a forest, they can inhibit the regeneration of native trees and plants. This reduced regeneration further reduces the forest's ability to regenerate in a timely and sufficient manner following a disturbance event. In addition, invasive plants have been shown to provide less valuable wildlife habitat and food sources.

As discussed previously, the movement of a number of invasive insects and diseases has increased with global trade. Many of these insects and diseases have been found in New England, including the hemlock woolly adelgid, the Asian long-horned beetle, and beech bark disease. These organisms have no natural predators or controls and are significantly affecting our forests by changing species composition as trees susceptible to these agents are selectively killed.

Invasive species interact with other forest stressors, such as climate change, increasing their negative impact. Examples include:

- A combination of an earlier growing season, more frequent gaps in the forest canopy from wind and ice storms, and carbon dioxide fertilization will likely favor invasive plants over our native trees and forest vegetation.
- Preferential browse of native plants by larger deer populations may favor invasive species and inhibit the ability of a forest to regenerate after wind and ice storms.
- Warming temperatures favor some invasive plants, insects, and diseases, whose populations have historically been kept in check by the cold climate.
- Periods of drought weaken trees and can make them more susceptible to insects and diseases.[58]

Aquatic invasive species pose a particular threat to water bodies. In addition to threatening native species, they can degrade water quality and wildlife habitat. Impacts of aquatic invasive species include:

- Reduced diversity of native plants and animals
- Impairment of recreational uses, such as swimming, boating, and fishing
- Degradation of water quality
- Degradation of wildlife habitat
- Increased threats to public health and safety
- Diminished property values
- Local and complete extinction of rare and endangered species

Vulnerability Summary

Overall, Buckland faces a "High" vulnerability to invasive species. Invasive speices are already

[58] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

impacting areas of town and are expected to continue to be a hazard as the climate changes.

Invasive Species Hazard Problem Statements
• Oriental bittersweet threatens mature trees and wildlife habitat in Town, as well as pastures and forests across rural Buckland.
• Japanese knotweed forms monocultures along stream and riverbanks in town, and is poor erosion control compared to native vegetation. The banks of the Deerfield River are dominated by this plant, which severely restricts access to the river from the village of Shelburne Falls and elsewhere in Town.
• While tillage agriculture inherently controls many invasive plants in farm fields, many species, including Japanese multiflora rose, oriental bittersweet, and knotweed, will crop up and become established along the edges of fields and forests.
• Buckland is 81% forested, and is vulnerable to pests and invasive species that may damage or alter the forest composition, such as Emerald ash borer, Hemlock woolly adelgid and Beech Bark Disease.
• Agriculture and forestry in Buckland rely on biodiverse ecosystems and are experiencing negative impacts due to invasive species. The scope of successfully controlling invasives long-term is often beyond the reach of what farmers and forest landowners can manage on their own.
• An inventory and assessment of the most threatening invasive species in Buckland is needed to help prioritize mitigation efforts and choose the most effective strategies for controlling specific pests, plants or pathogens, in specific locations.
• Education and outreach is needed to increase local awareness around invasive species and equip residents with appropriate control measure.

3.15 OTHER HAZARDS

In addition to the hazards identified above, the Hazard Mitigation Team reviewed the full list of hazards listed in the Massachusetts Hazard Mitigation and Climate Adaptation Plan. Due to the location and context of the Town, coastal erosion, coastal flooding, and tsunamis were determined not to be a threat. Manmade hazards are not addressed in the State plan, but were addressed in the 2014 Buckland Multi-Hazard Mitigation Plan, and are considered a risk to the town. The Committee updated the 2014 Manmade Hazard profile in the following section.

3.16 Manmade Hazards

General Description

Most non-natural or manmade hazards fall into two general categories: intentional acts and accidental events, although these categories can overlap. Some of the hazards included in these two categories, as defined by MEMA, consist of intentional acts such as explosive devices, biological and radiological agents, arson and cyberterrorism and accidental events such as nuclear hazards, invasive species, infrastructure failure, industrial and transportation accidents. Accidental events can arise from human activities such as the manufacture, transportation, storage, and use of hazardous materials.

This plan does not address all manmade hazards that could affect Buckland. A complete hazards vulnerability analysis was not within the scope of this update. For the purposes of the 2020 plan, the Committee has evaluated non-natural hazards that are of an accidental nature, including industrial transportation accidents and industrial accidents in a fixed facility. New to the 2020 plan is an evaluation of cyber-security, which has become a threat of greater concern in recent years.

Hazard Description

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products are shipped daily on the nation's highways, railroads, waterways, and pipelines. Chemical manufacturers are one source of hazardous materials, but there are many others, including service stations, hospitals, and hazardous materials waste sites. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in plants.

A release may occur at a fixed facility or in transit. Communities with a large industrial base may be more inclined to experience a hazardous materials release due to the number of facilities such materials in their manufacturing process. Communities with several major roadways may be at a greater risk due to the number and frequency of trucks transporting hazardous materials passing through.

Location and Extent

Industrial Accidents - Transportation

Franklin County transportation systems include road, rail, and air. Accessible and efficient freight transportation plays a vital function in the economy of the region. Most freight and goods being transported to and from Franklin County are by truck; however, a significant amount of freight that moves through the county is being hauled over the three main rail lines. Given that any freight shipped via air needs first to be trucked to an airport outside the region, air transportation is not being evaluated in this plan.

The major trucking corridors in Franklin County are Interstate 91, running north/south, and Route 2, running east/west. These two highways also represent the busiest travel corridors in the region for non-commercial traffic. Safe and efficient transportation routes for trucks to and through the region are important to the region's economy and to the safety of its citizens. The safer the transportation routes are, the less likely a transportation accident will occur. According to the Franklin County Hazardous Material Emergency Plan (HMEP), an estimated 12 or more trucks per hour travel through the region containing hazardous materials. Most of these trucks are on Interstate 91. However, approximately two vehicles per hour travel along Route 2, and up to one vehicle per hour travel along Route 112, both routes passing through Buckland. In addition, the HMEP notes that all roads in the county likely have vehicles carrying hazardous materials at varying intervals.

The major portions of hazardous chemicals transported by highways are petroleum-based products such as gasoline and heating fuels. According to the HMEP, the following hazardous materials are regularly carried on Route 2:

- Gasoline
- Fuel oil
- Kerosene
- Liquified Petroleum Gas (LPG)
- Propane
- Sodium aluminate
- Sulfuric acid
- NOS Liquids 3082

Materials regularly carried on Route 112 are as follows:

- Gasoline
- Fuel oil
- Kerosene
- Liquified Petroleum Gas (LPG)
- Propane

Ten to 24 trains per day travel on the main freight line of the Pan Am Systems Railroad, a single track that runs for less than a mile adjacent to the Deerfield River, crossing the river just north of at Bardwells Ferry Road. Rail accidents can be caused by faulty or sabotaged track; collision with another train, vehicle or other object on the track; mechanical failure of the train; or driver error. Depending on the freight, an accident could cause residents to evacuate the area. According to the HMEP, the 23 hazardous materials most frequently carried on these trains passing through Buckland include:

- Petroleum crude
- Liquefied petroleum
- Petroleum gases
- Sodium chlorate
- Sodium hydroxide
- Carbon dioxide
- Phenol molten
- Hydrochloric acid
- Acetone
- Methanol
- Air bag inflation
- chemicals
- Methyl methacrylate
- Alkylphenols
- Batteries, wet
- Adhesives
- Caustic alkali
- Helium, compressed
- Fire extinguisher
- chemicals
- Sulfuric acid
- Paint
- Gasoline
- Toluene
- Hydrogen peroxide

The trains themselves pose a potential hazard since 3 or 4 engines are used per train and each engine has a 2,000 gallon fuel tank. The Pan Am Systems Railroad runs adjacent to the Deerfield River through Conway, Buckland, and Charlemont. A spill along this line could easily contaminate the Deerfield River, and would pose both an immediate health and long term economic risk to Buckland residences, farms, and businesses located downstream. Stockpiles of old rail ties along the tracks also pose a serious fire hazard. Communication and notification of past derailments has been lacking between the railroad and the Town and is a major concern.

<u>Industrial Accidents – Fixed Facilities</u>

An accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas. Those facilities using, manufacturing, or storing toxic chemicals are required to report their locations and the quantities of the chemicals stored on-site to state and local governments. The Regional Emergency Planning Committee (REPC) maintains a list of facilities storing or using hazardous materials for the purpose of hazardous materials preparedness. Below are the facilities identified in Buckland:

Table 3-41: Facilities Reporting Chemical Inventories in or near Buckland

Facility	Location - Buckland
Great River Hydro; Deerfield No. 4 Station	22 Creamery Ave.
George Propane - Mohawk Trail Regional High School Station	24 Ashfield Rd.
Great River Hydro; Deerfield No. 3 Station	71 Conway St.
National Grid - Deerfield 4 Switchyard	Main St. (Rt. 112)
Facility	**Location – Neighboring Towns**
Shelburne DPW	24 Colrain-Shelburne Road - Shelburne
Kuzmeskus, Inc.	635 Mohawk Trail (Route 2) - Shelburne
Josh Simpson Glass	30 Frank Williams Road - Shelburne
Buckland-Shelburne Elementary School	75 Mechanic Street - Shelburne
Verizon Switching Building	Cross Street - Shelburne
Barnhardt Manufacturing	247 Main Road - Colrain
Verizon Colrain Dial OFC (VZ – MA 828307)	26 Main Road/Rt 112 - Colrain
Suburban Propane #2740 - Charlemon Bulk Plant	Rt. 8a - Charlemont
Verizon Charlemon Dial OFC (VZ- MA 828207)	South St. - Charlemont

Source: Franklin REPC Tier II facilities 2018, prepared by Franklin Regional Council of Governments; Shelburne 2018 CEM Plan.

Hazardous facilities located outside of town boundaries can potentially impact the Town as well. Most recently, in September 2019, a sulfuric acid leak from the Barnhardt Manufacturing facility on the North River in Colrain resulted in thousands of dead fish in the river, extending downstream to Buckland. This is the second acid spill in the North River in recent decades. On September 3, 1999, a truck released 670 gallons of sulfuric acid into the North River in Colrain. MassWildlife found dead and dying fish up to 2.6 miles downstream of the spill. Fish species included trout, salmon, smallmouth bass, American eel, common shiner, dace, white sucker and darter. In 2003, Massachusetts settled with the responsible parties for $28,125.[59]

The Vermont Yankee nuclear power plant is located on the Connecticut River in Vernon, Vermont, near the Vermont/Massachusetts border and approximately 16 miles from Shelburne Falls. In January 2010, the facility notified the Vermont Department of Health that samples taken in November 2009 from a ground water monitoring well on site contained tritium. This finding signals an unintended release of radioactive material into the environment. Testing has

[59] MA Department of Environmental Protection: https://www.mass.gov/service-details/more-nrd-settlements-massdep

shown that contaminated groundwater has leaked into the Connecticut River, though tritium levels in the river have remained below the lower limit of detection.[60]

On August 27, 2013, Entergy, then-owner of Vermont Yankee, announced that Vermont Yankee would cease operations at the end of 2014 for economic reasons. Vermont Yankee officially disconnected from the grid on December 29, 2014. The reactor was manually shut down without incident. Transfer of all Vermont Yankee spent fuel from the reactor to the spent fuel pool was completed on January 12, 2015. The transfer of all Vermont Yankee spent fuel to dry cask storage was completed on August 1, 2018. On December 6, 2018, the Vermont Public Utilities Commission (PUC) approved Entergy's sale of Vermont Yankee to subsidiaries of NorthStar Group Services, Inc., as a means of completing the decommissioning and site restoration on an accelerated schedule.[61]

Approximately 13 miles from downtown Shelburne Falls, the Yankee Atomic Electric Company (YAEC) stores spent nuclear fuel from the former Yankee Rowe nuclear facility, which operated for over three decades as a power generating facility until 1992. The plant was disassembled and officially decommissioned in 2007. However spent fuel from the plant's operation is still stored on site adjacent to the Sherman Reservoir on the Deerfield River, upstream from Shelburne. The fuel is stored in Nuclear Regulatory Commission – approved dry canisters and casks made of steel and concrete, which are placed on a concrete pad on the site. The stored fuel is monitored 24 hours a day. The fuel storage site is within the inundation zone for the Harriman Dam, which is located approximately 6.5 miles upstream from the site. According to the YAEC's website, the type of container that the fuel is stored in has been tested to withstand submersion under 50 feet of water for 8 hours, among other safety tests.[62]

The 2011 tsunami and earthquake in Japan that damaged a nuclear power plant demonstrates the potential vulnerability of these facilities to natural disasters, and the geographic extent that could be impacted by an accident. Town officials should stay abreast of proper evacuation procedures in the event of an accident at the Vermont Yankee nuclear power plant or Yankee Rowe fuel storage facility. In addition, at some point in the future, if the stored fuel at Yankee Rowe and other decommissioned nuclear facilities is to be moved, Town officials should be kept aware of transport plans, and training will be needed to address a potential nuclear waste spill.

Cyber Threats

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

A failure of networked computer systems could result in the interruption or disruption of town services (including public safety and other critical services), the disruption or interruption of the functioning of town departments, and the potential for loss or theft of important data (including financial information of the town and residents).

There are many possible causes of a network failure, but most either happen because of damage to the physical network/computer system infrastructure or damage to the network in cyberspace. Physical damages are incidents that damage physical telecommunications infrastructure or server/computer hardware. Examples are a water main break above a server room, fire/lighting strike that destroys equipment, construction accident damaging buried fiber line, or power outage and other issues effecting the Internet Service Provider (ISP) that interrupts access to the internet to the town.

Damage to the cyber infrastructure can be malicious attacks or critical software errors that affect computer systems, from individual computers to the entire network. These virtual hazards can cause lack of access to the network, permanent data loss, permanent damage to computer hardware, and impact the ability to access programs or systems on the network. When incidents are malicious attacks, they can impact:

- Confidentiality: protecting a user's private information.
- Integrity: ensuring that data is protected and cannot be altered by unauthorized parties.
- Availability: keeping services running and giving administration access to key networks and controls.
- Damage: irreversible damage to the computer or network operating system or "bricking" and physical, real world damages, caused by tampering with networked safety systems.
- Confidence: confidence of stakeholders in the organization who was victim of the attack.

Motives for cyber-attacks can vary tremendously, ranging from the pursuit of financial gain—the primary motivation for what is commonly referred to as "cyber-crimes" is for profit, retribution, or vandalism. Other motivations include political or social aims. Hacktivism is the act of hacking, or breaking into a computer system, for a political or social purpose. Cyber espionage is the act of obtaining secrets without permission of the holder of the information, using methods on the Internet, networks, or individual computers. [63] These threats are not only external; many acts of cyber-crime happened from current or former employees who were given network access legitimately.

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

For Buckland, the most likely cyber-threat effecting the town and town departments come from malware and social engineering. These crimes pray on the vulnerable and unprepared and every individual and organization that connects a device to the internet is a potential mark.

Social Engineering:
Social engineering involves obtaining confidential information from individuals through deceptive means by mail, email, over the phone, and increasingly through text messages.[64] These techniques are referred to as 'Phishing'.

Malware:
Malware, or malicious software, is any program or file that is harmful to a computer user. Types of malware can include computer viruses, worms, Trojan horses, and spyware. These malicious programs can perform a variety of different functions such as stealing, encrypting or deleting sensitive data, altering or hijacking core computing functions and monitoring users' computer activity without their permission. The most common way for malware to infect a town's network is through an employee opening an infected email attachment.

Previous Occurrences
Over the past few years a type of malware called ransomware has been targeted at local governments. Cyber-criminals will use social-engineering to infect a network, take control and block user access to that network, then request a ransom from the organization. Once the ransomware is on the network, it can be extremely expensive and time consuming to restore that network without paying the ransom. When the cost of the ransom is less than the cost of resorting the system, is when the cyber-criminals succeed.

In July 2019, school districts all across the United States were targeted by ransomware. Since 2013, there have been some 170 attacks against state and local governments and there is no sign that this trend is slowing. In July 2019, the Shelburne Falls Senior Center was the victim of a ransomware cyber-attack. Unlike other hazards, cyber-threats are global. Cyber-criminals don't care where you are or how small your town is. Many cyber-crimes aren't just lone criminals, they are more often than not committed by sophisticate criminal organizations and foreign governments who work around the clock looking to exploit small towns and big businesses alike.

The best way to prevent a cyber-attack is to follow best practices in cyber-security. Following

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

these best practices will greatly mitigate the likelihood a cyber-attack is successful. MA Executive Office of Technology Services and Security (EOTSS)[65] is the chief MA State program that can assist local governments with cyber-security. There are educational opportunities available throughout the region that aim to assist municipalities learn and implement these best practices.

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

4 MITIGATION CAPABILITIES & STRATEGIES

4.1 NATURE-BASED SOLUTIONS FOR HAZARD MITIGATION & CLIMATE RESILIENCY

Nature-Based Solutions are actions that work with and enhance nature to help people adapt to socio-environmental challenges. They may include the conservation and restoration of natural systems, such as wetlands, forests, floodplains and rivers, to improve resiliency. NBS can be used across a watershed, a town, or on a particular site. NBS use natural systems, mimic natural processes, or work in tandem with engineering to address natural hazards like flooding, erosion and drought.

The 2018 Massachusetts Hazard Mitigation and Climate Adaptation Plan and the MVP program both place great emphasis on NBS, and multiple state and federal agencies fund projects that utilize NBS. For this plan, Low Impact Development (LID) and Green Infrastructure (GI) are included under the blanket term of NBS. Following are examples of how NBS can mitigate natural hazards and climate stressors, and protect natural resources and residents:

- Restoring and reconnecting streams to floodplains stores flood water, slows it down and reduces infrastructure damage downstream
- Designing culverts and bridges to accommodate fish and wildlife passage also makes those structures more resilient to flooding, allowing for larger volumes of water and debris to safely pass through
- Managing stormwater with small-scale infiltration techniques like rain gardens and vegetated swales recharges drinking water supplies, reduces stormwater runoff, and reduces mosquito habitat and incidents of vector-borne illness by eliminating standing pools of water following heavy rain events
- Planting trees in developed areas absorbs carbon dioxide, slows and infiltrates stormwater, and provides shade, reducing summertime heat, lowering energy costs for village residents and improving air quality by reducing smog and particulate matter
- Vegetated riparian buffers absorb and filter pollutants before they reach water sources, and reduce erosion and water velocity during high flow events

This update of the Buckland Multi-Hazard Mitigation Plan incorporates Nature-Based Solutions into mitigation strategies where feasible.

4.2 EXISTING AUTHORITIES POLICIES, PROGRAMS, & RESOURCES

One of the steps of this Hazard Mitigation Plan update process is to evaluate all of the Town's existing policies and practices related to natural hazards and identify potential gaps in protection.

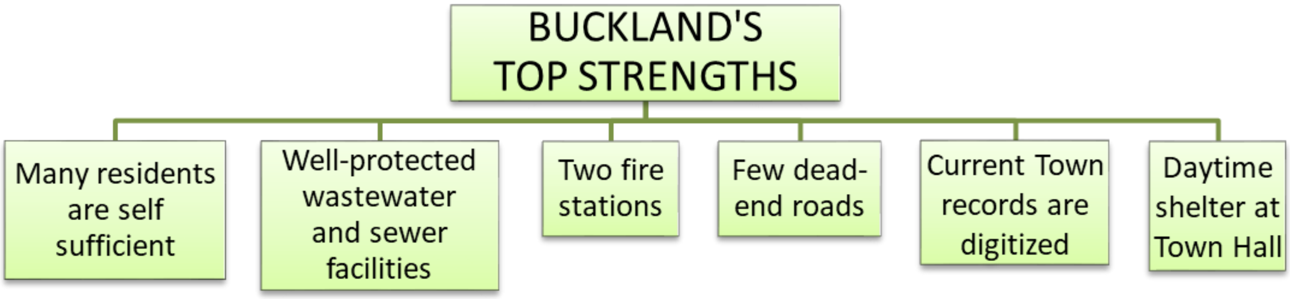
Buckland has most of the no cost or low cost hazard mitigation capabilities in place. Land use zoning, subdivision regulations and an array of specific policies and regulations that include hazard mitigation best practices, such as limitations on development in floodplains, stormwater management, tree maintenance, etc. Buckland has appropriate staff dedicated to hazard mitigation-related work for a community its size, including a Town Administrator, Emergency Management Director, a professionally run Highway Department, and a Tree Warden. Buckland is a member of the Franklin County Inspection Service, which provides Building, Plumbing, and Electrical permitting and inspections in town. In addition to Town staff, Buckland has an experienced Planning Board which reviews all proposed developments and assures that buildings are built to the current zoning requirements.

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

Buckland's Top Strengths and Assets

All Hazards

Participants at the 2018 MVP Community Resilience Building workshop expressed pride that people who have lived in Buckland for a long time are accustomed to weathering storms, "sheltering in place," and helping out neighbors. Many families in town know each other and know the first responders and Town staff who help run the Town. Participants sited several strengths and assets that help keep their community resilient in the face of climate change and other challenges. They include:



- **Self-sufficiency:** The "locals" or "old-timers" know how to deal with whatever nature brings their way.
- **Wastewater and sewer:** The wastewater treatment facility is well protected by the topography of the land. The wastewater treatment facility and the pumping station have their own stand-by power. The sewer line, located on the downstream side of the Iron Bridge, is protected as well.
- **Fire and Police:** A second fire station is located in Upper Buckland, well away from threat of flooding. Although fire and police facilities are located in the floodplain, department officials said they are able to move equipment and vehicles out of the floodplain if floodwaters are threatening the facilities.
- **Road network:** There are few dead end roads in Town, so there are alternatives in the event of road closures or washouts.
- **Town records:** Current Town Hall records are digitized and stored off-site (cloud storage).
- **Sheltering:** The Town Hall serves as an accessible, daytime heating and cooling center, with a generator and kitchen.

Overview of Mitigation Strategies by Hazard

An overview of the general concepts underlying mitigation strategies for each of the hazards identified in this plan is as follows:

Flooding

The key factors in flooding are the water capacity of water bodies and waterways, the regulation of waterways by flood control structures, and the preservation of flood storage areas (like floodplains) and wetlands. As more land is developed, more flood storage is demanded of the town's water bodies and waterways. FEMA has identified no flood control structures within the Town of Buckland. Floods on the Connecticut River and portions of its major tributaries that are prone to backwater effects are controlled by nine flood control reservoirs located upstream in Massachusetts, New Hampshire, and Vermont.

The Town of Buckland has adopted several land use regulations that serve to limit or regulate development in floodplains, to manage stormwater runoff, and to protect groundwater and wetland resources, the latter of which often provide important flood storage capacity. These regulations are summarized in Table 4-1.

Infrastructure like dams and culverts are also in place to manage the flow of water. However, some of this infrastructure is aging and in need of replacement, or is undersized and incapable of handling heavier flows our region is experiencing due to climate change. Existing culverts at road-stream crossings have been evaluated by UMass and Trout Unlimited.[66] The Town has further prioritized culverts for upgrades.

Severe Snowstorms / Ice Storms

Winter storms can be especially challenging for emergency management personnel even though the duration and amount of expected amount of snowfall usually is forecasted. The Massachusetts Emergency Management Agency (MEMA) serves as the primary coordinating entity in the statewide management of all types of winter storms and monitors the National Weather Service (NWS) alerting systems during periods when winter storms are expected.

To the extent that some of the damages from a winter storm can be caused by flooding, flood protection mitigation measures also assist with severe snowstorms and ice storms. The Town has adopted the State Building Code, which ensures minimum snow load requirements for roofs on new buildings. There are no restrictions on development that are directly related to severe winter storms, however, there are some Subdivision Rules and Regulations that could pertain to severe winter storms, summarized in Table 4-1.

Severe snowstorms or ice storms can often result in a small or widespread loss of electrical service. Back-up power generators serve the Shelburne Falls Water Department wells, and two storage tanks provide roughly 6 days of back-up water supply. The wastewater treatment plant in Buckland is equipped with standby power sources.

Hurricanes and Tropical Storms

Hurricanes provide the most lead warning time of all identified hazards, because of the relative

[66] See https://sce.ecosheds.org/ for more information.

ease in predicting the storm's track and potential landfall. MEMA assumes "standby status" when a hurricane's location is 35 degrees North Latitude (Cape Hatteras) and "alert status" when the storm reaches 40 degrees North Latitude (Long Island). Even with significant warning, hurricanes cause significant damage – both due to flooding and severe wind.

The flooding associated with hurricanes can be a major source of damage to buildings, infrastructure and a potential threat to human lives. Flood protection measures can thus also be considered hurricane mitigation measures. The high winds that often accompany hurricanes can also damage buildings and infrastructure, similar to tornadoes and other strong wind events. For new or recently built structures, the primary protection against wind-related damage is construction according to the State Building Code, which addresses designing buildings to withstand high winds. The Town of Buckland is a member of the Franklin County Cooperative Building Inspection Program, which provides building inspection services.

Severe Thunderstorms / Winds / Microbursts and Tornadoes

Most damage from tornadoes and severe thunderstorms come from high winds that can fell trees and electrical wires, generate hurtling debris and, possibly, hail. According to the Institute for Business and Home Safety, the wind speeds in most tornadoes are at or below design speeds that are used in current building codes, making strict adherence to building codes a primary mitigation strategy. In addition, current land development regulations, such as restrictions on the height and setbacks of telecommunications towers, can also help prevent wind damages.

Wildfires / Brushfires

Eighty-one percent of Buckland is forested, and is therefore at risk of fire. Wildfire and brushfire mitigation strategies involve educating people about how to prevent fires from starting, controlling burns within the town, as well as managing forests for fire prevention.

The Buckland Fire Department has an ongoing educational program in the schools to teach fire safety during Fire Prevention Week, which falls during the first week of October. Burn permits for the Town of Buckland are issued from the Shelburne Control Center of the Massachusetts State Police. During this process, the applicant is read the State Law, which includes guidelines for when and where the burn may be conducted as well as fire safety tips provided by the control center. The Town has the ability to restrict permits issued by Shelburne Control during high fire risk periods or when the Town is lacking staff capacity to deal with a brush fire if one were to break out.

There are currently no restrictions on development based on the need to mitigate wildfires.

However, the Buckland Fire Department reviews subdivision plans to ensure that their trucks will have adequate access and that the water supply is adequate for firefighting purposes.

Earthquakes

Although there are five mapped seismological faults in Massachusetts, there is no discernible pattern of previous earthquakes along these faults nor is there a reliable way to predict future earthquakes along these faults or in any other areas of the state. Consequently, earthquakes are arguably the most difficult natural hazard for which to plan. Most buildings and structures in the state were constructed without specific earthquake resistant design features. In addition, earthquakes precipitate several potential devastating secondary effects such as dam failure, building collapse, utility pipeline rupture, water contamination, and extended power outages. Therefore, many of the mitigation efforts for other natural hazards identified in this plan may be applicable during the Town's recovery from an earthquake.

Dam Failure

Dam failure is a highly infrequent occurrence, but a severe incident could prove catastrophic. In addition, dam failure most often coincides with flooding, so its impacts can be multiplied, as the additional water has nowhere to flow. The only mitigation measures currently in place are the state regulations governing the construction, inspection, and maintenance of dams. This is managed through the Office of Dam Safety at the Department of Conservation and Recreation. Owners of dams are responsible for hiring a qualified engineer to inspect their dams and report the results to the DCR. Owners of High Hazard Potential dams and certain Significant Hazard Potential dams are also required to prepare, maintain, and update Emergency Action Plans. Potential problems may arise if the ownership of a dam is unknown or contested. Additionally, the cost of hiring an engineer to inspect a dam or to prepare an Emergency Action Plan may be prohibitive for some owners.

According to the MA DCR Office of Dam Safety, there are eight dams located within Buckland, six of which are under the jurisdiction of the Federal Energy Regulatory Commission (FERC). The Deerfield #4 Dam and the Deerfield #3 Dam are owned by Great River Hydro and are categorized as high hazard. The Gardner Falls-Main Dam is categorized as a significant hazard dam, and the Gardner Falls Diversion is a low hazard dam. Both are owned by Hull Street Energy and operated by Ware River Hydro. The Great River Hydro Forebay #3, Forebay #4 and are all categorized as low hazard. The Hillman Ice Pond Dam is not FERC licensed and is categorized as a low hazard dam.

Drought

The Northeast is generally considered to be a moist region with ample rain and snow, but droughts are not uncommon. Widespread drought has occurred across the region as recently as 2016, and before that in the early 2000s, 1980s, and mid-1960s. More frequent and severe droughts are expected as climate change continues to increase temperatures, raise evaporation rates, and dry out soils - even in spite of more precipitation and heavier rainfall events.[67] The primary mitigation strategy currently in place is regulating uses within the aquifer recharge area of the public water supply wells, located in Colrain. According to the Shelburne Falls Fire District (SFFD) Water Department, the district is presently working with the Colrain Planning Board to identify and protect the recharge area for the wells located near the North River on Call Road utilizing Wellhead Protection Zoning. The process was started in 2019 and is ongoing. The SFFD owns its entire Zone I (a 400 ft. radius around Well 02G), except for a small portion across the North River on the west bank that is owned and organically farmed by the Hager family. The SFFD feels that as long as the field is not chemically treated with herbicides or pesticides it is a compatible use for the land.

Drought has not been an issue for the SFFD aquifer and water supply in the past. However, the SFFD is interested in establishing a second water supply source on the Buckland side of the Deerfield River to provide redundancy and a back-up supply in the event the Colrain wells are compromised. The District is actively seeking grant funds to purchase land for this purpose.

Forest landowners in town can be encouraged to conserve and manage their forests for climate resiliency, including resilience to drought. Strategies for promoting a resilient forest include increasing the diversity of tree species and age of trees in a forest, and promoting trees not currently threatened by pests or diseases that will thrive in a warming climate.[68]

Extreme Temperatures

A primary mitigation measure for extreme temperatures is establishing and publicizing warming or cooling centers in anticipation of extreme temperature events. Getting the word out to vulnerable populations, especially the homeless and elderly, and providing transportation is particularly important but can be challenging.

Planting and maintaining shade trees in villages and developed areas of towns can help mitigate extreme heat in these areas. Roofs and paving absorb and hold heat from the sun, making developed areas hotter during the summer than surrounding forested areas. Trees that shade these surfaces can significantly lower the temperature in a neighborhood, making it easier to be outside and reducing cooling costs for homeowners. Buckland's Subdivision Regulations

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

[68] Catanzaro, Paul, Anthony D'Amato, and Emily Silver Huff. *Increasing Forest Resiliency for an Uncertain Future*. University of Massachusetts Amherst, University of Vermont, USDA Forest Service. 2016

encourage preservation of trees over 12 inches diameter, and requires shade trees be planted along new subdivision streets.

Invasive Species

The spread of invasive species is a serious concern as species ranges shift with a changing climate. People can also be a carrier of invasive plant species. Installing boot brushes at hiking entrances can help slow the spread of invasive species by removing seeds being carried in soil on hiking boots. Landowners can learn the top unwanted plants and look for them when out on their land, and can be encouraged to work with neighbors to control invasive exotic plants.

Before implementing any forest management, landowners should be sure to inventory for invasive exotic species. They will need to be controlled before harvesting trees and allowing sunlight into the forest, which will trigger their growth and spread. Also, the timber harvester should be required to powerwash their machines before entering the woods. Financial assistance may be available to landowners through the USDA NRCS Environmental Quality Incentives Program (EQIP) to address invasive species.[69]

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

All Hazards

The Mohawk Trail Regional School is a designated regional emergency shelter in Buckland. A regional sheltering plan that identifies regional shelter sites was completed for Franklin County with funds from the Western Region Homeland Security Advisory Council (WRHSAC). The Franklin County REPC is now working on operationalizing the plan by creating Shelter Management Teams and cost sharing agreements between towns. Buckland officials can participate in this process to ensure its residents have clear guidance on where to shelter during an emergency.

Primary and secondary evacuation routes are shown on the Critical Infrastructure map for Buckland. A major concern identified at the 2018 MVP workshop and through this planning process is the potential for hazardous material spills from a derailment along the railroad tracks, as well as the potential for several neighborhoods to be isolated if a derailment occurs at certain roadway crossings. Another major concern are evacuation procedures in the event of a high hazard dam failure on the Deerfield River. Route 2 would be unavailable, and evacuation instructions will need to be coordinated with neighboring towns.

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

A regional disaster debris management plan was created for Franklin County in 2015; however, regional sites and agreements were not feasible. Buckland has several possible sites identified that could be used for debris management after a storm event, and is interested in exploring these options further.

Existing Mitigation Capabilities

The Town of Buckland has numerous policies, plans, practices, programs and regulations in place, prior to the creation of this plan, to mitigate the impact of natural hazards in the Town of Buckland. These various initiatives are summarized, described and assessed on the following pages and have been evaluated in the "Effectiveness" column.

Table 4-1: Existing Mitigation Capabilities

Strategy	Capability Type	Description	Hazards Mitigated	Effectiveness / Improvements
Floodplain District	Regulation – Zoning Bylaw	Overlay district to control development in the 100-year floodplain	Flooding	Partially Effective / FEMA floodplain maps are from 1980 and are outdated
Parking Regulations	Regulation – Zoning Bylaw	Requires stormwater to be handled on-site through use of swales or retention areas; requires shade trees for parking lots over 10 spaces.	Flooding Drought Extreme Temperatures	Effective
Cluster Development / Conservation Development	Regulation – Zoning Bylaw	Requires at least 40% of the total parcel to be set aside as common land for recreation, conservation or agricultural uses in exchange for smaller individual building lot sizes	Flooding Landslides Drought Extreme Temperatures	Partially Effective / Consider increasing the open space requirement and update using MA Smart Growth Toolkit model bylaw[70]
Special Permit Review Criteria	Regulation – Zoning Bylaw	Considers impacts to natural features, risk of erosion or siltation, increase in stormwater runoff, surface or groundwater pollution, and removal of mature trees	All Hazards	Effective for uses that require a Special Permit
Site Plan Review Criteria	Regulation – Zoning Bylaw	Considers adequacy of stormwater and drainage facilities and the protection of farmland and forestry resources	Flooding Landslides Drought Extreme Temperatures	Partially Effective / Consider encouraging or requiring LID stormwater manangement when feasible

[70] https://www.mass.gov/files/documents/2017/11/03/Open%20Space%20Design%20%28OSD%29-Natural%20Resource%20Protection%20Zoning%20%28NRPZ%29_0.pdf

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Wireless Service Facilities	Regulation – Zoning Bylaw	Requires wireless facilities be set back from property lines and neighboring structures to accommodate a "fall zone"	Wind-Related Hazards	Effective
Small Wind Energy Facilities	Regulation – Zoning Bylaw	Regulates the size, placement, and setbacks to inhabited buildings of small wind turbines	Wind / Snow / Ice-Related Hazards	Effective
Large-Scale Ground-Mounted Solar Electric Generating Installations	Regulation – Zoning Bylaw	Regulates use of herbicides and storage of hazardous materials; restricts land clearing to what is necessary for construction of the facility; clearing of forest cannot exceed 5 acres; grades over 15% shall be avoided; requires stormwater controls	Flooding Landslides Drought Extreme Temperatures	Effective
Subdivision Design Standards & Required Improvements	Regulation – Subdivision Rules & Regulations	Dictates street, utility, and drainage design and construction	All Hazards	Partially Effective / Update drainage requirements to reflect new rainfall data; encourage Low Impact Development (LID) & native drought-tolerant landscaping;[71]
Backlots with Farmland Set Aside	Zoning Regulation	Allows for the creation of up to four lots served by a common driveway and without frontage on a public way in exchange for the permanent protection of land with prime farmland soils	Flooding Drought Extreme Temperatures	Effective / Encourages permanent protection of land and reduced impervious surface through use of a common driveway
Maximum Lot Coverage	Zoning Regulation	Regulates the percentage of a building lot that may be covered by structures, walkways, drives, parking or other impervious or semi-pervious surfaces.	Flooding Drought Extreme Temperatures	Effective
Performance Standards	Zoning Regulations	Applies to by-right manufacturing uses up to 5,000 square feet; requires stormwater to be handled on-site	Flooding	Partially Effective / Standards could encourage use of LID stormwater management techniques
Participation in the National Flood Insurance Program	Program	As of 2018 there were 13 flood insurance policies in effect in Buckland	Flooding	Partially Effective / Floodplain maps are from 1980 and are outdated.

[71] See MassAudubon's regulation review checklist for subdivision regulation best practices for stormwater management: https://www.massaudubon.org/our-conservation-work/advocacy/shaping-the-future-of-your-community/publications-community-resources/bylaw-review

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Buckland Open Space and Recreation Plan	Plan	Inventories natural resources and identifies land protection priorities in the Town	Flooding Landslides Wildfire Drought Invasive Species	Effective / The plan is currently being updated
State Building Code	Regulation	The Town of Buckland has adopted the Massachusetts State Building Code	All Hazards	Effective for new construction & significant rehabilitation
Culvert Assessment	Practice / Plan	UMass Amherst and Trout Unlimited assessed all road-stream crossings in Buckland; FRCOG compiled a report for the Town of the High Risk culverts from this assessment	Flooding	Partially Effective / Funding will need to be pursued to follow through with culvert replacements
Tree Maintenance	Practice	The Highway Department and electric company trim tree branches near overhead power lines	Severe Snowstorms / Ice Storms Hurricanes / Tropical Storms Thunderstorms / Wind Events Invasive Species	Partially Effective / Invasive species need to be addressed along roadways to prevent weakening/killing of trees that may impact power lines and evacuation routes
Burn Permits	Regulation	Shelburne Control issues burn permits for Buckland. Personnel provide information on safe burn practices when issuing permits.	Wildfire	Effective
Fire Safety Education	Practice	The Fire Department has an ongoing fire safety educational program in the schools.	Wildfire	Effective
Dam Inspections	Regulation	DCR inspection schedule is based on the hazard rating of the dam; owners are responsible for inspections. FERC high & significant hazard dams are inspected annually.	Dam Failure	Partially Effective / DCR needs more resources to enforce inspection schedules
High / Significant Hazard Dam Emergency Action Plans	Regulation	Owners of high hazard and certain significant hazard dams are responsible for preparing Emergency Action Plans	Dam Failure	Partially Effective / FERC-licensed dams have up-to-date EAPs; a public notification plan is needed for a dam failure event
Back-Up Drinking Water Supply	Policy / Practice	Two 500,000 gallon water tanks store roughly 6 days of back-up water supply; the Fire District also has a propane generator that can pump up to 130,000 gallons/day for a week.	All Hazards	Partially Effective for residents on the public water supply / Locate a second water source on the Buckland side of the Deerfield River for added resilience.

Table 4-1: Existing Mitigation Capabilities				
Strategy	**Capability Type**	**Description**	**Hazards Mitigated**	**Effectiveness / Improvements**
Back-Up Power	Practice	Buckland's municipal buildings have back-up power generators.	All Hazards	Effective
Sheltering Plan	Plan	A regional sheltering plan has been completed; Shelter Management Teams need to be created and cost sharing agreements between towns established	All Hazards	Partially Effective / Participate in the REPC's planning process to operationalize the regional shelter plan
Evacuation Plan	Plan	Primary and secondary evacuation routes are identified	All Hazards	Partially Effective / Buckland should coordinate with surrounding towns on evacuation procedures for dam failure or other regional events.
Debris Management	Plan	Plan and location for storing storm debris.	All Hazards	Not Effective / Buckland does not currently have a plan or site in place.

4.3 HAZARD MITIGATION GOAL STATEMENTS AND ACTION PLAN

As part of the multi-hazard mitigation planning process undertaken by the Buckland Hazard Mitigation Planning Committee, existing gaps in protection and possible deficiencies were identified and discussed. The Committee then developed general goal statements and mitigation action items that, when implemented, will help to reduce risks and future damages from multiple hazards. The goal statements, action items, Town department(s) responsible for implementation, and the proposed timeframe for implementation for each category of hazard are described below. It is important to note that the Town of Buckland has limited capabilities and resources (especially staffing) to be able to expand and improve upon existing policies and programs when the town identifies a need for improvement.

Hazard Mitigation Goals

Based on the findings of the Risk Assessment, public outreach, and a review of previous town plans and reports, the Town of Buckland has developed the following goals to serve as a framework for mitigating the hazards identified in this plan:

- To provide adequate shelter, water, food and basic first aid to displaced residents in the event of a natural disaster.
- To provide adequate notification and information regarding evacuation procedures, etc., to residents in the event of a natural disaster.
- To minimize the loss of life, damage to property, and the disruption of governmental services and general business activities due to natural hazards.

Prioritization of Hazards

The Committee examined the results of the Risk Assessment (see Section 3) and used the results to prioritize the identified hazards. The Committee evaluated the natural hazards that can impact the town based on probability of occurrence, severity of impacts, area of occurrence and preparedness. Those hazards receiving the highest Overall Hazard Vulnerability Rating were assigned the highest priority, as shown in Table 4-2.

Table 4-2: Buckland Hazard Priority Level Rating		
Natural Hazard	**Overall Hazard Vulnerability Rating**	**Priority Level**
Drought	High	High
Invasive Species	High	High
Hurricanes / Tropical Storms	High	High
Flooding	High	High
Severe Thunderstorms / Wind / Microbursts	Medium	Medium
Extreme Temperatures	Medium	Medium
Severe Winter Storms	Medium	Medium
Dam Failure	Medium	Medium
Earthquakes	Medium	Medium
Wildfires	Medium	Medium
Tornadoes	Low	Low
Landslides	Low	Low

Prioritization of Action Items

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

Prioritization Methodology

The Buckland Hazard Mitigation Planning Committee reviewed and prioritized a list of mitigation strategies using the following criteria:

- **Application to high priority or multiple hazards** – Strategies are given a higher priority if they assist in the mitigation of hazards identified as high priorities (Table 4-2) or apply to several natural hazards.

- **Time required for completion** – Projects that are faster to implement, either due to the nature of the permitting process or other regulatory procedures, or because of the time it takes to secure funding, are given higher priority.
- **Estimated benefit** – Strategies which would provide the highest degree of reduction in loss of property and life are given a higher priority. This estimate is based on the Hazard Identification and Risk Assessment Chapter, particularly with regard to how much of each hazard's impact would be mitigated.
- **Cost effectiveness** – In order to maximize the effect of mitigation efforts using limited funds, priority is given to low-cost strategies. For example, regular tree maintenance is a relatively low-cost operational strategy that can significantly reduce the length of time of power outages during a winter storm. Strategies that have identified potential funding streams, such as the Hazard Mitigation Grant Program, are also given higher priority.

The following categories are used to define the priority of each mitigation strategy:

- **Low** – Strategies that would not have a significant benefit to property or people, address only one or two hazards, or would require funding and time resources that are impractical.
- **Medium** – Strategies that would have some benefit to people and property and are somewhat cost effective at reducing damage to property and people.
- **High** – Strategies that provide mitigation of high priority hazards or multiple hazards and have a large benefit that warrants their cost and time to complete.
- **Very High** – extremely beneficial projects that will greatly contribute to mitigation of high priority and multiple hazards and the protection of people and property. These projects are also given a numeric ranking within the category.

Cost Estimates

Each of the following implementation strategies is provided with a cost estimate. Projects that already have secured funding are noted as such. Where precise financial estimates are not currently available, categories were used with the following assigned dollar ranges:

- **Low** – cost less than $25,000
- **Medium** – cost between $25,000 – $100,000

- **High** – cost over $100,000

Cost estimates take into account the following resources:

- Town staff time for grant application and administration (at a rate of $25 per hour)
- Consultant design and construction cost (based on estimates for projects obtained from town and general knowledge of previous work in town)
- Town staff time for construction, maintenance, and operation activities (at a rate of $25 per hour)

Project Timeline

The timeframe for implementation of the action items are listed in the Action Plan as Year 0-1, which is the first year following plan adoption, and subsequent years after plan adoption through the 5 year life of the plan (Year 2, Year 3, Year 4 and Year 5). The Committee recognized that many mitigation action items have a timeframe that is ongoing due to either funding constraints that delay complete implementation and/or the action item should be implemented each of the five years of the plan, if possible. Therefore, a category of Year 0-1, to be reviewed annually and implemented in subsequent years (Years 2-5), as appropriate was added.

Even when the political will exists to implement the Action Items, the fact remains that Buckland is a small town that relies heavily on a small number of paid staff, many of whom have multiple responsibilities, and a dedicated group of volunteers who serve on town boards. However, some Action Items, when implemented by Town staff and volunteers, result in a large benefit to the community for a relatively small cost.

For larger construction projects, the town has limited funds to hire consultants and engineers to assist them with implementation. For these projects, the Town may seek assistance through the Franklin Regional Council of Governments (FRCOG). However, the availability of FRCOG staff can be constrained by the availability of grant funding.

The 2020 Buckland Hazard Mitigation Prioritized Action Plan is shown in Table 4-3. Potential funding sources for mitigation action items are listed when known. Other potential funding sources are listed in Table 5-1 of this plan. When Town funds are listed as a source to fund hazard mitigation projects or activities, either in part (match) or in full, these funds would be obtained from the town's "general fund".

Table 4-3: 2020 Buckland Hazard Mitigation Prioritized Action Plan

Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2013 Priority / 2020 Priority	Status
MULTI-HAZARD ACTIONS									
Critical Facilities & Infrastructure	Formalize sheltering agreements with the Mohawk Trail Regional School.	Multi-Hazard	Emergency Management Director, Selectboard, Town Administrator	Low	Town	2021	S	N/A / High	New Action Item. The Mohawk Trail Regional School serves as a regional shelter.
Critical Facilities & Infrastructure	Identify alternative shelter locations in upper Buckland and in the Buckland side of the village of Shelburne Falls that are equipped with an auxiliary power supply and are earthquake resistant as well as outside of the floodplain and inundation areas. Disseminate this information to appropriate town departments.	Multi-Hazard	Emergency Management Director	Low	Town, Volunteers	2023	S	High / High	Modified from 2013 plan. The Mohawk Trail Regional School is within the dam inundation area and may not be accessible during all hazard events. Greenfield High School and the Community Center in Shelburne are back-up locations.
Critical Facilities & Infrastructure	Inventory supplies for identified alternative shelters and develop a needs list and storage requirements. Establish arrangements with local or neighboring vendors for supplying shelters with potable water, food and first aid supplies in the event of a natural disaster.	Multi-Hazard	Police Department, Emergency Management Director	Low	Town, Volunteers	2023	S	High / High	Carried over from 2013 plan.
Critical Facilities & Infrastructure	Seek funding to replace the Nilman Road bridge.	Multi-Hazard	Highway Department, Select Board	High	MassDOT Small Bridge Program, Chapter 90, MA DER	2021	S, I, E	N/A / High	New Action Item. Design for the bridge is complete. Funding is needed for construction.
Education & Awareness	Continue to encourage seniors to sign up for TRIAD through the Franklin County Sheriff's Office.	Multi-Hazard	Emergency Management Director, Council on Aging, FCSO	Low	Town	Ongoing	S	N/A / High	New Action Item. TRIAD is a safety and wellness program for seniors run by the sheriff's office.
Local Plans & Regulations	Work with utility companies to underground new utility lines and existing lines where repetitive outages occur. Require undergrounding of utilities when feasible in the Site Plan Review and Special Permit regulations of the Zoning Bylaw.	Multi-Hazard	Select Board, Planning Board	High	Utilities MassWorks DLTA	2023	S, I, E	High / Medium	Carried over from 2013 plan. New utility lines have not been undergrounded but poles have been placed in less vulnerable locations when possible.
Local Plans & Regulations	Seek technical assistance to ensure annual update of the Town of Buckland CEM Plan.	Multi-Hazard	Emergency Management Director	Low	MEMA	Ongoing	S, I, E	High / Medium	Carried over from 2013 plan. MEMA provides assistance to towns with updating CEM Plans.
Education & Awareness	Collect, periodically update, and disseminate information on which local radio stations provide emergency information, what to include in a 'home survival kit,' how to prepare homes and other structures to withstand flooding and high winds, locations for filling water bottles during drought or prolonged power outages, and the proper evacuation procedures to follow during a natural disaster. Include information in tax bill mailing.	Multi-Hazard	Town Administrator, Select Board, Emergency Management Director	Low	Town	Annually	S	High / Medium	Carried over from 2013 plan. Not started.

Table 4-3: 2020 Buckland Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2013 Priority 2020 Priority**	**Status**
Local Plans & Regulations	Work with local farmers to develop a system for recording damage's to crops from extreme temperature and other hazards. Recording this data will help inform what the economic impacts of disasters and climate change are for the town's agricultural community.	Multi-Hazard	Agricultural Commission, Emergency Management Director	Low	Town, Volunteer Time, DLTA	2024	S	N/A Medium	New Action Item.
Local Plans & Regulations / Nature Based Solutions	Conduct a community discussion about adopting the Community Preservation Act (CPA) to provide funding for local and regional, watershed-wide open space protection efforts, particularly in floodplain areas and priority areas for protection identified in the Buckland Open Space and Recreation Plan, as updated.	Multi-Hazard	Planning Board, Board of Health, Finance Committee, Conservation Commission, Select Board	Low	Town, Volunteers	2025	S, I, E	NA Medium	New Action Item. The CPA could provide a steady source of funding for open space protection projects.
Critical Facilities & Infrastructure	Continue to participate in the Attorney General Office's Abandoned Housing Initiative to address the condition of vacant, abandoned buildings in town.	Multi-Hazard	Selectboard Board of Health	Low	AGO CDBG	2020 and Ongoing	S, I, E	NA Medium	New Action Item. A section of the village of Shelburne Falls in Buckland is designated a slum and blight area.
Critical Facilities & Infrastructure	Consider utilizing Community Development Block Grant home rehabilitation funds to assist homeowners and landlords in retrofitting aging housing stock, including mobile homes. Publicize available home rehabilitation and weatherization resources to residents.	Multi-Hazard	Select Board, Council on Aging, Board of Health, Energy Committee	High	DHCD, MassSave	Ongoing	S, I	Medium Medium	Modified from 2013 plan. Buckland does not currently fund a home rehabilitation program through CDBG.
Local Plans & Regulations	Explore locations in Buckland to serve as a staging area for storage of local storm debris, including the Transfer Station and Upper Buckland Fire Station. Pursue funding to purchase additional land if necessary.	Multi-Hazard	Select Board, Planning Board, FRCOG, Solid Waste Management District	Low	Town WRHSAC MVP DLTA	2023	S, I, E	Medium Medium	Modified from 2013 Plan. A debris management template is available on the WRHSAC website.[72]
HAZARD-SPECIFIC ACTIONS									
Critical Facilities & Infrastructure	Locate a public water supply source on the Buckland side of the Deerfield River to serve as a back-up supply and provide added resiliency to the system in the Shelburne Falls water district.	Flooding, Drought, Dam Failure, Earthquakes	Shelburne Falls Fire District, Select Board, Conservation Commission	High	Shelburne Falls Fire District, LAND Grant	2025	S, I	NA High	New Action Item. The Fire District is actively seeking funding for a new water supply source.
Critical Facilities & Infrastructure	Prepare an emergency action plan for a scenario where the Bridge of Flowers and/or Iron Bridge are damaged or destroyed. Include options for running a temporary drinking water line across the Deerfield River in the event the water main on the bridge is damaged.	Flooding, Dam Failure, Earthquakes	Shelburne Falls Fire District, Select Board	High	Shelburne Falls Fire District, MVP, HMGP	2023	S, I	NA High	New Action Item. New Action Item. An engineering study of the bridge documenting damage from Tropical Storm Irene is complete but results are not yet available. The Fire District does not have a temporary line on-hand, but the Army Corps of Engineers could set one up if needed.

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

Table 4-3: 2020 Buckland Hazard Mitigation Prioritized Action Plan

Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2013 Priority / 2020 Priority	Status
Local Plans & Regulations / Education & Awareness	Participate in emergency exercises and planning related to flooding and dam failure on the Deerfield River. Update communications and evacuation plans in coordination with surrounding communities. Establish a plan for notifying residents within the inundation area of evacuation procedures to follow.	Dam Failures	Emergency Management Director, Police Department, Fire Department, Great River Hydro, Brookfield Power	Low	Town, Great River Hydro, Brookfield Power, WRHSAC, MEMA	2020 and ongoing	S, I, E	High / High	Modified from 2013 plan. Vulnerabilities were identified during the FRCOG's 2018 Deerfield River Table Top Exercise. A second exercise is planned for spring 2020.
Local Plans & Regulations / Education & Awareness	As part of the evacuation planning, identify areas in town that are vulnerable to being isolated from landslides, flooding, dam failure, and other hazards. Include this information in a comprehensive evacuation plan and educate residents about this risk.	Landslides, Flooding, Dam Failure	Emergency Management Director	Low	Town	2021	S	N/A / High	New Action Item.
Critical Facilities & Infrastructure / Nature-Based Solutions	Seek funding to hire professional consulting and construction services to finalize designs and implement the Crittenden Hill Road stormwater management project. The project will help mitigate flooding in the village of Shelburne Falls by slowing, settling, and filtering stormwater runoff uphill of neighborhoods, and will provide water quality benefits by filtering out non-point source pollution prior to stormwater entering the Deerfield River.	Flooding Heavy-Precipitation Hazards	Highway Department, Select Board, Shelburne Falls Fire District, Conservation Commission	High	MVP, CDBG, Chapter 90, Complete Streets, MA DEP	2025	S, I, E	NA / High	New Action Item. Initiated by FRCOG in 2019, the initial phase of the project will be complete by June 30, 2020, and will produce MassDOT 25% design level documents stamped by a professional engineer.
Local Plans & Regulations	Continue to participate in the Regional Emergency Planning Committee (REPC) to address procedures to deal with hazardous materials emergencies and encourage community awareness.	Manmade Hazards	Emergency Management Director, REPC	Low	Town	Ongoing	S, I, E	High / High	Modified from 2013 plan.
Nature-Based Solutions	Review and implement the Seven-Year Action Plan strategies of the Buckland Open Space and Recreation Plan, as updated, particularly those dealing with protection of forests, farmland and floodplain forests.	Flooding	Select Board, Open Space and Recreation Committee	Low - High	Town MVP MA DCS DLTA	Ongoing	S, I, E	Low / High	Ongoing from 2013 plan. Buckland is currently updating the 2010 Open Space and Recreation Plan.
Critical Facilities & Infrastructure	Consider forming a working group or REPC subcommittee with other municipalities in the region that have rail lines to compile a list of concerns related to fire hazards and hazardous material spills along the rail lines. Work with local, regional, and state organizations to collectively take action to address these issues with the rail company.	Manmade Hazards Wildfire	Emergency Management Director, REPC, FRCOG	Low	Town REPC	2021 and ongoing	S, I, E	N/A / High	New Action Item.
Local Plans & Regulations	Participate in tabletop exercises and trainings for hazardous material accidents.	Manmade Hazards	Emergency Management Director, REPC	Low	MEMA WRHSAC	Ongoing	S, I, E	NA / High	New Action Item. The REPC and FRCOG offer hazardous material trainings and exercises annually
Local Plans & Regulations	Inventory Town land and right of ways for invasive species. Prioritize locations and species to focus on. Develop a management plan for controlling and mitigating the spread of invasive species on Town property.	Invasive Species	Highway Department, Conservation Commission, Select Board	Low	Town MVP MDAR	2022	S, I, E	N/A / High	New Action Item.

Table 4-3: 2020 Buckland Hazard Mitigation Prioritized Action Plan

Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2013 Priority / 2020 Priority	Status
Critical Facilities & Infrastructure	Seek funding to repair or replace high risk culverts. In particular, seek funding to replace culverts at Pine and Birch Streets that are vulnerable to washing out and isolating a neighborhood. Ensure projects are designed to take into account increased precipitation from climate change.	Flooding	Select Board, Highway Department	High	Chapter 90, MA DER, MVP, MassWorks, CDBG	Ongoing	S, I, E	N/A / High	New Action Item. High Risk culverts have been assessed and mapped in Buckland and are identified in the 2018 (amended in 2020) report "High Risk Stream Crossings in Buckland, MA"
Local Plans & Regulations / Critical Facilities & Infrastructure	Conduct Continuity of Operations Planning (COOP) for critical Town buildings located within or adjacent to the floodplain and dam inundation area, and include as an annex in the town Comprehensive Emergency Management Plan or as a stand-alone document.	Flooding Dam Failure	Emergency Management Director, Police, Fire, and Highway Departments	Low	DLTA Town	2021	S, I	N/A / High	New Action Item. The FRCOG Emergency Preparedness staff can assist with COOP planning.
Critical Facilities & Infrastructure	Monitor the Deerfield River and other rivers, brooks, and streams in Town for potential ice buildup and ice jams.	Ice Jams	Emergency Management Director, Fire Department, Great River Hydro, Highway Department	Low	Town	Ongoing	S, I, E	Medium / Medium	Carried over from 2013 plan.
Nature-Based Solutions	Support local and regional, watershed-wide open space protection efforts, particularly in floodplain areas, river corridor areas, and upland tributary areas.	Flooding	Conservation Commission, Select Board	High	Town MVP MA DCS	Ongoing	S, I, E	Low / Medium	Ongoing from 2013 plan. Buckland is currently updating the 2010 Open Space and Recreation Plan.
Local Plans & Regulations	Review and revise current regulations for new driveway openings or curb cuts to include grade and design standards to prevent runoff and icing conditions.	Flooding	Highway Department, Select Board	Low	Town	2022	I	Low / Medium	Carried over from 2013 Plan.
Critical Facilities & Infrastructure	Implement measures to mitigate inflow and infiltration (I&I) of groundwater into the wastewater treatment system, including replacement of pipes during public infrastructure projects, and disconnection of downspouts, basement drainage and sump pumps from private residences. Investigate funding mechanisms to assist residents with disconnecting.	Flooding, Manmade Hazards	Select Board, Highway Department, Wastewater Treatment Facility	High	Town HCI Small Town Grant CDBG MassWorks MVP	Ongoing	I, E	N/A / Medium	New Action Item. Phase II of an I&I study is underway. The town has evaluated Town-owned infrastructure, but has not fully addressed private residences.
Critical Facilities & Infrastructure	Hire a consultant to study the Japanese knotweed and other invasives along the banks of the Deerfield River to determine erosion threats to property and downstream infrastructure and options for mitigation	Flooding Invasive Species	Conservation Commission, Town Administrator	Low	Town MVP MA DEP	2023	S, I, E	N/A / Medium	New Action Item.
Education & Awareness	Provide public education and outreach to raise awareness about invasive species, including training sessions about the Outsmart Invasive Species program. Emphasize the need for "early detection and rapid response" and teach about species just beginning to invade Buckland or nearby communities, paying special attention to those species most likely to cause damage to agricultural crops and forest health, including forest regeneration and wildlife habitat, and aquatic systems.	Invasive Species	Conservation Commission, Franklin Land Trust, UMass Amherst Extension (MassWoods)	Low	MA DCR USFS NRCS	2021 and ongoing	S, I, E	N/A / Medium	New Action Item.

Table 4-3: 2020 Buckland Hazard Mitigation Prioritized Action Plan

Action Type	Action Description	Hazards Addressed	Responsible Department / Board	Estimated Cost	Potential Funding Source	Estimated Timeframe	Benefits: Society (S) Infrastructure (I) Environment (E)	2013 Priority 2020 Priority	Status
Education & Awareness	Provide landowner education about invasive species, and assist landowners with accessing funding for invasive plant/pest control. Promote forestry Best Management Practices during timber harvests or other forest management activities (trail building/maintenance, wildlife management etc.) to prevent the establishment of opportunistic invaders.	Invasive Species	Conservation Commission, Franklin Land Trust	Low	MA DCR NRCS	2020 and ongoing	S, I, E	N/A Medium	New Action Item.
Local Plans & Regulations / Nature-Based Solutions	Hire a consultant to conduct a geomorphic engineering assessment and fluvial erosion mapping of the Clesson Brook to determine possible bank stabilization measures to mitigate damages to the environment and nearby infrastructure. Seek funding to implement recommended measures.	Flooding	Conservation Commission, Planning Board	High	MVP MA DEP	2022	S, I, E	N/A Medium	New Action Item.
Local Plans & Regulations	Utilize the fluvial erosion mapping from the above action to draft a river corridor protection zoning bylaw and overlay for the Clesson Brook.	Flooding	Planning Board	Low	DLTA Volunteer Time	2024	S, I, E	N/A Medium	New Action Item. The FRCOG has a model River Corridor Bylaw for use with fluvial erosion hazard mapping.
Local Plans & Regulations	Seek technical assistance to inventory and map all sites and structures of historic and/or cultural value and overlay with the updated floodplain map to determine potential vulnerability to flooding.	Flooding	Planning Board, EMD, FRCOG, Open Space Committee, Historical Commission	Low	FEMA, Town, Volunteers, DLTA	2024	I	Low Low	Carried over from 2013 plan. This action item is also contained in the 2010 OSRP. FEMA is in the process of updating the floodplain maps for Buckland.
Local Plans & Regulations	Seek technical assistance to map the number of potential developable acres in the floodplain, and to update the Vulnerability Assessment for properties located within the 100-year floodplain, once updated floodplain maps are available from FEMA.	Flooding	Planning Board, FRCOG, Board of Assessors	Low	FEMA, Town, Volunteers, DLTA	2024	S, I, E	Low Low	Updated from 2013 plan. FEMA is in the process of updating the floodplain maps for Buckland.
Local Plans & Regulations	Once updated floodplain maps are available from FEMA, update the Critical Facilities and Infrastructure map to determine critical or hazardous facilities that are located in the floodplain or areas subject to chronic flooding, and determine the facilities' preparedness for the impacts of flooding.	Flooding	Planning Board, FRCOG, EMD	Low	FEMA, Town, Volunteers	2024	S, I, E	Low Low	Carried over from 2013 plan. FEMA is in the process of updating the floodplain maps for Buckland.
Local Plans & Regulations	Review and update the Floodplain District Overlay Zoning Bylaw using the new state Model Floodplain District Bylaw (will likely be available by 2021) to reduce the risk of flooding and damage to infrastructure and natural resources. Special consideration should be given to further restricting or limiting new development within the 100-year floodplain.	Flooding	Planning Board, EMD, FRCOG	Low	Town DLTA	2024	S, I, E	Low Low	Updated from 2013 plan. Not started. FEMA is in the process of updating the floodplain maps for Buckland.
Local Plans & Regulations / Nature-Based Solutions	Review and revise the Zoning Bylaw and Subdivision Regulations to incorporate Low Impact Development (LID) site planning and stormwater design into new development and redevelopment.	Flooding	Planning Board, FRCOG	Low	Town DLTA MVP Action Grant	2022	S, I, E	Low Low	Updated from 2013 plan. Not started. Mass Audubon has a LID regulatory review tool available online.[73]

[73] https://www.massaudubon.org/our-conservation-work/advocacy/shaping-the-future-of-your-community/publications-community-resources/bylaw-review

Table 4-3: 2020 Buckland Hazard Mitigation Prioritized Action Plan									
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Potential Funding Source**	**Estimated Timeframe**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**2013 Priority 2020 Priority**	**Status**
Local Plans & Regulations	Once, new floodplain maps are available for Buckland, re-evaluate if the town should join FEMA's Community Rating System based on information in this plan and available through FEMA.	Flooding	Planning Board, Select Board, Conservation Commission	Low	Town	2024	S	Low / Low	Carried over from 2013 plan. Not yet completed.
Education & Awareness	Educate homeowners about general fire safety, including the development and distribution of an educational pamphlet on fire safety and prevention.	Wildfires, Manmade Hazards	Shelburne Falls Fire District, Buckland Fire District	Low	Fire Districts	Ongoing	S, I, E	Low / Low	Ongoing from 2013 plan.
Local Plans & Regulations	Coordinate with the FRCOG and other appropriate agencies to request that the State revise burn permit guidelines to allow for burning during optimal seasons of the year.	Wildfires	Shelburne Falls Fire District, Buckland Fire District, FRCOG	Low	Fire Districts	2022	S, I, E	Low / Low	Carried over from 2013 plan. Not yet completed.

Table 4-4: Buckland Completed or Obsolete 2013 Hazard Mitigation Actions								
Action Type	**Action Description**	**Hazards Addressed**	**Responsible Department / Board**	**Estimated Cost**	**Funding Source**	**Benefits: Society (S) Infrastructure (I) Environment (E)**	**Priority in Past Plan**	**Current Status**
Critical Facilities & Infrastructure	Implement plan for erosion and stream bank stabilization issues at Buckland Recreation Center.	Landslides	Highway Department, Conservation Commission			E	Low	Bank stabilization project completed in 2019.
Critical Facilities & Infrastructure	Examine current notification system including feasibility of Reverse 911. Develop a preliminary project proposal and cost estimate and implement plan	Multi-Hazard	Town Administrator, Police Department, Select Board, Board of Health		Town	S	High	Buckland has implemented a Reverse 911 system and works to maintain contact list and educate public.
Critical Facilities & Infrastructure	Ensure that identified shelters have sufficient back-up utility service in the event of primary power failure.	All Hazards	Emergency Management Director		Town	S	High	Generators are in place.
Local Plans & Regulations	Review and update Chapter X of the Buckland Zoning Bylaw that regulates wireless communication facilities. Consider adding 'the prevention of wind-related damage' as one of the purposes of the bylaw	All High Wind Related Hazards	Planning Board	Low	NA	S, I, E	Medium	Complete. A purpose of Buckland's Bylaw for Personal Wireless Service Facilities is to "avoid damage to adjacent properties," and includes setbacks and height restrictions for towers and equipment.
Local Plans & Regulations	Ensure Compliance with the Massachusetts State Building Code. The Building Inspector should ensure that all new construction complies with the appropriate seismic and wind related requirements of the State Building Code. Ensure construction of new homes with a minimum of four (4) foot wall foundation such that basements or crawl spaces provide shelter during a tornado, hurricane or other storm event with high winds.	Multi-Hazard	Building Inspector	Low	Town	S , I, E	High	Ongoing. Buckland is a member of the Franklin County Cooperative Inspection Program.
Local Plans & Regulations	Using Assessors' data and other available information, expand and update the Vulnerability Assessment for properties located within the 100-year floodplain.	Flooding	Planning Board, EMD	Low	Town	S, E	Low	Duplicative action item.
Local Plans & Regulations	Coordinate with state and regional agencies to identify a location(s) for the temporary storage of contaminated/hazardous flood debris.	Flooding	Select Board, Planning Board, FRCOG, Solid Waste Management District	Low	Town	S, I, E	Low	Obsolete. Towns need to identify a site in their own town as regional agreements have not been made.
Local Plans & Regulations	Consider requiring tie downs for mobile homes to prevent wind-related damage or disallow mobile homes.	High Wind Hazards	Building Inspector, Planning Board	Low	Town	S	Medium	Obsolete. Retrofits of mobile homes is incorporated into the home rehabilitation action item in Table 4-3.

5 PLAN ADOPTION AND MAINTENANCE

5.1 PLAN ADOPTION

The Franklin Regional Council of Governments (FRCOG) provided support to the Buckland Hazard Mitigation Committee as they underwent the planning process. Town officials such as the Emergency Management Director and the Town Administrator were invaluable resources to the FRCOG and provided background and policy information and municipal documents, which were crucial to facilitating completion of the plan.

When the preliminary draft of the Buckland Hazard Mitigation Plan was completed, copies were disseminated to the Committee for comment and approval. The Committee was comprised of representatives of Town boards and departments who bear the responsibility for implementing the action items and recommendations of the completed plan (see the list of Committee members on the front cover).

Copies of the Final Review Draft of the Hazard Mitigation Plan for the Town of Buckland were distributed to Town boards and officials, and to surrounding towns for review. Copies were made available at the Town Hall and the library, and a copy of the plan was also posted on the Town website for public review. Once reviewed and approved by MEMA, the plan was sent to the Federal Emergency Management Agency (FEMA) for their approval. FEMA approved the plan on [enter date], and on [enter date], the Buckland Board of Selectmen voted to adopt the plan (see Appendix B).

5.2 PLAN MAINTENANCE PROCESS

The implementation of the Buckland Hazard Mitigation Plan will begin following its approval by MEMA and FEMA and formal adoption by the Buckland Board of Selectmen. Specific Town departments and boards will be responsible for ensuring the development of policies, bylaw revisions, and programs as described in the Action Plan (Table 4-3). The Buckland Hazard Mitigation Planning Committee will oversee the implementation of the plan.

Monitoring, Evaluating, and Updating the Plan

The measure of success of the Buckland Hazard Mitigation Plan will be the number of identified mitigation strategies implemented. In order for the Town to become more disaster resilient and better equipped to respond to natural disasters, there must be a coordinated effort between elected officials, appointed bodies, Town employees, regional and state agencies involved in disaster mitigation, and the general public.

Implementation Schedule

Annual Meetings

The Buckland Hazard Mitigation Planning Committee will meet on an annual basis or as needed (i.e., following a natural or other disaster) to monitor the progress of implementation, evaluate the success or failure of implemented recommendations, and brainstorm for strategies to remove obstacles to implementation. Following these discussions, it is anticipated that the Committee may decide to reassign the roles and responsibilities for implementing mitigation strategies to different Town departments and/or revise the goals and objectives contained in the plan. At a minimum, the Committee will review and update the plan every five years. The meetings of the Committee will be organized and facilitated by the Buckland Town Administrator and the Emergency Management Director.

Bi-Annual Progress Report

The Town Administrator and Emergency Management Director will prepare and distribute a biannual progress report in years two and four of the plan. Members of the Local Planning Committee will be polled on any changes or revisions to the plan that may be needed, progress and accomplishments for implementation, failure to achieve progress, and any new hazards or problem areas that have been identified. Success or failure to implement recommendations will be evaluated differently depending on the nature of the individual Action Items being addressed, but will include, at a minimum, an analysis of the following: 1) whether or not the item has been addressed within the specified time frame; 2) whether actions have been taken by the designated responsible parties; 3) what funding sources were utilized; 4) whether or not the desired outcome has been achieved; and 5) identified barriers to implementation. This information will be used to prepare the bi-annual progress report which may be attached as an addendum, as needed, to the local hazard mitigation plan. The progress report will be distributed to all of the local implementation group members and other interested local stakeholders. The Town Administrator, Emergency Management Director, and the Committee will have primary responsibility for tracking progress and updating the plan.

Five-Year Update Preparation

During the fourth year after initial plan adoption, the Town Administrator and Emergency Management Director will convene the Committee to begin preparations for an update of the plan, which will be required by the end of year five in order to maintain approved plan status with FEMA. The team will use the information from the annual meetings and the biannual progress reports to identify the needs and priorities for the plan update.

<ins>Updated Local Hazard Mitigation Plan – Preparation and Adoption</ins>

FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the town's approved plan status and its eligibility for FEMA mitigation grants. Because of the time required to secure a planning grant, prepare an updated plan, and complete the approval and adoption of an updated plan, the local Hazard Mitigation Planning Committee should begin the process by the end of Year 3. This will help the town avoid a lapse in its approved plan status and grant eligibility when the current plan expires.

The Committee may decide to undertake the update themselves, request assistance from the Franklin Regional Council of Governments, or hire another consultant. However the Committee decides to proceed, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The updated Buckland Hazard Mitigation Plan will be forwarded to MEMA and to FEMA for approval.

As is the case with many Franklin County towns, Buckland's government relies on a few public servants filling many roles, upon citizen volunteers and upon limited budgets. As such, implementation of the recommendations of this plan could be a challenge to the Committee. As the Committee meets regularly to assess progress, it should strive to identify shortfalls in staffing and funding and other issues which may hinder Plan implementation. The Committee can seek technical assistance from the Franklin Regional Council of Governments to help alleviate some of the staffing shortfalls. The Committee can also seek assistance and funding from the sources listed in Table 5-1.

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
National Flood Insurance Program	Pre-disaster insurance	Rolling	DCR	Property Owner, FEMA
Community Assistance Program	State funds to provide assistance to communities in complying with NFIP requirements	Annually	DCR	FEMA/NFIP
Community Rating System (Part of the NFIP)	Flood insurance discounts	Rolling	DCR	Property Owner
Flood Mitigation Assistance (FMA) Program	Cost share grants for pre-disaster planning & projects	Annual	MEMA	75% FEMA/ 25% non-federal
Hazard Mitigation Grant Program (HMGP)	Post-disaster cost-share Grants	Post Disaster	MEMA	75% FEMA/ 25% non-federal
Pre-Disaster Mitigation (PDM) Program	National, competitive grant program for projects & planning	Annual	MEMA	75% FEMA/ 25% non-federal
Small Business Administration Disaster Loans	Post- disaster loans to qualified applicants	Ongoing	MEMA	Small Business Administration
Public Assistance Program	Post-disaster aid to state and local governments	Post Disaster	MEMA	FEMA/ plus a non-federal share
Dam & Seawall Repair & Removal Program	Grant and loan funds for design, permitting, and construction of repair or removal of dams	Annual	EEA	Dam and Seawall Repair or Removal Fund
Emergency Management Performance Grant (EMPG)	Funding to assist local emergency management departments in building and maintaining an all-hazards emergency preparedness system, including planning; organizational support; equipment; training; and exercises	When funds are available	MEMA	
Volunteer Fire Assistance (VFA) Program	Grants and materials to towns with less than 10,000 population for technical, financial and other assistance for forest fire related purposes, including training, Class A foam, personal protective gear, forestry tools, and other fire suppression equipment	Annual	DCR	USDA Forest Service

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Federal 604b Water Quality Management Planning Grant	Funding for assessment and planning that identifies water quality problems and provides preliminary designs for Best Management Practices to address the problems	Annual	MA DEP	EPA Clean Water Act
Section 319 Nonpoint Source Competitive Grant Program	Provides grants for wide variety of activities related to non-point source pollution runoff mitigation	Annual	MassDEP	EPA
Economic Development Administration Grants and Investment	Provides grants for community construction projects, which can include mitigation activities	Rolling	FRCOG	U.S. Department of Commerce, EDA
Emergency Watershed Protection	A disaster recovery program made available in emergency situations when neither the state nor the local community is able to repair a damaged watershed	Post-Disaster	NRCS MA	USDA NRCS
Agricultural Management Assistance	Funding for producers to develop or improve sources of irrigation water supply, construct new or reorganize irrigation delivery systems on existing cropland to mitigate the risk of drought	Rolling	NRCS MA	USDA NRCS
Conservation Stewardship Program	Agricultural producers and forest landowners earn payments for actively managing, maintaining, and expanding conservation activities – like cover crops, rotational grazing, ecologically-based pest management, buffer strips, and pollinator and beneficial insect habitat – while maintaining active agricultural production	Rolling	NRCS MA	USDA NRCS
Environmental Quality Incentives Program (EQIP)	Provides technical and financial assistance to forestry & agricultural producers to plan and install conservation practices that address natural resource concerns including water quality degradation, water conservation, reducing greenhouse gases, improving wildlife habitat, controlling invasive plant species, and on-farm energy conservation and efficiency.	Rolling	NRCS MA	USDA NRCS
Agricultural Lands Conservation Program (ACEP)	Provides financial and technical assistance to help conserve agricultural lands and wetlands.	Rolling	NRCS MA	USDA NRCS

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Forest Stewardship Program	Supports private landowners and municipalities to manage woodlands for timber, soil and water quality, wildlife and fish habitat, and recreation	Rolling	DCR / MA Woodlands Institute	USDA Forest Service
Community Forest Stewardship Implementation Grants for Municipalities	Municipalities that manage a town forest or have water supply land currently enrolled in the Forest Stewardship Program apply for 75-25 matching reimbursement grants to implement their forest stewardship plan	Rolling as funding permits	DCR	USDA Forest Service
USDA Community Facilities Direct Loan & Grant	Provides grants and loans for infrastructure and public safety development and enhancement in rural areas	Annual	USDA Rural Development MA	USDA Rural Development
Transportation Improvement Program	Prioritized, multi-year listing of transportation projects in a region that are to receive Federal funding for implementation. Projects are limited to certain roadways and are constrained by available funding for each fiscal year. Any transportation project in Franklin County that is to receive federal funding must be listed on the TIP.	Rolling	Franklin County Transportation Planning Organization / FRCOG	80% Federal / 20% State
Chapter 90 Program	Funds maintaining, repairing, improving and constructing town and county ways and bridges which qualify under the State Aid Highway Guidelines	Annual	Mass DOT	State Transportation Bond
Culvert Replacement Municipal Assistance Grant	Funds replacement of undersized, perched, and/or degraded culverts located in an area of high ecological value with better designed crossings that meet improved structural and environmental design standards and flood resiliency criteria	Annual	MA Division of Ecological Restoration	State Appropriation
MassWorks Infrastructure Program	Funds for public infrastructure such as roadways, streetscapes, water, and sewer	Annual	EOHED	State Appropriation
Municipal Small Bridge Program	5 year program (FY17 – FY21) to assist cities and towns with replacing or preserving bridges with spans between 10' and 20'	Bi-Annual	MassDOT	State Appropriation

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation

Program	Type of Assistance	Availability	Managing Agency	Funding Source
Municipal Vulnerability Preparedness (MVP) Planning and Action Grant Programs	Funding to support cities and towns to begin the process of planning for climate change resiliency and implement priority projects; projects proposing nature-based solutions that rely on green infrastructure or conservation and enhancement of natural systems to improve community resilience are given priority for implementation funding through the MVP Action Grant	Annual	EEA	State Appropriation
Land and Water Conservation Fund Grant Program	Funding for municipalities for the acquisition of parkland, development of a new park, renovation of an existing park, development of trails in an existing conservation or recreation area, or the acquisition of conservation land	Annual	EEA	National Park Service
Drinking Water Supply Protection Grant	Provides financial assistance to public water systems and municipal water departments for the purchase of land in existing Department of Environmental Protection (DEP)-approved drinking water supply protection areas, or land in estimated protection areas of identified and planned future water supply wells or intakes	Annual	EEA	EEA
Landscape Partnership Grant	Funding for large-scale (min. 500 acres), joint conservation projects completed in partnership with federal, state, and local governments, and non-profits	Annual	EEA	EEA
Conservation Partnership Grant	Funds acquisition of conservation or recreation land by non-profit entities	Annual	EEA	EEA
LAND – Local Acquisitions for Natural Diversity	Funding for municipal conservation and agricultural commissions to acquire interests in land that will be used for conservation and passive recreation purposes	Annual	EEA	EEA
PARC - Parkland Acquisitions and Renovations for Communities	Funding for municipalities to acquire parkland, build a new park, or to renovate an existing park	Annual	EEA	EEA

Table 5-1: Potential Funding Sources for Hazard Mitigation Plan Implementation				
Program	**Type of Assistance**	**Availability**	**Managing Agency**	**Funding Source**
Table Acronym Key: DCR = MA Department of Conservation & Recreation; FEMA = Federal Emergency Management Agency; MEMA = MA Emergency Management Agency; EEA = MA Executive Office of Energy & Environmental Affairs; USDA = U.S. Department of Agriculture; NRCS = Natural Resource Conservation Service; EDA = U.S. Economic Development Administration; EPA = U.S. Environmental Protection Agency; FRCOG = Franklin Regional Council of Governments; MassDOT = MA Department of Transportation; EOHED = MA Executive Office of Housing & Economic Development				

Incorporating the Plan into Existing Planning Mechanisms

2013 Multi-Hazard Mitigation Plan
The Town of Buckland has taken steps to implement findings from the 2013 Multi-Hazard Mitigation Plan into the following policy, programmatic areas and plans: the 2016 Buckland Housing Plan; the 2018 Municipal Vulnerability Preparedness (MVP) Resiliency Plan; the update to the Buckland Open Space & Recreation Plan (OSRP); and implementation of the Regional Shelter Plan. The 2010 OSRP is in the process of being updated and incorporates flood mitigation and stormwater management recommendations from the 2013 Plan. The 2016 Housing Plan includes zoning recommendations from the 2013 Plan. Since the 2013 Plan, the Regional Shelter Plan has been put into practice through trainings and exercises at the Mohawk Trail Regional School.

2020 Hazard Mitigation Plan
Upon approval of the Buckland Hazard Mitigation Plan by FEMA, the Committee will provide all interested parties and implementing departments with a copy of the plan, with emphasis on Table 4-3: 2020 Buckland Hazard Mitigation Prioritized Action Plan. The Committee should also consider initiating a discussion with each department on how the plan can be integrated into that department's ongoing work. At a minimum, the plan should be distributed to and reviewed with the following entities:

- Fire Departments/Fire District
- Emergency Management Director
- Police Department
- Public Works / Highway Department
- Planning Board
- Zoning Board of Appeals
- Conservation Commission
- Franklin County Regional Emergency Planning Committee
- Building Inspector/FCCIP
- Select Board
- Wastewater Treatment Facility / Sewer District

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

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

- Any future development of master plans and scenic byway plans could incorporate relevant material from this plan into sections such as the Natural Resources section and any action plans.
- When the Final Draft Hazard Mitigation Plan for the Town of Buckland is distributed to the Town boards for their review, a letter asking each board to endorse any action item that lists that board as a responsible party would help to encourage completion of action items.
- The Planning Board could include discussions of the Hazard Mitigation Plan Action Items in one meeting annually and assess progress. Current Subdivision Rules and Regulations and Zoning Bylaws should be reviewed and revised by the EMD, Planning Board and Select Board based upon the recommendations of this plan. Technical assistance from the FRCOG may be available to assist in the modification of Buckland's current Bylaws.

Continued Public Involvement

The Town of Buckland is dedicated to continued public involvement in the hazard mitigation planning and review process. During all phases of plan maintenance, the public will have the opportunity to provide feedback. The 2020 Plan will be maintained and available for review on the Town website through 2025. Individuals will have an opportunity to submit comments for the Plan update at any time. Any public meetings of the Committee will be publicized. This will provide the public an opportunity to express their concerns, opinions, or ideas about any updates/changes that are proposed to the Plan.