

The Town of Worthington

# Local Natural Hazards Mitigation Plan



**Adopted by the Worthington Select Board on \_\_\_\_\_, 2020**

**Prepared by:**

The Worthington Natural Hazards Mitigation Planning Committee

and

The Pioneer Valley Planning Commission  
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This project was funded by a grant received from the Executive Office of Energy & Environmental Affairs  
Municipal Vulnerability Preparedness (MVP) program with support from the Massachusetts Emergency  
Management Agency (MEMA)

**CERTIFICATE OF ADOPTION**

**Town of Worthington, MASSACHUSETTS**

**BOARD OF SELECTMEN**

**A RESOLUTION ADOPTING THE TOWN OF WORTHINGTON HAZARD MITIGATION PLAN**

WHEREAS, the Town of Worthington established a Committee to create the Town's local Hazard Mitigation plan; and

WHEREAS, the Town of Worthington participated in the Town of Worthington local Hazard Mitigation Plan; and

WHEREAS, the Town of Worthington's Hazard Mitigation Plan contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Worthington, and

WHEREAS, a duly-noticed public meeting was held by the Select Board ON \_\_\_\_\_, 2020 for the public and municipality to review prior to consideration of this resolution; and

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

NOW, THEREFORE BE IT RESOLVED that the Town of Worthington Select Board formally approves and adopts the Town of Worthington Hazard Mitigation Plan, in accordance with M.G.L. c. 40.

ADOPTED AND SIGNED this \_\_\_\_\_ day of \_\_\_\_\_ 2020.

\_\_\_\_\_  
Charley Rose, SelectBoard Chair

ATTEST

# Acknowledgements

The Worthington Select Board extends special thanks to the Worthington Natural Hazards Mitigation Planning Committee as follows:

David Mendelson, Emergency Management Director

Albert (Cork) Nugent, Highway Superintendent

Charley Rose, Select Board

Amy Wang, Planning Board

Peggy O'Neal, Executive Assistant

The Worthington Select Board offers thanks to the Massachusetts Emergency Management Agency (MEMA) for developing the State Hazard Mitigation and Climate Adaptation Plan which served as a model for this plan. In addition, special thanks are extended to the staff of the Pioneer Valley Planning Commission for professional services, process facilitation and preparation of this document.

The Pioneer Valley Planning Commission

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# 1. INTRODUCTION

## **Planning Requirements under the Federal Disaster Mitigation Act**

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The Federal Disaster Mitigation Act, passed in 2000, requires that after November 1, 2004, all municipalities that wish to continue to be eligible to receive FEMA funding for hazard mitigation grants, must adopt a local multi-hazard mitigation plan and update this plan in five year intervals. This planning requirement does not affect disaster assistance funding.

Federal hazard mitigation planning and grant programs are administered by the Federal Emergency Management Agency (FEMA) in collaboration with the states. These programs are administered in Massachusetts by the Massachusetts Emergency Management Agency (MEMA) in partnership with the Department of Conservation and Recreation (DCR).

Massachusetts takes a regional approach and has encouraged the regional planning agencies to prepare plans for their member communities. The Town of Worthington received funding for their Hazard Mitigation plan update from the Executive Office of Environmental Affairs (EOEEA) through the Municipal Vulnerability Preparedness (MVP) program, Massachusetts innovative effort to enhance community resilience to the threat of our changing climate.

## **What is a Hazard Mitigation Plan?**

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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 Worthington and the Pioneer Valley Planning Commission, 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 a local natural hazard mitigation plan before a disaster occurs 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.

The 2020 Worthington Hazard Mitigation Plan (HMP) is an update to the previous plan published in 2010. In addition to updating the plan to reflect changes in development, mitigation priorities, and recent hazards in the town, the planning team revised the content, structure, and plan update process. A primary difference between the 2010 and 2019 plans is that this HMP update includes a new focus on climate adaptation. The integrated nature of this plan provides the opportunity to identify climate change impacts, describe the effect climate change is anticipated to have on natural hazards, and prepare an integrated strategy to understand and mitigate risks. The concurrent development of the town’s Municipal Vulnerability Preparedness (MVP) planning process supported the integration of climate impacts into this HMP update, and the results of the MVP process are incorporated into this plan’s Mitigation Strategy.

In addition to integrating climate change, the structure of the plan was further revised and reorganized based on the integrated nature of the plan and to align with the recently published 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan.

## Previous Federal/State Disasters

The Town of Worthington has experienced 18 natural hazards that triggered federal or state disaster declarations since 1991. These are listed in Table 1 below. The majority of these events involved severe winter weather, while 6 involved flooding, and 5 were due to hurricanes or nor’easters.

<b>Disaster Name (Date of Event)</b>	<b>Type of Assistance</b>	<b>Declared Areas</b>
March Blizzard, EM-3103 (March 1993)	PA	All 14 Counties
Russell Fire, FSA-2116 (September 1995)	PA	N/A
January Blizzard, DR-1090 (January 1996)	PA	All 14 Counties
February Snowstorm, EM-3175 (Feb 17-18, 2003)	PA	All 14 Counties
Snow EM-3191 (Dec 6-7, 2003)	PA	12 Counties including Hampshire
January Blizzard EM-3201 (January 22-23, 2005)	PA	All 14 Counties
Hurricane Katrina, EM-3252 (August 29, 2005)	PA	All 14 Counties
Severe Storms and Flooding, DR-1614 (Oct 7-16, 2005)	IA and PA	9 Counties including Hampshire
May Rainstorm/ Flood, DR-1642 (May 12-23, 2006)	IA and PA	Statewide
April Nor’easter, DR-1701 (April 15-27, 2007)	PA	Statewide
Severe Winter Storm, EM-3296/Severe Winter Storm and Flooding DR-1813 (Dec 11-18, 2008)	PA	EM - 9 Counties including Hampshire DR - 7 Counties including Hampshire

**Table 1. Previous Federal/State Disaster Declarations**

Disaster Name (Date of Event)	Type of Assistance	Declared Areas
Severe Winter Storm and Snowstorm, DR-1959 (Jan 11-12, 2011)	PA and HMGP	7 Counties including Hampshire
Severe Storms and Tornadoes, DR-1994 (June 01, 2011)	PA and HMGP	
Hurricane Irene, EM-3330 (Aug 26-Sept. 5, 2011) / Tropical Storm Irene, DR-4028 (Aug 27-29, 2011)	EM-3330 - PA DR-4028 - PA and HMGP	EM-3330 – Statewide DR-4028 - 9 Counties including Hampshire
Severe Storm, EM-3343 (Oct 29-30, 2011) / Severe Storm and Snowstorm, DR-4051 (Oct 29-30, 2011)	PA and HMGP	EM-3343 - 9 Counties including Hampshire DR-4051- 6 counties including Hampshire
Hurricane Sandy, EM-3350/DR-4097 (Oct 27-30, 2012)	PA	Statewide
Severe snowstorm and Flooding, DR-4110 (Feb 8-9, 2013)	PA	Statewide

Source: FEMA, 2019

Notes:

- HMGP Hazard Mitigation Grant Program
- IA FEMA Individual Assistance
- PA FEMA Public Assistance Project Grants

## 2. LOCAL PROFILE

### Community Setting

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Worthington is a rural community comprised of over 32 square miles (approximately 20,500 acres) located in the Hilltowns of Western Massachusetts. The Hilltowns are a cluster of rural towns in western Hampshire and Hampden counties and eastern Berkshire county. Neighboring Hilltowns include Middlefield and Chester, to the south, Chesterfield to the east, Cummington to the north, and Peru to the west. Worthington lies on the border of Hampshire and Berkshire Counties, situated in the uplands west of the Connecticut River Valley; northwest of Northampton, and east of Pittsfield. Worthington is located approximately 35 miles northwest of Springfield, Massachusetts; 65 miles from Albany, New York; and 120 miles from Boston.

Worthington was originally settled in 1764, and the Town's history is rich in agriculture, a successful industry which still thrives today. In recent years, Worthington has also earned the reputation of being a center of entrepreneurship. New ventures in biotechnology, hand tools, and baby furniture are examples of small businesses developed by town residents. Culturally, Worthington has gained national recognition for its hosting of the Sevenars Concerts, one of the best small music festivals in the country. With a population density of less than 40 residents per square mile, the Town maintains a quiet, rural character highlighted by a forested landscape and historic villages. Despite the waning influence of agriculture on the landscape, Worthington remains largely undeveloped and fundamentally rural in nature. Dense forests, several rivers, and abundant farmland and open fields highlight the landscape in town. The overall quality of life and rural character make Worthington a desirable place to live, but the Town saw its population decline from 1270 in 2000 to 1156 in the 2010 census.

### Infrastructure

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Worthington's infrastructure reflects its small population and rugged terrain.

#### ***Roads and Highways***

Worthington is comprised of several hamlets or village centers (West Worthington, Worthington Corners, Worthington Center, Ringville and South Worthington), mostly along Route 112, the main thoroughfare. Route 112 runs north-south through town; and meets up with Route 143, which runs east-west through the northern portion of town

#### ***Public Water and Sewer Service***

Worthington's water supply comes from four spring-fed reservoirs, seven bedrock wells, and individual private wells. Worthington also has five transient non-community wells, all considered for interim wellhead protection.

Worthington does not have a public sewer system or any publicly owned wastewater treatment plants in the town. The Maples Apartments operate a minor sanitary

wastewater treatment plant through the NPDES program. All other private residences and businesses are served by on-site septic systems.

## **Natural Resources**

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Worthington's most significant natural resource is the Worthington River and the large wildlife areas and parks with town limits. However, this historically rural town has been shaped by several of its other natural resources as well.

### ***Water Resources***

The Nationally designated Wild and Scenic Middle Branch of the Worthington River originates near the heavily forested Worthington-Peru town line and flows south through the western portion of the town. The topography of the community is further defined by Watts and Wards Streams, which both flow south through the center of Worthington before joining the Little River. Other streams include: Bronson Brook, Fuller Brook, Jackson Brook, Kinne Brook, Trout Brook, and Whitmarsh Brook.

Additionally, Worthington contains about 324 acres of wetlands, and over 600 acres of inner riparian zone habitat. Furthermore, there are several unnamed ponds and small lakes within the Town's borders. These water resources all provide important wildlife habitat, flood storage capacity, and recreation outlets, and in some cases they are water supply sources as well.

### ***Forests and Fields***

The vast majority (84%) of the total acreage of Worthington is forested, approximately 17,194 acres. The predominant forest habitat in Worthington is the northern hardwoods hemlock. Species vary with the topography but consist primarily of hemlock, beech, sugar maple, and yellow birch. Stands of white pines, red maple, and birch appear in abandoned agricultural lands and clearings.

There are also approximately 1,700 acres of cropland, pastureland, and open land in Worthington, providing additional vegetation types and habitat opportunities.

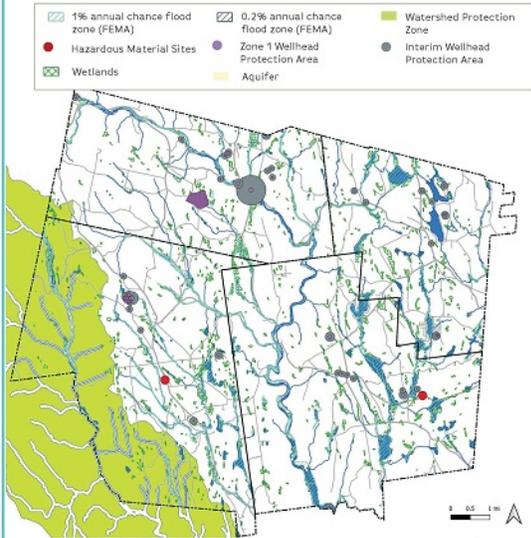
As part of Worthington's integrated Hazard Mitigation & Municipal Vulnerability Preparedness process, PVPC prepared the Natural Resource posters for the four communities. Worthington is in the bottom left corner of each poster.

# NORTHERN HILLTOWNS

## NATURAL RESOURCES

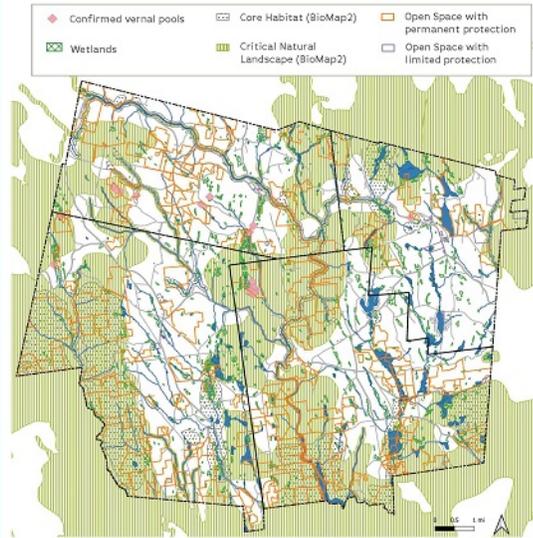
Natural resources lessen climate impacts by absorbing and storing CO2 and by providing vital ecosystem services such as flood storage, protecting water quality, and regulating ambient temperatures. Natural resources are often erased from the urban environment, but by intentionally protecting or mimicking these systems within developed areas, we can increase human and environmental health.

### FRESHWATER RESOURCES



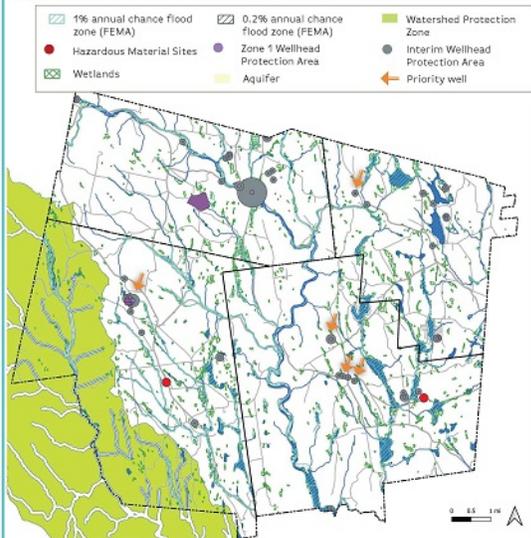
Water resources sustain critical ecosystem functions as well as offering recreational and aesthetic value. For example, wetlands can provide natural flood storage and water bodies can act as heat-sinks. Most residents of all four communities rely on wells for drinking water and are therefore dependent on healthy local groundwater supplies. Spills or storage of hazardous materials within flood-prone areas can pose a risk to both the human and/or the natural environments.

### HABITAT & PROTECTED OPEN SPACE



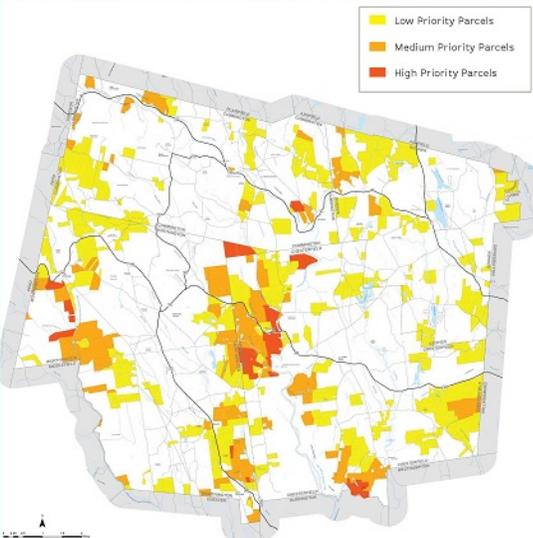
NHESP's BioMap2 report (2012) identified Core Habitat and Critical Natural Landscapes within every municipality in the Commonwealth. Core Habitat identifies key areas to ensure the long-term persistence of species of conservation concern, exemplary natural communities, and intact ecosystems. Critical Natural Landscape identifies larger landscape areas that are better able to support ecological processes, disturbances, and wide-ranging species.

### PRIORITY WELLS FOR PROTECTION



In 2019, Smith College students conducted a study to prioritize wells in the Northern Hilltowns for the protection of drinking water quality. These students analyzed surficial geology and road ownership and maintenance practices to determine where the practice of winter road salting may have an impact on local drinking water supply contamination. The five locations pointed to here are considered the highest priority to protect based on these considerations.

### PARCELS PRIORITIZED FOR RESILIENCE



Mass Audubon's Mapping And Prioritizing Parcels for Resilience (MAPPR) identifies parcels within areas of interest that are the highest priorities for protection based on habitat quality, climate change resilience, and other metrics such as parcel size and adjacency to existing protected parcels. The MAPPR Resilience Model, shown here, combines BioMap2 values with sites where the direct effects of climate change are moderated by complex topography and connected natural cover.

Created by Pioneer Valley Planning Commission in 2020 for The Towns of Chesterfield, Cummington, Goshen, and Worthington (Northern Hilltowns) Municipal Vulnerability Preparedness Community Resilience Building Workshop. Sources: NHESP Bio-Map2 Report (2012); MassGIS (Bureau of Geographic Information); Massachusetts Department of Environmental Protection; United States Forest Service.



## Land Use & Development Trends

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Worthington's growth was initiated first by farmers, and more recently, residential development. But the town's topography, soils, and physiography (lakes, rivers, wetlands and watershed areas) shape and constrain these land use patterns. Another key factor is that the Commonwealth of Massachusetts is the largest single land-owner in Worthington; this is due to several state-owned wildlife areas and state forests which constitute over 33% of Town land.

### ***Existing Land Use***

In addition to other factors, zoning and other land use regulations constitute Worthington's "blueprint" for its future. Land use patterns over time will continue to look more and more like the town's zoning map until the town is finally "built out"—that is, there is no more developable land left. Therefore, in looking forward over time, it is critical that the town focus not on the current use and physical build-out today, but on the potential future uses and build-out that are allowed under the town's zoning map and zoning bylaws. Zoning is the primary land use tool that the town may use to manage development and direct growth to suitable and desired areas while also protecting critical resources and ensuring that development is in keeping with the town's character.

Worthington recently completed a comprehensive zoning review and has identified some key areas for hazard mitigation-related zoning, land use and other regulatory strategies.

Recommended Short-Term items include:

- Establishing Zoning Permit
- Creating Site Plan Review Considerations

Recommended Medium-Term items include the following:

- Stormwater Management Bylaw
- Low Impact Development Standards (LID)

Recommended Long-Term Items include:

- Update Sub-division regulations with a focus on green infrastructure
- Create a scenic ridgeline overlay district

The proposed Zoning Permit and Site Plan Review Considerations as well as the Stormwater Management bylaw and the adoption of Low Impact Development (LID) standards could strengthen the Town's Hazard Mitigation capability, especially for flood hazard mitigation. In the longer term, the zoning review suggests consideration of updated subdivision regulations as well as adoption of a Scenic Ridgeline Overlay District.

Hazard Mitigation related Short-Term Recommendations:

- 1) Zoning Permit--The town should consider adopting a Zoning Permit provision in the Zoning Bylaw. A Zoning Permit is a simple, free, form filed by applicants requesting a written determination from the Building Inspector/Zoning Enforcement Officer as to the zoning compliance of a particular project or change in use. This ensures that it is the Building Inspector/Zoning Enforcement Officer who is interpreting the Zoning Bylaw (which is his/hers responsibility) and determining which permits are required before they are filed with the Special Permit Granting Authority. This ensures a continuity and consistency in the interpretation and enforcement of the Zoning Bylaw, and avoids applicants applying to Boards for the wrong thing.
- 2) Creating Site Plan Review Considerations--The bylaw currently provides the procedures and means of which to get approval for a development through the Site Plan and Special Permit sections. The Town should explore adding site plan review performance standards or review considerations for approval. Doing so would allow a more objective review for the Boards, having the developer accountable to the standards of the proposal that they would need to demonstrate.

Medium-Term Hazard Mitigation related Recommendations:

- 1) Stormwater Bylaw--Most development and changes in land use result in an increase in impervious cover which results in an increase in the volume, rate and change in direction of storm water run-off. Unrestricted each project can incrementally result in an increase in pollution, erosion, siltation and flooding adversely effecting abutters, downstream property owners, wetlands and water bodies, and public ways and drainage systems. A general town Stormwater Management Bylaw could require all new development to provide a stormwater system design that incorporates Best Management Practices (BMPs) to prevent post-development increases (or decreases) in the total volume and/or rate of stormwater discharges from the site, as compared with pre-development conditions, and controlling off-site erosion and sedimentation.
- 2) Low Impact Development Standards (LID)-- In concert with the Stormwater Bylaw, LID is a form of stormwater management that is accomplished as a two-step process: 1) thoughtful site planning, and 2) incorporation of best management practices (BMPs). Thoughtful site planning begins with an approach that identifies critical site features such as wetlands, poor soils, or drinking water protection areas that should be set aside as protected open space. After the critical open space areas are identified and set aside, sustainable development areas are then identified as building envelopes. Within the delineated building envelopes, a broad range of design techniques or BMPs, such as shared driveways, permeable pavers, and bioretention are used to reduce the level of impervious cover and improve the quantity and quality of stormwater drainage. Other LID design techniques include green roofs, rain barrels, rain gardens, grassed swales, stormwater infiltration systems, and

alternative landscaping. Through these techniques, natural drainage pathways are conserved, open space is preserved, and the overall impact from development is significantly reduced.

#### Long-Term Recommendations:

- 1) Update Subdivision Regulations--Should the Town decide to update stormwater bylaws and regulations and adopt a Low Impact Development standards, a review of Worthington's Subdivision Regulations should be undertaken as a review would provide recommendations of commonly accepted road and drainage construction standards. *PVPC's Model Subdivision Regulations, as prepared in 2019, are located on the PVPC website [here](#).*
- 2) Scenic Ridgeline Overlay District--Scenic upland protection zoning bylaws can protect a community's scenic areas such as prominent ridge lines and exceptional vistas, important resources which contribute to the character and quality of life in a community. Upland District bylaws function in a similar manner to site plan review bylaws where a development is evaluated for potential negative effects on the environment, and on the scenic amenities of the town. In addition to preserving scenic qualities and natural resources, such reviews also help avoid problems with erosion, sedimentation, septic tank failures, and flooding and water pollution.

The Worthington Zoning Bylaw establishes one base zone for the entire town: Residential-Agricultural District; and two overlay zones: Water Supply Protection District and Floodplain/Worthington River Protection District. Although appropriate zoning is relevant to protecting the health and safety of the Town residents, Worthington's two overlay districts are specifically relevant to natural hazard mitigation.

Floodplain and Worthington River Protection District - The floodplain overlay applies to those areas within the boundary of the one-hundred-year flood that are considered hazardous according to FEMA. This is also extended, where applicable, to lands within 100 feet of the riverbank. It limits some uses for preventing potential flood damage and/or minimizing erosion and sedimentation of the Worthington River.

Water Supply Protection District - This purpose of this overlay district is to protect and preserve Worthington's groundwater resources from potentially damaging pollution or environmental degradation by regulating certain uses within the district. The regulations state specific prohibited and restricted uses, regulates drainage, details site plan requirements and special permit procedures.

The Zoning Bylaw also establishes a Site Plan/Special Permit Approval procedure for specific uses and structures within Worthington. This review allows the Special Permit Granting Authority the ability to review development to ensure that the basic safety and welfare of the people of Worthington are protected, and includes several specific evaluation criteria that are relevant to natural hazards.

### **Recent and Projected Development Trends**

Today, the vast majority of Worthington's 32.1 square miles is undeveloped land, totaling close to 17,730 acres. Agricultural land is the second most prolific land use, at approximately 1,781 acres, followed by residential land at approximately 894 acres. There are over 60 acres of outdoor recreational land in Town, and land characterized as urban open/public land constitutes another 18 acres. Land used for commercial and industrial uses constitutes a relatively small 33 acres, and 5.5 acres, respectively. Because of its relatively remote location, the town has been able to maintain a quiet, country character. Most current development consists of single-family homes; the remainder of land in Worthington is hilly and forested, with scattered open and agricultural fields. The town's population doubled from 1960 to 2000, growing by approximately 160 residents every ten years, culminating in a population increase of nearly 10 percent from 1990 to 2000. But then the population declined slightly from 2000 to 2010 and the Town anticipates flat population growth in the 2020 census. **Worthington has had \_\_\_\_ building permits in the last # years.** Development in the Town consists of a very small number of single-family homes that are built on agricultural fields and forested land.

LAND USE DESCRIPTION	Acres	Percent
Agriculture	529	2.6%
Commercial	102	0.5%
Forest	874	4.3%
Industrial	2	0.0%
Mixed use, other	217	1.1%
Mixed use, primarily commercial	344	1.7%
Mixed use, primarily residential	4252	20.7%
Open land	2905	14.1%
Recreation	266	1.3%
Residential - multi-family	635	3.1%
Residential - other	625	3.0%
Residential - single family	5041	24.5%
Right-of-way	519	2.5%
Tax exempt	3882	18.9%
Unknown	318	1.5%
Water	35	0.2%
<b>TOTAL</b>	<b>20547</b>	<b>100.0%</b>

Currently, the zoning laws serve to space houses out along the roads. Worthington's land use regulations encourage development where most appropriate, and discourage it in hazard areas, and the necessity of private septic systems also acts as a constraint on development.

## **Potential Future Development**

Most hazards identified in this plan are regional risks and, as such, all new development falls into the hazard area. The exception to this is flooding. According to the Community Information System (CIS) of FEMA, there were 10 residential structures located within the Special Flood Hazard Area (SFHA) in Worthington as of November 2018, the most current records in the CIS for the Town of Worthington.

## **Critical Facilities**

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A Critical Facility is defined as a building, structure, or location which:

- Is vital to the hazard response effort;
- Maintains an existing level of protection from hazards for the community;
- Would create a secondary disaster if a hazard were to impact it.

### **Critical Facilities within Hazard Areas**

Hazards identified in this plan are regional risks and, as such, all critical facilities fall into the hazard area. The exception to this is flooding. There are several critical facilities that fall within the 100-year floodplain as shown in the table at the end of this section.

The Critical Facilities List for the Town of Worthington has been identified utilizing a Critical Facilities List provided by the State Hazard Mitigation Officer. Worthington's Hazard Mitigation Committee has broken up this list of facilities into four categories:

- The first category contains facilities needed for Emergency Response in the event of a disaster.
- The second category contains Non-Emergency Response Facilities that have been identified by the Committee as non-essential. These are not required in an emergency response event, but are considered essential for the everyday operation of Worthington.
- The third category contains Facilities/Populations that the Committee wishes to protect in the event of a disaster.
- The fourth category contains Potential Resources, which can provide services or supplies in the event of a disaster.

The critical facilities and evacuation routes potentially affected by hazard areas are identified in Table 4-1, following this list. The Past and Potential Hazards/Critical Facilities Map (Appendix D) identifies these facilities.

### **Category 1 – Emergency Response Services**

The Town has identified the Emergency Response Facilities and Services as the highest priority in regards to protection from natural and man-made hazards.

- 1) Emergency Operations Center

Primary: Worthington Fire Station – 51 Huntington Rd.  
Secondary: Worthington Town Hall – 160 Huntington Rd.

- 2) Fire Station  
Worthington Fire - Rescue – 51 Huntington Rd.
- 3) Police Station  
Worthington Police Department – 51 Huntington Road
- 4) Highway Department  
Department of Public Works (DPW) Headquarters – 64 Huntington Rd.
- 5) Water  
Eight small community wells
- 6) Emergency Fuel Stations  
Highway Department – 64 Huntington Road
- 7) Emergency Electrical Power Facility  
Fire Station  
3 portable generators and a stationery generator to power the EOC
- 8) Emergency Shelters\*  
Worthington Fire Station – 51 Huntington Rd.  
Worthington Town Hall – 160 Huntington Rd.  
Worthington School – 147 Huntington Rd.  
\*Shelters also have generators.
- 9) Water Sources  
Numerous locations in Worthington, identified on map
- 10) Transfer Station  
Town of Worthington Transfer Station and Recycling Center – Route 112
- 11) Helicopter Landing Sites  
Rte 143 N 42 25 651 / W 72 58 992  
Rte 112 N 42 26 337 / W 72 56 365  
Rte 143 N 42 24 958 / W 72 56 316  
Rte 143 N 42 24 841 / W 72 54 342  
Rte 112 N 42 23 563 / W 72 56 004  
Prentice Rd N 42 21 687 / W 72 55 407  
Rte 112 N 42 21 734 / W 72 54 465  
(Permitted anywhere feasible.)
- 12) Communications  
none
- 13) Primary Evacuation Routes  
Route 112

Route 143

- 14) Bridges/Culverts Located on Evacuation Routes
  - Route 143 at Middle River
  - Route 112 at Wards Stream
  - Route 112 at Watts Stream
  - Route 112 at Little River
  - Route 112 at Bronson Brook

## **Category 2 – Non Emergency Response Facilities**

The town has identified these facilities as non-emergency facilities; however, they are considered essential for the everyday operation of Worthington.

- 1) Problem Culverts
  - Route 143, Dingle Road
  - 63 problem culverts along Old North Road
- 2) Water Supply
  - Privately owned water supply company and privately owned residential wells.

## **Category 3 – Facilities/Populations to Protect**

The third category contains people and facilities that need to be protected in event of a disaster.

- 1) Special Needs Population
  - none
- 2) Elderly Housing/Assisted Living
  - Maples-48 Old North Road
- 3) Public Buildings/Areas
  - Sevenars Concerts - Rt. 112 and S. Ireland St.
  - Roads End Audubon Wildlife Sanctuary – Corbett Rd.
  - Worthington Library - 1 Huntington Rd.
  - Worthington Post Office – 2 Packard Park
  - Worthington Town Hall - PO Box 247
- 4) Schools
  - Elementary School – Russel H. Conwell - 147 Huntington Rd.
- 5) Churches
  - First Congregational Church - Huntington Rd.
- 6) Historic Buildings/Sites

Town Hall  
South Worthington Church-Ireland Street  
School House-Dingle and Capen  
Sevenars  
North Cemetery  
Converse Cemetery  
Old Leonard Cemetery

7) Apartment Complexes  
none

8) Employment Centers  
Hillside Electronics-17 Buffington Hill Road  
Worthington Assembly-4 South Worthington Road

#### **Category 4 – Potential Resources**

Contains facilities that provide potential resources for services or supplies.

- 1) Food/Water
  - Corners Grocery – 2 Packard Park
  - Kendall Food Co – 448 Huntington Rd.
  - Worthington Inn - Old North Rd. and Rt. 143
  - Fiddlehead Inn – 144 Huntington Rd.
  - Worthington Golf Club – 133 Ridge Rd.
  - Liston’s Bar and Grille – 324 Old North Rd, Rte 143
- 2) Hospitals/Medical Supplies
  - Worthington Health Center- 58 Old North Rd
- 3) Gas
  - none
- 4) Building Materials Suppliers
  - none
- 5) Heavy & Small Equipment Suppliers
  - Dean Messick
  - Burt Nugent

**Table 2.1: Critical Facilities and Evacuation Routes Potentially Affected by Hazard Areas**

Hazard Type	Hazard Area	Critical Facilities Affected	Evacuation Routes Affected
Flooding (100-year)	Bronson Brook	Bridges on 112	112
		Bridge on River Road	River Road
Flooding (localized)	Little River below Ringville		Rtes 112, 143
Severe Snow/Ice Storm			Rtes 112, 143
Hurricane/Severe Wind	Trees come down on Rte 112		
Wildfire/Brushfire			
Earthquake			
Dam Failure	If Knightsville dam failed		Rte 112 would be blocked
Drought			
Hazardous Materials			

(Past & Potential Hazards/Critical Facilities Map Located In Appendix D)

## Climate Change Projections

**Table 2.2. Climate Change Projections and Related Natural Hazards**

Climate Changes	Related Natural Hazards	Projections by the end of this century
Changes in precipitation	<ul style="list-style-type: none"> <li>- Inland flooding</li> <li>- Drought</li> <li>- Landslide</li> </ul>	<ul style="list-style-type: none"> <li>- Annual precipitation: Increase up to 16% (+7.3 inches)</li> <li>- Days with rainfall accumulation 1+ inch: Increase up to 57% (+4 days)</li> <li>- Consecutive dry days: Increase 18% (+3 days)</li> <li>- Summer precipitation: Decrease</li> </ul>
Rising temperatures	<ul style="list-style-type: none"> <li>- Average/extreme temperatures</li> <li>- Wildfires</li> <li>- Invasive species</li> </ul>	<ul style="list-style-type: none"> <li>- Average annual temperature: Increase up to 23% (+10.8 degrees Fahrenheit)</li> <li>- Days/year with daily minimum temperatures below freezing: Decrease up to 42% (-62 days)</li> <li>- Winter temperatures: Increase at a greater rate than spring, summer, or fall</li> <li>- Long-term average minimum winter temperature: Increase up to 66% (+11.4 degrees Fahrenheit)</li> <li>- Days/year with daily maximum temperatures over 90 degrees Fahrenheit: Increase by up to 1,280% (+64 days)</li> <li>- Growing degree days: Increase by 23% to 52%</li> </ul>
Extreme weather	<ul style="list-style-type: none"> <li>- Hurricanes/tropical storms</li> <li>- Severe winter storms/nor'easters</li> <li>- Tornadoes</li> <li>- Other severe weather</li> </ul>	<ul style="list-style-type: none"> <li>- Frequency and magnitude: Increase</li> </ul>

Note: This plan also assesses earthquakes and hazardous materials, but there is no established correlation between climate change and these hazards. Source: NE Climate Adaptation Science Ctr, UMASS Amherst

### 3. PLANNING PROCESS

The natural hazard mitigation planning process for the Town of Worthington included the following tasks:

- Integrating with the four community (Worthington, Chesterfield, Goshen and Cummington Northern Hilltown Municipal Vulnerability Preparedness (MVP) certification process
- Identifying the natural hazards that may impact the community.
- Conducting a Vulnerability/Risk Assessment to identify the infrastructure 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 strategies and establishing goals for updating, revising, or adopting new strategies.
- Adopting and implementing the final Local Natural Hazards Mitigation Plan.

The key product of the Hazard Mitigation portion of this integrated process is the development of a Hazard Mitigation Action Plan with a Prioritized Implementation Schedule. The process for developing Worthington’s Hazard Mitigation Plan 2019-2020 Update is summarized below.

Table 2.3. Worthington’s 2019 Hazard Mitigation Plan Update Planning Process	
Section	Reviews and Updates
Committee Meetings and Public Meeting	<p>This Local Hazard Mitigation Plan update took place during the COVID-19 pandemic, so in person community engagement was not possible on the final plan. Nevertheless the Committee maintained an emphasis on public participation for the update of the Hazard Mitigation Plan, transitioning from in person engagement to virtual and on-line engagement. We issued a community-wide survey and held a virtual community meeting after the plan update was posted on the Town’s website for public comment. Because the hazard mitigation plan update process was integrated with the MVP Community Resilience Building (CRB), there was significant stakeholder participation prior to the pandemic at the CRB workshop on 2/1/20.</p> <p>Note public comments here</p>
Risk Assessment	PVPC gathered the most recently available hazard and land use data and met with Town staff to identify changes in local hazard areas and development trends. Town staff reviewed critical

Table 2.3. Worthington's 2019 Hazard Mitigation Plan Update Planning Process	
Section	Reviews and Updates
	infrastructure with PVPC staff in order to create an up-to-date list. The hazard mitigation process was complemented by the Town's MVP process and CRB workshop process that engaged key community, regional and state stakeholders.
Risk Assessment	Updated risk assessment format following 2018 SHMCAP methodology of presenting hazards by primary climate change interaction.
Hazard Mitigation and Climate Adaptation Strategies	The list of existing mitigation measures was updated to reflect current mitigation activities in the town and enhanced by the concurrent MVP CRB process.
Hazard Mitigation and Climate Adaptation Strategies; Prioritized Implementation Schedule	Mitigation measures from the 2010 plan were reviewed and assessed as to whether they were completed, in progress, or deferred. The Local Hazard Mitigation Planning Committee determined whether to carry forward measures into the 2020 Plan update or modify or delete them. The Plan Update's hazard mitigation strategy reflects both new measures and measures carried forward from the 2010 plan. The Local Hazard Mitigation Team prioritized all of these measures based on current conditions.
Plan Adoption & Maintenance	This section of the plan was updated with a new on-going plan implementation review and five year update process that will assist the Town in incorporating hazard mitigation issues into other Town planning and regulatory review processes and better prepare the Town for the next comprehensive plan update.

## **2010 Plan Implementation and Maintenance**

The 2010 Town of Worthington Hazard Mitigation Plan contained a risk assessment of identified hazards for the town and mitigation measures to address the risk and vulnerability from these hazards. Since approval of the plan by FEMA and local adoption, progress has been made on implementation of the measures. The Town has committed to becoming certified in the Commonwealth of Massachusetts Municipal Vulnerability Preparedness (MVP) program. Since 2010 oversight of dams has been transferred from the Office of Dam Safety to local owners of dams. The planned regional debris management plan did not move forward. The town determined that participation in FEMA's Community Rating System was not financially feasible for the Town. The Highway Department has been working to replace and/or right-size problem

culverts. The Town undertook a comprehensive zoning review and is working to implement recommendations.

## Local Hazard Mitigation Planning Committee

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PVPC worked with local community representatives to organize a Local Hazard Mitigation Planning Committee for Worthington. PVPC briefed the local representatives as to the desired composition of that team as well as the need for public participation in the local planning process.

The Local Hazard Mitigation Planning Committee is central to the planning process as it is the primary body tasked with developing a mitigation strategy for the community. The local team was tasked with working with PVPC to set plan goals, provide information on the hazards that impact the town and existing mitigation measures, and helping to develop new mitigation measures for this plan update. The Local Hazard Mitigation Planning Committee (HMPC) membership is listed below.

<b>Table 2.4. Worthington Hazard Mitigation Planning Committee (HMPC)</b>	
<b>Name</b>	<b>Representing</b>
David Mendelson	Emergency Management Director
Albert (Cork) Nugent	Highway Superintendent
Charley Rose	Select Board
Amy Wang	Planning Board
Peggy O'Neal	Executive Assistant
Catherine Ratté	Pioneer Valley Planning Commission

The Worthington Planning Board, the Conservation Commission and the Select Board are the primary entities responsible for regulating development in town. Input from the Planning Board, the Conservation Commission and the Select Board was assured through the participation of members on the local HMPC who regularly interface with those bodies. In addition, PVPC, the State-designated regional planning authority for Worthington, works with all agencies that regulate development in the region, including the listed municipal entities and state agencies, such as the Massachusetts Department of Transportation and the MassWorks Program.

## Committee Meetings

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The Local Hazard Mitigation Planning Committee met on the following dates in 2019 and 2020: December 18, 2019, January 23, 2020, March 12, 2020, and May 7, 2020. The purpose of the early meetings was to introduce the Hazard Mitigation planning program, review and update hazard mitigation goals, and to gather information on local hazard mitigation issues and sites or areas related to these. Later meetings focused on verifying information gathered by PVPC staff and discussion of existing mitigation practices, the status of mitigation measures identified in the 2010 hazard

mitigation plan, and potential new or revised mitigation measures. The agendas for these meetings are included in Appendix F.

The Executive Assistant to the Select Board communicated with members of the local HMPC in advance of each meeting to assure informed and prepared participation and engagement and all meetings were posted to the Town's website and publicized so that the public was informed of the plan update process and able to participate.

## Public Meetings

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NOTE → The planned public engagement period for this Hazard Mitigation Plan update occurred during the COVID-19 pandemic in March-June 2020, during which time people were not allowed to congregate, so all engagement was virtual.

In 2019 the Town of Worthington received a Municipal Vulnerability Preparedness (MVP) grant (in collaboration with a number of neighboring communities) for the towns to undertake a stakeholder driven analysis of climate vulnerabilities and resilience actions. The town hired the Pioneer Valley Planning Commission to assist in development of both the Hazard Mitigation Plan update and the MVP planning process. Public engagement for the two plans was coordinated where possible. Worthington also used PVPC's Local Technical Assistance funds to supplement the work of updating this plan.

**DATE, 2020:** The SelectBoard voted to adopt the Local Natural Hazard Mitigation Plan. Meeting held at Worthington City Offices.

## Public and Neighboring Jurisdiction Involvement in the Planning Process

Because this Hazard Mitigation plan update was part of a four municipality regional Municipal Vulnerability Preparedness (MVP) initiative, surrounding communities were very well informed of this plan update process, and indeed engaged throughout. The Commonwealth of Massachusetts issued a media release announcing the four communities' success in securing funding for MVP certification including Worthington's Hazard Mitigation plan update. On 2/2/20, stakeholders from Worthington and Cumington participated in the Community Resilience Building workshop process (see Appendix for media coverage).

**On April \_\_, 2020** the Town issued a media release targeted at residents and people from surrounding communities informing them of the Hazard Mitigation survey posted on the Town's website and seeking their responses.

In May 2020 the Pioneer Valley Planning Commission sent a media release (see Appendix E) to all area media outlets to inform the public that a draft of Worthington's Hazard Mitigation Plan had had been placed on both the Town's and PVPC's website and that all residents, businesses and other concerned parties of Worthington and adjacent communities were encouraged to participate in a virtual meeting to comment on the plan. The plan was made available in this manner for 30 days. Citizens

from adjacent municipalities were also encouraged to comment on Worthington’s plan.

Additionally, the Western Region Homeland Security Advisory Council (WRHSAC) and the Regional Emergency Planning Committees of western Massachusetts were kept informed of the Hazard Mitigation planning process underway in Worthington. The WRHSAC includes representatives of all emergency disciplines who are charged with bringing the information they learn at the meetings back to their colleagues. In this way, emergency response professionals, Fire Fighters, Police, Ambulance, municipal officials, dispatch, transit and EMS from all of western Massachusetts were encouraged to review and comment on this plan update.

In addition to media outreach, all public meetings were posted at the Worthington Municipal Office Building in compliance with the Commonwealth of Massachusetts’ open meeting law.

## Planning Timeline

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**Table 2.5. Planning Timeline**

<b>Table 2.5. Planning Timeline</b>	
December 18 2019	Meeting of the Worthington Local Hazard Mitigation Planning Committee
January 23 2020	Meeting of the Worthington Local Hazard Mitigation Planning Committee
February 1, 2020	Worthington/Cummington Community Resilience Building workshop
March 12 2020	Meeting of the Worthington Local Hazard Mitigation Planning Committee
May 7 2020	Meeting of the Worthington Local Hazard Mitigation Planning Committee
April 2020	Public Survey—COVID-19 pandemic does not allow in-person meeting
May 2020	Draft Plan Update posted to Town & PVPC website
May 2020	Draft Plan Update submitted to MEMA

# 3. RISK ASSESSMENT: HAZARD IDENTIFICATION & ANALYSIS

## Profiling the Natural Hazards

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To identify natural hazards of concern for the Hazard Identification and Risk Assessment (HIRA), the Committee and its consulting team reviewed the 2010 Worthington Hazard Mitigation Plan, the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP), available hazard mapping, and other weather-related databases. Historical research and conversations with local officials and emergency management personnel were also used to identify and profile the natural hazards which are most likely to have an impact on Worthington.

Natural hazards are natural events that threaten lives, property, and other assets. Often, natural hazards can be predicted. They tend to occur repeatedly in the same geographical locations because they are related to weather patterns or physical characteristics of an area. The assessment conducted for the 2010 Worthington HMP recognized the following 9 natural hazards and one man-made hazard that could potentially impact Worthington:

- Flooding (100-year)
- Flooding (localized)
- Severe Snow/Ice Storms/Nor'easter
- Hurricanes/Severe Wind
- Tornado/Microburst
- Wildfire/Brushfire
- Earthquake
- Dam Failure
- Drought
- Man-Made Hazard: Hazardous Materials

Each of these hazards was assessed by the Committee for location of occurrence, extent, previous occurrences, and probability of future events. (See Appendix C for sources, methodology.) This resulted in a ranking of hazard, by risk, see Table 3.1. All of the hazards identified and assessed in the 2010 HMP were determined to be relevant for the 2019-2020 Plan Update through a Committee kickoff meeting and subsequent risk assessment methodology development. However, some of these hazards were reclassified and/or regrouped to align with the 2018 SHMCAP (for example, "Flooding (100-year)" and "Flooding (localized)" were combined into a single "flood" hazard profile which also includes "dam overtopping" in place of "dam failure," and two new hazards—average/extreme temperatures and invasive species—were added. The natural hazards assessed in this 2019 Plan Update are described later in this chapter.

In addition to the hazards discussed above, the Hazard Mitigation committee reviewed the other hazards listed in the Massachusetts Hazard Mitigation Plan: coastal hazards, atmospheric hazards, ice jams, coastal erosion, sea level rise, and tsunamis. It was determined that these hazards are not threatening Worthington due to the Town's location.

## **Sectors Assessed**

A number of key sectors were evaluated as part of the risk assessment for each of the hazards profiled in the sections below. These sectors are introduced here and are included in the hazard profiles where appropriate and where sufficient data allowed.

### **Populations**

The impacts on human health, particularly vulnerable populations, were considered by the Committee and incorporated into the hazard profiles where possible. The risk analysis relied on U.S. Census data and stakeholder information regarding vulnerable populations (including but not limited to disabled, low-income, elderly) that could potentially be more severely impacted by each hazard. Among other factors, these populations may require extra time or outside assistance during evacuations or during events that cause power outages or isolation, and are considered to be more likely to seek or require emergency services.

Vulnerability is influenced by three factors: exposure or contact with the hazard; sensitivity or degree to which people or communities are affected by the exposure to the hazard; and capacity to adapt or the ability of communities, institutions, or people to adjust and respond to and recover from potential hazards. As summarized in Table 2, the major health impacts from natural hazards and climate change include:

- Heat-related illnesses and death from an increase in extreme temperatures and poor air quality (SHMCAP, 2018).
- Increases in food and waterborne illnesses and other infectious diseases from altering geographic and seasonal distributions of existing vectors and vector-borne diseases (SHMCAP, 2018).
- Injuries and accidental premature death associated with extreme weather events. Extreme weather events can result in acute health impacts, such as injuries and accidental premature death during an event (e.g., drowning during floods). In addition, health impacts can also occur during disaster preparation and post-event cleanup. Other impacts include damage to property, destruction of assets, loss of infrastructure and public services, social and economic impacts, environmental degradation, and other factors (SHMCAP, 2018).
- Exacerbation of chronic diseases (SHMCAP, 2018).
- Mental health and stress-related disorders ranging from minimal stress and distress symptoms to clinical disorders such as anxiety, depression, post-traumatic stress, and suicidality. Specific groups of people who are at higher risk for distress and other adverse mental health consequences from exposure to climate-related or weather-

related disasters include children, the elderly, women (especially pregnant and post-partum women), people with preexisting mental illness, the economically disadvantaged, the homeless, and first responders. Populations living in areas most susceptible to specific climate change events are at increased risk for adverse mental health outcomes (SHMCAP, 2018).

**Table 2. Populations Vulnerable to Natural Hazards and Climate Change**

Vulnerability Category	Vulnerable Population	Heat-related illnesses	Changes in the prevalence and geographical distribution of food- and waterborne illnesses and other infectious diseases	Injuries and accidental premature death	Exacerbation of chronic diseases (respiratory and cardiovascular diseases, diabetes)	Mental health and stress-related disorders
Age	Individuals over 65	X	X	X	X	X
	Individuals over 65 and living alone	X		X	X	X
	Children under 5	X	X	X		
Socioeconomic Status	People living in poverty	X	X	X	X	X
	The homeless	X	X	X	X	X
	People with limited English proficiency	X	X	X	X	X
	People lacking access to air conditioning	X			X	X
Race	Communities of color	X	X	X	X	X
Place	People living in an urban area with limited green space	X			X	X
	People living near high-traffic roadways				X	X
Current Health Status	Adults with chronic diseases (e.g., respiratory and cardiovascular diseases; compromised immune systems)	X	X	X	X	X
	Children with respiratory disease (e.g., asthma)	X			X	X
	Individuals using electricity-dependent medical equipment and/or medications that need refrigeration	X		X	X	X
	Individuals with disabilities or mobility problems	X	X	X	X	X
	Individuals with mental health challenges	X		X		X

Source: SHMCAP, 2018

### **Built Environment**

The built environment sector includes all buildings in Worthington including critical facilities owned by the municipality and critical infrastructure sectors that provide or link to key lifeline services, social welfare, and economic development. Assessments were based on assessor's data of the total value of all structures in Worthington (\$183,024,376 in 2019 according to MassGIS L3 data), along with the median value of a home in Worthington (\$246,200). The critical facilities assessed were derived from a combination of a Critical Facilities List provided by the State Hazard Mitigation Officer and critical facilities inventory review by the Worthington HMP Committee. The facility types include police facilities, fire facilities, hospitals, emergency operation centers, schools, and more. Other critical infrastructure sectors including transportation facilities, water infrastructure, etc. were assessed when applicable and where information was available.

### **Natural Resources and Environment**

The natural resources and environment sector includes land-based assets in the town. It also includes key habitats and natural landscapes documented in the Worthington's BioMap 2 (Conserving the Biodiversity of Massachusetts in a Changing World) and Areas of Critical Environmental Concern, as well as species identified in the State's Wildlife Action Plan as being present in Worthington, 2012.

### **Economy**

Economic impacts include economic loss resulting from damage to critical facilities, the built environment, municipal resources, natural resources, and other sectors. Many sectors of the economy are dependent on the integrity of natural resources. For example, if a major recreation area is damaged beyond repair by a storm, that property will no longer attract tourists and the local economy may experience a loss of revenue from tourism and recreation.

## **Climate Change and Natural Hazards**

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A key distinction between the 2010 HMP and the 2019 Plan Update is the broadened lens through which natural hazards were assessed: climate change, or the statistically significant variation in climate data or patterns over multiple decades due to climate variability or human activity. The Northeast Climate Adaptation Science Center (NE CASC) developed downscaled climate data that was used in the development of the 2018 SHMPCAP, forming a new basis and format for the categorization of natural hazards as they relate to the primary climate change interactions discussed in this section. The risk assessment presented below follows the format of the 2018 SHMPCAP and is organized by primary climate change interactions.

A categorization of traditional natural hazards, within the context of climate change, was included to demonstrate the connections between traditional natural hazard analysis and climate change projections. This categorization also aligns with the four climate change categories included on the Commonwealth's resilient MA Climate

Change Clearinghouse website (<http://www.resilientma.org/>). Those categories are illustrated as follows.

**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.

**Sea Level Rise:** Climate change will drive rising sea levels, and rising seas will have wide-ranging impacts on communities, natural resources, and infrastructure along the Commonwealth's 1,519 tidal shoreline miles.

**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 9 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).

**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.

The hazards presented in this risk assessment, and the order in which they appear, are based on the taxonomy presented in the Table below- Table 9.

**Table 2. Climate Change and Natural Hazard Taxonomy**

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	
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		
	Tornadoes		
	Other Severe Weather (Including Strong Wind and Extreme Precipitation)		
Non-Climate-Influenced Hazards	Earthquake	Not Applicable	There is no established correlation between climate change and this hazard
	Hazardous Materials	Not Applicable	There is no established correlation between climate change and this hazard

## Natural Hazard Identification and Vulnerability Assessment

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The 2019 hazard profiles for Worthington are based on a wide range of information and data including best available science and most current information on hazards, impacts, and vulnerability within the town. Detailed descriptions of each of the points of analysis are included in the Hazard Identification and Vulnerability Assessment (below).

The following is a description of natural and manmade disasters, and the areas affected by them, that have or could affect the Town of Worthington. The *Past and Potential Hazards/Critical Facilities Map* (Appendix D) reflects the contents of this analysis. All hazard profiles were updated for the 2019 Plan Update with any new available information, and data from the 2010 HMP were retained where it was appropriate and still deemed current.

### Vulnerability Assessment Methodology

In order to determine estimated losses due to natural hazards in Worthington, each hazard area was analyzed with results shown below. The data below was calculated using FEMA's *Understanding Your Risks: Identifying Hazards and Estimating Losses*, August 2001.

**Total value of all structures in Worthington (2019): \$183,024,376**

**Median value of a home in Worthington (2019): \$246,200**

**Average household size: 2.4 persons**

Human losses are not calculated during this exercise, but could be expected to occur depending on the type and severity of the hazard. Most of these figures exclude both the land value and contents of the structure. The damage calculations are rough estimate and likely reflect worst-case scenarios. Computing more detailed damage assessment based on assessor's records is a labor-intensive task and beyond the scope of this project.

**Table 3. Hazard Profiling and Risk Index**

Primary Climate Change Interaction	Natural Hazard	Location (% Town impacted)	Extent (of impact)	Previous Occurrence	Probability of Future Events	Hazard Risk Index Rating
Changes in Precipitation	Flooding (including Dam Overtopping and Dam Failure)	Small (100-year and localized) Small (dam failure)	Limited (100-year) Minor (Localized) Minor (dam failure)	Yes	Low (100-year) Very High (Localized) Very Low (dam failure)	Low (100-year) High (Localized) Low (dam overtopping/failure)
	Drought	Large	Minor	Yes	Low	Low
Rising Temperatures	Average/Extreme Temperatures	Large	Minor	Yes	High	Medium
	Wildfire/Brushfire	Medium	Limited	Yes (only minor events)	Low	Medium
	Invasive Species	Medium	Limited	Yes	High	Medium
Extreme Weather	Severe Winter Storm (including Ice Storms) / Nor'easter	Large	Critical	Yes	High	Medium-High
	Hurricanes/Tropical Storms (including severe wind)	Medium	Limited - Critical	Yes (no direct hit)	Moderate	Medium
	Tornado (including microburst)	Medium	Catastrophic	Yes	Low (tornado) Moderate (micro-burst)	Medium-Low
Non-Climate-Influenced Hazards	Earthquake	Large	Minor	No (none impacting Worthington)	Very Low	Low
Man-Made Hazard	Hazardous Materials	Small	Limited - Critical	No (only minor spills)	Low	Medium-Low

## Primary Climate Change Interaction: Changes in Precipitation

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### Flooding

As a non-coastal municipality, the flood hazard in Worthington focuses on inland flooding, which includes riverine flooding and urban or localized flooding, and the associated impacts of dam overtopping or failure. Inland flooding is the result of moderate precipitation over several days, intense precipitation over a short period, or melting snowpack (U.S. Climate Resilience Toolkit, 2017). 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).

Developed, impervious areas can contribute to inland flooding, and increases in precipitation and extreme storm events will result in increased occurrences of inland flooding (U.S. Climate Resilience Toolkit, 2017). Common types of inland flooding are described in the following subsections.

Various types of major storms bring precipitation to Worthington. Continental storms that originate from the west continually move across the region. These storms are typically low-pressure systems that may be slow-moving frontal systems or more intense, fast-moving storms. Nor'easters are coastal storms that travel into New England from the south generally bringing heavy precipitation. In the late summer or early fall, the most severe type of these coastal storms, hurricanes, may reach Massachusetts and result in significant amounts of rainfall. Finally, thunderstorms that form on warm, humid summer days can cause locally significant rainfall and damage from lightning, hail, or high winds.

Floods can be classified as either *flash floods*, which are the product of heavy, localized precipitation in a short time period over a given location or *general floods*, which are caused by precipitation over a longer time period in a particular river basin. There are several local factors that determine the severity of a flooding event, including: stream and river basin topography, precipitation and weather patterns, recent soil moisture conditions, amount of impervious surface area, and the degree of vegetative clearing. Furthermore, flooding can be influenced by larger, global climate events. Global warming and climate change are shifting rainfall and storm patterns, resulting in increased precipitation and the frequency and intensity of flooding in the region.

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).

In contrast, general flooding events may last for several days. 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).

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. Although periodic flooding of a floodplain area is a natural occurrence, past and current development and alteration of these areas will result in flooding that is a costly and frequent hazard. In addition to damage of buildings directly in the floodplain, development can result in a loss of natural flood storage capacity and can increase the water levels in water bodies. Flood levels may then increase, causing damage to structures not normally in the flood path.

The Floodplain Map for the Town of Worthington shows the 100-year and 500-year flood zones identified by FEMA flood maps. The 100-year flood zone is the area that will be covered by water as a result of a flood that has a one percent chance of occurring in any given year. Likewise, the 500-year flood has a 0.2 percent chance of occurring in any given year. In Worthington, there are several floodplain areas – primarily along Branch Brook, Bronson Brook, Watts Stream and Little River. There are some smaller 500-year floodplains mapped as well, in several low-lying areas throughout Worthington.

The average annual precipitation for Worthington and surrounding areas in Hampshire County is roughly 46 inches<sup>1</sup>. The major floods recorded in northwestern Massachusetts during the 20th century have been the result of rainfall alone or rainfall combined with snowmelt. Worthington has experienced many small flooding events over the last decade. Generally, these floods have had minor impacts, temporarily impacting roads and residents’ yards.

**Flooding (100-year base flood): Low Risk**

NFIP data on flood insurance policies, repetitive loss (RL) properties, and severe repetitive loss (SRL) properties are useful for determining the location of areas vulnerable to flood and severe storm hazards. 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

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<sup>1</sup> Averaged 1990-2010 amounts from Amherst, East Brimfield Lake, and Knighville Dam in Huntington. <https://www.currentresults.com/Weather/Massachusetts/average-yearly-precipitation.php>

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).

### **Location**

FEMA published new flood insurance rate maps for Hampshire County in 2017 and the Town of Worthington adopted the new maps in order to stay compliant with NFIP participation and for residents to remain eligible to buy flood hazard insurance through NFIP.

According to the Community Information System (CIS) of FEMA, there were 10 residential structures located within the Special Flood Hazard Area (SFHA) in Worthington as of January 2018, the most current records in the CIS for the Town of Worthington. Therefore, a vulnerability assessment for a 100-year flood equals approximately \$1.95 million of damage to residential structures, with approximately 24 people impacted. At this time the Town of Worthington has no repetitive loss properties as defined by FEMA’s NFIP.

### **Extent**

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.

The extent of 100 year base flooding is Limited (moderate by NWS standards). See information in Location section.

### **Previous Occurrences**

Between 1954 and 2018, Massachusetts has had 22 major flood (or flood-related) events, 8 of which included Hampshire County. The historical record indicates Hampshire County has experienced 8 flood-related disaster declaration events from 1954 to 2018. Therefore, based on these statistics, Worthington may experience a flood event of disaster declaration proportions approximately once every 8 years. However, the frequency of flooding varies significantly based on watershed, riverine reach, and location along each reach.

Worthington’s most significant flood event on record was the flood of March 1936. Direct accounts of the extent of the flooding in Worthington from this event do not seem to exist, however there is extensive documentation of the flooding in nearby Northampton. The account of the flood is as follows:

An unusually cold and snowy winter, followed by a spell of warm and rainy weather, turned the normal spring rising of the Connecticut River into an unprecedented natural catastrophe. The flood inundated Hadley, Hatfield, Northampton, Holyoke, and Springfield, as well as smaller towns (Worthington was one) and villages along its course. In Massachusetts alone, the Great Flood killed ten people and left 50,000 homeless. It was an unmatched natural catastrophe for the Bay State, causing over \$200,000,000 in damage in 1936 dollars.

Since the 2010 HMP update, the NOAA NCDC reports 23 flood events in Hampshire County.

**Flood & Flash Flood Event Hampshire County -NOAA NCDC Storm Events Database 2009-2019**

<u>Location</u>	<u>County/Zone</u>	<u>St.</u>	<u>Date</u>	<u>Time</u>	<u>I.Z.</u>	<u>Type</u>
<b>Totals:</b>						
<a href="#"><u>NORTHAMPTON</u></a>	HAMPSHIRE CO.	MA	01/25/2010	15:00	EST-5	Flood
<a href="#"><u>NORTHAMPTON</u></a>	HAMPSHIRE CO.	MA	08/28/2011	08:52	EST-5	Flood
<a href="#"><u>BAY STATE</u></a>	HAMPSHIRE CO.	MA	08/28/2011	10:30	EST-5	Flood
<a href="#"><u>SOUTH HADLEY FALLS</u></a>	HAMPSHIRE CO.	MA	08/28/2011	14:22	EST-5	Flood
<a href="#"><u>WESTHAMPTON</u></a>	HAMPSHIRE CO.	MA	08/28/2011	15:11	EST-5	Flood
<a href="#"><u>WEST WARE</u></a>	HAMPSHIRE CO.	MA	09/08/2011	03:28	EST-5	Flood
<a href="#"><u>COOKS CORNER</u></a>	HAMPSHIRE CO.	MA	07/28/2012	15:10	EST-5	Flood
<a href="#"><u>HADLEY</u></a>	HAMPSHIRE CO.	MA	06/28/2013	17:05	EST-5	Flash Flood
<a href="#"><u>SOUTH HADLEY FALLS</u></a>	HAMPSHIRE CO.	MA	07/01/2013	11:38	EST-5	Flash Flood
<a href="#"><u>GRANBY</u></a>	HAMPSHIRE CO.	MA	08/09/2013	11:51	EST-5	Flash Flood
<a href="#"><u>SOUTH HADLEY</u></a>	HAMPSHIRE CO.	MA	05/23/2014	18:53	EST-5	Flash Flood
<a href="#"><u>HATFIELD STATION</u></a>	HAMPSHIRE CO.	MA	08/13/2014	13:40	EST-5	Flash Flood
<a href="#"><u>GOSHEN</u></a>	HAMPSHIRE CO.	MA	07/27/2015	15:40	EST-5	Flash Flood
<a href="#"><u>HAYDENVILLE</u></a>	HAMPSHIRE CO.	MA	09/30/2015	07:50	EST-5	Flood
<a href="#"><u>BUZZARDS BAY</u></a>	HAMPSHIRE CO.	MA	09/30/2015	08:15	EST-5	Flood
<a href="#"><u>BAY STATE</u></a>	HAMPSHIRE CO.	MA	02/25/2016	05:37	EST-5	Flood
<a href="#"><u>WARE</u></a>	HAMPSHIRE CO.	MA	08/13/2016	21:30	EST-5	Flood
<a href="#"><u>BAY STATE</u></a>	HAMPSHIRE CO.	MA	08/05/2017	14:14	EST-5	Flood
<a href="#"><u>NORTHAMPTON</u></a>	HAMPSHIRE CO.	MA	10/24/2017	21:14	EST-5	Flood
<a href="#"><u>GRANBY</u></a>	HAMPSHIRE CO.	MA	10/24/2017	23:17	EST-5	Flood
<a href="#"><u>WARE</u></a>	HAMPSHIRE CO.	MA	01/13/2018	10:18	EST-5	Flood
<a href="#"><u>AMHERST</u></a>	HAMPSHIRE CO.	MA	09/18/2018	08:01	EST-5	Flash Flood
<a href="#"><u>WARE</u></a>	HAMPSHIRE CO.	MA	07/06/2019	16:08	EST-5	Flood

## Probability of Future Events

The Floodplain Map for the Town of Worthington shows the 100-year and 500-year flood zones identified by FEMA flood maps. The 100-year flood zone is the area that will be covered by water as a result of a flood that has a one percent chance of occurring in any given year. Likewise, the 500-year flood has a 0.2 percent chance of occurring in any given year. In Worthington, there are several floodplain areas – primarily along Branch Brook, Bronson Brook, Watts Stream and Little River. There are some smaller 500-year floodplains mapped as well, in several low-lying areas throughout Worthington.

The major floods recorded in Western Massachusetts during the 20th century have been the result of rainfall alone or rainfall combined with snowmelt. Worthington has experienced flooding events over the last decade. Generally, these small floods have had minor impacts, temporarily impacting roads and residents' yards.

### **Flooding (localized/urban drainage): High Risk**

There are approximately 1,004 acres of land within the FEMA mapped 100-year floodplain and 26 acres of land within the 500-year floodplain within the Town of Worthington. Specific vulnerability assessments were estimated for sites within the SFHA which have been susceptible to 100-year floods in the past, they are described below. At this time the Town of Worthington has no repetitive loss properties as defined by FEMA's NFIP.

In addition to the floodplains mapped by FEMA for the 100-year and 500-year flood, Worthington often experiences minor flooding at isolated locations due to drainage problems, or problem culverts.

There are a total of 135 problem culverts or other localized flooding areas are all over Town, and have been mapped on the Past and Potential Hazards/Critical Facilities Map (Appendix D). Most of the flood hazard areas listed here were identified due to known past occurrence in the respective area. There are many areas with no record of previous flood incidents that could be affected in the future by heavy rain and runoff. Additionally, the vast majority of culverts throughout town tend to be impacted by beavers, so localized flooding can potentially occur at any culvert crossing.

### **Location**

#### **Dingle Road**

Bronson Brook along Dingle Road has experienced significant flooding in the past.

- 7 homes affected;
- Threat includes property damage, septic system damage, and damage to the stream banks;
- Vulnerability assessment: \$1,365,000 (assuming 100% damage to 100% of the structures);

- Cost for repairing or replacing any power lines, telephone lines, and contents of structures are not included.

Williamsburg Road (Route 143 from Capen Street to the Chesterfield Line)

Bronson Brook along Route 143 from Capen Street to the Chesterfield line has experienced significant flooding the past, to include the stream completely overflowing it's banks and flooding the roadway and residences.

- 4 homes affected
- Threat includes property damage, septic system damage, and damage to the stream banks;
- Vulnerability assessment: \$780,000 (assuming 100% damage to 100% of the structures);
- Cost for repairing or replacing any power lines, telephone lines, and contents of structures are not included.

Capen Street (from 112-143)

Bronson Brook along Capen Street has experienced significant flooding the past, to include the stream completely overflowing it's banks and flooding the roadway.

- 3 homes affected
- Threat includes property damage, septic system damage, and damage to the stream banks;
- Vulnerability assessment: \$585,000 (assuming 100% damage to 100% of the structures);
- Cost for repairing or replacing any power lines, telephone lines, and contents of structures are not included.

**Extent**

There are a number of roads in low-lying areas that do get flooded in severe rain events. However, the flooding lasts only a short time and does not usually cause significant property damage or any physical harm or loss of life. Most localized flooding has a Minor extent, where less than 10% of property in the affected area is damaged or destroyed and a temporary shutdown of facilities (such as roads) for less than 1 day is possible.

**Previous Occurrences**

Localized floods of lesser magnitude occur at a much higher frequency than minor floods; in the last ten years (2009-2019) the national Oceanic and Atmospheric Administration (NOAA) Storm Events Database reported 23 flood or flash flood events in Hampshire County.

The Town of Worthington has only limited records of previous flooding events. Locations identified as having experienced previous occurrences of localized flooding were based on local knowledge of staff and volunteers who worked on the Worthington Hazard Mitigation plan update.

### **Probability of Future Events**

Overall it is anticipated that the severity of flood-inducing weather events and storms will increase as a result of climate change. Research has shown that rainfall is increasingly concentrated into the most severe events (Easterling, 2017). While trends in overall precipitation are less clear, the increase in severe rainfall events will exacerbate the risk of localized flooding.

### **Dam Overtopping (dam failure) – Low Risk**

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

Many dams in Massachusetts were built in the 19th century without the benefit of modern engineering design and construction oversight. Dams can fail because of structural problems due to age and/or lack of proper maintenance. Dam failure can also be the result of structural damage caused by an earthquake or flooding brought on by severe storm events. Most earthen dam failures occur when floodwaters above overtop and erode the material components of the dam.

The Massachusetts Department of Conservation and Recreation (MA DCR) was the agency responsible for regulating dams in the state (M.G.L. Chapter 253, Section 44 and the implementing regulations 302 CMR 10.00). Until 2002, DCR was also responsible for conducting dam inspections but then state law was changed to place the responsibility and cost for inspections on the owners of the dams. This means that individual dam owners are now responsible for conducting inspections.

The state has four 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.
- Non-jurisdictional: The storage capacity of the impoundment and height of dam are such that they need not be regulated.

The inspection schedule for dams is as follows:

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

The time intervals represent the maximum time between inspections. More frequent inspections may be performed at the discretion of the state. 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. All other dams are subject to the regulations unless exempted in writing by DCR.

**Location**

According to DCR sources, as well as local knowledge, there are currently six (6) dams<sup>2</sup> in Worthington. The follow table identifies the dams within the town as well as whether they are classified as low, significant, or high hazard.

<b>Dam name/ date built</b>	<b>ID</b>	<b>Owner</b>	<b>Purpose</b>	<b>Condition/last inspected</b>	<b>Hazard Risk</b>
Little Gallilee Pond Dam	MA02649	George Bresnick & Geraldine Hendriksen	Recreation	Unknown / Unknown	Low
Smith Farm Lower Pond Dam	MA02650	A.E. Albert & Sons, Inc.	Irrigation	Unknown / Unknown	Non-jurisdictional
Smith Farm Upper Pond Dam	MA02651		Irrigation	Unknown / Unknown	Non-jurisdictional
Ward Stream Dam	MA02652		Irrigation	Unknown / Unknown	Non-jurisdictional
House Lot Pond Dam	MA02653		Irrigation	Unknown / Unknown	Non-jurisdictional
Chesterfield Road Lot Pond Dam	MA02654		Irrigation	Unknown / Unknown	Non-jurisdictional
Earten Dam Old Port Rd,	Not permitted	Chet Kellogg		Ordered to be reconstructed	Non-jurisdictional

<sup>2</sup> It is difficult to track down accurate records of dams, as ownership and exact location is not clear. Furthermore, many very old dams listed in DCR records are not in existence anymore, according to local knowledge. This list is compiled from a combination of sources, and then verified by the Committee.

Radacher Rd				years ago	
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**Extent**

Dam failure is not a common occurrence but dams do represent a potentially disastrous hazard. When a dam fails, the potential energy of the stored water behind the dam is released. Often dam breaches lead to catastrophic consequences as the water ultimately rushes in a torrent downstream flooding an area engineers refer to as an “inundation area.” The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area. In many cases, the extent of a total dam failure is critical to catastrophic to the impacted area within the inundation zone.

**Previous Occurrences**

Worthington has no history of dam failures.

**Probability of Future Events**

Based upon the past events, it is reasonable to say that there is a low (less than 1% probability in the next year) of dam failure in Worthington.

**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. Landslides can occur following flood events when high flows oversaturate soils on steep slopes, causing them to fail. Roadways and bridges are impacted when floods undermine or wash out supporting structures. 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.

**Vulnerable Populations**

The most vulnerable populations exposed to the flood hazard 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. Populations that live or work in proximity to facilities that use or store toxic substances are at greater risk of exposure to these substances during a flood event.

Advance weather forecasting, blockades, and emergency alerts and warnings help to minimize the total number of injuries and casualties that typically result from riverine flooding. However, even a relatively low-level flood can be hazardous and can result in direct mortality to individuals interacting with the flood zone. 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. Floodwater can also carry a wide range of infectious organisms from raw sewage and/or chemicals and hazardous materials swept away from containment areas.

### **Built Environment and Economy**

Flooding can cause direct damage to critical facilities and result in roadblocks and inaccessible streets that impact the ability of public safety and emergency vehicles to respond to calls for service.

Buildings, infrastructure, and other elements of the built environment are vulnerable to inland flooding. Buildings within the floodplain are highly vulnerable to inland flooding and 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 (SHMCAP, 2018). 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.

### **Natural Resources**

Flooding is a natural environmental phenomenon. 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 and the built environment 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. This process can clog riverbeds and streams, disrupting the water supply to downstream habitats.

### **Drought: Low Risk**

Like flooding, drought is a normal, recurrent feature of climate. Drought happens almost everywhere, although its features vary from region to region. Generally, drought originates from a deficiency of precipitation over an extended period of time, resulting in a water shortage for some activity, group, or environmental sector.

Direct impacts of drought include reduced crop and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish habitat. Since drought is not a local hazard, but rather

occurs on a larger regional scale, these impacts often have far-reaching effects throughout the region and even the country.

### ***Location***

How a drought is experienced can depend on geographic 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. A drought in Worthington would affect the entire town.

### ***Extent***

When evaluating the region's risk for drought on a national level, utilizing a measure called the Palmer Drought Severity Index, Massachusetts is historically in the lowest percentile for severity and risk of drought. Even so, there have been several years of drought-like conditions in Western Massachusetts: 1940-1952, 1980-1983, 1995-2001, 2010 and 2016. Furthermore, global warming and climate change may have an effect on drought risk in the region. With the projected temperature increases, some scientists think that the global hydrological cycle will also intensify. This would increase the severity and duration of droughts.

The extent of a severe drought in Worthington would be minor, with very few injuries, if any, only minor property damage and minimal disruption on quality of life, and a temporary shutdown of facilities or limits placed on water usage.

### ***Previous Occurrences***

In Massachusetts, six major droughts have occurred statewide since 1930, the most severe in 1960 and the most recent in 2016. Droughts range in severity and length, from three to eight years. Although it was shorted in duration, the severity of the 2016 drought state-wide was equivalent to that of the 1960s. In many of these droughts, water-supply systems were found to be inadequate. Water was piped in to urban areas, and water-supply systems were modified to permit withdrawals at lower water levels.

Worthington has had limited experience with severe drought conditions. According to the Massachusetts SHMCAP, between 2001 and 2017 Hampshire county experienced up to 49 weeks of Severe Drought and 14 weeks of Extreme Drought, as classified by the U.S. Drought Monitor.

### ***Probability of Future Occurrences***

The frequency and intensity of droughts are projected to increase during summer and fall as higher temperatures lead to greater evaporation and earlier winter and spring snowmelt, and precipitation patterns become more variable and extreme. Also due to climate change, the proportion of precipitation falling as rain instead of snow in our region and the extent of time snowpack remains are both expected to decrease. This

reduces the period during which snow melt can recharge groundwater supplies, bolster streamflow, and provide water for the growing period.

### ***Secondary Hazards***

Another hazard commonly associated with drought is wildfire. A prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. As a result, a drought may increase the probability of a wildfire occurring. Additional information is provided in the wildfire hazard later in this section.

## ***Vulnerability***

### **Populations**

The entire population of Worthington would be vulnerable to the impacts of a drought. Residents with a private water supply such as a well, who receive water through a public supplier, and populations with respiratory health conditions are most vulnerable.

### **Built Environment**

Some infrastructure may not be built to operate in drought conditions. Intake pipes may be too high above drought water levels, and wells may be too shallow. Private suppliers or residents with private systems may need to drill deeper wells or find alternative supplies for emergency back-up during severe droughts.

### **Natural Resources**

Prolonged droughts can have severe impacts on groundwater and surface water-dependent ecosystems and natural resources, as most organisms require water throughout their life cycle.

### **Economy**

Economic impacts of drought can be significant in the agriculture, recreation, forestry, and energy sectors. Impacts on the individual level include the need to buy water from an alternative source during a drought emergency. Crop failure can also increase food prices, straining a larger portion of the economy.

## Primary Climate Change Interaction: Rising Temperatures

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### Average/Extreme Temperature: Medium

What constitutes “extreme cold” or “extreme heat” can vary across different geographies, based on what the population of a particular place is accustomed to. According to the Massachusetts State Hazard Mitigation and Climate Adaptation Plan, extreme heat for Massachusetts is usually defined as a period of 3 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.

More broadly, extreme temperatures can be defined as those that are far outside the normal ranges. The average highs and lows of the hottest and coolest months in the neighboring town of Westfield, the closest site for which data was available, are provided in Table 3 below.

	<b>July (Hottest Month)</b>	<b>January (Coldest Month)</b>
Average High (°F)	83	33
Average Low (°F)	59	13

Source: NOAA NWS, 2019. Monthly Climate Normals (1981 – 2010) Westfield Barnes Municipal AP, MA

The highest temperature recorded at the Barnes Municipal Airport in Westfield for the period from 1926 to present<sup>3</sup> was 103°F in on July 6, 2010 (NOAA NOW Data, Boston / Norton Weather Forecast Office, <https://w2.weather.gov/climate/xmacis.php?wfo=box>).

Projected temperature extremes will shift with climate change, according to research conducted by the Massachusetts Executive office for Energy and Environmental Affairs and the University of Massachusetts, Amherst. By 2050, summer maximum temperatures (including the presumed hottest month of July) are expected to reach 84.9°F in Hampshire County, as opposed to a 2001-2005 5-year mean of 79.6°F (resilientma.org).

Extreme cold events are when temperatures drop well below normal in an area. Generally, extreme cold temperatures are characterized by the ambient air temperature dropping to or below 0 degrees Fahrenheit (°F) (National Weather Service [NWS] 2015). When winter temperatures drop significantly below normal, staying warm and safe can become a challenge. Extremely cold temperatures may accompany or follow a winter storm, which may also cause power failures and icy roads. Many homes will be too cold, either due to a power failure or because the heating system is not adequate for the weather. Extensive exposure to extreme cold temperatures can cause frostbite or hypothermia and can become life-threatening.

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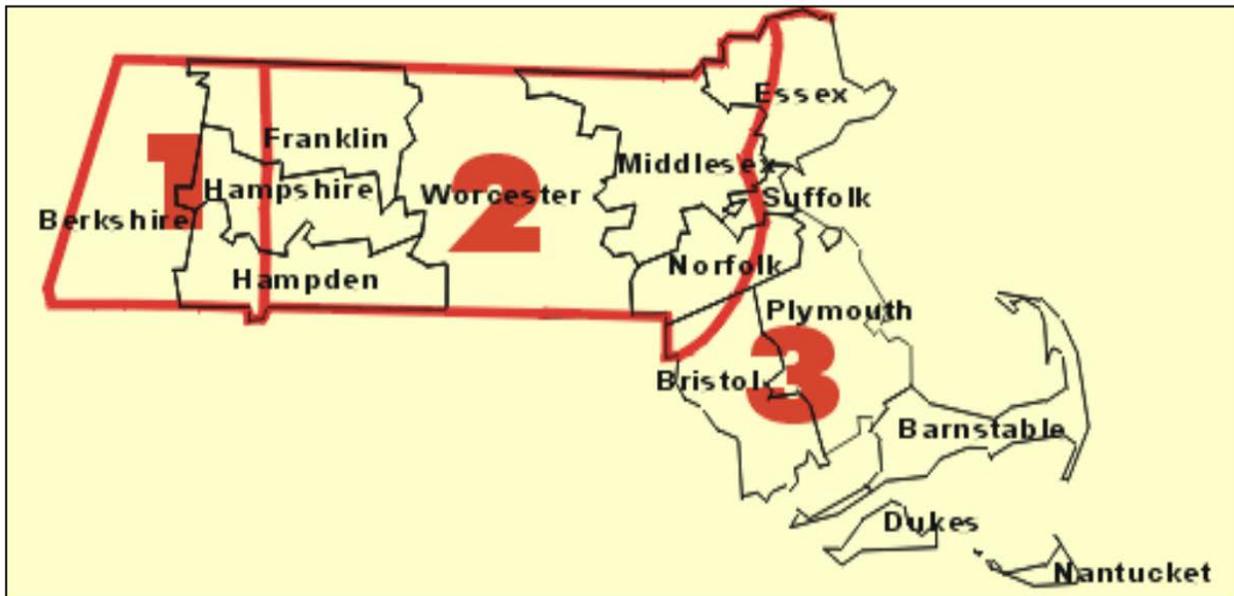
<sup>3</sup> <https://www.ncdc.noaa.gov/extremes/scec/records>

Extreme heat is defined by the Center for Disease Control (CDC) as temperatures which hover 10 degrees or more above the average high temperature for a region and that last for several weeks (CDC 2016). Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. Since 1979, more than 9,000 Americans have died from heat-related ailments (EPA, 2016). In Massachusetts, a heat wave is defined as 3 or more days of temperatures of 90°F or above and is often accompanied by high humidity. The designation implies an extended period of unusually high atmosphere-related heat stress, which forces affected populations to make temporary modifications in lifestyle to avoid adverse health consequences (MA HMCAP, 2018).

### Location

NOAA divides Massachusetts up into three climate divisions - Western, Central, and Coastal - and average annual temperatures vary slightly over the divisions. Another distinction between the divisions is that extreme temperature events occur more frequently and vary more in the inland regions where temperatures are not moderated by the Atlantic Ocean. Worthington sits along the western edge of the Central Division, with annual average temperatures of around 49°F.

Figure 1. Climate Divisions of Massachusetts



Source: NOAA, n.d.

Extreme temperatures would affect the whole community in Worthington, resulting in a “large” location of occurrence, or more than 50 percent of total land area affected.

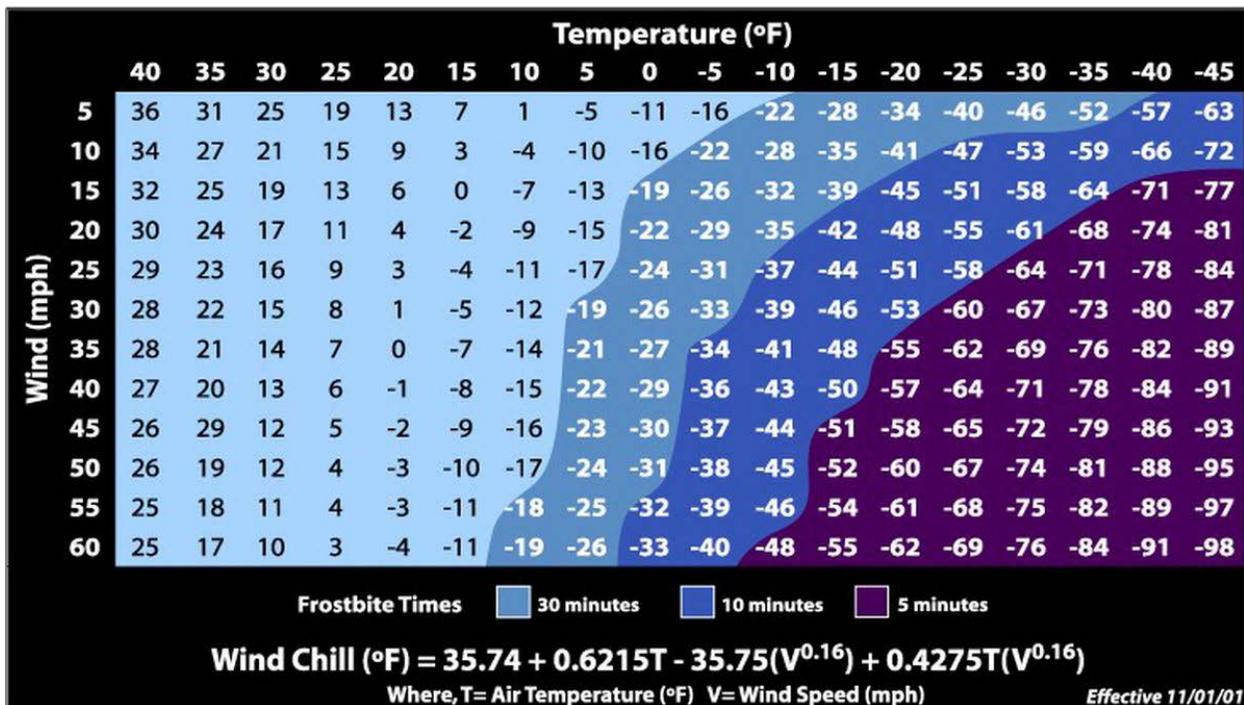
### Extent

The extent (severity or magnitude) of extreme cold temperatures are generally measured through the Wind Chill Temperature (WCT) Index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate

of heat loss from exposed skin by the effects of wind and cold. The chart shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops. In Massachusetts, a wind chill warning is issued by the NWS Taunton Forecast Office when the Wind Chill Temperature Index, based on sustained wind, is -25°F or lower for at least three hours. The WCT is presented in Figure 2.

**Figure 2. NWS Wind Chill Index**


Wind Chill Chart

Source: NWS 2018

The NWS Heat Index is used to measure extremely hot temperatures, combining relative humidity with actual air temperature to determine the risk to humans. The NWS issues a Heat Advisory when the Heat Index is forecast to reach 100-104°F for 2 or more hours, and an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for 2 or more hours. The chart in Figure 3 indicates the relationship between heat index and relative humidity and illustrates the adverse effects that prolonged exposure to heat and humidity can have on an individual.

Figure 3. NWS Heat Index Chart

		Temperature (°F)															
		80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Relative Humidity (%)	40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
	45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
	50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
	55	81	84	86	89	93	97	101	106	112	117	124	130	137			
	60	82	84	88	91	95	100	105	110	116	123	129	137				
	65	82	85	89	93	98	103	108	114	121	128	136					
	70	83	86	90	95	100	105	112	119	126	134						
	75	84	88	92	97	103	109	116	124	132							
	80	84	89	94	100	106	113	121	129								
	85	85	90	96	102	110	117	126	135								
	90	86	91	98	105	113	122	131									
	95	86	93	100	108	117	127										
100	87	95	103	112	121	132											
Category		Heat Index		Health Hazards													
Extreme Danger		130 °F – Higher		Heat Stroke or Sunstroke is likely with continued exposure.													
Danger		105 °F – 129 °F		Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.													
Extreme Caution		90 °F – 105 °F		Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.													
Caution		80 °F – 90 °F		Fatigue possible with prolonged exposure and/or physical activity.													

Source: National Weather Service (NWS), Heat Index, 2018

According to recent downscaled climate projections for Massachusetts, high, low, and average temperatures in Hampshire County are likely to increase significantly over the next century as a result of climate change (resilient MA, 2019). This gradual change will put long-term stress on a variety of social and natural systems, and will exacerbate the influence of discrete events. In the event of an extreme cold or heat event, multiple injuries and health impacts would be possible. Therefore, the extent of this hazard is Critical.

**Previous Occurrences**

The following are the lowest temperatures recorded in parts of Massachusetts for the period from 1895 to present according to NOAA’s State Climate Extremes Committee (SCEC)<sup>4</sup>:

- Taunton: -35°F, January 5, 1904
- Coldbrook: -35°F, February 15, 1943
- Chester: -35°F, January 12, 1981

Since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events. In February 2015, a series of snowstorms piled up to 60 inches in some areas in 3 weeks and caused recurrent blizzards across eastern Massachusetts. Temperature gauges across the

<sup>4</sup> <https://www.ncdc.noaa.gov/extremes/scec/records>

Commonwealth measured extreme cold, with wind chills as low as -31°F. Four indirect fatalities occurred as a result of this event: two adults died shoveling snow and two adults were hit by snowplows. In February 2016, one cold weather event broke records throughout the state. Extreme cold/wind chill events were declared in 16 climate zones across the Commonwealth (MASHMCAP, 2018).

According to the NOAA's Storm Events Database, there were 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) in Massachusetts between 1995 and 2018, the most recent of which occurred in July 2013. 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. 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 (MASHMCAP, 2018). None of these events was known to impact individuals in Worthington.

The lowest temperature recorded at the Barnes Municipal Airport in Westfield for the period from 1926 to present<sup>5</sup> was -20°F on Feb. 9, 1934 (NOAA NOW Data, Boston / Norton Weather Forecast Office, <https://w2.weather.gov/climate/xmacis.php?wfo=box>).

Between 1954 and 2019, Hampshire County was not included in any FEMA declared extreme temperature -related disasters (DR) or emergencies (EM).

### **Probability of Future Occurrences**

The NE CASC data support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events. Figure 4 and Figure 5 show the projected changes in these variables between 2020 and the end of this century.

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<sup>5</sup> <https://www.ncdc.noaa.gov/extremes/scec/records>

Figure 4. Projected Annual Days with Temperature Above 90°F

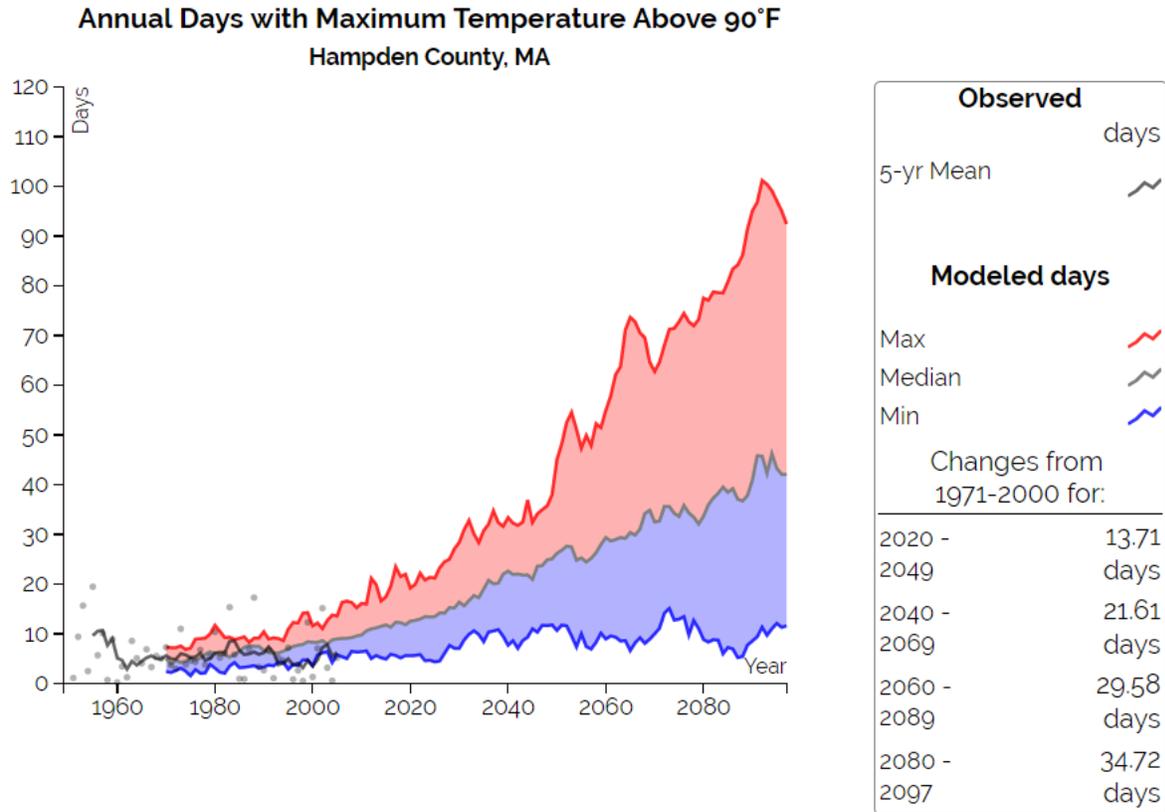
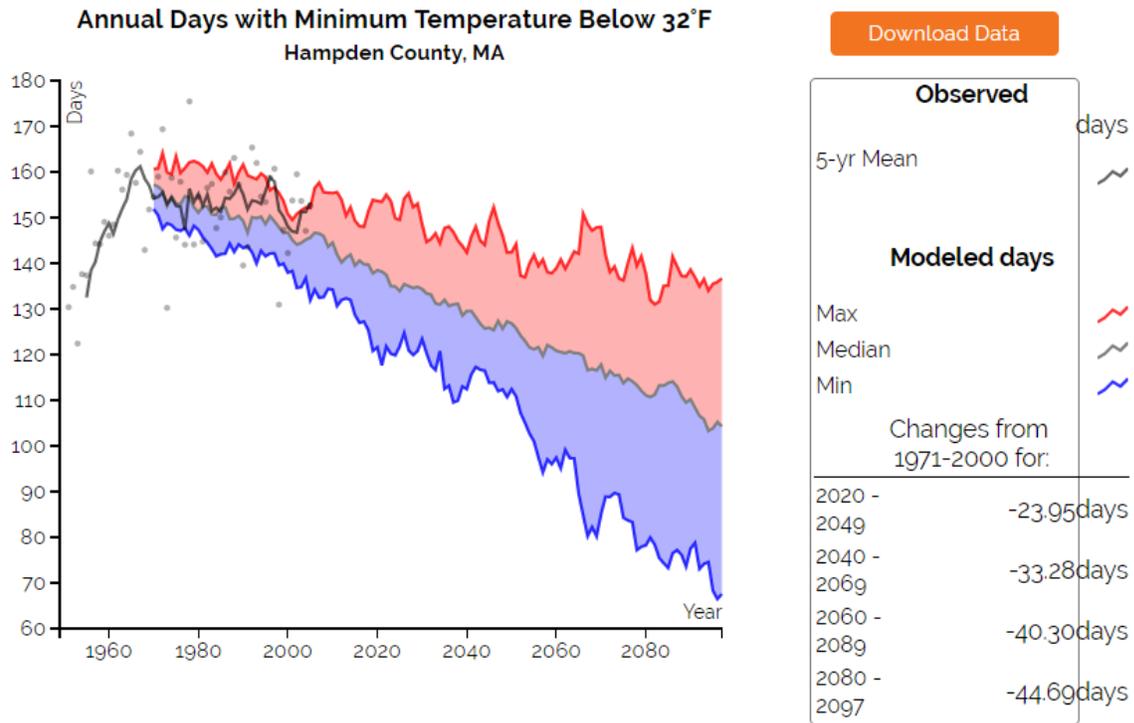


Figure 5. Projected Annual Days with Temperature below 32°F



Source: resilient MA, 2019

The probability of future extreme heat and extreme cold is considered to be "high," or between 40 and 70 percent in any given year.

### **Secondary Hazard**

According to the 2018 SHMCAMP, the most significant secondary hazard associated with extreme temperatures is a severe weather event. Severe heat events are often associated with drought, as evaporation increases with temperature, and with wildfire, as high temperatures can cause vegetation to dry out and become more flammable. Warmer weather will also have an impact on invasive species (see Invasive Species section below for additional detail). More commonly, heat events contribute to poor air quality that can exacerbate asthma and result in an increase in emergency department visits.

Conversely, extreme cold events are primarily associated with severe winter storms. The combination of cold weather with severe winter storm events is especially dangerous because winter weather can knock out heat and power, increasing exposure to extreme cold temperatures. Loss of heat and power may also lead to carbon monoxide poisoning from inappropriate use of combustion-powered generators, heaters, and cooking appliances, and heavy snowfall may block vents for gas dryers and heaters. Similarly, prolonged exposure to extreme heat can compromise power infrastructure, leaving customers without power or the ability to operate air conditioning. Power failure leads to increased use of diesel generators for power and

more wood stoves are used in extreme cold; both situations lead to increasing air pollution and health impacts.

**Vulnerability**

Extreme temperature can have a significant impact to human health, commercial/agricultural businesses and primary and secondary effects on infrastructure (e.g., burst pipes and power failure).

**Population**

Extensive exposure to extreme cold temperatures can cause frostbite or hypothermia and can become life-threatening. Extreme cold and extreme heat are dangerous situations that can result in health emergencies for individuals without shelter or some other way to stay cool, or who live in homes that are poorly insulated, or without heat or air conditioning. Power outages may also result in inappropriate use of combustion heaters and other appliances, as discussed under Secondary Impacts above. Extreme heat events can also contribute to a worsening of air quality, as high temperatures increase the production of ozone from aerosols such as volatile organic compounds. Weather patterns that bring high temperatures can also transport air pollutants from other areas of the continent. Additionally, atmospheric inversions and low wind speeds associated with heat waves allow polluted air to remain in one location for a prolonged period of time (UCI, 2017).

According to the 2018 SHMCAP, the interaction of heat and cardiovascular disease caused approximately 25 percent of the heat related deaths since 1999. The rate of emergency department visits and hospital admissions for heat-related illness under existing conditions in Hampshire County and the town of Worthington is shown in Table 4. In 2012, the annual average age-adjusted rate of hospital admission for heat stress in Hampshire County was 14.7 (admissions per 100,000 people). The annual average age-adjusted hospital admissions for heart attacks in Hampshire County is \_\_\_\_, and in Worthington was \_\_ per 10,000 residents. (need to research)

Table 5. General Vulnerability Indicators				
Location	Estimated Increase in Average Temperature by 2100 (°F)	Proportion of Population Aged 65 or Older	Proportion of Population Aged Younger than 5 Years	Proportion of the Population Living Below Poverty Level
Hampshire County	+6.4°	6%	6%	17%
Worthington	N/A	15.2% (1)	5.7% (1)	12.1 (1)

Notes: (1) 2017 American Community Survey states that estimates are not comparable to other geographic levels due to methodology differences that may exist between different data sources.

**Built Environment**

With the exception of power infrastructure, most structures and infrastructure within the town are not at risk for damage due to extreme temperatures, but populations that are not prepared to contend with these temperature extremes could be most vulnerable.

However, extreme cold temperature events can damage buildings through freezing or bursting pipes and freeze and thaw cycles. Furthermore, secondary impacts of this hazard include extreme temperature fluctuations, which have serious implications for transportation infrastructure life-span and maintenance needs.

## **Natural Resources**

Individual extreme temperature 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, changing average temperatures and the changing frequency of extreme climate events will likely have a major impact on natural resources throughout the Commonwealth and worldwide (2018 SHMCAP).

Changing temperatures will impact the natural environment in many ways. 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.

Massachusetts ecosystems that are expected to be particularly vulnerable to warming temperatures include:

- Coldwater streams and fisheries
- Vernal pools
- Spruce-fir forests
- Northern hardwood (Maple-Beech-Birch) forests, which are economically important due to their role in sugar production
- Hemlock forests, particularly those with the hemlock wooly adelgid
- Urban forests, which will experience extra impacts due to the urban heat island effect (2018 SHMCAP)

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.

## **Economy**

Extreme temperatures can impact a municipal and regional economy in various ways. Worthington 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). There is a loss of productivity and income when the transportation sector is impacted and people and commodities cannot get to their intended destination. Employers with outdoor workers (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 – these shifts can impact the earnings of both the company and the individual employee. 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 (2018 SHMCAP).

## **Wildfires/Brushfire – Low Risk**

According to FEMA, there are three different classes of wildland fires: surface fires, ground fires and crown fires. The most common type of wildland fire is a surface fire that burns slowly along the floor of a forest, killing or damaging trees. A ground fire burns on or below the forest floor and is usually started by lightning. Crown fires move quickly by jumping along the tops of trees. A crown fire may spread rapidly, especially under windy conditions.

Hampshire County has approximately 252,000 acres of forested land, which accounts for 72% of total land area. Forest fires are therefore a potentially significant issue. In Worthington, approximately 84% of the town's total land area is in forest, or about 17,194 acres, and is therefore at risk of fire.

While wildfires or brushfires have not been a significant problem in Worthington, there is always a possibility that changing land use patterns and weather conditions will increase a community's vulnerability. For example, drought conditions can make forests and other open, vegetated areas more vulnerable to ignition. Once the fire starts, it will burn hotter and be harder to extinguish. Soils and root systems starved for moisture are also vulnerable to fire. Residential growth in rural, forested areas increases the total area that is vulnerable to fire and places homes and neighborhoods closer to areas where wildfires are more likely to occur. Global climate changes may also influence precipitation patterns, making the region more susceptible to drought and therefore, wildfires.

Low risk exists for potential wildfire incidents, especially near some of the town's forested, agricultural, and recreational lands.

### **Location**

In Massachusetts, the DCR Bureau of Forest Fire Control has been the state agency responsible for providing aid, assistance, and advice to the Commonwealth's cities and towns since 1911. The Bureau provides assistance and cooperation with fire departments, local law enforcement agencies, the Commonwealth's county and statewide civil defense agencies, and mutual aid assistance organizations.

### **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 are vulnerable to wildfires, particularly during droughts. Forested and agricultural areas with high fuel content have more potential to burn. In addition, it is often very difficult to access some of the locations to extinguish brush fires. However, the greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. Again, the wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas. Based on the total area of this type of condition within town, the extent of a significant wildfire or brushfire in Worthington is deemed Limited.

### ***Previous Occurrences***

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. Few wildfires have been recorded in the past 100 years in the Pioneer Valley, and none has ever resulted in a FEMA disaster declaration.

The Worthington Fire Department reports that it has records of only small brush fires covering less than a few acres at most. One of the fires was a permitted burn that got out of control. Medium risk exists for potential wildfire incidents, especially near some of the town's forested, agricultural, and recreational lands. Forested and agricultural areas with high fuel content have more potential to burn. In addition it is very often difficult to access some of the locations to extinguish brushfires. On Route 112 up to 10 structures could be impacted by a wildfire. Assuming 100% damage to 100% of structures, not including costs repairing or replacing power lines, telephone lines, and contents of structures; could result in \$1,950,000 in damages.

### ***Probability of Future Events***

Research has found that the frequency of lightning strikes – an occasional cause of wildfire – could increase by approximately 12 percent for every degree Celsius of warming (2018 SHMCAP). Even with the increased lightning risks, based upon the past events, it is reasonable to say that there is a low probability (1-10% probability in the next year) of wildfires in Worthington.

### ***Vulnerability***

#### **Population**

Human health and the lives of residents and responders are at risk from wildfire. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment.

#### **Built Environment**

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.

Critical facilities are particularly important for routine town operation and emergency response in case of a severe wildfire. Energy distribution lines are subject to wildfire risk because most poles are made of wood and susceptible to burning. Transmission lines are also at risk to faulting during wildfires, which can result in a broad area outage.

### **Natural Resources**

Fire can serve important ecological purposes as a natural part of many ecosystems. Functions include facilitating the nutrient cycling from dead and decaying matter, removing diseased plants and pests, and regenerating seeds or stimulating germination of certain plants. Conversely, wildfires can also have significant negative impacts on the environment. Specifically, the ash they generate can distort the flow of nutrients through an ecosystem, reducing the biodiversity that can be supported.

### **Economy**

The initial loss of structures and the subsequent loss of revenue from destroyed businesses from a wildfire can have major economic impacts on a community. Individuals and families will face economic challenges if their home is impacted by wildfire. The exposure of homes to this hazard is widespread. According to the characterization of wildland hazard areas by Radeloff et al., the Massachusetts intermix hazard area contains 476,934 housing units (or approximately 17 percent of the total housing units in the Commonwealth). The interface hazard area contains 715,209 housing units (or approximately 26 percent of the total housing units in the Commonwealth).

## Invasive Species: Medium-Low Risk

Invasive species are non-native species that threaten and damage local ecosystems, economies, and/or public health (NISC 2006). The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by EOEEA to provide recommendations to the Commonwealth to manage invasive species. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems" (MIPAG, n.d.).

Invasive terrestrial plants are the most studied and managed type of invasive, but invasive insects are also relevant to Worthington. In all cases, 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.

The spread of invasive species is primarily caused by human activity. Common examples include:

- Wood Products: Insects can get into wood, shipping palettes, and crates that are shipped around the world as well as travel in firewood.
- Ornamental Plants: Some ornamental plants can escape into the wild and become invasive.
- Pet Trade: Some invasive species start as pets that are intentionally or accidentally released.
- Climate change: Warmer temperatures place stress on cold-weather species, while allowing non-native species accustomed to warmer climates to spread northward. 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.

Invasive plant species such as Asian honeysuckles, Japanese barberry, autumn olive, burning bush, multiflora rose, garlic mustard, and glossy buckthorn, are considered by the Massachusetts Department of Agricultural Resources, New England Wildflower Society, U.S. Forest Service, and others as some of the worst invaders in the region. Three non-native insects which currently threaten the region are the emerald ash borer (EAB), Asian longhorned beetle (ALB) and hemlock wooly adelgid (HWA). Only hemlock wooly adelgid is currently present in the area; emerald ash borer was identified in Holyoke, Springfield, and Westfield 2018 (and other towns in Hampshire and Hampden counties), and Asian longhorned beetle populations are currently being quarantined in central Massachusetts.

## Location

Invasive species can travel far distances (either via natural mechanisms or accidental human interference) and therefore can propagate rapidly over a large geographic area. Open freshwater ecosystems generally don't have physical barriers to prevent establishment (outside of physiological tolerances) so invasive species can quickly spread once introduced, and find myriad opportunities for transport to new locations (by boats, for example).

In general, invasive species represent the greatest threat to native or minimally managed ecosystems in Worthington. This includes many of the rivers and streams in town, as well as the town's water supply land around Eastern Mountain and Bear Hole.

## Extent and Previous Occurrences

Many invasive species have been identified in Worthington from 2010 to 2019. Japanese Knot Weed flourishes near riverbanks and highways, choking out native plants for light and nutrients.

Hemlock woolly adelgid, a small aphid-type insect, was first detected in Massachusetts in the Forest Park section of Springfield in the late 1980s. The adelgid has been found primarily on Canadian hemlocks and is now fairly widespread in the state. Hemlock woolly adelgid hasn't killed trees outright locally as it has in areas to our south, but it has weakened many of hemlocks to the point that the health of the trees has declined.

The Asian Longhorned Beetle (*Anoplophora glabripennis*, or ALB) is a major threat to hardwood trees. The species has decimated tree stock in Worcester County, but has not yet spread to western Massachusetts. The ALB has the potential to cause more damage than Dutch elm disease, chestnut blight and gypsy moths combined, destroying millions of acres of America's treasured hardwoods, including national forests and backyard trees. With no current cure, early identification and eradication are critical to its control.

A full list of "Invasive" terrestrial, freshwater, and marine species are available on the MIPAG website (last updated April 2016) [https://www.massnrc.org/mipag/speciesreviewed\\_category.htm](https://www.massnrc.org/mipag/speciesreviewed_category.htm) and in the 2018 SHMCAP, which also includes details on the nature of the ecological and economic challenges presented by each species as well as information on when and where the species was first detected in Massachusetts.

Despite the presence of these species, their impacts have not been clearly recorded. Anticipated impacts include increased tree mortality leading to more downed trees and power outages during storm events. Based on current understanding of the impact and previous occurrences, the extent of significant impacts Worthington will likely suffer from invasive species is limited.

## Probability of Future Events

Changes in temperature and precipitation may increase chances of a successful invasion of non-native species. Given this, and the fact that some invasive species are

already present in Worthington, the frequency of occurrence and annual probability of this hazard is high.

### **Vulnerability**

Risk to native or minimally managed ecosystems has increased as dispersion of exotic species has increased.

Invasive species can directly or indirectly cause harm to human health. Some invasive plant species like giant hogweed and wild parsnip have phytophototoxic properties, meaning direct contact of their sap with human skin can cause a chemical reaction that makes skin hypersensitive to ultraviolet light. Another example is that of Japanese barberry, which has been proven to increase the incidence of Lyme disease by providing sheltered habitat that increases the abundance of small rodents, which act as hosts to the ticks that carry Lyme disease pathogens (<https://mnfi.anr.msu.edu/invasive-species/JapaneseBarberryBCP.pdf>).

The Nature Conservancy reports that invasive species have contributed directly to the decline of 42% of the threatened and endangered species in the United States. Further, the annual cost to the U.S. economy is estimated at \$120 billion per year, with more than 100 million acres suffering from invasive plant infestation. Freshwater ecosystems and estuaries are especially vulnerable to invasion, as these areas are very difficult to contain and reverse (the nature conservancy, <https://www.nature.org/en-us/about-us/where-we-work/united-states/ohio/stories-in-ohio/invasive-species-protecting-native-plants-and-animals/>).

## Primary Climate Change Interaction: Extreme Weather

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### Severe Winter Storm (Including Ice Storm and Nor'Easter) – Medium-High Risk

Severe winter storms include ice storms, nor'easters, heavy snow, blowing snow, and other extreme forms of winter precipitation.

Snow is characterized as frozen precipitation in the form of six-sided ice crystal. In order for snow to occur, temperatures in the atmosphere (from ground level to cloud level) must be at or below freezing. The strongest form of a severe snow storm is a blizzard. Blizzards are characterized by frequent wind gusts above 35 miles per hour, limited to no visibility due to falling snow and extreme cold that lasts longer than three hours. Ice storms are liquid rain that falls and freezes upon contact with cold objects. There must be an ice build-up of greater than ¼ inch for it to be considered an ice storm. When more than a ½ inch of ice build-up is forecasted a winter storm warning can be triggered

Nor'easters are among winter's most ferocious storms. They are characterized by a large counter-clockwise wind circulation around a low-pressure center, and are known for producing heavy snow, high winds, and rain. These storms occur most often in late fall and early winter.

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

New England generally experiences at least one or two severe winter storms each year with varying degrees of severity. Research on climate change indicates that there is great potential for stronger, more frequent storms as the global temperature increases. Severe winter storms typically occur during January and February; however, they can occur from late September through late April.

## Location

Severe winter weather occurs regionally and therefore would impact the entire town, although several specific locations are more susceptible to damage. These problem areas have been identified and assessed for vulnerability: Route 112 between the top of Witt Hill Road and the Eastern end of Kinnebrook Road.

Any severe winter weather incident can cause critical snow and ice hazards due to wind blown snow across the roadway. This is due to open areas prone to high winds, causing driving difficulties and impairing visibility.

## Extent

Since 2005, the RSI has become the descriptor of choice for measuring winter events that impact the six climactic regions in the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale system from 1 to 5 as depicted in the table below. The RSI is similar to the scale used to measure tornadoes (Fujita) or hurricanes (Saffir-Simpson), with the added benefit of considering population as a variable. The RSI is based on three factors: the spatial extent of the storm, the amount of snowfall, and population (NOAA, n.d.). As a regional index, the RSI incorporates region-specific parameters and thresholds for calculating a storm's category. 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.

<b>Regional Snowfall Index Categories, Corresponding RSI Values, and Description</b>		
<b>Category</b>	<b>RSI Value</b>	<b>Description</b>
1	1—3	Notable
2	3—6	Significant
3	6—10	Major
4	10—18	Crippling
5	18.0+	Extreme

Source: NCDC, n.d.

Prior to the RSI, the Northeast Snowfall Impact Scale (NESIS) was the ranking system used. It was developed by Paul Kocin of The Weather Channel and Louis Uccellini of the National Weather Service (Kocin and Uccellini, 2004) characterizes and ranks high-impact Northeast snowstorms. These storms have large areas of 10-inch snowfall accumulations and greater. NESIS has five categories: Extreme, Crippling, Major, Significant, and Notable. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus NESIS gives an indication of a storm's societal impacts.

NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The aerial distribution of

snowfall and population information are combined in an equation that calculates a NESIS score which varies from around one for smaller storms to over ten for extreme storms. The raw score is then converted into one of the five NESIS categories. The largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers.

<b>Northeast Snowfall Impact Scale Categories</b>		
<b>Category</b>	<b>NESIS Value</b>	<b>Description</b>
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: <http://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis>

The Sperry-Piltz Ice Accumulation (SPIA) Index (below) is a prediction tool (algorithm) that can be used in conjunction with National Weather Service data to predict the impact of winter weather in terms of ice damage. It is currently being tested by the National Weather Service and FEMA in several regions with potential implementation in the future. In the meantime, the index provides an outline of the potential damage impacts of ice storms based on accumulation and wind.

<b>The Sperry-Piltz Ice Accumulation (SPIA) Index</b>	
<b>Ice Damage Index</b>	<b>Damage and Impact Descriptions</b>
0	Minimal risk of damage to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
2	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
3	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1-5 days.
4	Prolonged and widespread utility interruptions with extensive damage to main distribution feeder lines and come high voltage transmission lines/structures/ Outages lasting 5-10 days.
5	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeks in some areas. Shelters needed.

Source: <http://www.spia-index.com/images/SPIAIndexDescription.png>

The extent of a severe winter storm event would be “Critical,” with 25 percent or more of property in the affected area damaged, multiple injuries possible, and a complete shutdown of facilities for more than one week.

**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.

There is significant overlap between winter weather disasters and other types of disaster, such as flooding. Based on data available from the National Oceanic and Atmospheric Administration, there were 27 winter storms in the Northeast Urban Corridor since 2010 that have registered on the NESIS scale. Of these, approximately 13 storms resulted in snow falls of at least 10 inches in the Pioneer Valley. These storms are listed in Table 18, in order of their NESIS severity.

<b>Table 6. Winter Storms Producing Over 10 inches of Snow in the Pioneer Valley, 2010-2018</b>			
<b>Date</b>	<b>NESIS Value</b>	<b>NASIS Category</b>	<b>NESIS Classification</b>
2/23/2010	5.46	3	Major
1/29/2015	5.42	3	Major
1/9/2011	5.31	3	Major
2/11/2014	5.28	3	Major
3/12/2017	5.03	3	Major
2/7/2013	4.35	3	Major
3/5/2018	3.45	2	Significant
3/4/2013	3.05	2	Significant
1/25/2015	2.62	2	Significant
3/11/2018	3.16	2	Significant
10/29/2011	1.75	1	Notable
1/3/2018	1.65	1	Notable
2/8/2015	1.32	1	Notable

Source: <http://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis>

Between 2010 and 2019, Hampshire County was included in 3 FEMA declared severe winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following hazards: blizzard, severe winter storm, snowstorm, record snowfall, and snow (See Table 1). Worthington may not have been impacted by all of these events. It should be noted that because population is used as a criteria for FEMA declarations, the storms that rank higher will be those that impact densely populated areas and regions such as Boston and other large cities and, as such, might not necessarily reflect the storms that impact lightly populated areas

The October Snow Storm in 2011, which caused major damages and disruptions across New England, also impacted Worthington. Most residents of the town were without electricity for over a week. While this was a severe storm paired with trees still in full foliage, most winter storms that hit Worthington are manageable and simply more of a nuisance.

In recent history, Worthington recorded one loss of life due to extreme weather when a man froze to death in his home. Each year there are incidences of property damage and personal injuries. There currently is no good local data on ice storms in Worthington. The 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan indicates that ice storms of lesser magnitudes occur on at least an annual basis. Areas located in higher elevations are more likely to experience ice storms. Well-known as the most serious storm to impact Pioneer Valley communities in recent history was the Ice Storm of December 11, 2008. The storm created widespread downed trees and power outages all across New York State, Massachusetts and New Hampshire. Over one million customers were without electricity, with 800,000 without power three days later and some without power weeks later. Challenging living conditions were exacerbated by extremely cold temperatures in the days following the event.

Known severe snowstorm and ice storm events, including FEMA disaster declarations, that have impacted Worthington after 2010, are identified in Table 19. Detailed information on damages and impacts are included when available. Please note that not all events that have occurred in the town are included due to the extent of documentation and the fact that not all sources may have been identified or researched.

**Table 7. Severe snowstorm and ice storm events in Pioneer Valley, 2010-2019**

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	Losses/Impacts
February 23, 2010	Heavy Snow	N/A	About nineteen inches of snow fell across Hampshire County. The weight of the snow resulted in downed branches and wires, leading to power outages in a few towns.
January 11-12, 2011	Severe winter storm and snowstorm, DR-1959	Yes	A developing nor'easter coastal storm brought up to two feet of snow across Massachusetts in a 24-hour period. Strong winds, combined with heavy snow, produced numerous downed trees and wires and resulted in power outages to 100,000 homes statewide. This event resulted in a federal disaster declaration (FEMA DR-1959) for the following counties: Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, and Suffolk. Those counties received over \$25 million in public assistance grants.
February 1,	Winter Storm	N/A	A series of low pressure centers impacted the

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	Losses/Impacts
2011			Southern New England Region with a combination of heavy snows and ice. A total of 10-13 inches of snow fell across Hampshire County over the two day period. A series of significant heavy snow events occurred between December 26, 2010 and February 2, 2011. Snow for the winter season totaled 86.4 inches, most of which fell during this period. Across Massachusetts, numerous roof collapses due to heavy snow load occurred following the February 2nd storm.
October 29-30, 2011	Severe storm and snowstorm, DR-4051	Yes	A rare October nor'easter brought heavy snow to portions of southern New England on October 29. The accumulation of the heavy, wet snow on foliated trees and power lines resulted in widespread tree damage and power outages across central and western Massachusetts. At the peak, approximately 665,000 customers in Massachusetts were without power. Seventy-seven shelters were opened and housed over 2,000 residents. Six fatalities occurred during and in the aftermath of the storm. This event resulted in a federal emergency declaration (FEMA EM-3343) for the following counties: Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, and Worcester. \$50,000 in damages was reported in Hampshire County.
November 1, 2011	Severe storm, EM-3343	Yes	See DR-4051 above
February 8-9, 2013	Severe Winter Storm, Snowstorm, and Flooding, DR-4110	Yes	An historic winter storm deposited tremendous amounts of snow over all of southern New England, mainly from the mid-afternoon on Friday, February 8 and lasting into the daylight hours of Saturday, February 9. What made this an amazing storm was the widespread coverage of heavy snowfall. Most locations received 2 to 2.5 feet of snow. Isolated thunderstorms were common across the entire region during the height of the snow.
February 5,	Heavy Snow	N/A	This storm spread heavy snow across all of

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	Losses/Impacts
2014			southern New England. Ten to eleven inches of snow fell across Hampshire County.
February 13, 2014	Heavy Snow	N/A	A significant winter storm brought six to twelve inches of snow across much of southern New England. Eight to ten inches of snow fell across Hampshire County.
January 18, 2015	Winter Weather	N/A	Freezing rain occurring across much of western Massachusetts and northern Connecticut. Numerous accidents occurred throughout Hampshire County. About a tenth of an inch of ice accreted on roads and other surfaces.
March 14, 2017	Heavy Snow	N/A	This storm dropped 12 to nearly 20 inches of snow across much of western, Massachusetts. Snowfall rates of 3 inches per hour were observed in western MA. Gusty winds to 30-50 mph were common in the interior.
January 4, 2018	Winter Storm	N/A	This storm brought heavy snow and damaging winds to Massachusetts with twelve to thirteen inches of snow fell across Hampshire County.
March 7, 2018	Winter Storm	N/A	From ten to thirteen inches of snow fell on Hampshire County.
March 13, 2018	Winter Storm	N/A	From nine to fourteen inches of snow fell on Hampshire County.

Source: NOAA Storm Events Database, 2019

### **Probability of Future Events**

Based on the NESIS scale, Worthington’s risk of a major to extreme winter storm in any given year is slightly less than 50 percent.

Extreme weather events—including extreme precipitation and snowfall levels—are anticipated to occur more frequently as climate change occurs. However, as temperatures throughout the year increase, it is possible that nor’easter events may become more concentrated in the coldest winter months when atmospheric temperatures are still low enough to result in snowfall rather than rain. Therefore, this hazard has a High probability of occurrence (40-70% probability in the next year) in Worthington.

### **Vulnerability**

#### **Populations**

Winter storms are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. They generally bring strong winds which

create blizzard conditions with blinding wind-driven snow, drifting snow, and extreme cold temperatures with dangerous wind chill. 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 paralyze a region or town, shutting down 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. Rural populations especially may become isolated by downed trees, blocked roadways, and power outages. Residents may be displaced or require temporary to long-term sheltering.

Elderly populations are particularly susceptible to risks of extreme winter weather such as injury from falls, hypothermia, and overexertion. Low income residents are also susceptible if they are not able to secure housing with adequate insulation and heating.

### **Built Environment and Economy**

The Town of Worthington's power and communication infrastructure are vulnerable to the impacts of a severe winter storm. This could cause residents, businesses and municipal offices to lose power and could impact the Town's ability to operate normally, impacting the Town's economy. Additionally, buildings with flat roofs are especially vulnerable to damage, especially when the snow is wet and heavy. Lastly, because parts of Worthington are well forested, a severe snow or ice storm could also cause damage and power outages from downed trees.

To approximate the potential impact to property that could be affected by this hazard, the total value of all property in town, \$2,681,497,810, is used.

An estimated 20 percent of damage would occur to 25 percent of structures, resulting in a total of \$134,074,890 worth of damage. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

### **Natural Resources**

Severe winter weather is common in Massachusetts and native species and habitats are well adapted to withstand most winter weather.

### **Hurricanes/Tropical Storm/Severe Wind: Medium Risk**

Hurricanes and tropical storms are classified as cyclones and defined as any closed circulation developing around a low-pressure center in which the winds rotate counter-clockwise in the Northern Hemisphere (or clockwise in the Southern Hemisphere). The primary damaging forces associated with these storms are high-level sustained winds and heavy precipitation. Tropical cyclones (tropical depressions, tropical storms, and hurricanes) form over the warm, moist waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, and are classified into one of three categories:

- A tropical depression is declared when there is a low-pressure center in the tropics with sustained winds of 25 to 33 mph.

- A tropical storm is a named event defined as having sustained winds from 34 to 73 mph.
- If sustained winds reach 74 mph or greater, the storm becomes a hurricane. The Saffir-Simpson scale ranks hurricanes based on sustained wind speeds—from Category 1 (74 to 95 mph) to Category 5 (156 mph or more). Category 3, 4, and 5 hurricanes are considered “major” hurricanes. Hurricanes are categorized based on sustained winds; wind gusts associated with hurricanes may exceed the sustained winds and cause more severe localized damage (NOAA, n.d.[b]).

Hurricanes are violent rainstorms with strong winds that can reach speeds of up to 200 miles per hour and which generate large amounts of precipitation. Hurricanes generally occur between June and November and can result in flooding and wind damage to structures and above-ground utilities.

Climate change increases the threat of hurricanes and severe wind as oceans and the atmosphere warms. Warmer water fuels more intense and longer-lasting storms and expands the area in which hurricanes can form. Warmer air can hold more moisture than cool air, increasing potential rainfall rates.

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, etc. High winds can cause scattered power outages. High winds are also a hazard for the boating, shipping, and aviation industry sectors.

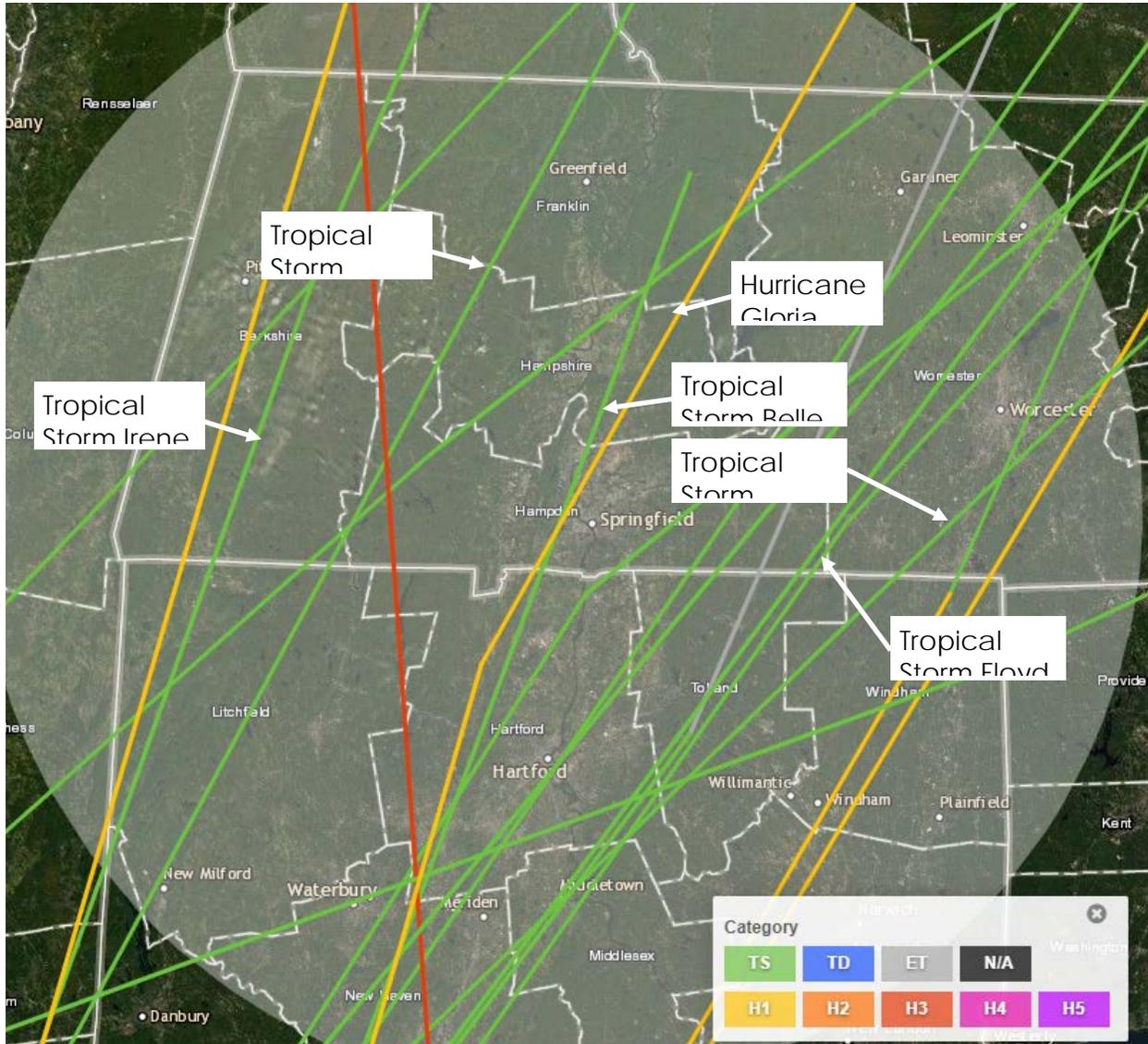
### **Location**

Because of the hazard’s regional nature, all of Worthington is at risk from hurricanes and tropical storms. However, some locations in town are more susceptible to damage from a hurricane or tropical storm than others, so the location of occurrence in Worthington is “medium,” with between 10 and 50 percent of land area affected by the event in some way. Ridgetops are more susceptible to wind damage and flood-prone areas are susceptible to flooding from heavy rains that usually accompany hurricane.

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 catalogs tropical cyclones that have occurred from 1859 and 2017 (earliest and latest dates available from data source). Between 1859 and 2017, 18 tropical cyclones of a tropical storm strength or higher tracked within 50 nautical miles of Worthington. Figure 7 displays the tropical storm and hurricane tracks that occurred

with 50 nautical miles of Worthington between 1859 and 2017. For reference, labels are provided for those storms that occurred within the last 50 years.

Figure 6. NOAA Hurricane Tracker



Source: NOAA National Hurricane Center, 2019

### Extent

As a hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Hurricane Wind

Scale, which rates hurricane wind intensity on a scale of 1 to 5, with 5 being the most intense.

A description of the damages that could occur due to a hurricane is described by the Saffir-Simpson scale, as shown below.

Hurricane Damage Classifications			
Storm Category	Damage Level	Description of Damages	Wind Speed (MPH)
1	MINIMAL	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal flooding and minor pier damage. An example of a Category 1 hurricane is Hurricane Dolly (2008).	74-95
	Very dangerous winds will produce some damage		
2	MODERATE	Some roofing material, door, and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings may break their moorings. An example of a Category 2 hurricane is Hurricane Francis in 2004.	96-110
	Extremely dangerous winds will cause extensive damage		
3	EXTENSIVE	Some structural damage to small residences and utility buildings, with a minor amount of curtain wall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures, with larger structures damaged by floating debris. Terrain may be flooded well inland. An example of a Category 3 hurricane is Hurricane Ivan (2004).	111-129
	Devastating damage will occur		
4	EXTREME	More extensive curtain wall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland. An example of a Category 4 hurricane is Hurricane Charley (2004).	130-156
	Catastrophic damage will occur		
5	CATASTROPHIC	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required. An example of a Category 5 hurricane is Hurricane Andrew (1992).	157+
	Catastrophic damage will occur		

Source: National Hurricane Center, 2012

Worthington’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. During hurricanes or severe wind events, the Town has experienced small blocks of downed timber and uprooting of trees onto structures and parked vehicles. Overall, the extent of the impacts of a Hurricane making a direct hit to Worthington would be

“Critical,” with multiple injuries possible, more than 25% of property in affected area damaged or destroyed, and a complete shutdown of facilities for more than 1 week.

**Previous Occurrences**

Between 2010 and 2019, Hampshire County was included in 2 FEMA declared severe Hurricane/Tropical Storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following hazards: hurricane and tropical storm (See Table 1). Worthington may not have been impacted by all of these events.

According to NOAA’s Historical Hurricane Tracks tool, Hurricane Irene is the only hurricane or tropical storm that tracked within 50 nautical miles of Worthington since 2010. While Hurricane Irene did not track directly through Worthington, it dropped a significant amount of rain in Worthington and caused flooding and road closures. Known hurricane and tropical storm events, including FEMA disaster declarations, which have impacted Worthington after 2010 are identified in Table 20. Detailed information on damages and impacts are included when available. Please note that not all events that have occurred in the town are included due to the extent of documentation and the fact that not all sources may have been identified or researched. Loss and impact information could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this plan.

<b>Table 8. Hurricane/ Tropical Storm Events in Hampshire County, 2010-2019</b>			
<b>Dates of Event</b>	<b>Event Type</b>	<b>FEMA Declaration Number (if applicable)</b>	<b>Losses/Impacts</b>
August 27-29, 2011	Tropical Storm / Hurricane Irene EM-3330 DR-4028	Yes	<p>Tropical Storm Irene (August 27-29, 2011) produced significant amounts of rain, storm surge, inland and coastal flooding, and wind damage across southern New England and much of the east coast of the U.S. In Massachusetts, rainfall totals ranged between 0.03 inches (Nantucket Memorial Airport) to 9.92 inches (Conway, MA). These heavy rains caused flooding throughout the Commonwealth and a presidential disaster was declared (DR-4028).</p> <p>In Southern New England, the minimum surface pressure recorded was 976.9mb taken at Barnes Municipal Airport in Westfield, Massachusetts. The highest sustained wind speed on land was 38 knots (44 mph) recorded on the Automated Surface Observing Systems at both Barnstable Municipal Airport in Hyannis, MA (KHYA) and Logan International Airport in Boston, MA (KBOS). Rainfall amounts ranged from nearly zero (0.03 at Nantucket</p>

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	Losses/Impacts
			<p>Memorial Airport - ACK) to nearly 10 inches (9.92 in Conway, MA).</p> <p>This rainfall contributed to significant flooding in northwestern Massachusetts where mainstem rivers and their tributaries reached levels not seen since 1987, and in some cases (The Connecticut River at Montague) since 1938. The Deerfield River at West Deerfield set a new flood of record at 23.8 feet, the previous record was 17.71 feet set in April of 1987. The Westfield River reached its highest level since 1980.</p> <p>Tropical Storm Irene was closely followed by the remnants of Tropical Storm Lee, which brought additional heavy rain to Massachusetts and extended flooding. Severe river erosion occurred in northwestern Massachusetts, closing State Route 2. Landslides were also triggered by the heavy rain and wet soil in this area of steep slopes containing layers of glacial lake clay. The Commonwealth received over \$31 million in individual and public assistance from FEMA.</p>
Oct 27- Nov 8, 2012	Hurricane Sandy EM-3350	Yes	No damages reported.

Sources: NOAA Storm Events Database, 2019, FEMA 2019

**Probability of Future Events**

Worthington’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. Furthermore, the intensity of tropical storms and hurricanes is likely to increase as a result of climate change. Based upon past occurrences, it is reasonable to say that there is a “moderate” probability of hurricanes or tropical storms, or a 10 to 40 percent probability in any given year.

**Impact**

The location and path of a system can also be a major factor in the severity of storm impact. The Town of Worthington faces a “limited” impact from hurricanes, with 10 percent or more of property in the affected area damaged, but may face more of a critical impact from other severe wind events.

To approximate the potential impact to property and people that could be affected by this hazard, the total value of all property in town, \$2,681,497,810 is used. Wind damage of 5 percent with 10 percent of structures damaged would result in estimated \$13,407,489 of damage. Estimated flood damage to 10 percent of the structures with 20 percent damage to each structure would result in \$53,629,956 of damage. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

## ***Vulnerability***

### **Populations**

Populations unable to safely evacuate are most at risk during a Hurricane or Tropical Storm hazard. Low income populations may lack means to evacuate. The elderly often face physical challenges or require regular medical attention. Low-English speaking populations may face challenges receiving and understanding emergency directions.

### **Built Environment and Economy**

The entire town would be vulnerable to the impact of a hurricane. Hurricanes and tropical storms can result in power outages and road closures that impact emergency response. Heavy rains can lead to contamination of well water, septic system failure, and overburdened stormwater systems. Areas prone to flooding are particularly vulnerable. Additionally, high winds could impact the town's communication and energy infrastructure, and damage older buildings.

- Estimated wind damage: 5% of the structures with 10% damage, \$13,407,489;
- Estimated flood damage: 10% of the structures with 20% damage, \$53,629,956;
- Vulnerability assessment for a hurricane event (both wind and flood damages): \$67,037,445;
- Cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included.

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. Roads may become impassable due to downed trees or roadway flooding resulting from a severe wind or thunderstorm.

### **Natural Environment**

High winds, flooding, and large quantities of debris can damage the natural environment through contamination of resources, felling trees, scouring riverbeds, and injury and mortality of animals.

### **Tornadoes/Microbursts: Medium-Low Risk**

Tornadoes are swirling columns of air that typically form in the spring and summer during severe thunderstorm events. In a relatively short period of time and with little or no advance warning, a tornado can attain rotational wind speeds in excess of 250 miles

per hour and can cause severe devastation along a path that ranges from a few dozen yards to over a mile in width. The path of a tornado may be hard to predict because they can stall or change direction abruptly. Within Massachusetts, tornadoes have occurred most frequently in Worcester County and in communities west of Worcester, including towns in eastern Hampden County. 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.

Microbursts often cause tornado-like damage and can be mistaken for tornadoes. In contrast to the upward rush of air in a tornado, air blasts rapidly downward from thunderstorms to create microbursts. Microbursts and tornadoes are expected to become more frequent and more violent as the earth’s atmosphere warms, due to predictions of climate change from global warming.

**Location**

As per the Massachusetts Hazard Mitigation Plan, the entire Town is at risk of tornadoes and microbursts. However, the actual area that would be affected by these hazards is "Medium," or between 10 and 50 percent of total land area.

**Extent**

The potential for locally catastrophic damage is a factor in any severe weather event. In Worthington, a tornado that hit residential areas would leave much more damage than a tornado with a travel path that ran along the town’s forested areas, where little settlement has occurred.

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

Tornadoes are measured using the enhanced F-Scale, shown with the following categories and corresponding descriptions of damage:

Enhanced Fujita Scale Levels and Descriptions of Damage			
EF-Scale Number	Intensity Phrase	3-Second Gust (MPH)	Type of Damage Done
EF0	Gale	65–85	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
EF1	Moderate	86–110	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
EF2	Significant	111–135	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.

Enhanced Fujita Scale Levels and Descriptions of Damage			
EF-Scale Number	Intensity Phrase	3-Second Gust (MPH)	Type of Damage Done
EF3	Severe	136–165	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
EF4	Devastating	166–200	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.

Because tornadoes and microbursts occur irregularly in this part of the country, assessing damages is difficult. Furthermore, buildings have not been built to Zone 2, Design Wind Speed Codes. The entire Town of Worthington is vulnerable.

- Tornadoes/microburst hazard estimates 20% damage to 10% of structures in Town;
- Vulnerability assessment estimates in damages; \$53,629,956;
- Estimated cost does not include building contents, land values or damages to utilities.

**Previous Occurrences**

Within Massachusetts, tornadoes have occurred most frequently in Worcester County and in communities west of Worcester. The most common months are June, July, and August, but the Great Barrington, MA tornado (1995) occurred in May and the Windsor Locks, CT tornado (1979) occurred in October. Fourteen incidents of tornado activity (F3 or less) have occurred in Hampshire County since 1956. In 2011, a tornado ranked F3 (Severe Damage) on the Fujita Scale of Tornado Intensity, blew through the region impacting the towns of Westfield, Springfield, Monson, Wilbraham, Brimfield, Sturbridge, Southbridge, and West Springfield. The tornado and related storm killed 3 people and resulted in hundreds of injuries across the state. The 2011 tornado is the only FEMA declared tornado-related disaster (DR) to have been recorded between 1954 and 2019.

On February 25, 2017, an EF1 tornado touched down in Conway and Goshen, Massachusetts. The tornado damaged dozens of homes, hundreds of trees and left 75% of the residents without power. This was the first tornado in Massachusetts to touch down in February since record keeping stated in the 1950s. Most recently, on July 23, 2019 two EF1 tornados touched down on Cape Cod, damaging tens of thousands of homes and leaving many without power.

No microbursts have ever been officially reported in Worthington, although some residents recall incidents of large trees being blown down quickly in discreet areas. Known tornado, and microburst events, including FEMA disaster declarations, which have impacted Hampshire County between 1950 and 2019 are identified in Table 21. Detailed information on damages and impacts are included when available. Please

note that not all events that have occurred in the town are included due to the extent of documentation and the fact that not all sources may have been identified or researched. Loss and impact information could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this plan.

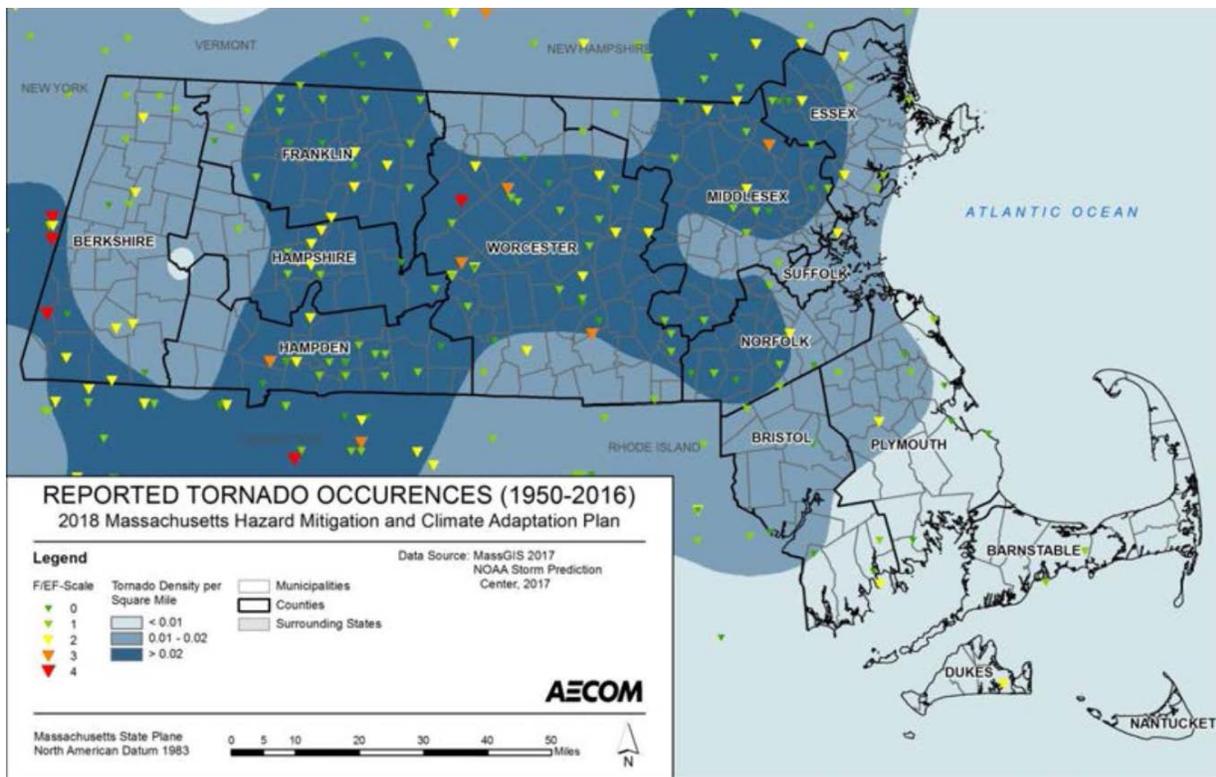
**Table 9. Tornado and Microburst Events in Hampshire County, 1950-2019**

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	Losses/Impacts
6/1/2011	Severe storms & Tornadoes	DR-1994	<p>A supercell thunderstorm developed over western Massachusetts. This storm strengthened and produced a long-lived, very significant tornado that did extensive damage across southwest and south central Massachusetts. This storm will be noted not only for its intensity, but also for the length of the continuous damage path, approximately 38 miles, 31 of which were in Hampden County. In West Springfield the tornado caused extensive damage to industrial buildings and homes. Several buildings had their roofs removed by the tornado, a few structures collapsed, and several multi-story buildings lost their upper stories.</p> <p>Three fatalities were directly attributable to the tornado, two in West Springfield. A thirty-nine year old woman in West Springfield was killed when her house collapsed on her while she sheltered her 15 year old daughter in the bathtub. Also in West Springfield, a twenty-three year old man was killed when his van was crushed by a falling tree. In addition, two hundred people were treated for injuries sustained in the tornado.</p> <p>It was estimated that 1400 houses and at least 78 businesses were either damaged or destroyed. Of these 1400 houses, roughly 300 of them had been completely destroyed. Two hundred residential buildings were condemned and more than 300 rental units were lost throughout western Massachusetts.</p> <p>Nearly 10,000 acres of woodlands were destroyed with the Massachusetts Forest Landowners Association estimating a clean-up cost of \$3.6 million.</p> <p>President Obama issued a Major Disaster</p>

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	Losses/Impacts
			Declaration for Hampden County shortly after the tornado. The Massachusetts Division of Insurance reported that 9500 insurance claims were completed by residents as a result of the June 1 tornadoes, adding up to \$175 million worth of damage.

Sources: NOAA Storm Events Database, 2019

In Western Massachusetts, the majority of sighted tornadoes have occurred in a swath directly over Worthington, known as "tornado alley," as shown in the figure below.



Source: NOAA Storm Prediction Center (SPC)

**Figure 7. Reported Tornado Occurrences in Massachusetts, 1950-2016**

Source: Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 2018

### **Probability of Future Events**

According to the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan, the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts. One measure of tornado activity is the tornado index value. It is calculated based on historical tornado events data using USA.com algorithms. It is an indicator of the tornado level in a region. A higher tornado index

value means a higher chance of tornado events. Data was used for Hampshire County to determine the Tornado Index Value as shown in the table below. Counter to the statement in the SHMCAP, the Tornado Index suggests that Hampshire County has a higher Tornado Index Value than the State of Massachusetts.

<b>Table 10. Tornado Index for Hampshire County</b>	
Hampshire County	125.73
Massachusetts	87.60
United States	136.45

Source: USA.com, <http://www.usa.com/hampshire-county-ma-natural-disasters-extremes.htm>

Based upon the available historical record, the estimated probability of a tornado in Worthington is "low," or between 1 and 10 percent in any given year. Based upon local knowledge and the increased prevalence of microburst in surrounding communities, the estimated probability of a microburst in Worthington is "moderate," or between 10 and 40 percent in any given year. Overall, there is a "Moderate," or 10 to 40 percent, probability that Worthington will be impacted by tornadoes and/or microbursts in a given year.

### ***Vulnerability***

The entire town would be vulnerable to the destruction caused by microbursts or tornadoes. Most buildings in town have not been built to Zone 1, Design Wind Speed Codes. The first edition of the Massachusetts State Building Code went into effect on January 1, 1975, with most of the town's housing built before this date. Large hail commonly accompanies a tornado, and can damage cars and buildings as well as cause serious injuries for individuals without shelter.

### **Populations**

Populations unable to safely evacuate are most at risk from tornadoes. Low income populations may lack means to evacuate. The elderly often face physical challenges or require regular medical attention. Low-English speaking populations may face challenges receiving and understanding emergency directions.

### **Built Environment and Economy**

To approximate the potential impact to property that could be affected by a tornado or microburst, the total value of all property in town, \$2,681,497,810 is used. An estimated 100 percent of damage would occur to 1 percent of structures, resulting in a total of \$26,814,978 worth of damage. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

- Tornadoes/microburst hazard estimates 20% damage to 10% of structures in Town;
- Vulnerability assessment estimates in damages; \$53,629,956;
- Estimated cost does not include building contents, land values or damages to utilities.

The most common problem associated with severe weather is loss of utilities. Downed trees from severe wind storms can create serious impacts on power and aboveground communication lines. Water and sewer systems may not function if power is lost. The vulnerabilities associated with flooding could be present if substantial rain accompanies severe thunderstorms. Additionally, severe wind may damage older buildings. With the notable exception of the Public Safety Complex, many of the town's critical facilities are older and designed to withstand lower wind speeds, meaning they are more vulnerable to damage from high wind events, microbursts or tornadoes.

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. Roads may become impassable due to downed trees or roadway flooding resulting from a severe wind or thunderstorm.

### **Natural Resources**

Downed trees and the transportation of small flora and fauna by high winds can cause damage to the natural environment.

## Non-Climate Influenced Hazards

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### Earthquakes: Low Risk

An earthquake is a sudden, rapid shaking of the ground that is caused by the breaking and shifting of rock beneath the Earth's surface. 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. Earthquakes can occur suddenly, without warning, at any time of the year. New England experiences an average of 30 to 40 earthquakes each year although most are not noticed by people.<sup>6</sup>

#### **Location**

In the event of an earthquake, all of Worthington would be affected with some portions more impacted than others, depending on the magnitude of the earthquake, population density, predominant building type, and underlying soil types. Although the zone of greatest seismic activity in the United States is along the Pacific Coast in Alaska and California, a number of damaging earthquakes have occurred in New England. In fact, New Englanders feel an average of six earthquakes each year. Due to differing geology, earthquakes in New England have different characteristics than those on the West Coast. New England is situated in the middle of the North American Plate and earthquakes in the region are the result of the compression of this plate as it is slowly squeezed by its neighboring plates. Because of this, earthquakes can occur throughout New England independent of fault lines and particular geology. Additionally, due to geological differences, earthquakes in New England tend to have a significantly wider impact area than those on the West Coast.

#### **Extent**

The magnitude of an earthquake is measured using the Richter Scale, which measures the energy of an earthquake by determining the size of the greatest vibrations recorded on the seismogram. On this scale, one step up in magnitude (from 5.0 to 6.0, for example) increases the energy more than 30 times.

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<sup>6</sup> Northeast States Emergency Consortium Web site: <http://nsec.org/earthquakes-hazards/>.

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.

The intensity of an earthquake is measured using the Modified Mercalli Scale. This scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale of I through XII, with I denoting a weak earthquake and XII denoting an earthquake that causes almost complete destruction.

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

Modified Mercalli Intensity Scale for and Effects			
Scale	Intensity	Description Of Effects	Corresponding Richter Scale Magnitude
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves.	> 8.1

Source: Federal Emergency Management Agency

The extent of earthquakes likely to impact Worthington would be “Minor.”

### **Previous Occurrences**

Nineteen earthquakes, intensity V (Modified Mercalli scale) or greater, have centered in Massachusetts since it was colonized by Europeans. A shock in 1755 reached intensity VIII at Boston and was felt across the State. In addition, Massachusetts was affected by some of the more severe Canadian shocks plus the earthquake of 1929 that centered on Grand Banks of Newfoundland.

In addition to the earthquakes from within the region, Massachusetts also has been strongly affected by a number of earthquakes that were centered outside of New England. Most recently, the magnitude 5.8 earthquake on August 23, 2011 centered at Mineral, VA was felt throughout Massachusetts, but no damage was reported. Between 1954 and 2019, Hampshire County was not included in any FEMA earthquake - related disasters (DR) or emergencies (EM). No known seismic events have impacted Worthington between 1950 and 2019. Please note that not all events that have occurred in the town are included due to the extent of documentation and the fact that not all sources may have been identified or researched.

According to the Northeast States Emergency Consortium, only one magnitude 4 or higher earthquake has occurred in New England since 2010. This was a 4.6 magnitude earthquake centered at Hollis Center Maine, on October 16, 2012. This earthquake was not noted to cause any damage in Worthington or the surrounding area.

**Table 11. Number of Felt Earthquakes in New England States**

State	Years of Record	Number Of Earthquakes
Connecticut	1678 - 2016	115
Maine	1766 - 2016	454
Massachusetts	1668 - 2016	408
New Hampshire	1638 - 2016	320
Rhode Island	1766 - 2016	34
Vermont	1843 - 2016	50
New York	1737-2016	551
Total Earthquakes in New England (1568-2007)		1,932

Source: Northeast States Emergency Consortium, 2019 website:  
[www.nesec.org/hazards/earthquakes.cfm](http://www.nesec.org/hazards/earthquakes.cfm)

### **Probability of Future Events**

One measure of earthquake activity is the Earthquake Index Value. It is calculated based on historical earthquake events data using USA.com algorithms. It is an indicator of the earthquake activity level in a region. A higher earthquake index value means a higher chance of earthquake events. Data was used for Hampshire County to determine the Earthquake Index Value as shown in the table below.

Hampshire County	0.24
Massachusetts	0.70
United States	1.81

Based upon existing records, there is a “very low” frequency of earthquakes in Worthington, with less than a 1 percent chance of an earthquake in any given year.

### **Vulnerability**

Massachusetts introduced earthquake design requirements into their 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.

### **Populations**

Socially vulnerable populations are at the highest risk from earthquakes. These populations may lack the means physically or financially to respond to an earthquake. They may not be able to prepare and live self-sufficiently in the aftermath of an earthquake. Low-income populations are more likely to live in structurally compromised buildings.

### **Built Environment and Economy**

Older buildings are particularly vulnerable to earthquakes because their construction pre-dates building codes that included strong seismic consideration. The town has a number of historical buildings that could be damaged or destroyed if a large enough earthquake were to happen. A loss of these historic buildings could represent a loss of Worthington’s history and culture

To approximate the potential impact to property and people that could be affected by this hazard, the total value of all property in town, **\$2,681,497,810** is used. An estimated 25 percent of damage would occur to 25 percent of structures, resulting in a total of \$16,759,361 worth of damage. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

- Moderate potential for serious damage in downtown Worthington;

- Structures are mostly wood frame construction, so loss estimates predict 25% damage to 25% of town assessed value, not including Costs of repairing or replacing roads, bridges, power lines, telephone lines, or the contents of the structures;

There are many ways in which Worthington's structures, infrastructure, and individuals would be vulnerable to earthquakes. Road closures could isolate populations and keep people from getting to work, and loss of utilities could impact populations that suffered no direct damage from the earthquake itself. Following a severe earthquake, damage to roadways, bridges or underpasses that serve as evacuation routes would limit access to emergency services and hospitals.

### **Natural Resources**

A strong earthquake can cause trees to fall and cliffs to collapse. Such environmental damage can impact the balance within a habitat or ecosystem leading to increased vulnerability to invasive species.

## **Man-Made Hazards – Hazardous Materials – Medium Risk**

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Hazardous materials are chemical substances, which if released or misused can pose a threat to the environment or health. These chemicals come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes and businesses routinely. These products are also shipped daily on the nation's highways, railroads, waterways, and pipelines.

The Toxics Release Inventory (TRI), a publicly available EPA database that contains information on specific toxic chemical releases and other waste management activities reported annually by certain covered industry groups as well as federal facilities. According to TRI, there are no industries currently releasing hazardous materials within Worthington's town limits.

Worthington relies on the regional HazMat team located in Holyoke for responding to incidents involving hazardous materials through a mutual aid agreement.

### **Location**

Two sites in Town considered Tier II Hazardous Materials storage facilities, and are included on the Past & Potential Hazards/Critical Facilities Map (Appendix D).

In addition, varying quantities of hazardous materials are manufactured, used, or stored at an estimated 4.5 million facilities in the United States--from major industrial plants to local dry cleaning establishments or gardening supply stores. These hazardous materials are transported regularly over our highways and by rail and if released can spread quickly to any community. Incidents can occur at any time without warning. Human error is the probable cause of most transportation incidents and associated consequences involving the release of hazardous materials. Some hazardous material is transported on Rte.

<b>Table 3-7 Tier II Hazardous Materials storage facilities in Worthington</b>	
<b>Site Name</b>	<b>Site Address</b>
First Student, Inc. (diesel fuel)	786 Old North Road
Verizon Worthington Dial Office (ma823907)	Williamsburg Road
Town storage (2000 gallons diesel)	64 Huntington Road

### **Extent**

The extent of hazardous chemical release is not predictable as it is dependent on the location including whether it is from a stationary or moving source, amount and type of chemical released, and weather conditions at the time of the release, but given the

relative lack of hazardous chemicals present in Worthington the extent is likely to be limited/critical.

### **Previous Occurrences**

Available data dating from 1998-20019 shows zero releases of hazardous materials.

There is no history of any major accidents involving some sort of oil or chemical spill, but transportation of chemicals and bio-hazardous materials by vehicle transport on Route 112 or Route 143 is a concern. Small areas of hazardous materials storage increase the potential for future incidents.

### **Probability of Future Events**

Based upon the past events, it is reasonable to say that there is a low likelihood of hazardous chemical releases in Worthington.

### **Vulnerability**

#### **Populations**

While the entire town could be vulnerable to the impact of a chemical release, such an incident would most likely focus around existing hazardous material facilities or transportation corridors. Therefore, vulnerable populations would include low-income residents who are more likely to live in proximity to industrial and potentially hazardous sites.

#### **Built Environment and Economy**

Impacts to the built environment would likely be limited due to the limited impact area of such an event. Such an incident could lead to closure along transportation lines or in hazardous material facilities. Such closures could have a limited impact on the Town's economy.

#### **Natural Resources**

Damage to natural resources would depend on the location and scope of the incident. Certain hazardous materials could lead to contamination of natural resources.

## 4. HAZARD MITIGATION & CLIMATE ADAPTATION STRATEGIES

One of the steps of this Natural Hazard Mitigation Plan is to evaluate all of the town's existing policies and practices related to natural hazards and identify potential gaps in protection. Once these gaps in protection are identified, future mitigation strategies can be crafted and recommended. This is done by evaluating existing and future measures in comparison to the Town's goal statement for natural hazard mitigation.

### Goal Statement

To minimize the loss of life, damage to property, and the disruption of governmental services and general business activities due to natural disasters. To provide adequate shelter, water, food and basic first aid to displaced residents in the event of a natural disaster and to provide adequate notification and information regarding evacuation procedures, etc., to residents in the event of a natural disaster.

For the extent of this analysis, the Committee reviewed the following Town documents:

- Zoning By-Law
- Subdivision Rules and Regulations
- Worthington Community Development Plan, Open Space & Recreation Plan (update 2014), & CEM Plan, Municipal Vulnerability Preparedness Statement of Findings
- Other relevant By-Laws as identified (Fire Department Burn Permit Procedures, Building Code, etc.)
- Healthy Hilltowns Report & AIA Hilltown Assessment

This section of the plan serves to identify current mitigation strategies and list recommended future mitigation strategies. This is done both generally, and by hazard type.

### General Mitigation Measures

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Several of the recommended mitigation measures have multiple benefits because, if implemented, they will mitigate or prevent damages from more than one type of natural hazard. These do not fall under one hazard type, but could be put into place for facilitation of better natural hazard protection generally.

#### What's the CEM Plan?

An important existing general preparedness and response tool is Worthington's Comprehensive Emergency Management Plan (CEM Plan). Although the CEM Plan is focused on the procedural response to an emergency, it organizes information, includes supply and information inventories, and outlines detailed steps for increasing

Some of these general hazard-related strategies and measures do not fall specifically under the category of “mitigation,” but are instead tools for preparedness. The Hazard Mitigation Planning Committee recognizes that these are also important recommendations for the Town.

## **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 and wetlands. As more land is developed, more flood storage is demanded of the town’s water bodies and waterways.

### **Current Mitigation Measures**

The Town currently addresses this problem with a variety of mitigation tools and strategies. Flood-related regulations and strategies are included in the Town’s zoning by-law, subdivision regulations, as well as a proposed stormwater management by-law. Relevant goals are included in the adopted Open Space and Recreation Plan. Infrastructure like dams and culverts are in place to manage the flow of water. These current mitigation strategies are outlined in the following table.

**Table 4.1: Existing Flood Hazard Mitigation Measures**

<b>Existing Strategy</b>	<b>Description</b>	<b>Effectiveness</b>	<b>Potential Changes</b>
Flood Control Structures	Six dams.	Effective as all dams in Town are very low hazard.	Ensure dam owners realize their responsibility to inspect the dams.
Culvert Replacement plan with long-term implementation.	Due to constrained municipal budget, the Highway Superintendent has a priority list of necessary culvert replacements and other construction projects to effectively manage flooding, which he implements whenever he and the Town can secure funding to do so.	Effective for managing flood control needs within a constrained municipal budget.	MA MVP Action grants may be useful for this work especially if the Town integrates nature based solutions and securing a large amount of funding to address multiple priority culverts at one time would be significantly more effective.
Zoning Bylaws Floodplain/Worthington River Protection District	Overlay district to protect areas delineated as part of the 100-year floodplain or within 100’ of riverbank, by regulating uses and special permit	Very effective for preventing incompatible development within the flood prone areas.	As part of the Town’s comprehensive zoning review in 2019-2020 the Town is considering adopting a Zoning

		requirements.		Permit-a simple no cost form filed by applicants, -- ensures continuity and consistency in interpretation and enforcement of Zoning Bylaw.
	Water Supply Protection District	District to protect groundwater resources by regulating certain uses, drainage, and other requirements within recharge area of aquifer.	Very effective for preventing groundwater contamination and managing infiltration.	As above
	Special Permit	With just one base zone in town, many uses require special permit approval.	Somewhat effective for preventing incompatible development.	The Town is also looking at site plan review considerations or performance standards..
Subdivision Regulations	Preliminary and Definitive Plan	Proposed storm drainage, sewer, water supply, and major site features (including natural features) must be included.	Somewhat effective for preventing incompatible development.	Zoning Permit-for all regulatory strategies.
	Design Standards	Environmental Analysis – includes impact analysis of recharge and infiltration.	Effective for protecting natural processes like flood mitigation.	
		Development Impact Statement – describes natural features, drainage systems	Effective for encouraging compatible development.	
		Storm Drainage – determines impact of development to downstream.	Effective for mitigating impacts of development to downstream.	
		Site Preservation – significant natural and cultural sites must be noted and preserved when applicable.	Effective for protecting important natural features.	
		Excavation and Grading – regulates how earth removal must be conducted.	Effective for minimizing earth removal and preventing sedimentation.	
National Flood Insurance Program Participation	As of 2018, there were 10 homeowners with flood insurance policies. [Note: 10 properties on CIS list]	Effective, provided that the town remains enrolled in the National Flood Insurance Program.		

**Future Mitigation Measures**

Securing funding from the Commonwealth of Massachusetts MVP Action grant program for either a Worthington only or regional Northern Hilltown culvert assessment and right-sizing/integrated nature-based solutions Implementation Process is a high priority for the Town. In addition, Worthington recently completed a comprehensive zoning review and has identified some key areas for hazard mitigation-related zoning, land use and other regulatory strategies. Acting on these recommendations is also a high priority.

Recommended Short-Term items include:

- Establishing Zoning Permit
- Creating Site Plan Review Considerations

Recommended Medium-Term items include the following:

- Stormwater Management Bylaw
- Low Impact Development Standards (LID)

Recommended Long-Term Items include:

- Update Sub-division regulations with a focus on green infrastructure
- Create a scenic ridgeline overlay district

**Dam Failure/Over-topping**

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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 no where to flow.

**Current Mitigation Measures**

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.

**Table 4.6: Existing Dam Failure Hazard Mitigation Measures**

Existing Strategy	Description	Effectiveness	Potential Changes
New Dam Construction Permits	State law requires a permit for the construction of any dam.	Effective. Ensures dams are adequately designed.	
Dam Inspections	DCR has an inspection schedule that is based on the hazard rating of the dam (low, medium, high hazard).	Effective as the dams are all very low hazard	

**Future Mitigation Measures**

None proposed but the Town is committed to keeping tier local policies up to date of state and federal policies and practices.

## Drought

Although Massachusetts does not face extreme droughts like many other places in the country, it is susceptible to dry spells and drought. And unlike other places, drought can most likely be effectively mitigated in regions like the Pioneer Valley if measures are put into place.

### Current Mitigation Measures

Worthington has several water protection regulations in place, as evidenced in the section on flooding. Additional regulations and mitigation options, specific to drought mitigation, are included here.

**Table 5.7: Existing Drought Hazard Mitigation Measures**

Existing Strategy		Description	Effectiveness	Potential Changes
Zoning By-law	Water Supply Protection District John Sullivan 238-5344	District to protect groundwater resources by regulating certain uses, drainage, and other requirements within recharge area of aquifer.	Very effective for preventing groundwater contamination and increasing infiltration.	
Subdivision Regulations	Preliminary and Definitive Plan	Proposed storm drainage, sewer, water supply, and major site features (including natural features) must be included.	Effective for ensuring adequate water supply and preventing drainage problems.	
	Design Standards	Environmental Analysis – includes impact analysis of recharge and infiltration.	Effective for protecting natural processes like flood mitigation.	
		Site Preservation – significant natural and cultural sites must be noted and preserved when applicable.	Effective for protecting important natural features including waterbodies.	
		Excavation and Grading – regulates how earth removal must be conducted.	Effective for minimizing earth removal and preventing sedimentation.	
Worthington MVP Statement of Findings	Makes several relevant recommendations regarding preventing drought, protecting water supply and quality.	Potentially effective step, if taken.	Implement recommendations.	

### Future Mitigation Measures

Participate in regional Northern Hilltown Water Quality Assessment—to assess the impact of climate change on groundwater quality in the Hilltowns, specifically measure

road salt impacts on drinking water quality by conducting tests at private wells and identifying trends. Findings would outline best practices for remediation and future protection, and propose requirements for alternative ice management strategies.

## **Average/Extreme Temperatures**

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The town has not struggled with issues pertaining to extreme heat, but certainly experiences extreme cold. No improvements are recommended at this time

## **Wildfire/Brushfire**

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Although somewhat common, the vast majority of brushfires in Worthington are small and quickly contained. However, as with any illegal fire or brushfire, there is always the risk that a small brushfire could grow into a larger, more dangerous wildfire, especially if conditions are right. Therefore, it is important to take steps to prevent wildfires and brushfires from turning into natural disasters.

### **Current Mitigation Measures**

The following table identifies what the Town is currently doing to manage brushfires and makes some suggested potential changes and recommendations for decreasing the Town’s likelihood of being heavily impacted by a wildfire or brushfire.

**Table 4.4: Existing Wildfire/Brushfire Hazard Mitigation Measures**

Existing Strategy		Description	Effectiveness	Potential Changes
Zoning By-Law	Wireless Communications Structures and Facilities	Fire Chief is involved in final review of site plan for structure.	Effective.	
Subdivision Regulations	General	Fire Chief may be consulted on any subdivision approval.	Effective.	
	Design Standards	Fire protection is included in the required Development Impact Statement and as a part of the rules regulating water supply to the subdivision.	Effective.	
Burn Permits		Residents must obtain burn permits, and personnel provide information on safe burn practices.	Somewhat effective.	
Public Education/ Outreach		The Fire Department has an ongoing educational program in the schools.	Effective.	None.

### **Future Mitigation Measures**

The community feels very comfortable with their Fire prevention and response activities. However, due to the changing climate and predicted increased temperatures and invasive species, the committee does support the MVP CRB workshop recommendation for a wildfire resilience plan that would study how climate change affects wildfire risk in the Hilltowns, specifically studying existing forest health and projected climate-related threats including prolonged dry periods, higher-intensity storms, and increases in tree-damaging insects. This study would lead to the creation of a regional forest adaptation Action plan outlining management practices for municipalities and private landowners to reduce wildfire risk and increase resilience, and ideally funding for implementation as well.

## **Invasive Species**

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This a new hazard identified over the course of the MVP CRB workshop process. The committee recommends the Town stay abreast of regional and state-wide efforts to understand and mitigate the spread of invasive species, but does not have any specific recommendations at this time.

## **Severe Snow/Ice Storm/Nor'easter**

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Winter storms can be especially challenging for emergency management personnel. 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. Even though the storm has usually been forecast, there is no certain way for predicting its length, size or severity. Therefore, mitigation strategies must focus on preparedness prior to a severe snow/ice storm.

### **Current Mitigation Measures**

The Town's current mitigation tools and strategies focus on preparedness, with many regulations and standards established based on safety during storm events. These current mitigation strategies are outlined in the following table.

Note: To the extent that some of the damages from a winter storm can be caused by flooding, all of the flood protection mitigation measures described in Table 5-1 in the previous section can also be considered as mitigation measures for severe snow/ice storms.

**Table 4.2: Existing Severe Snow/Ice Storm Hazard Mitigation Measures**

Existing Strategy		Description	Effectiveness	Potential Changes
Zoning By-Law	Wireless Communications Structures and	Structures are required to be as minimally invasive as possible to the environment,	Very effective for preventing damage in the case of a severe	

	Facilities	have height restrictions, and must have be setback 1.25 times the structure’s height.	storm.	
Subdivision Regulations	Design Standards	Utilities must be placed underground at time of construction	Effective for preventing power loss.	
		Street grade regulations (maximum 10%)	Effective.	
State Building Code		The Town of Worthington has adopted the Massachusetts State Building Code.	Effective.	
Backup Electric Power		Shelters have backup power, three mobile generators	Very effective in case of power loss.	
Tree Management		List of dangerous trees created annually for WMECO.	Very effective, preventative collaboration.	

***Future Mitigation Measures***

As can be seen, existing mitigation measures are deemed effective. Nevertheless, the Town did identify a need for a sub-regional plan (of the four participating Hilltowns) that considers more frequent storms, extreme precipitation events, and frequent freezing and thawing brought by climate change. The committee recommends studying all roads—dirt and gravel, local and inter-municipal—for their vulnerability to failure and costs of repair, followed by the development of a climate-adaptive prioritization and improvement plan to improve current and future mobility.

**Hurricanes/Severe Wind**

Of all the natural disasters that could potentially impact Worthington, hurricanes provide the most lead warning time because of the relative ease in predicting the storm’s track and potential landfall. MEMA assumes “standby status” when a hurricane’s location is 35 degrees North Latitude (Cape Hatteras) and “alert status” when the storm reaches 40 degrees North Latitude (Long Island). Even with significant warning, hurricanes can do 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. Therefore, all of the flood protection mitigation measures described in Table 5-1 can also be considered hurricane mitigation measures.

The high winds that oftentimes accompany hurricanes can also damage buildings and infrastructure. But regulations can be put into place to help minimize the extent of wind damages.

The Town’s current mitigation strategies to deal with severe wind are equally applicable to wind events such as tornadoes and microbursts. Therefore, the analysis of severe wind strategies is coupled with this hazard.

## **Tornadoes/Microbursts**

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The location and extent of potential damaging impacts of a tornado are completely unpredictable. Most damage from tornadoes or microbursts comes 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. In addition, current land development regulations can also help prevent wind damages.

The following table outlines the Town’s existing mitigation strategies that help prevent wind damages, whether from hurricanes, tornadoes, microbursts, or any other event.

<b>Table 4.3: Existing Severe Wind Hazard Mitigation Measures (Including Hurricane, Tornado, Microburst Hazards)</b>				
<b>Existing Strategy</b>		<b>Description</b>	<b>Effectiveness</b>	<b>Potential Changes</b>
Zoning	Wireless Communications Structures and Facilities	Structures are required to be as minimally invasive as possible to the environment, have height restrictions, and must have be setback 1.25 times the structure’s height.	Very effective for preventing damage in the case of a severe storm.	
Subdiv Regs	Design Standards	Utilities must be placed underground	Effective for preventing power loss.	
State Building Code		The Town has adopted the MA State Building Code.	Effective.	
Tree Management		List of dangerous trees created annually for WMECO.	Very effective, preventative collaboration.	

### ***Future Mitigation Measures***

None proposed but the Town is committed to keeping tier local policies up to date of state and federal policies and practices.

## **Earthquake**

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Although there are five mapped seismological faults in Massachusetts, there is no discernable 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 to plan for.

Most buildings and structures in the state were constructed without specific earthquake resistant design features. In addition, earthquakes precipitate several potential devastating secondary effects such as building collapse, utility pipeline rupture, water contamination, and extended power outages. Therefore, many of the mitigation efforts for other natural hazards identified in this plan may be applicable during the Town's recovery from an earthquake.

**Current Mitigation Measures**

The Town's most relevant existing mitigation measures are described in the following table.

Table 4.5: Existing Earthquake Hazard Mitigation Measures				
Existing Strategy		Description	Effectiveness	Potential Changes
Zoning By-law	Wireless Communications Structures and Facilities	Structures are required to be as minimally invasive as possible to the environment, have height restrictions, and must have be setback 1.25 times the structure's height.	Very effective for preventing damage in the case of an earthquake.	
State Building Code		The Town of Worthington has adopted the State Building Code.	Effective for new buildings only.	

**Future Mitigation Measures**

None proposed but the Town is committed to keeping tier local policies up to date of state and federal policies and practices.

**Hazardous Materials**

Hazardous materials are in existence throughout Town, and are constantly being moved on Worthington's roads and highways. However, there is no way to anticipate where and when a hazardous materials spill or explosion could take place. Therefore, it makes is somewhat difficult to determine mitigation strategies, but Worthington has some regulations currently in place to mitigate the impacts of a hazardous materials disaster.

Table 4.8: Existing Hazardous Materials Hazard Mitigation Measures				
Existing Strategy		Description	Effectiveness	Potential Changes
Zoning By-law	Water Supply Protection District	No hazardous materials permitted within areas delineated as recharge areas	Very effective for preventing groundwater	

		for groundwater aquifers.	contamination.	
		All hazardous materials usage or storage must be registered with the Fire Chief.	Effective.	

***Future Mitigation Measures***

None proposed but the Town is committed to keeping tier local policies up to date of state and federal policies and practices.

## 5. PRIORITIZED IMPLEMENTATION SCHEDULE

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

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The Worthington Hazard Mitigation Planning Committee reviewed and prioritized a list of mitigation strategies using the following criteria:

- **Application to multiple hazards** – Strategies are given a higher priority if they assist in the mitigation of 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 Analysis 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.
- **Eligibility Under Hazard Mitigation Grant Program** – The Hazard Mitigation Grant Program (HMGP) provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. Funding is made available through FEMA by the Massachusetts Emergency Management Agency. Municipalities apply for grants to fund specific mitigation projects under MEMA requirements

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 several 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 multiple hazards and the protection of people and property.

In addition to the definitions above, the Worthington Hazard Mitigation Planning Committee reviewed each of the proposed mitigation measures using the following factors to determine level of priority:

- Ability to reduce loss of life
- Ability to reduce disaster damage
- Social acceptability
- Ability to complete or be combined w/other actions
- Technical feasibility / potential success
- Impact on the environment
- Administrative workability
- Ability to meet regulations
- Political acceptability
- Ability to save or protect historic structures
- Legal implementation
- Ability to meet other community objectives
- Economic impact
- The duration of its implementation period
- Environmental compatibility

## 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, or marked as "unknown":

- **Low** – cost less than \$10,000
- **Medium** – cost between \$10,000 – \$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

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The following chart is a completed list of projects recommended by the Committee. The following action plan identifies Responsibility, Funding and a Time Frame for the mitigation projects recommended. The actions will begin as soon as the plan is approved and the community is eligible for funding, unless otherwise stated, and will be completed as noted in the implementation date column in the table below (called "Timeframe" in table).

Note: As additional information becomes available regarding project leadership, timeline, funding sources, and/or cost estimates, the Plan will be reviewed and amended accordingly.

**Table 5.1: Prioritized Implementation Schedule – Action Plan**

Priority	Mitigation Action	Responsible Department/Board	Proposed Completion Date	Funding Source/ Estimated Cost	Incorporation into Existing Plans
1	Secure funding from the Commonwealth of Massachusetts MVP Action grant program for either a Worthington only or regional Northern Hilltown culvert assessment and right-sizing/integrated nature-based solutions Implementation Process is a high priority for the Town. In addition, .	Select Board, Emergency Manager, Highway Dept	2025	MVP Action Grant, HMGP	Capital Improvement Plan
2	<p>Worthington recently completed a comprehensive zoning review and has identified some key areas for hazard mitigation-related zoning, land use and other regulatory strategies. Acting on these recommendations is also a high priority.</p> <p>Recommended Short-Term items include:</p> <ul style="list-style-type: none"> <li>• Establishing Zoning Permit</li> <li>• Creating Site Plan Review Considerations</li> </ul> <p>Recommended Medium-Term items include the following:</p> <ul style="list-style-type: none"> <li>• Stormwater Management Bylaw</li> <li>• Low Impact Development</li> </ul>	Select Board, Emergency Manager, Planning Board	2022	DLTA, MVP Action Grant	OSRP, Master Plan—if the Town develops one

	<p>Standards (LID)</p> <p>Recommended Long-Term Items include:</p> <ul style="list-style-type: none"> <li>Update Sub-division regulations with a focus on green infrastructure</li> </ul> <p>Create a scenic ridgeline overlay district</p>				
3	<p>Participate in regional Northern Hilltown Water Quality Assessment—to assess the impact of climate change on groundwater quality in the Hilltowns, specifically measure road salt impacts on drinking water quality by conducting tests at private wells and identifying trends. Findings would outline best practices for remediation and future protection, and propose requirements for alternative ice management strategies.</p>	<p>Select Board, Emergency Manager, Hwy Dept</p>	<p>2024</p>	<p>MVP Action grant</p>	<p>OSRP</p>
4	<p>Wildfire resilience plan that would study how climate change affects wildfire risk in the Hilltowns, specifically studying existing forest health and projected climate-related threats including prolonged dry periods, higher-intensity storms, and increases in tree-damaging insects. This study would lead to the creation of a regional forest adaptation Action plan outlining management practices for</p>	<p>Select Board, Emergency Manager, Fire Dept</p>	<p>2025</p>	<p>MVP Action grant</p>	<p>NA</p>

	municipalities and private landowners to reduce wildfire risk and increase resilience, and ideally funding for implementation as well.				
5	Sub-regional plan (of the four participating Hilltowns) that considers more frequent storms, extreme precipitation events, and frequent freezing and thawing brought by climate change --study all roads—dirt and gravel, local and inter-municipal—for their vulnerability to failure and costs of repair, followed by the development of a climate-adaptive prioritization and improvement plan to improve current and future mobility.	Planning Board, Conservation Commission, Emergency Manager	2025	MVP Action grant	CIP

## 6. PLAN ADOPTION & IMPLEMENTATION

### Plan Adoption

Upon completion, copies of the Draft Local Hazards Mitigation Plan for the Town of Worthington were distributed to the town boards for their review and comment. A public meeting was held by the Worthington Select Board to present the draft copy of the Worthington Local Natural Hazards Mitigation Plan to town officials and residents and to request comments from this committee and the general public. The Natural Hazards Mitigation Plan was formally approved by the Select Board and forwarded to the Massachusetts Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA) for their approval.

### Plan Implementation

The implementation of the Worthington Local Natural Hazards Mitigation Plan update will begin following its formal adoption by the Worthington Select Board and approval by MEMA and FEMA. Specific town departments and boards will be responsible for ensuring the development of policies, bylaw revisions, and programs as described in Sections 5 and 6 of this plan. The Worthington Natural Hazards Planning Committee will oversee the implementation of the plan.

#### *Incorporation of Plan Requirements into other Planning Mechanisms/ Documents*

At times when the Town of Worthington is considering creation of or changes to local planning documents or procedures including, but not limited to comprehensive plans, capital improvement plans, zoning and building codes site reviews and permitting processes the information and recommendations contained in this plan will be reviewed by the people and committees involved in those processes and, when appropriate, will incorporate those recommendations into the new planning procedures.

### Plan Monitoring and Evaluation

The measure of success of the Worthington Local Natural Hazards 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.

The Worthington Natural Hazards Planning Committee will meet on an annual basis or as needed (i.e., following a natural disaster) to monitor the progress of implementation, evaluate the success or failure of implemented recommendations, and brainstorm for strategies to remove obstacles to implementation. Those parties noted in Section 6 of the plan, all of whom have a representative on the Worthington Natural Hazards Planning Committee, will be responsible for seeing that the actions are implemented and will report on their progress at the annual plan review meetings. The approved

Worthington Hazard Mitigation plan will be available for public review at the Town Hall and the public library and from PVPC. Comments and suggestions will be received by the EMD and integrated into plan updates as appropriate.

Outreach to the public, surrounding communities, agencies, businesses, academia, non-profits, or other interested parties outside of the town of Worthington will be done in advance of each annual meeting in order to solicit their participation in assessment of the plan. 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, beginning in the winter of 2024. The meetings of the committee will be organized and facilitated by the Emergency Management Director or the Worthington Select Board.

# APPENDICES

## Appendix A – Capability Assessment

### Hazard Mitigation Capability Assessment

**Jurisdiction:** Worthington, Massachusetts

Local mitigation capabilities are existing authorities, policies, programs, and resources that reduce hazard impacts or that could be used to implement hazard mitigation activities. Please complete the tables and questions in the worksheet as completely as possible. Complete one worksheet for each jurisdiction.

### Planning and Regulatory

Planning and regulatory capabilities are the plans, policies, codes, and ordinances that prevent and reduce the impacts of hazards. Please indicate which of the following your jurisdiction has in place.

Plans	Yes/No Yr	Does the plan address hazards? Does the plan identify projects to include in the mitigation strategy? Can the plan be used to implement mitigation actions?
Comprehensive/Master Plan	N	Worthington has a 2003 Community Development plan and an updated 2014 Open Space and Recreation plan; the Town is also just completing a Municipal Vulnerability Preparedness (MVP) project.
Capital Improvements Plan	N, but in process	The Town received funding from the Commonwealth to undertake a CIP and does have funds in a stabilization fund.
Economic Development Plan	N	The region had an EDA approved CEDS as well as regional Economic Development Plan-the Plan for Progress
Local Emergency Operations Plan	Y	All MA Munis are required to have a Comprehensive Emergency Management Plan (CEMP)
Continuity of Operations Plan	N	This plan update was wrapping up in March 2020—when the COVID Pandemic hit the United States; the Town will certainly look into having a COOP post COVID.
Transportation Plan	N	The Town actively participates in the regional transportation planning process and Joint

		Transportation Committee.
Stormwater Management Plan	N	
Community Wildfire Protection Plan	N	
Other special plans (e.g. brownfields, redevelopment, disaster recovery, coastal zone management, climate change adaptation)	Y	Town is completing a Municipal Vulnerability Preparedness (MVP) process and related Statement of Findings.

<b>Building Code, Permitting, and Inspections</b>	<b>Y/N</b>	<b>Are codes adequately enforced?</b>
Building Code	Y	Version/Year: MA complies with the International Code Council and will update to the 9 <sup>th</sup> edition Building code in 2021— now using 8 <sup>th</sup> edition, 2018.
Building Code Effectiveness Grading Schedule (BCEGS) Score	N	Score:
Fire Department ISO Rating	N	Rating:
Site plan review requirements	Y	The zoning bylaw provides the procedures and means to get approval for a development through the site plan and special permit sections. The Town is working to add site plan review performance standards or review considerations for approval.

<b>Land Use Planning &amp; Ordinances</b>	<b>Y/N</b>	<b>Is the ordinance an effective measure for reducing hazard impacts? Is the ordinance adequately administered and enforced?</b>
Zoning Ordinance	Y	Y-and is being updated as described.
Subdivision ordinance	Y	Y-as above
Floodplain ordinance	Y	Y-as above
Natural hazard specific ordinance (stormwater, steep slope, wildfire)	Y	Westfield River Protection District & Water Supply Protection District
Flood insurance rate maps	Y	yes
Acquisition of land use for open space and public recreation uses	Y	As needed
Other		

<b>How can these capabilities be expanded and improved to reduce</b>	
--	--

<b>risk?</b>	
Regulatory updates underway as described in plan narrative.	

## Administrative & Technical

Identify whether your community has the following administrative and technical capabilities. These include staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions. For smaller jurisdictions without local staff resources, if there are public resources at the next higher level of government that provide technical assistance, indicate so in your comments.

<b>Administration</b>	<b>Y/N</b>	<b>Describe capability Is coordination effective?</b>
Planning Board	Y	yes
Mitigation Planning Committee	Y	Yes-retired FEMA Haz Mit staff serving as EMD!
Maintenance programs to reduce risk (e.g. tree trimming, clearing drainage systems)	Y	Tree Warden
Mutual aid agreements	Y	Fire and Police and DPW via W Region Homeland Security Advisory Council

<b>Staff</b>	<b>Y/N FT/PT</b>	<b>Is staffing adequate to enforce regulations? Is staff trained on hazards and mitigation? Is coordination between agencies and staff effective?</b>
Chief Building Official	Y	Y
Floodplain Administrator	N	
Emergency Manager	Y	Y
Community Planner	N	Regional Planning Agency is available and Town engages with them routinely.
Civil Engineer	N	
GIS Coordinator	N	RPA is available for GIS TA
Other		

<b>Technical</b>	<b>Y/N</b>	<b>Describe capability Has capability been used to assess/mitigate risk in the past?</b>
Warning systems/services (Reverse 911, outdoor warning signals)	Y	Robust and useful
Hazard data and	Y	Used to understand risks

information		
Grant writing	Y	Yes
Hazus analysis	N	
Other		

<b>How can these capabilities be expanded and improved to reduce risk?</b>	
n/a==RPA fills gaps and MEMA is very helpful.	

## Financial

Identify whether your jurisdiction has access to or is eligible to use the following funding resources for hazard mitigation.

<b>Funding Resource</b>	<b>Access Eligibility Y/N</b>	<b>Has the funding resource been used in the past and for what type of activities? Could the resource be used to fund future mitigation actions?</b>
Capital Improvements Project funding	Y	Capital Improvements and not likely.
Authority to levy taxes for specific purposes	Y	Not likely as budget is so constrained
Fees for water, sewer, gas or electric services	N	
Impact fees for new development	N	
Storm water utility fee	N	
Incur debt through general obligation bonds and/or special tax bonds	N	
Community development block grants	Y	Not likely as budget is so constrained and MVP Action grants are available.
Other federal funding programs	Y	No, possibly
State funding programs	Y	MVP
Other		

<b>How can these capabilities be expanded and improved to reduce risk?</b>	
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MVP is a good possibility	
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## Education & Outreach

Identify education and outreach programs and methods already in place that could be used to implement mitigation activities and communicate hazard-related information.

Program/Organization	Y/N	Describe program/organization and how it relates to disaster resilience and mitigation
Local citizens groups or non-profit organizations focused on environmental protection, emergency preparedness, access and functional needs populations, etc.	N	
Ongoing public education or information program (e.g. responsible water use, fire safety, household preparedness, environmental education)	N	
Natural disaster or safety related school programs	Y	Fire Dept
StormReady certification	N	
Firewise Communities certification	N	
Public-private partnership initiatives addressing disaster-related issues	N	
Other		

<b>How can these capabilities be expanded and improved to reduce risk?</b>	

## Appendix B – Technical Resources

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### 1) Agencies

Massachusetts Emergency Management Agency (MEMA)	508/820-2000
Hazard Mitigation Section	617/626-1356
Federal Emergency Management Agency (FEMA)	617/223-4175
MA Regional Planning Commissions:	
Berkshire Regional Planning Commission (BRPC)	413/442-1521
Cape Cod Commission (CCC)	508/362-3828
Central Massachusetts Regional Planning Commission (CMRPC)	508/693-3453
Franklin Regional Council of Governments (FRCOG)	413/774-3167
Martha’s Vineyard Commission (MVC)	508/693-3453
Merrimack Valley Planning Commission (MVPC)	978/374-0519
Metropolitan Area Planning Council (MAPC)	617/451-2770
Montachusett Regional Planning Commission (MRPC)	978/345-7376
Nantucket Planning and Economic Development Commission (NP&EDC)	508/228-7236
Northern Middlesex Council of Governments (NMCOG)	978/454-8021
Old Colony Planning Council (OCPC)	508/583-1833
Pioneer Valley Planning Commission (PVPC)	413/781-6045
Southeastern Regional Planning and Economic Development District (SRPEDD)	508/823-1803
MA Board of Building Regulations & Standards (BBRS)	617/227-1754
MA Coastal Zone Management (CZM)	617/626-1200
DCR Water Supply Protection	617/626-1379
DCR Waterways	617/626-1371
DCR Office of Dam Safety	508/792-7716
DFW Riverways	617/626-1540
MA Dept. of Housing & Community Development	617/573-1100
Woods Hole Oceanographic Institute	508/457-2180
UMass-Amherst Cooperative Extension	413/545-4800
National Fire Protection Association (NFPA)	617/770-3000
New England Disaster Recovery Information X-Change (NEDRIX – an association of private companies & industries involved in disaster recovery planning)	781/485-0279
MA Board of Library Commissioners	617/725-1860
MA Highway Dept, District 2	413/582-0599
MA Division of Marine Fisheries	617/626-1520
MA Division of Capital & Asset Management (DCAM)	617/727-4050
University of Massachusetts/Amherst	413/545-0111
Natural Resources Conservation Services (NRCS)	413/253-4350
MA Historical Commission	617/727-8470
U.S. Army Corps of Engineers	978/318-8502
Northeast States Emergency Consortium, Inc. (NESEC)	781/224-9876
National Oceanic and Atmospheric Administration: National Weather Service; Tauton, MA	508/824-5116
US Department of the Interior: US Fish and Wildlife Service	413/253-8200
US Geological Survey	508/490-5000

### 2) Mitigation Funding Resources

404 Hazard Mitigation Grant Program (HMGP)	Massachusetts Emergency Management Agency
406 Public Assistance and Hazard Mitigation	Massachusetts Emergency Management Agency
Community Development Block Grant (CDBG)	DHCD, also refer to RPC
Dam Safety Program	MA Division of Conservation and Recreation
Disaster Preparedness Improvement Grant (DPIG)	Massachusetts Emergency Management Agency
Emergency Generators Program by NESEC†	Massachusetts Emergency Management Agency
Emergency Watershed Protection (EWP) Program	USDA, Natural Resources Conservation
Service Flood Mitigation Assistance Program (FMAP)	Massachusetts Emergency Management Agency

Flood Plain Management Services (FPMS).....	US Army Corps of Engineers
Mitigation Assistance Planning (MAP).....	Massachusetts Emergency Management Agency
Mutual Aid for Public Works.....	Western Massachusetts Regional Homeland Security Advisory Council
National Flood Insurance Program (NFIP) † .....	Massachusetts Emergency Management Agency
Power of Prevention Grant by NESEC‡ .....	Massachusetts Emergency Management Agency
Roadway Repair & Maintenance Program(s).....	Massachusetts Highway Department
Section 14 Emergency Stream Bank Erosion & Shoreline Protection .....	US Army Corps of Engineers
Section 103 Beach Erosion.....	US Army Corps of Engineers
Section 205 Flood Damage Reduction.....	US Army Corps of Engineers
Section 208 Snagging and Clearing .....	US Army Corps of Engineers
Shoreline Protection Program.....	MA Department of Conservation and Recreation
Various Forest and Lands Program(s).....	MA Department of Environmental Protection
Wetlands Programs .....	MA Department of Environmental Protection

‡NESEC – Northeast States Emergency Consortium, Inc. is a 501(c)(3), not-for-profit natural disaster, multi-hazard mitigation and emergency management organization located in Wakefield, Massachusetts. Please, contact NESEC for more information.

† Note regarding National Flood Insurance Program (NFIP) and Community Rating System (CRS): The National Flood Insurance Program has developed suggested floodplain management activities for those communities who wish to more thoroughly manage or reduce the impact of flooding in their jurisdiction. Through use of a rating system (CRS rating), a community’s floodplain management efforts can be evaluated for effectiveness. The rating, which indicates an above average floodplain management effort, is then factored into the premium cost for flood insurance policies sold in the community. The higher the rating achieved in that community, the greater the reduction in flood insurance premium costs for local property owners. MEMA can provide additional information regarding participation in the NFIP-CRS Program.

### 3) Internet Resources

Sponsor	Internet Address	Summary of Contents
Natural Hazards Research Center, U. of Colorado	<a href="http://www.colorado.edu/litbase/hazards/">http://www.colorado.edu/litbase/hazards/</a>	Searchable database of references and links to many disaster-related websites.
Atlantic Hurricane Tracking Data by Year	<a href="http://wxp.eas.purdue.edu/hurricane">http://wxp.eas.purdue.edu/hurricane</a>	Hurricane track maps for each year, 1886 – 1996
National Emergency Management Association	<a href="http://nemaweb.org">http://nemaweb.org</a>	Association of state emergency management directors; list of mitigation projects.
NASA – Goddard Space Flight Center “Disaster Finder:	<a href="http://www.gsfc.nasa.gov/ndrd/disaster/">http://www.gsfc.nasa.gov/ndrd/disaster/</a>	Searchable database of sites that encompass a wide range of natural disasters.
NASA Natural Disaster Reference Database	<a href="http://ftpwww.gsfc.nasa.gov/ndrd/main/html">http://ftpwww.gsfc.nasa.gov/ndrd/main/html</a>	Searchable database of worldwide natural disasters.

U.S. State & Local Gateway	<a href="http://www.statelocal.gov/">http://www.statelocal.gov/</a>	General information through the federal-state partnership.
National Weather Service	<a href="http://nws.noaa.gov/">http://nws.noaa.gov/</a>	Central page for National Weather Warnings, updated every 60 seconds.
USGS Real Time Hydrologic Data	<a href="http://h20.usgs.gov/public/realtime.html">http://h20.usgs.gov/public/realtime.html</a>	Provisional hydrological data
Dartmouth Flood Observatory	<a href="http://www.dartmouth.edu/artsci/geog/floods/">http://www.dartmouth.edu/artsci/geog/floods/</a>	Observations of flooding situations.
FEMA, National Flood Insurance Program, Community Status Book	<a href="http://www.fema.gov/fema/csb.html">http://www.fema.gov/fema/csb.html</a>	Searchable site for access of Community Status Books
Florida State University Atlantic Hurricane Site	<a href="http://www.met.fsu.edu/explores/tropical.html">http://www.met.fsu.edu/explores/tropical.html</a>	Tracking and NWS warnings for Atlantic Hurricanes and other links
The Tornado Project Online	<a href="http://www.tornadoject.com/">http://www.tornadoject.com/</a>	Information on tornadoes, including details of recent impacts.
National Severe Storms Laboratory	<a href="http://www.nssl.uoknor.edu/">http://www.nssl.uoknor.edu/</a>	Information about and tracking of severe storms.
Independent Insurance Agents of America IIAA Natural Disaster Risk Map	<a href="http://www.iaa.iix.com/ndcmap.html">http://www.iaa.iix.com/ndcmap.html</a>	A multi-disaster risk map.
Earth Satellite Corporation	<a href="http://www.earthsat.com/">http://www.earthsat.com/</a>	Flood risk maps searchable by state.
USDA Forest Service Web	<a href="http://www.fs.fed.us/land">http://www.fs.fed.us/land</a>	Information on forest fires and land management.

## Appendix C – List of Acronyms

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FEMA	Federal Emergency Management Agency
MEMA	Massachusetts Emergency Management Agency
PVPC	Pioneer Valley Planning Commission
EPA	Environmental Protection Agency
DEP	Massachusetts' Department of Environmental Protection
NWS	National Weather Service
HMGP	Hazard Mitigation Grant Program
FMA	Flood Mitigation Assistance Program
SFHA	Special Flood Hazard Area
CIS	Community Information System
DCR	Massachusetts Department of Conservation and Recreation
FERC	Federal Energy Regulatory Commission
TRI	Toxics Release Inventory
FIRM	Flood Insurance Rate Map
NFIP	National Flood Insurance Program
CRS	Community Rating System
BOS	Board of Selectmen
BOH	Board of Health
LEPC	Local Emergency Planning Committee
EMD	Emergency Management Director
Con Com	Conservation Commission
EOC	Emergency Operations Center
CEM Plan	Comprehensive Emergency Management Plan
WMECO	Western Massachusetts Electric Company
HAZMAT	Hazardous Materials

## Appendix D – Natural Hazard Profiling Methodology<sup>7</sup>

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In order to adeptly profile each of the hazards, a Hazard Identification and Analysis Matrix was prepared to organize the information that was gathered for this project.

The matrix is organized into the following sections: Type of Hazard, Location of Occurrence, Extent of Impacts, Previous Occurrences, Probability of Future Occurrence, and Hazard Index. The Hazard Index was completed to rank the hazards according to the frequency of occurrence and the amount of potential damage likely to occur. The Hazard Index forms the basis for concentrating the future mitigation efforts outlined in this plan. A description of each of the matrix categories is provided below. The completed Matrix is shown as Table 3.1 (Section 3, page 7).

### *Location of Occurrence*

The classifications are based on the area of the Town of Worthington that would potentially be affected by the hazard. The following scale was used:

<b>Table C.1: Location of Occurrence, Percentage of Town Impacted of Given Natural Hazard</b>	
<b>Location of Occurrence</b>	<b>Percentage of Town Impacted</b>
Large	More than 50% of the town affected
Medium	10 to 50% of the town affected
Small	Less than 10% of the town affected

### *Extent of Impacts*

The extent of direct impacts an affected area could potentially suffer were classified according to the following scale:

<b>Table C.2: Extent of Impacts, Magnitude of Multiple Impacts of Given Natural Hazard</b>	
<b>Extent of Impacts</b>	<b>Magnitude of Multiple Impacts</b>
Catastrophic	Multiple deaths and injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of facilities for 30 days or more.
Critical	Multiple injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 week.
Limited	Minor injuries only. More than 10% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 day.

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<sup>7</sup> Source: information adapted from Town of Holden Beach, NC Community-Based Hazard Mitigation Plan, July 15, 2003, and Hyde County, NC Multi-Hazard Mitigation Plan, Sept 2002; and the Massachusetts Emergency Management Agency (MEMA).

Minor	Very few injuries, if any. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of facilities.
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**Previous Occurrences**

Whether or not previous hazard events had occurred is also included, with detailed descriptions of specific previous occurrences within the hazard identification and vulnerability assessments, if necessary.

**Probability of Future Occurrence**

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

<b>Table C.3: Frequency of Occurrence and Annual Probability of Given Natural Hazard</b>	
<b>Frequency of Occurrence</b>	<b>Probability of Future Event</b>
Very High	70-100% probability in the next year
High	40-70% probability in the next year
Moderate	10-40% probability in the next year
Low	1-10% probability in the next year
Very Low	Less than 1% probability in the next year

**Hazard Index**

The hazard index ratings were determined after assessing the frequency, location and impact classifications for each hazard. The hazard index ratings are based on a scale of 1 (highest risk) through 5 (lowest risk). The ranking is qualitative and is based, in part, on local knowledge of past experiences with each type of hazard. The size and impacts of a natural hazard can be unpredictable however; many of the mitigation strategies currently in place and many of those proposed for implementation can be applied to the expected natural hazards, regardless of their unpredictability.

The Hazard Ratings are labeled as follows:

- 1 – High Risk
- 2 – Medium-High Risk
- 3 – Medium Risk
- 4 – Medium Low Risk
- 5 – Low Risk

**Appendix E – Past & Potential Hazards/Critical Facilities Map**

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## Appendix F – Documentation of the Planning Process

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**Worthington Hazard Mitigation Planning Committee  
Meeting #1 July 21, 2008 7-9 pm  
Worthington Fire Department  
AGENDA**

**1. Introduction & Purpose of Committee**

**2. What is Hazard Mitigation Planning?**

**3. Hazards Analysis Methodology**

- Identify Past Hazard Occurrences, Location and Damage Assessments
- Hazard Identification and Analysis Worksheet

**4. Analyze Development Trends**

Review local zoning districts. Identify planned and proposed subdivisions and other common developments. Is planned development at risk by natural hazards? Are there mitigation measures that can be taken to prevent loss of life, property damage, and disruption of governmental services and general business activities.

**5. Review Vulnerability Assessment Methodology and Potential Loss Estimates**

**TOWN CLERK: Please Post this notice per M.G. L. Chapter 39, Section 23, A-C**

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**Worthington Hazard Mitigation Planning Committee  
Meeting #2, August 18, 2008 7-9 pm  
Worthington Fire Department  
AGENDA**

**1. Identify Critical Facilities** (to be shown on Base map)

- Identify Critical Facilities on Base Map. The following list contains items that should be clearly identified on the map, as they apply to your community:
  - Emergency Operations Center - Nursing Homes
  - Emergency Fuel Facilities
  - Town/City Hall
  - Police Station
  - Fire Station
  - Public Works Garages
  - Water Treatment Facilities
  - Sewage Treatment Plants
  - Water Tower/Supply Pumps
  - Power Plants
  - Electrical Power Substations
  - Schools
  - Major Highways and Roadways
  - Elderly Housing
  - Day-Care Facilities
  - Correctional Facilities
  - Other Congregate Care Facilities
  - Shelters
  - Special Needs Populations
  - Hazardous Materials Facilities
  - Access Roads to Critical Facilities
  - Evacuation Routes
  - Unique or Historic Resources
  - Commercial Economic Impact Areas
  - Socio-Economic Impact Areas

- Bridges
- Dams

- Areas with Second Language Needs
- Hospitals

**2. Identify Evacuation Routes Potentially Affected By Hazard Areas**

**3. Establish Mitigation Goals and Objectives**

**TOWN CLERK: Please Post this notice per M.G. L. Chapter 39, Section 23, A-C**

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## Appendix G – Public Outreach

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