



# Shrewsbury Hazard Mitigation Plan Update

*[Last Revised – January 23, 2019]*



*Shrewsbury, MA*

Adopted by the Board of Selectmen January 22, 2019

Prepared by the **Central Massachusetts Regional Planning Commission**

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&

Local Hazard Mitigation Team  
**Town of Shrewsbury, Massachusetts**

## **Acknowledgements**

The Shrewsbury Board of Selectmen extends its thanks to participants in the Local Hazard Mitigation Team:

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Bernard Cahill, Town Planner  
Seth Colby, Fire Captain  
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Angela Snell, Director Parks & Rec.  
Andy Truman, Civil Engineer  
Jim Vuona, Fire Chief

The Board likewise offers thanks to the Massachusetts Emergency Management Agency (MEMA) for guidance and feedback regarding this plan.

In addition, thanks are extended to the staff of the Central Massachusetts Regional Planning Commission for process facilitation and preparation of this document.

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## TOWN OF SHREWSBURY

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### CERTIFICATE OF ADOPTION

### TOWN OF SHREWSBURY, MASSACHUSETTS

BOARD OF SELECTMEN

### A RESOLUTION ADOPTING THE *NATURAL HAZARD MITIGATION PLAN*

WHEREAS, the Town of Shrewsbury established a Committee to prepare the Hazard Mitigation plan; and

WHEREAS, the Town of Shrewsbury participated in the development of the *NATURAL HAZARD MITIGATION PLAN*;


and WHEREAS, the *NATURAL HAZARD MITIGATION PLAN* contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Shrewsbury and

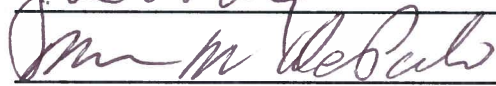
WHEREAS, a duly-noticed public meeting was held by the BOARD OF SELECTMEN on September 27, 2018 for the public and municipality to review prior to consideration of this resolution; and

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

NOW, THEREFORE BE IT RESOLVED that the Town of Shrewsbury BOARD OF SELECTMEN, formally approves and adopts the *NATURAL HAZARD MITIGATION PLAN*, in accordance with M.G.L. c. 40.

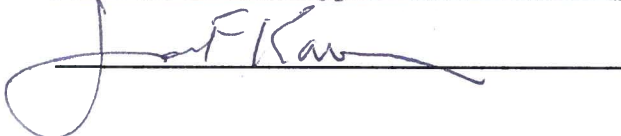
ADOPTED AND SIGNED this 22<sup>nd</sup> day of January, 2019.

  
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Contents

- 1.0 INTRODUCTION ..... 3
  - 1.1 Disaster Mitigation Plan..... 3
  - 1.2 Plan Purpose..... 3
  
- 2.0 PLANNING PROCESS..... 3
  
- 3.0 REGIONAL AND COMMUNITY PROFILE ..... 6
  
- 4.0 NATURAL HAZARD IDENTIFICATION AND ANALYSIS ..... 7
  - 4.1 Overview of Hazards and Impacts ..... 8
  - 4.2 Dam Failure..... 11
  - 4.3 Drought..... 16
  - 4.4 Earthquakes ..... 21
  - 4.5 Extreme Temperatures ..... 25
  - 4.6 Flooding ..... 28
  - 4.7 Hurricanes ..... 32
  - 4.8 Severe Snowstorms / Ice Storms / Nor’easters ..... 37
  - 4.9 Severe Thunderstorms / Wind / Tornado ..... 41
  - 4.10 Wildfires / Brush Fires ..... 46
  - 4.11 Other Hazards..... 51
  - 4.12 Impacts of Climate Change on Hazards ..... 53
  
- 5.0 CRITICAL FACILITIES & VULNERABLE POPULATIONS..... 56
  - 5.1 Critical Facilities within Shrewsbury ..... 56
    - Category 1 – Emergency Response Facilities ..... 57
    - Category 2 – Non-Emergency Response Facilities..... 57
    - Category 3 – Dams ..... 59
    - Category 4 – Facilities/Populations to Protect ..... 59
  
- 6.0 EXISTING PROTECTION ..... 65
  - 6.1 Existing Protection Matrix ..... 66
  
- 7.0 MITIGATION STRATEGY..... 70
  - 7.1 Impact..... 70
  - 7.2 Priority..... 70
  - 7.3 Estimated Cost..... 71

8. PLAN ADOPTION, IMPLEMENTATION, AND MAINTENANCE ..... 81

- 8.1 Plan Adoption..... 81
- 8.2 Plan Implementation ..... 81
- 8.3 Plan Monitoring and Evaluation ..... 82
- 8.4 Potential Federal and State Funding Sources ..... 84

APPENDICES ..... 94

- A. Maps..... 94
- B. Public Survey Results ..... 94
- C. Planning Team & Public Meetings ..... 94
- D. Glossary ..... 94
- E. 2012/2018 Priorities Comparison ..... 94

## **1.0 INTRODUCTION**

### **1.1 Disaster Mitigation Plan**

Congress enacted the Disaster Mitigation Act of 2000 (DMA 2000) on October 10, 2000. Also, known as the Stafford Act Amendments, the bill was signed into law by President Clinton on October 30, 2000, creating Public Law 106-390. The law established a national program for pre-disaster mitigation and streamlined the federal administration of disaster relief. Specific rules on the implementation of DMA 2000 were published in the Federal Register in February 2002 and required that all communities must have a Hazard Mitigation Plan in place in order to qualify for future federal disaster mitigation grants following a Presidential disaster declaration each plan must be updated every five years to remain valid. The Hazard Mitigation Plan emphasizes measures that can be taken to reduce or prevent future disaster damages caused by natural hazards. In the context of natural hazard planning, hazard mitigation refers to any action that permanently reduces or eliminates long-term risks to human life and property.

### **1.2 Plan Purpose**

New England weather is renowned for its mercurial and dramatic nature. Late summer hurricanes, major winter blizzards, and summer droughts are all part of climactic atmosphere in Central Massachusetts. These occur frequently enough to be familiar scenes to residents of Shrewsbury. The intersection of these natural hazards with the built environment can transition these routine events into classified natural disasters. Since many cities and towns historically developed along waterways as a corridor for transportation and power, much development is present in riverine floodplains. The historical development pattern of Central Massachusetts makes the likelihood of a devastating impact of a natural disaster more likely.

This plan identifies the natural hazards facing the Town of Shrewsbury, assesses the vulnerabilities of the area's critical facilities, infrastructure, residents, and businesses, and presents recommendations on how to mitigate the negative effects of typical natural hazards.

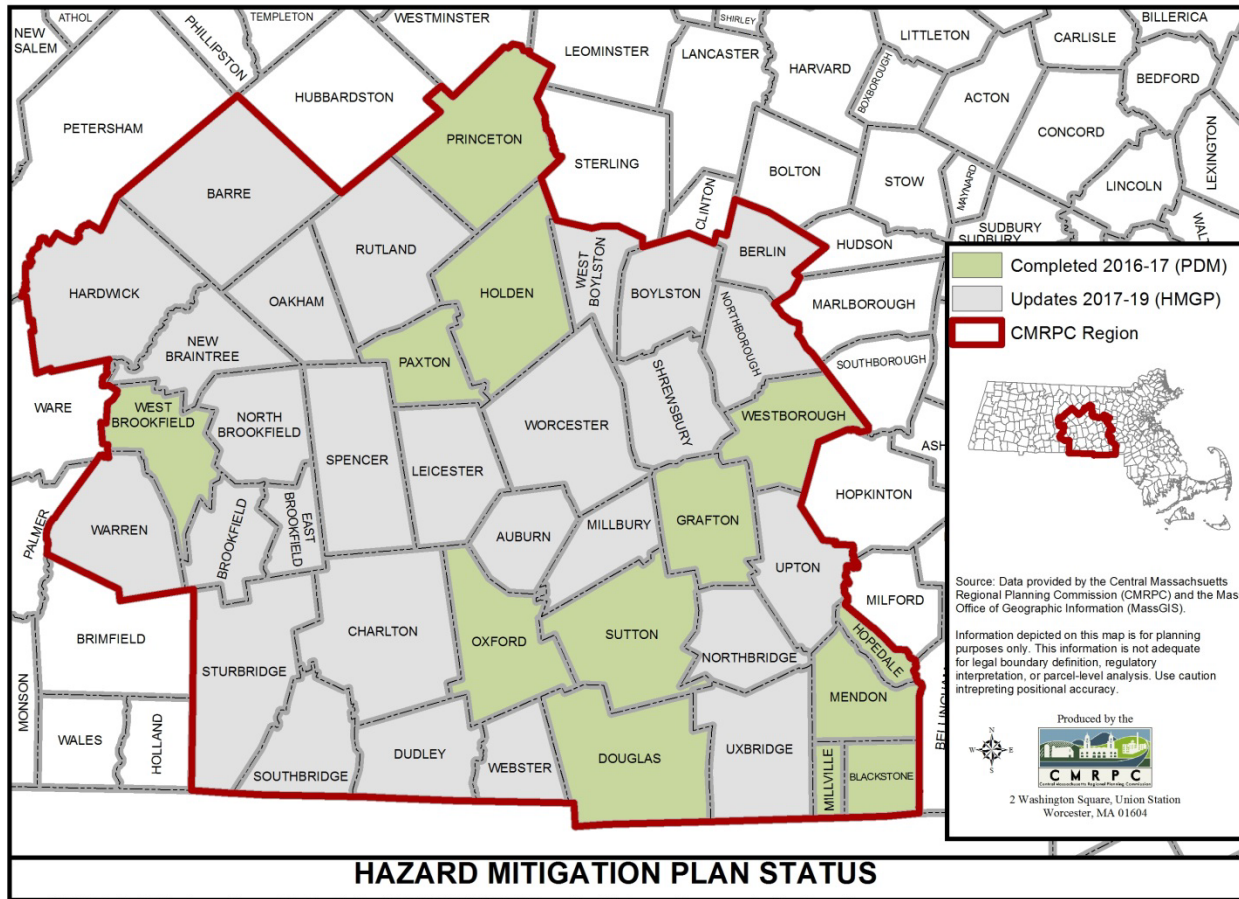
This effort has drawn from the knowledge of local municipal officials and residents, and the recommendations presented are intended to be realistic and effective steps for mitigating natural hazards. Implementation of these actions will translate into savings for the community, fewer lives lost, less property destroyed, and less disruption to essential services.

## **2.0 PLANNING PROCESS**

This Plan is funded by a Fiscal Year 2017 Hazard Mitigation Grant Program (HMGP) grant to CMRPC from the Federal Emergency Management Agency (FEMA) through the Massachusetts Emergency Management Agency (MEMA). Twenty-Seven Central Massachusetts communities

are participating in this effort, which involves community-specific updates to a regional plan adopted in March of 2013. Aside from Shrewsbury, the twenty-six other communities are Auburn, Barre, Berlin, Boylston, Brookfield, Charlton, Dudley, East Brookfield, Hardwick, Leicester, Millbury, New Braintree, North Brookfield, Northborough, Northbridge, Oakham, Rutland, Southbridge, Spencer, Sturbridge, Upton, Uxbridge, Warren, Webster, West Boylston and Worcester.

Figure 1



The planning process in each community was composed of two distinct but related phases – data collection and technical review, and public input and planning. Identification of natural hazards impacting participating communities was accomplished through review of available information from various sources. These included federal and state reports and datasets, existing plans, and in some cases engineering documents. An assessment of risks and vulnerabilities was performed primarily using geographic information systems (GIS) to identify the infrastructure (critical facilities, public buildings, roads, homes, businesses, etc.) at the highest risk for being damaged by hazards, particularly flooding. Local knowledge as imparted by town officials, staff, emergency management volunteers and others was a critical element of this phase.



The second phase of the process was focused on outreach, public participation and input, and planning. This phase was critical to ensuring awareness of the planning process among a wide range of local officials, coordinating plan elements with other sectors of the community, and providing opportunities for public comment and input from a representative base of residents and other stakeholders in each community. Through this engagement, CMRPC was better able to gauge community priorities for mitigation and to understand local resources and existing policies and procedures. With this information in hand, the planning team was able to develop an informed and community-specific list of mitigation strategies for each participating town.

In Shrewsbury, a planning team of local staff and volunteers led by Kristen Las, Assistant Town Manager met four times on the following dates to discuss hazard areas, critical infrastructure and other assets, and plan priorities and strategies: June 28, 2018, and August 8, 2018. Participants included Kristen Las, Assistant Town Manager, Steve Rocco, EMD, Jim Vuona, Fire Chief, Jeff Howland, DPW Director and Nick Repekta, Highway Manager, and others, (see sign-in sheets in appendix C for all participants). Between meetings and during development of the draft and final plans, information and comments were shared among the local team and CMRPC. Additionally, in the summer of 2018, a public survey to gauge residents' concerns about (and experiences with) hazards was distributed on the town's website. 59 residents participated, offering opinions on hazards and vulnerabilities, preferred means of emergency communication, and priorities and suggestions for future mitigation action. Survey responses were discussed by the planning team at its August 2018 meeting and informed development and prioritization of mitigation strategies.

As planning activities progressed, a public presentation was made by CMRPC at the September 26, 2018 meeting of the Shrewsbury Board of Selectmen to provide a summary of key aspects of the draft Plan report then being finalized. The opportunity for public comment was emphasized. Materials and notes from the presentation and subsequent public discussion are included in the appendix. A full draft Plan was provided to the town for distribution and made available online at CMRPC's website for public comment for two weeks starting on September 27, 2018. No substantive comments were received. In addition, the final draft Plan was distributed to officials in all neighboring communities for review and input regarding shared hazards. No substantive comments were received.

The final draft Plan was submitted to MEMA for review on October 19, 2018 and was then relayed to FEMA for federal review. After receipt of FEMA's revisions on November 23, 2018, a presentation of the final plan was made by CMRPC at the January 22, 2019 meeting of the Board of Selectmen. At the meeting, the plan was formally adopted by vote of the Board.

The Shrewsbury Planning Board is the primary town agency responsible for regulating development in the town. Feedback to the Planning Board was ensured through the participation



of Town Management on the local hazard planning team. In addition, CMRPC, the State-designated regional planning authority for Shrewsbury, works with all agencies that regulate development in its region, including the municipal entities listed above and state agencies, such as Department of Conservation and Recreation and Mass DOT. This regular involvement ensured that during the development of the Shrewsbury Hazard Mitigation Plan, the operational policies and any mitigation strategies or identified hazards from these entities were incorporated.

See Appendix C for additional documentation of local stakeholder and public participation in the planning process.

### **3.0 REGIONAL AND COMMUNITY PROFILE**

The Central Massachusetts Regional Planning Commission (CMRPC) region occupies roughly 1,000 square miles in the southern two-thirds of Worcester County, Massachusetts. The area surrounds the City of Worcester, which is the second-largest city in Massachusetts and New England, with a population of 183,382 as of the 2015 American Community Survey (five-year estimate). Nearly 563,000 people live in the CMRPC Region, of whom 36,352 reside in Shrewsbury.

The CMRPC area is framed on the west by the Central Massachusetts uplands, on the south by Rhode Island and Connecticut, on the east by the Boston metropolitan area, and on the north by the Montachusett region in northern Worcester County. The forty-community region has been divided for planning purposes into six sub-regions, determined by shared characteristics and roadway corridors. Shrewsbury is located in the Northeast sub-region consisting of five towns lying within the Blackstone and Concord River valleys, including: Berlin, Boylston, Northborough, Shrewsbury and Westborough.

Massachusetts has a humid continental climate, with maritime influences increasing from northwest to southeast. The Shrewsbury area, as represented by National Weather Service data collected from 2000 through 2016 in nearby Worcester, sees monthly mean temperatures ranging from 24.4 degrees in January to 71 in July. Precipitation is relatively high at 49.15 inches annually, including 78 inches of snowfall. With a temperate climate and a location some 40 miles from the Atlantic coast, Shrewsbury and its neighboring communities are subject to a variety of severe weather, including hurricanes, nor'easters, thunderstorms, and blizzards. All of these are discussed more fully in Chapter 4.

The Town of Shrewsbury, Massachusetts was incorporated in 1727. Shrewsbury is located on Route 9, 7 miles east of the City of Worcester and is largely a bedroom community. Half of Shrewsbury lies within the Blackstone River Basin and the remaining portion lies within the Concord River Basin. Shrewsbury is bordered by Worcester on the west, Westborough and

Northborough on the east, Grafton on the south, and Boylston and West Boylston on the north.

Shrewsbury has a total area of 21.6 square miles and a population of 36,352 (2015 American Community Survey). Shrewsbury is a demographically stable community, with population growth average. According to the Central Massachusetts Regional Planning Commission's (CMRPC) Long Range Transportation Plan, Mobility 2040, the Town of Shrewsbury is expected to experience average population growth, compared to the region, over the next 25 years.

The number of residents has grown from 24,146 in the 1990 US Census to 31,640 in 2000 to the currently (2015) estimated 36,352. Shrewsbury is a largely white community, with some 74.4% of residents identifying within that group. Asian are the largest minority group, at 15.8%. The age breakdown is broadly similar to Massachusetts state splits, with children under 19 (28.4%) and seniors 65 or over (13.7%) close to the state rates of 24% and 14.7% respectively. Median age is 40.3, slightly above the state median of 39.3. At \$94,017, median household annual income is somewhat above the state (\$68,563) and Worcester County (\$65,313) medians. Poverty is low at 5.2%, or less than half the state rate (11.6%) and county rates (11.8%). Housing costs are relatively high, with a median owner-occupied home valued at \$366,200, compared to \$333,100 for Massachusetts and \$252,600 for the county. More than 70% of occupied homes are detached or semi-detached single family houses; the remainder is multi-unit structures. At 6.7%, vacancies are below the state (9.8%) and county (8.4%) numbers. Most homes are relatively new, with only 14.3% built before 1940, compared to 34% for Massachusetts and 32.5% for Worcester County.

#### **4.0 NATURAL HAZARD IDENTIFICATION AND ANALYSIS**

The following section includes a summary of disasters that have affected or could affect Worcester. Historical research, discussions with local officials and emergency management personnel, available hazard mapping and other weather-related databases were used to develop this list. The most significant identified hazards are the following:

- Dam Failure
- Drought
- Earthquakes
- Extreme Temperatures
- Flooding
- Hurricanes
- Severe Snowstorms/Ice Storms/Nor'easter
- Severe Thunderstorms/Tornadoes/Wind
- Wildfire/Brushfire
- Other hazards

## 4.1 Overview of Hazards and Impacts

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

### *Hazard Description*

The natural hazards identified for Shrewsbury are: Dam Failure, Drought, Earthquakes, Extreme Temperatures, Flooding, Hurricanes, Severe Snowstorms / Ice Storms / Nor'easters, Severe Thunderstorms / Tornadoes / Wind, Wildfire/Brushfire. Many of these hazards result in similar impacts to a community. For example, hurricanes, tornadoes, and severe snowstorms may cause wind-related damage.

### *Location*

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

Table 1

Percentage of Town Impacted by Natural Hazard	
Land Area Affected by Occurrence	Percentage of Town Impacted
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*

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

### *Previous Occurrences*

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

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

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

*Table 2*

<b>Frequency of Occurrence and Annual Probability of Given Natural Hazard</b>	
<b>Frequency of Occurrence</b>	<b>Probability of Future Events</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

### ***Impact***

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

*Table 3*

<b>Impacts, Magnitude of Multiple Impacts of Given Natural Hazard</b>	
<b>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.
Minor	Very few injuries, if any. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of facilities.

### ***Vulnerability***

Based on the above metrics, a hazard index rating was determined for each hazard. The hazard index ratings are based on a scale of 1 through 5 as follows:

- 1 – Highest risk
- 2 – High risk
- 3 – Medium risk
- 4 – Low risk
- 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.

Table 4

Hazard Identification and Analysis for the Town of Shrewsbury				
Type of Hazard	Location of Occurrence	Probability of Future Events	Impact	Hazard Risk Index Rating
Dam Failure	Small	Very Low	Limited	4
Drought	Large	Very Low	Minor	4
Earthquakes	Large	Very Low	Minor	5
Extreme Temperatures	Large	Moderate	Limited	4
Flooding	Medium	Low	Minor	3
Hurricanes	Large	Low	Limited	3
Severe Snowstorms / Ice Storms/ Nor'easter	Large	Very High	Limited	2
Severe Thunderstorms / Tornadoes / Wind	Small	Moderate	Minor	2
Wildfire / Brushfire	Medium	Moderate	Minor	4

Source: based on Massachusetts State Hazard Mitigation Plan, 2013; modified to reflect conditions in Shrewsbury

## 4.2 Dam Failure

### *Hazard Description*

Dams and their associated impoundments provide many benefits to a community, such as water supply, recreation, hydroelectric power generation, and flood control. However, they also pose a potential risk to lives and property. Dam 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 rapidly. Most dam failures occur when extreme floodwaters overtop dams, causing rapid deterioration through erosion of upper dam surfaces. Often dam breaches lead to catastrophic consequences as the water rushes in a torrent downstream flooding an area engineers refer to as an “inundation area.” The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents,

the number of people living or working in the inundation area, and the number of structures in the inundation area.

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

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

***Location***

According to the Massachusetts Office of Dam Safety, there are 16 dams in Shrewsbury, of which 4 are Significant Hazard. The names and hazard levels of dam structures within Shrewsbury are:

*Table 5*

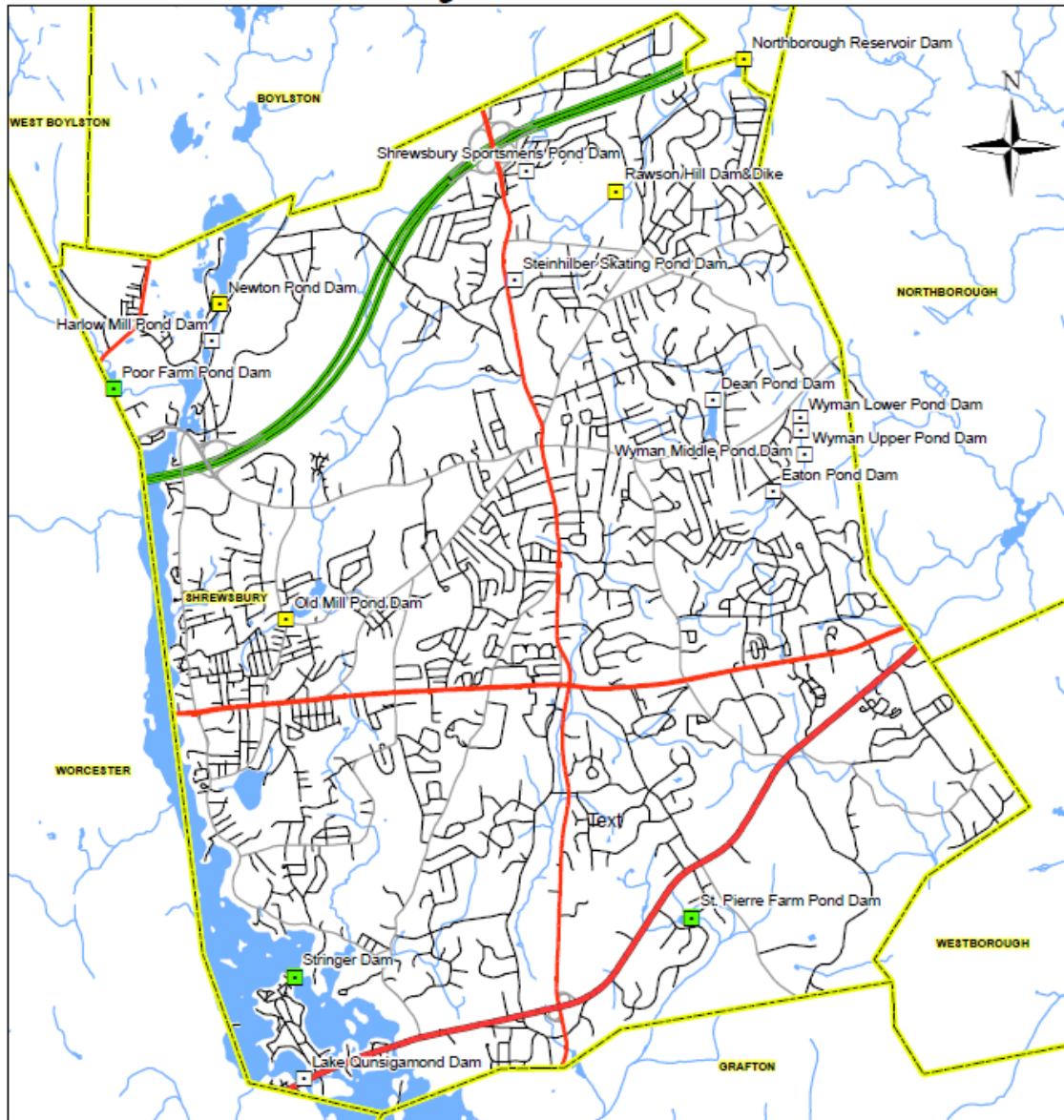
<b>National ID</b>	<b>Dam Name</b>	<b>Owner Type</b>	<b>Hazard Potential</b>
MA02338	Dean Pond Dam	Town of Shrewsbury	N/A
MA02869	Eaton Pond Dam	Town of Shrewsbury	N/A
MA02870	Harlow Mill Pond Dam	Private	N/A
MA00945	Lake Quinsigamond Dam	DCR - Dept. of Conservation & Recreation	N/A
MA00682	Newton Pond Dam	Town of Shrewsbury	Significant Hazard
MA01234	Northborough Reservoir Dam	Town of Northborough	Significant Hazard
MA00680	Old Mill Pond Dam	Town of Shrewsbury	Significant Hazard
MA02339	Poor Farm Pond Dam	City of Worcester	Low Hazard



<b>National ID</b>	<b>Dam Name</b>	<b>Owner Type</b>	<b>Hazard Potential</b>
MA00681	Rawson Hill Dam & Dike	DCR - Dept. of Conservation & Recreation	Significant Hazard
MA01657	Shrewsbury Sportsmens Pond Dam	Private	N/A
MA01656	St. Pierre Farm Pond Dam	Town of Shrewsbury	Low Hazard
MA01653	Steinhilber Skating Pond Dam	Private	N/A
MA02522	Stringer Dam	DCR - Dept. of Conservation & Recreation	Low Hazard
MA01652	Wyman Lower Pond Dam	Private	N/A
MA01654	Wyman Middle Pond Dam	Private	N/A
MA01655	Wyman Upper Pond Dam	Private	N/A

*Note: this list does NOT include town-owned dams outside Shrewsbury or other dams outside Shrewsbury*

# Shrewsbury Dam Locations



Date: 10/30/2017

0 0.25 0.5 1 Miles

### Legend

<span style="color: red;">■</span>	High Hazard	<span style="color: green;">■</span>	Low Hazard
<span style="color: yellow;">■</span>	Significant Hazard	<span style="border: 1px solid black; display: inline-block; width: 10px; height: 10px;"></span>	N/A



Information depicted on this map is for planning purposes only. This information is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analysis. Use caution interpreting positional accuracy.  
Produced by the Central Massachusetts Regional Planning Commission.  
2 Washington Square, Union Station, Second Floor

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Figure 2 – Shrewsbury Dam Locations

Inundation areas for these dams cover less than 10% of the town, or a “small” portion of its area.

### ***Extent***

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

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

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

### ***Previous Occurrences***

To date, there have been no catastrophic dam failures in Shrewsbury.

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

While Shrewsbury has a fairly high number of High and Significant Hazard dams, there are no reported previous dam failure events in the 150-plus years that dams have been present. Probability for future failure events is therefore “very low” with less than 1 percent chance of a dam bursting in any given year.

### ***Impact***

The town faces a “limited” impact from failure of dams with, with 10 to 25 percent of the affected area likely to see damage.

It is not possible to estimate the property loss impacts of dam failure quantitatively given the large number of variables involved in failure events. Qualitatively, losses from failure of an individual

dam could be significant but would be geographically limited to portions of the dam's inundation zone.

### ***Vulnerability***

In accordance with the Massachusetts Hazard Mitigation Plan, a quantitative vulnerability analysis could not be completed to estimate potential losses from a dam failure event. Based on a mostly qualitative assessment, Shrewsbury has a hazard index rating of "4 – limited" from dam failure.

## **4.3 Drought**

### ***Hazard Description***

Drought is a normal, recurrent feature of climate. It occurs almost everywhere, although its features vary from region to region. In the most general sense, 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. Reduced crop, rangeland, and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish habitat are a few examples of the direct impacts of drought. These impacts can have far-reaching effects throughout the region and even the country.

### ***Location***

Because of this hazard's regional nature, a drought would likely impact the entire community, meaning the location of occurrence is "large" or over 50 percent of the town.

### ***Extent***

The severity of a drought determines the scale of the event. Most of Shrewsbury, about 95%, is served by the Shrewsbury Water Department. The U.S. Drought Monitor also records information on historical drought occurrence based on its categorization of drought on a D0-D4 scale as shown below.

Table 6

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

Source: US Drought Monitor, <http://droughtmonitor.unl.edu/>.

**Previous Occurrences**

In Massachusetts, seven major droughts have occurred statewide between 1930 and the recently-notable 2016 event, though the Shrewsbury area has been spared the most severe impacts in each case according to USGS Water Supply Paper for Massachusetts #2375. The drought of 2016 lead to some problems with the towns water supply, there was a contamination issue, high manganese content, due to drawing deeper water and the town had to cap the amount of withdrawal. These historic major droughts range in severity and in length, lasting from three to eight years. In many of these droughts, water-supply systems around the state were found to be inadequate. Water was piped into urban areas, and water-supply systems were modified to permit withdrawals at lower water levels. The following table displays peak drought severity since 2000, from the US Drought Monitor:

Table 7

Annual Drought Status in Worcester County, Mass.	
Year	Maximum Severity
2000	No drought
2001	D2 conditions in 7% of the county
2002	D2 conditions in 100% of the county
2003	No drought
2004	D0 conditions in 96% of the county

Annual Drought Status in Worcester County, Mass.	
Year	Maximum Severity
2005	D0 conditions in 100% of the county
2006	D0 conditions in 100% of the county
2007	D1 conditions in 87% of the county
2008	D0 conditions in 98% of the county
2009	D0 conditions in 76% of the county
2010	D1 conditions in 43% of the county
2011	No drought
2012	D2 conditions in 70% of the county
2013	D1 conditions in 91% of the county
2014	D1 conditions in 79% of the county
2015	D1 conditions in 100% of the county
2016	D3 conditions in 57% of the county
2017	D2 conditions in 77% of the county

Source: US Drought Monitor, 2017.

In Shrewsbury, the last known drought event with substantial impacts occurred in 2016.

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

In Shrewsbury, as in the rest of the state, extreme and exceptional droughts occur at a “very low” probability (1 to 10 percent in the next year). Based on past events and current criteria outlined in the Massachusetts Drought Management Plan, it appears that central Massachusetts may be slightly more vulnerable than parts of eastern Massachusetts to severe drought conditions. However, many factors, such as water supply sources, population, economic factors (i.e., agriculture based economy), and infrastructure, may affect the severity and length of a drought event. When evaluating the region’s risk for drought on a national level, utilizing a measure called the Palmer Drought Severity Index from the National Drought Mitigation Center at the University of Nebraska, Massachusetts is historically in the lowest percentile for severity and risk of drought.

As with all communities in normally precipitation-rich Massachusetts, Shrewsbury is unlikely to be adversely affected by anything other than a major, extended drought. While such a drought would require water saving measures to be implemented, foreseeable damage to structures or loss of life resulting from the hazard would likely be very limited, with modest increased risk of damaging forest or brush fires. Shrewsbury should ensure capacity is maximized to limit the impact of future droughts.

# Palmer Drought Severity Index

1895–1995

Percent of time in severe and extreme drought

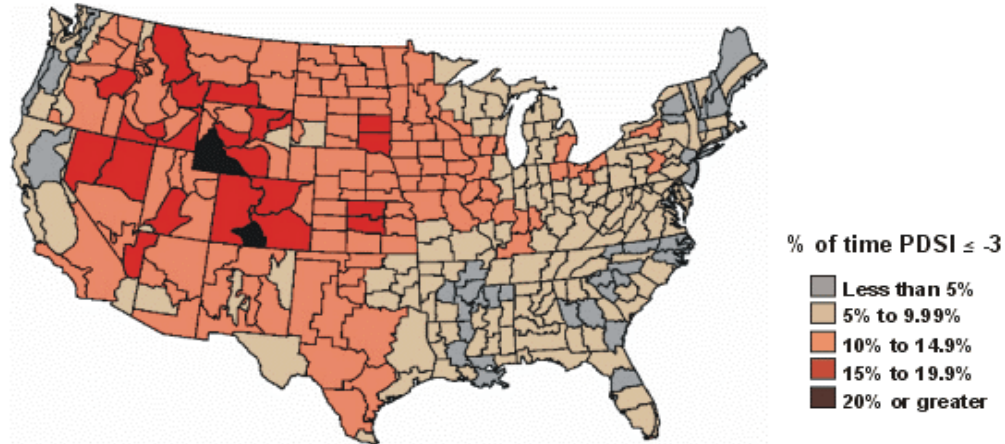


Figure 3

## ***Impact***

The impact of droughts is categorized by the U.S. Drought Monitor include:

- Slowing or loss of crops and pastures
- Water shortages or restrictions
- Minor to significant damage to crops, pastures;
- Low water levels in streams, reservoirs, or wells

Impacts in Shrewsbury may vary among customers of the water system and private well users. So, while the impact of a drought can be assessed as “minor” overall, with very little damage to people or property likely to occur, impacts may be higher in parts of the town that are not located within the town’s water service area.

Agricultural impacts due to drought are generally not substantial in the area, and agriculture is a relatively insignificant industry in Shrewsbury. On a county-wide scale, the extreme drought of 2016 caused crop failures on roughly 0.4% of all harvested cropland based on USDA loss claims and the Massachusetts Agricultural Census.

## ***Vulnerability***

Based on the above assessment, Shrewsbury has a hazard index rating of “4 – low risk” from drought. Minimal or no loss of property, or damage to people or property is expected due to this hazard. Vulnerability is higher in areas outside the municipal water service area (see Figure 7).



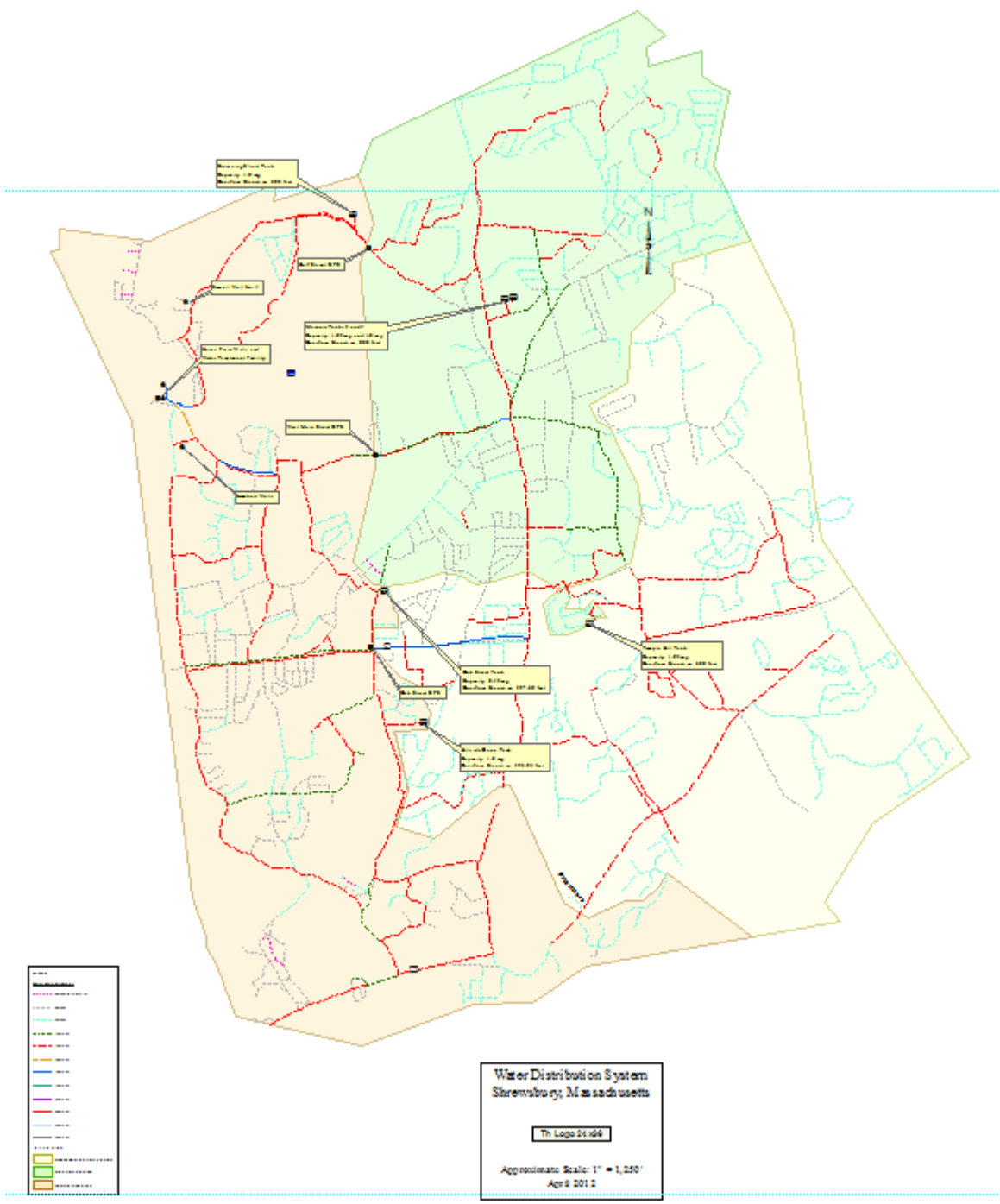


Figure 4 Town of Shrewsbury Water Service

## 4.4 Earthquakes

### *Hazard Description*

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. Earthquakes can occur suddenly, without warning, at any time of the year. 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.

### *Location*

Because of the regional nature of the hazard, the entire Town of Shrewsbury is susceptible to earthquakes. This makes the location of occurrence “large,” or over 50 percent of the total area.

### *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.

Table 8

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.

Table 9

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

Source: U.S. Federal Emergency Management Agency

### ***Previous Occurrences***

Although New England has not experienced a damaging earthquake since 1755, seismologists state that a serious earthquake occurrence is possible. There are five seismological faults in Massachusetts, but there is no discernible pattern of previous earthquakes along these fault lines. Earthquakes occur without warning and may be followed by aftershocks. Most older buildings and infrastructure were constructed without specific earthquake resistant design features.

The most recent notable (Magnitude or Intensity 4 or greater) earthquakes to affect Massachusetts since 1900 are shown in the table below:

Table 10

Notable Earthquakes in Massachusetts 1900 – 2016			
Location	Date	Magnitude	MMI
Nantucket, MA	October 25, 1965	4.7	5.0
Cape Ann, MA	January 7, 1925	4.0	5.0
Wareham, MA	April 25, 1924	4.0	5.0
Newbury, MA	June 10, 1951	4.0	5.0

Source: Northeast States Emergency Consortium website, <http://nsec.org/massachusetts-earthquakes/>

Additionally, a table showing historic incidences of earthquakes for the six New England states are shown in the table below:

Table 11

New England States Record of Historic Earthquakes		
State	Years of Record	Number of Earthquakes
Connecticut	1668 – 2016	115
Maine	1766 – 2016	454
Massachusetts	1668 – 2016	408
New Hampshire	1638 – 2016	320
Rhode Island	1776 – 2016	34
Vermont	1843 - 2016	50
<i>Total Number of Earthquakes within the New England states between 1638 and 2016 is 1,381.</i>		

Source: Northeast States Emergency Consortium website, <http://nsec.org/massachusetts-earthquakes/>

### ***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 Worcester County to determine the Earthquake Index Value as shown in the table below:

Table 12

Earthquake Index for Worcester County	
Worcester County	0.34
Massachusetts	0.70
United States	1.81

Source: USA.com

The local Hazard Mitigation Team reports that no earthquakes have been felt in Shrewsbury. Based upon existing records, there is a “very low” frequency (less than 1 percent probability in any given year) of an earthquake in Shrewsbury.

### ***Impact***

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 first edition of the Massachusetts State Building Code went into effect on January 1, 1975, and 59.5% percent of the city’s 13,807 occupied housing units was constructed in 1979 or earlier (American Communities Survey, 2015 5-year estimate). The seismic standards were upgraded with the 1997 revision of the State Building Code. Despite its older housing stock, Shrewsbury faces a “minor” impact from earthquakes, with little damage likely to occur due to the extreme rarity of damaging events.

### ***Vulnerability***

Based on the above analysis, Shrewsbury has a hazard index rating of “5- lowest risk” from earthquakes. HAZUS- MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. The HAZUS earthquake module allows users to define an earthquake magnitude and model the potential damages caused by that earthquake as if its epicenter had been at the geographic center of the study area. For the purposes of this plan, a magnitude 5.0 earthquake was selected for analysis. Historically, major earthquakes are rare in New England, although a magnitude 5 event occurred in 1963.

Table 13 - Estimated Damages from an Earthquake

<b>Magnitude 5.0</b>	
<b>Building Characteristics</b>	
Estimated total number of buildings	12,000
Estimated total building replacement value (2010 \$)	\$ 4,671,000,000
<b>Building Damages</b>	
# of buildings sustaining slight damage	3,546
# of buildings sustaining moderate damage	1,864
# of buildings sustaining extensive damage	494
# of buildings completely damaged	123
<b>Population Needs</b>	
# of households displaced	538
# of people seeking public shelter	273
<b>Debris</b>	
Building debris generated (tons)	12,000
# of truckloads to clear debris (@ 25 tons/truck)	4,800
<b>Value of Damages (dollars)</b>	
Total property damage	\$547,850,000
Total losses due to business interruption	\$97,500,000

For more information on the HAZUS-MH software, visit [www.fema.gov/hazus-software](http://www.fema.gov/hazus-software).

## 4.5 Extreme Temperatures

### *Hazard Description*

As per the Massachusetts Hazard Mitigation Plan, extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. There is no universal definition for extreme temperatures, with the term relative to local weather conditions. For Massachusetts, extreme temperatures can be defined as those that are far outside the normal ranges. The average temperatures for Massachusetts are:

- Winter (Dec-Feb) Average = 27.51°F
- Summer (Jun-Aug) Average = 68.15°F

Criteria for issuing alerts for Massachusetts are provided on National Weather Service web pages at [www.weather.gov/box/criteria](http://www.weather.gov/box/criteria).

**Location**

Extreme temperatures can be expected to be fairly uniform across Shrewsbury during a given weather event, due to the town’s lack of extreme elevations and coastal areas. Therefore, this hazard is of “large” geographic coverage.

**Extent**

As per the Massachusetts Hazard Mitigation Plan, the extent (severity or magnitude) of extreme cold temperatures are generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. 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.

Extreme temperatures would affect the whole community.

**Wind Chills**

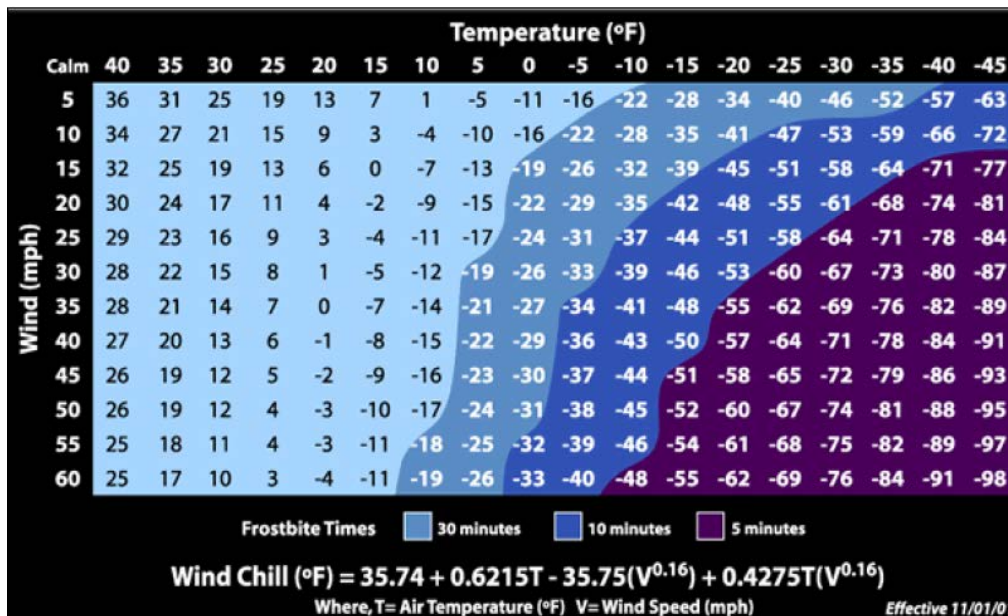


Figure 5



For extremely hot temperatures, the heat index scale is used, which combines 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 degrees F for 2 or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105+ degrees F for 2 or more hours. The following chart indicates the relationship between heat index and relative humidity:

### *Heat Index*

Table 14

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

### *Previous Occurrences*

The following are some of the lowest temperatures recorded in parts of Massachusetts for the period from 1895 to present (Source: NOAA, [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)). Worcester’s annual average temperature range is 56° for the high and 39.6° for the low. Shrewsbury’s temperature range is essentially the same as in Worcester, located some 5 miles away and at a similar elevation.

- Blue Hills, MA: -21°F
- Boston, MA: -12°F
- Worcester, MA: -24°F

The following are some of the highest temperatures recorded for the period from 1895 to present (NOAA):

- Blue Hills, MA: 101°F
- Boston, MA: 102°F
- Worcester, MA: 102°F

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

The probability of future extreme heat and extreme cold is considered to be "moderate," or between 10 and 40 percent in the next year.

### ***Impact***

The impact of extreme heat or cold in Shrewsbury is considered to be "limited," with no property damage and very limited effect on humans. Extreme temperatures are of some concern for the local Hazard Mitigation Team due to health threats to the very young and very old.

### ***Vulnerability***

Shrewsbury's vulnerability to extreme heat and cold is considered to be, "4 - Low Risk."

## **4.6 Flooding**

### ***Hazard Description***

Flooding was the most prevalent natural hazard identified by local officials in Shrewsbury. Flooding is generally caused by hurricanes, nor'easters, severe rainstorms, and thunderstorms. Global climate change has the potential to exacerbate these issues over time with the potential for more severe and frequent storm and rainfall events. In the Northeast, we are seeing 71% more rainfall in large storms than in the past. There are several different types of flood hazards – from stormwater inundation and poor drainage infrastructure to riverine flooding and storm surges to dam failures. The most extensive damage would result from dam failure. However, the most frequent flood threat is due to riverine and stormwater flooding.

### ***Location***

Flooding and flood-prone areas in Shrewsbury are closely associated with the course of the Quinsigamond Lake and its tributary water bodies and waterways. According to a GIS analysis

performed by CMRPC, there are 1,319 parcels in Shrewsbury that are susceptible flooding during a 100-year or base flood events, with 242 of these parcels containing structures. Much of Shrewsbury is upland, away from rivers and ponds and as a result, the location of this hazard is relatively “small”. Map 2 in Appendix A illustrates the FEMA FIRM 100-year flood zones in the town, as well as other locally-identified flooding areas. Despite much of the town being upland, the suburban environment, and extensive network of imperviousness combined with inadequate drainage systems and steep slopes often leads to localized flooding due to excessive surface water runoff.

### ***Extent***

The average annual precipitation for Shrewsbury and surrounding areas in central Massachusetts has been 45 to 50 inches during the past several years.

Water levels in Shrewsbury’s rivers, streams, and wetlands rise and fall seasonally and during high rainfall events. High water levels are typical in spring, due to snowmelt and ground thaw combined with rainfall. This is a period when flood hazards are normally expected. Low water levels occur in summer due to high evaporation and plant uptake (transpiration). At any time, heavy rainfall may create conditions that raise water levels in rivers and streams above bank full stage, which then overflow to adjacent land.

Based on past records and the knowledge and experience of members of the Shrewsbury Hazard Mitigation team and residents, the extent of the impact of localized flooding would be considered "minor".

### ***Previous Occurrences***

In addition to the floodplains mapped by FEMA for the 100-year and 500-year flood, Shrewsbury often experiences minor flooding at isolated locations due to drainage problems, or problem culverts. The following specific flooding locations were identified by the Shrewsbury Hazard Mitigation Team based on knowledge of past flood events:

- MA-9- This location floods regularly in heavy rain storms, this location flooded as recently as 2016 and 2018
- Maple Avenue and Main Street-
- Lake Street at Quinsigamond Lake-There is an undersized culvert in this location, in heavy rains the culvert can become clogged with debris.
- Harrington Avenue- The flooding at this location impacts Fire Station 2.
- South Street & Brook Street- Undersized culvert at this location leads to flooding in rain events

- Gold Street & Grafton Street- Undersized culvert in this location leads to recurrent flooding
- Lake Avenue-Floods in heavy rain events due to inadequate drainage.

In addition to the locations listed here (and mapped in Appendix A, Map 2), there are many areas with no record of previous flood incidents that could be affected in the future by heavy rain and runoff.

There have been recent flooding situations that has led to FEMA Disaster Declarations in Massachusetts. Most recently the June 1 2011, March 12- April 26, 2010 and April 15-25, 2007 storms and subsequent flooding. Shrewsbury was minimally affected by these storms. According to the Local Hazard Mitigation Team there have been negligible impacts to the town. The situations that lead to FEMA Disaster Declaration are fairly rare.

In recent years, there have been 0 loss claims in Shrewsbury made to FEMA by National Flood Insurance Program (NFIP) participants. As of January, Shrewsbury has 0 repetitive loss properties. As defined by the NFIP, a repetitive loss property is any property which the NFIP has paid for two or more flood claims of \$1,000 or more in any given 10-year period since 1978.

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

Based upon previous data, there is "low" probability of localized flooding occurring in Shrewsbury.

### ***Impact***

With less than 10% of total town area likely to be affected by a flooding event, the town faces a potential "minor" impact.

Utilizing the GIS analysis noted above, the total value of the structures, as of February 2017, on the 1,319 parcels that are susceptible to a 100-year flood is approximately \$61,193,400.

HAZUS- MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. The HAZUS software was used to model potential damage to the community from a 100-year flood event, assuming a 1 square mile data resolution.

Table 15

**Estimated Damages from Flood**

	<b>100 Year flood event</b>
<b>Building Characteristics</b>	
Estimated total number of buildings	12,059
Estimated total building replacement value (2010 \$)	\$4,672,000,000
<b>Building Damages</b>	
# of buildings sustaining minor damage (1-10%)	32
# of buildings sustaining moderate damage (11-40%)	21
# of buildings sustaining severe damage (41-50%)	0
# of buildings destroyed	0
<b>Population Needs</b>	
# of households displaced	165
# of people seeking public shelter	249
<b>Value of Damages</b>	
Total property damage (buildings and content)	\$ 12,990,000
Total losses due to business interruption	\$100,000

This model was included in order to help planners and emergency personnel quantify the impact scale of a plausible and increasingly likely flood event as we observe increasing frequency of severe weather events due to climate change.<sup>1</sup>

***Vulnerability***

Based on this HAZUS-MH analysis, Shrewsbury faces a hazard index rating of “3 - medium risk” from flooding.

The Shrewsbury Fire Station #2 is located within the 100-year flood zone. Additionally, sections of evacuation routes including MA- 9 and US-20 are located in or adjacent to areas prone to flooding. Other Critical Facilities include, the Electrical Substation at several businesses. If evacuation routes and critical facilities such as those listed above are flooded, emergency response and/or evacuations could be hampered.

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<sup>1</sup> For more information on the HAZUS-MH software, go to <http://www.fema.gov/hazus-software>.

## 4.7 Hurricanes

### *Hazard Description*

Hurricanes 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) and whose diameter averages 10 to 30 miles across. The primary damaging forces associated with these storms are high-level sustained winds and heavy precipitation. Hurricanes are powerful rainstorms with strong winds that can reach speeds of up to 200 miles per hour and 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.

### *Location*

Because of the hazard's regional nature, the entire Town of Shrewsbury is at risk from hurricanes, meaning the location of occurrence is "large." Ridgetops are more susceptible to wind damage while areas susceptible to flooding are likely to be affected by heavy rainfall.

### *Extent*

As an incipient 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 by category on a scale of 1 to 5, with 5 being the most intense.

Table 16

Saffir-Simpson Scale	
Hurricane Category	Maximum Sustained Wind Speed (MPH)
1	74–95
2	96–110
3	111–129
4	130–156
5	157 +

Source: National Hurricane Center, 2012

**Previous Occurrences**

Hurricanes that have affected the region in which Shrewsbury is located through 2017 are shown in the following table:

Table 17

Major Hurricanes and Tropical Storms Affecting the region		
Hurricane/Storm Name	Year	Saffir/Simpson Category (when reached MA)
Great Hurricane of 1938	1938	3
Great Atlantic Hurricane	1944	1
Hurricane Dog	1950	Unclear
Carol	1954	3
Edna	1954	1
Diane & Connie	1955	Tropical Storms, 5 days apart
Donna	1960	Unclear, 1 or 2
Belle	1976	Minor Storm
Gloria	1985	1
Bob	1991	2
Floyd	1999	Tropical Storm
Irene	2011	Tropical Storm
Sandy	2012	Tropical Storm

Source: National Oceanic and Atmospheric Administration

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

Shrewsbury's location, approximately 40 miles inland, in central Massachusetts reduces the risk of extremely high winds that are associated with hurricanes, although it can still experience some high wind events. Based upon past occurrences, it is reasonable to say that there is a "low" probability (1 percent to 10 percent in any given year) of hurricanes in Shrewsbury. Climate change is projected to result in more severe weather, including increased occurrence and intensity of hurricanes and tropical storms. Because of this, the occurrence of hurricanes in Shrewsbury will increase in the future.

### ***Impact***

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



Table 18

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		

The town faces a “limited” impact from hurricanes, with 10 percent or less of Shrewsbury affected.

***Vulnerability***

Based on the above analysis, Shrewsbury has a hazard index rating of “3 – medium risk” from hurricanes.

HAZUS- MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. The HAZUS software was used to model potential damages to the community from a 100-year and 500-year hurricane event; storms that are 1% and .02% likely to happen in a given year, and roughly equivalent to a Category 2 and Category 4 hurricane. The damages caused by these hypothetical storms were modeled as if the storm track passed directly through the town, bringing the strongest winds and greatest damage potential.

Table 19

<b>Estimated Damages from Hurricanes</b>		
	<b>100 Year</b>	<b>500 Year</b>
<b>Building Characteristics</b>		
Estimated total number of buildings	12,000	
Estimated total building replacement value (2014 \$)	\$ 4,672,000,000	
<b>Building Damages</b>		
# of buildings sustaining minor damage	285	1,729
# of buildings sustaining moderate damage	30	326
# of buildings sustaining severe damage	1	13
# of buildings destroyed	0	5
<b>Population Needs</b>		
# of households displaced	7	80
# of people seeking public shelter	1	16
<b>Debris</b>		
Building debris generated (tons)	1,138	5,978
Tree debris generated (tons)	3,075	22,113
# of truckloads to clear building debris	46	240
<b>Value of Damages (thousands of dollars)</b>		
Total property damage (buildings and content)	\$24,050.11	\$88,596.28
Total losses due to business interruption	\$ 813.45	\$5,409.25

Though there are no recorded instances of a hurricane equivalent to a 500-year storm passing through Massachusetts, this model was included in order to present a reasonable “worst case scenario” that would help planners and emergency personnel evaluate the impacts of storms that may be more likely in the future, as we enter into the climate change era. For more information on the HAZUS-MH software visit: <http://www.fema.gov/hazus-software>.

## 4.8 Severe Snowstorms / Ice Storms / Nor'easters

### *Hazard Description*

Severe winter storms can pose a significant risk to property and human life. Severe snowstorms and ice storms can involve rain, freezing rain, ice, snow, cold temperatures and wind. Heavy snowfall and extreme cold can immobilize an entire region. Even areas that normally experience mild winters can be hit with a major snowstorm or extreme cold. Winter storms can result in flooding, storm surge, closed highways, blocked roads, downed power lines and hypothermia. A northeast coastal storm, known as a nor'easter, is typically a large counter-clockwise wind circulation around a low-pressure center often resulting in heavy snow, high winds, and rain.

### *Location*

The entire Town of Shrewsbury is susceptible to severe snowstorms, which means the location of occurrence is “large.” Because these storms occur regionally, they would impact the entire town.

### *Extent*

The Northeast Snowfall Impact Scale (NESIS) 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.

Table 20

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

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

### *Previous Occurrences*

The 2011 Halloween Nor'easter produced unusually early snowfall on trees that were often still in leaf, adding extra weight, with the ground in some areas still soft from a preceding warm, rainy period that increased the possibility trees could be uprooted. Based on data available from the National Oceanic and Atmospheric Administration (NOAA), there are 62 high-impact snowstorms, according to the NESIS scale, since 1958 which affected the Northeast Corridor. Of these, 33 storms resulted in snowfalls in Shrewsbury of at least 10 inches. These storms are listed in the table below:

Table 21

Winter Storms Producing Over 10 Inches of Snow in Shrewsbury, 1958-2018			
Date	NESIS Value	NESIS Category	NESIS Classification
3/15/2018	3.16	2	Significant
3/5/2018	3.45	2	Significant
1/3/2018	2.27	1	Notable
3/12/2017	5.03	3	Major
2/8/2015	1.32	1	Notable
1/29/2015	5.42	3	Major
1/25/2015	2.62	2	Significant
3/4/2013	3.05	2	Significant
2/7/2013	4.35	3	Major
10/29/2011	1.75	1	Notable
1/26/2011	2.17	1	Notable

Winter Storms Producing Over 10 Inches of Snow in Shrewsbury, 1958-2018			
1/9/2011	5.31	3	Major
2/12/2006	4.1	3	Major
1/21/2005	6.8	4	Crippling
2/15/2003	7.5	4	Crippling
3/31/1997	2.29	1	Notable
2/2/1995	1.43	1	Notable
2/8/1994	5.39	3	Major
3/12/1993	13.2	5	Extreme
2/10/1983	6.25	4	Crippling
4/6/1982	3.35	2	Significant
2/5/1978	5.78	3	Major
1/19/1978	6.53	4	Crippling
2/18/1972	4.77	3	Major
2/22/1969	4.29	3	Major
2/8/1969	3.51	2	Significant
2/5/1967	3.5	2	Significant
2/2/1961	7.06	4	Crippling
1/18/1961	4.04	3	Major
12/11/1960	4.53	3	Major
3/2/1960	8.77	4	Crippling
2/14/1958	6.25	4	Crippling

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

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

Based upon the availability of records for Worcester County, the likelihood that a severe snow storm will affect Shrewsbury is “very high” (greater than 70 percent in any given year).

Research on climate change indicates that there is great potential for stronger, more frequent storms as the global temperature increases. The Massachusetts State Climate Change Adaptation Report says that predicted changes in the amount, frequency, and timing of precipitation, and the shift toward more rainy and icy winters would have significant implications. By the end of the century, under the high-emissions scenario, annual precipitation is expected to increase by 14%,

with a slight decrease in the summer, and a 30% increase in the winter. Additionally, it is predicted that most of the winter precipitation will be in the form of rain rather than snow <sup>2</sup>

### ***Impact***

The town faces a “limited” impact or less than 10 percent of total property damaged, from snowstorms.

The weight from multiple snowfall events can test the load ratings of building roofs and potentially cause significant damage. Multiple freeze-thaw cycles can also create large amounts of ice and make for even heavier roof loads and lead to ice dams and both interior and exterior structural damage.

Other impacts from snowstorms and ice storms include:

- Disrupted power, internet, and phone service
- Damage to telecommunications structures and utility infrastructure
- 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 – particularly during ice, sleet, or heavy snow storms
- Unsafe driving conditions and increased traffic accidents
- Reduced ability of emergency officials to respond promptly to medical emergencies or fires

### ***Vulnerability***

Based on the above assessment, Shrewsbury has a hazard index rating of “2 — high risk” from snowstorms and ice storms.

Utilizing the town’s total value of all property, \$5,196,075,499 (Massachusetts Department of Revenue, 2016), and an estimated 5 percent of damage to 10 percent of residential structures, approximately \$25,980,377 worth of damage could occur from a severe snowstorm. This is a rough estimate and likely reflects a worst-case scenario. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

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<sup>2</sup> <https://www.mass.gov/service-details/climate-change-in-massachusetts-and-its-impacts>

## **4.9 Severe Thunderstorms / Wind / Tornado**

### ***Hazard Description***

A thunderstorm is a storm with lightning and thunder produced by a cumulonimbus cloud, usually producing gusty winds, heavy rain, and sometimes generating hail. Effective January 5, 2010, the NWS modified the hail size criterion to classify a thunderstorm as ‘severe’ when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013).

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.

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 the Connecticut River Valley and in western Worcester County, with Shrewsbury some 20 miles east of the zone of most frequent past occurrence. 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.

### ***Location***

As per the Massachusetts Hazard Mitigation Plan, the entire town is at risk of high winds, severe thunderstorms, and tornadoes. The plan identifies Shrewsbury and its surrounding communities as having a moderate frequency of tornado occurrence within the Massachusetts context. However, the actual area affected by thunderstorms, wind, or tornadoes is “small,” with less than 10 percent of the town generally affected.

## ***Extent***

An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms. Thunderstorms can cause hail, wind, and flooding.

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

*Table 22*

<b>Enhanced Fujita Scale Levels and Descriptions of Damage</b>			
<b>EF-Scale Number</b>	<b>Intensity Phrase</b>	<b>3-Second Gust (MPH)</b>	<b>Type of Damage Done</b>
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.
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.



Table 23 - Extent Scale for Hail

CONVERTING TRADITIONAL HAIL SIZE DESCRIPTIONS	
Traditional object-to-size conversion for assessment and translation of severe hail reports. We encourage <i>measurement</i> , not estimation, of hail size.	
HAIL SIZE (in.)	OBJECT ANALOG REPORTED
.50	Marble, moth ball
.75	Penny
.88	Nickel
1.00	Quarter
1.25	Half dollar
1.50	Walnut, ping pong
1.75	Golf ball
2.00	Hen egg
2.50	Tennis ball
2.75	Baseball
3.00	Tea cup
4.00	Grapefruit
4.50	Softball

**Previous Occurrences**

Because thunderstorms and wind affect the town regularly on an annual basis, there are not significant records available for these events. As per the Massachusetts Hazard Mitigation Plan, there are approximately 10 to 30 days of thunderstorm activity in the state each year.

In Worcester County, there have been a number of F1 tornadoes occurring sporadically over the years. However, a data search for tornadoes rating 3 or above, or resulting in death/injury, or significant property damage, identifies the following events:

- In 1953, a F4 tornado struck Worcester. The event resulted in at least 90 fatalities, and more than 1,200 injured. There was extensive property damage. On the same date, a F3 tornado began in the Town of Sutton, South of Worcester.
- In 1981 a F3 tornado struck, resulting in just 3 injuries and very little reported property damage.



Figure 6- Photo: MEMA 2011

- In June 2011, a F3 tornado struck Massachusetts. Few deaths were reported, all in Hampden County. No deaths were reported in Worcester County.



Figure 7 - Above: NASA released this image of part of the 39-mile-long tornado track through south-central Mass. The image was captured June 5, 2011 by Landsat 5 satellite.

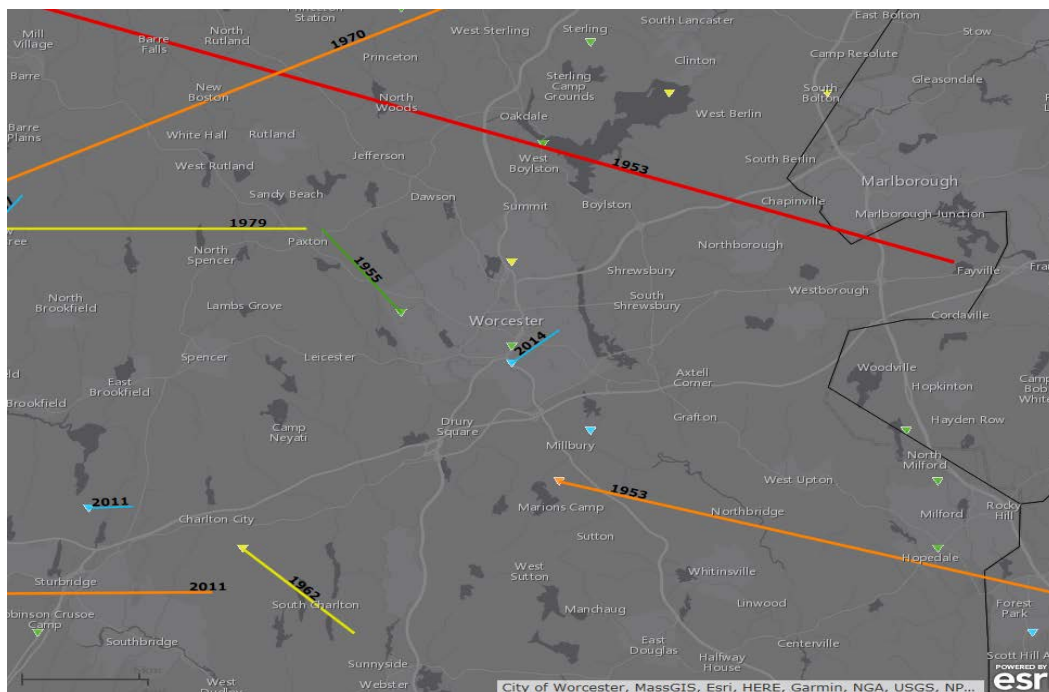


Figure 8 - Tornado Tracks, 1950-2016 in the Shrewsbury area. <http://mrcc.isws.illinois.edu/gismaps/cntytor.htm>

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

One measure of tornado activity is the tornado index value. Activity is calculated based on historical tornado events data using USA.com algorithms. The index is an indicator of the relative tornado activity level in a region. A higher tornado index value means a higher chance of tornado events. Index values for Worcester and its surroundings are shown below.

Table 24

<b>Tornado Index Value</b>	
Town of Shrewsbury	129.31
Worcester County	120.35
Massachusetts	87.60
United States	136.45

Source : <http://www.usa.com/massachusetts-state-natural-disasters-extremes.htm>

Based upon the available historical record, as well as Shrewsbury’s location in a moderate-density cluster of tornado activity for Massachusetts, there is a “very low” probability (less than 1 percent chance in any given year) of a tornado affecting the town, and a moderate (10 percent to 40 percent chance in any given year) probability of a severe thunderstorm and/or high winds.

### ***Impact***

Overall, Shrewsbury faces a “minor” impact from severe thunderstorms, and a “limited” impact from severe winds, or tornados, with 10 percent or less of the town likely to be affected.

As indicated as part of the Enhanced Fujita Scale Levels for tornados, the following impacts can result from a tornado:

- EF0 - Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
- EF1 - 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 - Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.

- EF3 - Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
- EF4 - Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large projectiles generated.

### ***Vulnerability***

Based on the above assessment, Shrewsbury has a hazard index rating of “2- high risk” from severe thunderstorms and winds, and a “4 – low risk” from tornadoes.

The potential for locally catastrophic damage is a factor in any tornado, severe thunderstorm, or wind event. In Shrewsbury, a tornado that hit residential areas would leave much more damage than a tornado with a travel path that ran along the town’s uplands, where less settlement has occurred. Most buildings in the 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, and 59.5% percent of the city’s 13,807 occupied housing units were constructed in 1979 or earlier (American Communities Survey, 2015 5-year estimate). Private homes and town facilities are vulnerable to strong winds and tornados. Utility lines throughout the town are also vulnerable, particularly where trees have not been trimmed recently.

Utilizing the town’s total value of all property, \$5,196,175,499 (Massachusetts Dept. of Revenue, 2016), and an estimated 10 percent of damage to 5 percent of all structures, the estimated amount of damage from a tornado is \$25,980,377. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.

## **4.10 Wildfires / Brush Fires**

### ***Hazard Description***

Wildfires are typically fires triggered by lightning or accidents, involving full-sized trees as well as meadows and scrublands. Brushfires are uncontrolled fires that occur in meadows and scrublands, but do not involve full-sized trees. Typical causes of brushfires and wildfires are lightning strikes, human carelessness, and arson.

FEMA has classifications for 3 different classes of wildfires:

- Surface fires are the most common type of wildfire, with the surface burning slowly along the floor of a forest, killing or damaging trees.

- Ground fires burn on or below the forest floor and are 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.

Potential vulnerabilities to wildfires include damage to structures and other improvements, and impacts on natural resources. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases.

### ***Location***

Worcester County has approximately 645,000 acres of forested land, which accounts for 64% of total land area (Massachusetts Office of GIS, 2007). In Shrewsbury, an estimated 36% of the land is forested. Shrewsbury is developed in a mostly suburban pattern and few uninterrupted tracts of forest are present, the tree coverage does present some risk for wildfires and brush fires. The total amount of the town that could be affected by a wildfire is categorized as “small,” or less than 10 percent of the total area.

### ***Extent***

Wildfires can cause widespread damage. They can spread very rapidly, depending on local wind speeds and can be very difficult to get under control. Fires can last for several hours up to several days.

In Shrewsbury, approximately 36% percent of the town’s total land area is forested, and is therefore at risk of fire. This forested area is generally scattered throughout the community, with developed areas, rivers and major transportation corridors (I-290, I-190 and Route 9) breaking up the forest. In drought conditions, a brushfire or wildfire would be a matter of concern. As noted in the next section describing previous occurrences of wildfire, there have not been any major wildfires recorded in Shrewsbury in recent decades. Based on historic data for 2006-2017, it is estimated that a brush fire might destroy 288 acres of forested area (Massachusetts Fire Incident Reporting System).

Rating of wildfires is shown in the table below:



Table 25 - Extent of Wildfires

<b>Rating</b>	<b>Basic Description</b>	<b>Detailed Description</b>
<p>CLASS 1: Low Danger (L)</p> <p>Color Code: Green</p>	<p>Fires not easily started</p>	<p>Fuels do not ignite readily from small firebrands. Fires in open or cured grassland may burn freely a few hours after rain, but wood fires spread slowly by creeping or smoldering and burn in irregular fingers. There is little danger of spotting.</p>
<p>CLASS 2: Moderate Danger (M)</p> <p>Color Code: Blue</p>	<p>Fires start easily and spread at a moderate rate</p>	<p>Fires can start from most accidental causes. Fires in open cured grassland will burn briskly and spread rapidly on windy days. Woods fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel – especially draped fuel -- may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.</p>
<p>CLASS 3: High Danger (H)</p> <p>Color Code: Yellow</p>	<p>Fires start easily and spread at a rapid rate</p>	<p>All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High intensity burning may develop on slopes or in concentrations of fine fuel. Fires may become serious and their control difficult, unless they are hit hard and fast while small.</p>
<p>CLASS 4: Very High Danger (VH)</p> <p>Color Code: Orange</p>	<p>Fires start very easily and spread at a very fast rate</p>	<p>Fires start easily from all causes and immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics - such as long-distance spotting - and fire whirlwinds, when they burn into heavier fuels. Direct attack at the head of such fires is rarely possible after they have been burning more than a few minutes.</p>
<p>CLASS 5: Extreme (E)</p> <p>Color Code: Red</p>	<p>Fire situation is explosive and can result in extensive property damage</p>	<p>Fires under extreme conditions start quickly, spread furiously and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the Very High Danger class (4). Direct attack is rarely possible and may be dangerous, except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions, the only effective and safe control action is on the flanks, until the weather changes or the fuel supply lessens.</p>

**Previous Occurrences**

Shrewsbury has a full-time fire department with professional firefighters supported by on-call volunteers. There have not been any major wildfires in Shrewsbury in recent decades. During the period 2006-2017, there were 362 total forest and brush fire incidents, with 288 total acres burned (Massachusetts Fire Incident Reporting System).

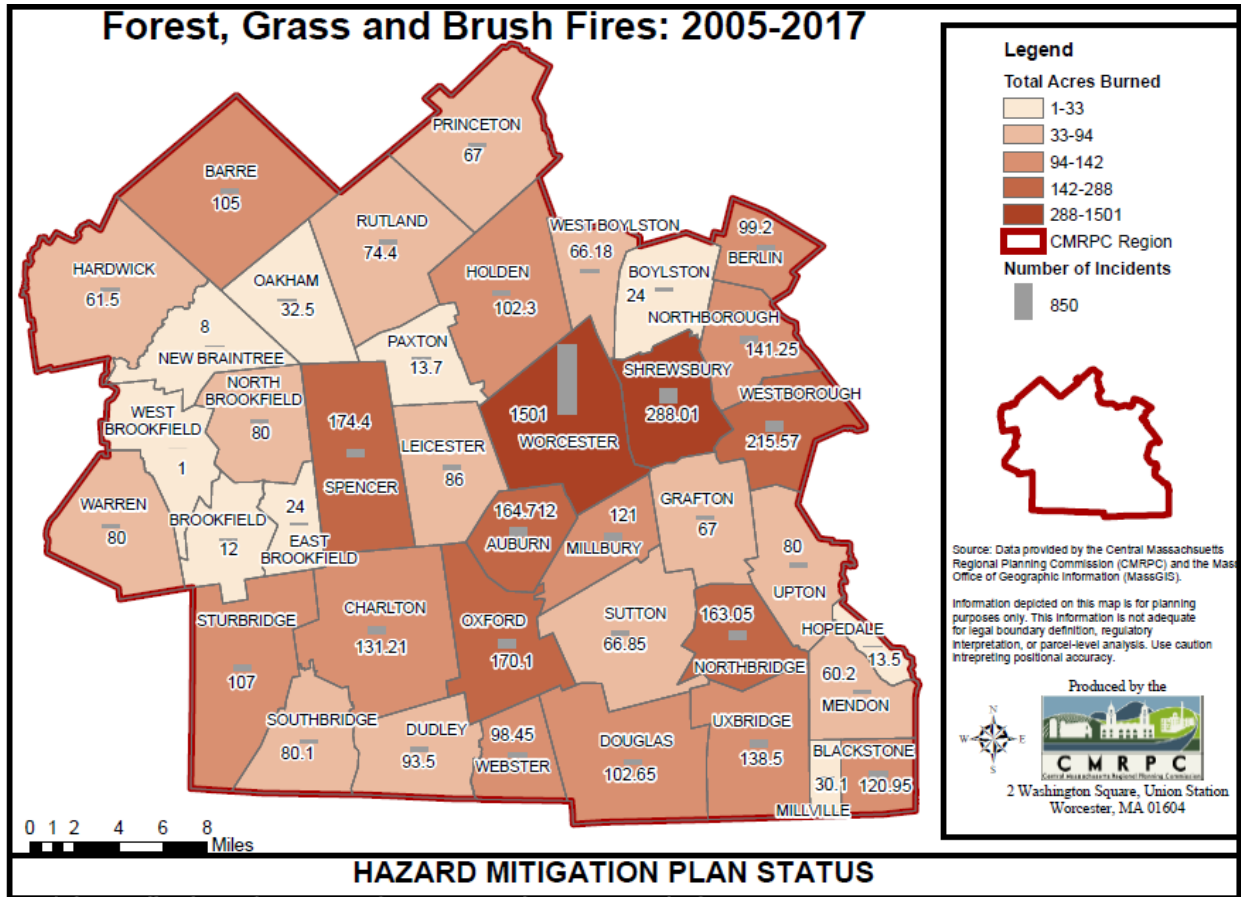


Figure 9 - Forest, Grass and Brush Fires, 2006-2017

**Probability of Future Events**

In accordance with the Massachusetts Hazard Mitigation Plan, the Shrewsbury Hazard Mitigation Team found it is difficult to predict the likelihood of wildfires in a probabilistic manner because the number of variables involved. However, based on regular previous occurrences of minor brush fires, the planning team determined the probability of future damaging wildfire events to be “moderate” (10 percent to 40 percent probability in the next year).

Climate scenarios project summer temperature increases between 2° C and 5° C and precipitation decreases of up to 15 percent. Such conditions would exacerbate summer drought and further

promote high-elevation wildfires, releasing stores of carbon and further contributing to the buildup of greenhouse gases. Forest response to increased atmospheric carbon dioxide—the so-called “fertilization effect”—could also contribute to more tree growth and thus more fuel for fires, but the effects of carbon dioxide on mature forests are still largely unknown.

Climate change is also predicted to bring increased wind damage from major storms, as well as new types of pests to the region. Both increased wind and the introduction of new pests could potentially create more debris in wooded areas and result in a larger risk of fires.

### ***Impact***

While a large wildfire could in theory damage much of the landmass of Shrewsbury, most forested areas are sparsely developed, meaning that wildfire affected areas are not likely to cause damage to personal property. For this reason, the town faces a “minor” impact from wildfires, with little damage likely to occur.

Both wildfires and brush fires can consume homes, other buildings and/or agricultural resources. The impact of wildfires and brush fires are as follows:

- Impact to benefits that people receive from the environment, such as food/water and the regulation of floods and drought
- Impact on local heritage, through the destruction of natural features
- Impact to the economy, due to damage to property and income from land following a wildfire
- Impact through the destruction of people and property

### ***Vulnerability***

Based on the above assessment, Shrewsbury has a hazard risk index of “4 – low risk” from wildfires.

There are several areas considered vulnerable in the town, High Tension Wires throughout town, Worcester Sand & Gravel, Swamp along Crawford Street and Little Chauncey Pond area. Utilizing the town’s total value of all property, \$5,196,075,499 (Massachusetts Dept. of Revenue, 2016), and an estimated 5 percent of damage to 1 percent of all structures, the estimated amount of damage from a wildfire is \$25,980,377. The cost of repairing or replacing the roads, bridges, utilities, and contents of structures is not included in this estimate.



## 4.11 Other Hazards

In addition to the hazards identified in previous sections, the Hazard Mitigation Team reviewed the other hazards listed in the Massachusetts Hazard Mitigation Plan: coastal hazards, atmospheric hazards, ice jams, coastal erosion, sea level rise, nor'easters, and tsunamis. It was determined that these hazards are either irrelevant to Shrewsbury due to the town's location, or in the case of nor'easters, that the hazard is already included within another hazard described above (severe winter storms). The Hazard Mitigation Team noted the major impact of invasive species to Shrewsbury, notably the Asian Longhorned Beetle which the entire town is part of the quarantine area. Also of concern is the increasing population beavers and the damming of wetlands and streams.

### *Invasive Species*

The Asian Longhorned Beetle (ALB, *Anoplophora glabripennis*) is a destructive wood-boring pest of maple and other hardwoods. ALB is believed to have been introduced into the United States from wood pallets and other wood packing material accompanying cargo shipments from Asia. The tree species preferred as hosts by the Asian Longhorned Beetle are hardwoods including several maple species (Norway, sugar, silver, and red maple), box elder, horse chestnut, buckeye, elm, London plane, birch, and willow. All of Shrewsbury and several neighboring communities have been impacted by the infestation. A quarantine remains in place and public education efforts should be continued. Trees weakened by the infestation could be further damaged and impacted by natural hazards such as snowstorms and severe rain/wind events. Weakened limbs could in turn damage power lines and other infrastructure. Continued monitoring of trees should occur, especially in August, as adult beetles are most active during the summer and early fall and is the time of year when beetles are most active and mobile. The larvae that spent the previous year maturing and eating through their host trees emerge as adults and look for a new place to colonize and start the next generation.

### *Beavers*

Beavers are common and abundant throughout most of Massachusetts and they are becoming increasingly more common and plentiful. Beavers play an important role in controlling downstream flooding by storing and slowly releasing floodwater. They also improve water quality by removing or transforming excess nutrients, trapping silt, binding and removing toxic chemicals, and filtering out sediment. However, many towns, including Shrewsbury, have concerns with the growing number of beavers and the potential hazard of the beaver dams. Beavers may pose threats to public water supply, the animals carry a couple pathogens which can contaminate drinking water. Also, the beavers dam flowing water, potentially creating water quality and quantity issues.

MassDEP can determine if the presence of beavers is a threat to the health and safety of residents. Another risk is abandonment of the dam for various reasons and subsequent failure of the dam. Failures result in rapid entrenchment downstream of the dam, some evacuation of pond sediments, and rapid colonization of exposed sediments by vegetation. Furthermore, abandoned beaver dams were often found to transform from a pond to a meadow in less than a decade as they filled up with sediment and these sediments were colonized by plants.<sup>3</sup> This abandonment could dramatically reshape parts of Shrewsbury in a relatively short amount of time, the shift in wetlands would likely have impacts beyond the localized beaver pond. A major storm or rapid snow melt in the region could significantly impact the stability of beaver dams, though the dams are generally solidly built, the risk of multiple breaches at once should be taken into account. Cascade failure of the dams is also a concern, if one dam collapses others downstream might not be able to handle the sudden increase in the surge of water. Catastrophic flooding would occur and sediment of likely unknown quality would be washed downstream. Municipal officials should be aware of the risk and monitor the beaver population when possible. Cooperation with the Board of Health and MassDEP to trap beavers should occur when appropriate. Also, educating the community at large would ensure they are aware of the risk and encourage the monitoring of various beavers in the town.

### *Landslides*

An additional hazard that can affect Shrewsbury is landslides. Landslides occur in all U.S. states and territories. In a landslide, masses of rock, earth, or debris move down a slope. Landslides may be small or large, slow or rapid. They are generally activated by:

- storms
- earthquakes
- volcanic eruptions
- fires
- alternate freezing or thawing
- steepening of slopes by natural erosion or by human modification

Debris and mud flows are rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or “slurry.” They can flow rapidly, striking with little or no warning at avalanche speeds. They also can travel several miles from their source, growing in size as they pick up trees, boulders, cars, and other materials.

There are no documented previous occurrences of significant landslides in Shrewsbury. The town

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<sup>3</sup> <https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1231&context=gradreports>

is relatively flat so risk of landslides is minimal. Most of the town’s rivers are slow moving and frequently dammed, which can minimize landslide risk. Roadways are not generally built close to river channels, reducing undercutting risk from stormwater-induced bank erosion. Development is present in these areas and, should a landslide occur in the future in Shrewsbury, the type and degree of impacts would be highly localized. Vulnerabilities could include damage to structures, damage to transportation and other infrastructure, and localized road closures, though our data review and the local planning team noted no specific concerns. Injuries and casualties, while possible, would be unlikely given the low extent and impact of landslides in Shrewsbury.

Shrewsbury, like nearly all communities in the CMRPC region, is categorized in the Massachusetts Natural Hazard Mitigation Plan as a low incidence/low susceptibility area for landslide hazards based on review of past occurrences. Landslides are therefore considered low frequency events that may occur once in 50 to 100 years (a 1% to 2% chance of occurring per year).

#### 4.12 Impacts of Climate Change on Hazards

Over the next several decades, climate change can be expected to exacerbate many of the hazards described previously in this chapter. This section identifies the impacts that a changing climate may have on Shrewsbury’s hazard risk profile going forward. Sources for this section include:

- Northeast Climate Impacts Assessment (NECIA) (2007)
- Massachusetts Climate Change Adaptation Report (2011)
- Massachusetts Multi-Hazard Mitigation Plan (2013)

#### *Expected Changes*

The NECIA and state Climate Change Adaptation Report offer Massachusetts state-level predictions for temperature and precipitation for upcoming decades, which show dramatic increases in both measures:

Table 5

Category	Current (1961-1990 avg.)	Predicted Change 2040-2069	Predicted Change 2070-2099
Average Annual Temperature (°F)	46°	50° to 51°	51° to 56°
Average Winter Temperature (°F)	23°	25.5° to 27°	31° to 35°
Average Summer Temperature (°F)	68°	69.5° to 71.5°	74° to 82°
Days over 90 °F	5 to 20 days	-	30 to 60 days
Days over 100 °F	0 to 2 days	-	3 to 28 days
Annual Precipitation	41 inches	43 to 44 inches	44 to 47 inches
Winter Precipitation	8 inches	8.5 to 9 inches	9 to 10.4 inches
Summer Precipitation	11 inches	10.9 to 10.7 inches	10.9 to 11 inches

### ***Flooding***

A warming climate is expected to lead to higher precipitation throughout the region. The Massachusetts Multi-Hazard Mitigation Plan estimates that precipitation will increase 6 to 14% by mid-century, with an increased frequency of floods meeting current 10-year flood levels. Much of the winter precipitation increase is projected to be in the form of rain rather than snow, which may actually reduce peak spring flooding but could lead to more frequent winter runoff events. Overall, the frequency of flooding events and their impacts on people and property can be expected to increase over time, largely in locations that are already of flood concern. Public health may be impacted through increased mosquito populations, which depend on the availability of standing water.

### ***Severe Snowstorms/Ice Storms/Nor'easters***

The Massachusetts Multi-Hazard Mitigation Plan estimates that as the climate warms, winter snowfall will be reduced and will generally fall later in the winter season. The Climate Change Adaptation Report predicts that snowfall events will decline over time from around 5 per month during winter to 1 – 3, but that the frequency of the strongest winter storms may actually increase until winter average temperatures warm above the freezing point late in the century. Overall, the risk of winter storms to people and property can be expected to decline.

### ***Hurricanes***

The Massachusetts Multi-Hazard Mitigation Plan notes that there is still a great deal of uncertainty about the impacts of climate change on hurricanes and tropical storms, but that the limited evidence available indicates that stronger storms (Category 4 and 5) are becoming more frequent. Overall, the risk from hurricanes and their associated flooding can be expected to increase.

### ***Severe Thunderstorms/Wind/Tornado***

Evidence shows that severe weather including thunderstorms, damaging wind and tornados is already increasing as temperatures rise. The Massachusetts Multi-Hazard Mitigation Plan notes that smaller storm events are becoming less frequent, while more severe storms are becoming more common. Overall, the risk from severe storms can be expected to increase.

### ***Wildfire/Brush Fire***

The Massachusetts Multi-Hazard Mitigation Plan projects summer rainfall to decrease as much as 15% in the next decades. In combination with higher temperatures and winds, this drop in

precipitation would contribute to additional fire risk. Forest response to increased atmospheric carbon dioxide – the so-called “fertilization effect” – could also contribute to more tree growth and thus provide more fuel for wildfires. Climate change may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods. Reduced stream flows and pond depths may also impact the number and quality of access points for rural firefighting. Overall, the risk of wildfires to people and property can be expected to increase.

### ***Earthquake***

Climate change is not expected to significantly impact the risk of earthquakes. The state Multi-Hazard Mitigation Plan notes that there may be additional earthquake risk in conjunction with other hazards such as higher rainfall (which can contribute to soil liquefaction during earthquakes), but that research is not yet mature. At this time, overall risk from earthquake to people and property can be expected to stay around the same as the current risk level.

### ***Dam Failure***

The Massachusetts Multi-Hazard Mitigation Plan does not note major concerns about catastrophic dam failure due to climate change. It does, however, mention that increased heavy rainfall events may lead to more frequent dam design failures, in which spillways overflow due to flow rates exceeding design capacity. This type of failure may have a secondary result of increased riverine flooding below dams. Overall, the risk of dam failure to people and property can be expected to stay around the same as the current risk level.

### ***Drought***

While the projections noted above show overall increases in precipitation going forward, summer rainfall is actually expected to decline slightly as the climate warms, raising the risk of seasonal droughts. According to the Massachusetts Multi-Hazard Mitigation Plan, droughts are expected to increase in frequency, severity and length. The Massachusetts Climate Change Adaptation Report finds that by the end of the century, under a high carbon emissions scenario, the occurrence of droughts lasting one to three months could go up by as much as 75% over existing conditions. Secondary to drought, wildfire risk can be expected to rise. Overall, the risk of drought to people and property can be expected to increase.

### ***Extreme Temperatures***

According to records of the US Historical Climatology Network, average temperatures in the region have increased about 0.2 degrees C (0.5°F) per decade since 1970. These higher average temperatures have primarily been the result of warmer winters (December through March), during

which there has been an increase of 1.3°F per decade since 1970. In addition to average temperature increases, the number of extremely hot and record heat days has also increased: the number of days with temperatures of 90°F and higher throughout the Northeast has doubled during the past 45 years. As noted in the table elsewhere in this section, the number of days exceeding 90 degrees is expected to surge several times over, presenting a health risk to young children, the elderly, and to persons with various health conditions. Overall, the risk of extreme temperatures to people and property can be expected to increase.

## **5.0 CRITICAL FACILITIES & VULNERABLE POPULATIONS**

Critical Infrastructure provides the essential services to the Town of Shrewsbury and serve as the backbone to the town's security and health. The systems and networks that make up the infrastructure would be disrupted by a natural disaster and would impact response to the disaster and safety of the town.

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.

### **5.1 Critical Facilities within Shrewsbury**

The Critical Facilities List for the Town of Shrewsbury has been identified utilizing several sources, and the knowledge and expertise of the team:

- Shrewsbury's Comprehensive Emergency Management Plan
- MassGIS data
- Critical infrastructure mapping undertaken by CMRPC under contract with the Central Region Homeland Security Advisory Council, which is charged by the Executive Office of Public Safety and Security to administer and coordinate the State Homeland Security Grant for central Massachusetts.

Shrewsbury's Hazard Mitigation Team has broken up this list of facilities into four categories:

- Emergency Response Facilities needed in the event of a disaster
- Non-Emergency Response Facilities that have been identified by the Team as non-essential. These are not required in an emergency response event, but are considered essential for the everyday operation of Shrewsbury
- Dams

- Facilities/Populations that the Team wishes to protect in the event of a disaster  
Critical infrastructure and facilities are mapped in Appendix A.

**Category 1 – Emergency Response Facilities**

The Town of Shrewsbury 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**

Town Hall                      100 Maple Avenue

**2. Police Station**

Police HQ/Dispatch    106 Maple Avenue

**3. Fire Station**

Fire Headquarters      11 Church Road  
 Fire Station 2/EMS    11 Harrington Avenue  
 Fire Station 3            20 Centec Boulevard

**4. Highway Department**

Highway Department 211 South Street

**5. Primary Evacuation Routes**

I-290  
 MA-9  
 US-20  
 MA-140

**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 Shrewsbury.

**1. Water Supply**

Water Treatment Plant	45 Main Street
Lambert Wells	N. Quinsigamond Avenue
Temple Hill Tank	MA-9
Oak Street Tank	Oak Street
Hillside Drive Tank	Lake Street





Pumping Station	US-20
Pumping Station	Stoney Hill Road
Pumping Station	Quail Hollow Drive
Pumping Station	MA-9
Pumping Station	Tennis Drive
Pumping Station	N Quinsigamond Avenue
Pumping Station	Maplewood Drive
Pumping Station	Maple Avenue
Pumping Station	Orchard Meadow Drive
Pumping Station	Harrison Place
Pumping Station	Slocum Meadow Lane
Pumping Station	Adams Farm Road
Pumping Station	Grafton Street

**3. Town Facilities**

Senior Center	98 Maple Avenue
Public Library	609 Main Street

**4. Utilities**

SELCO Substation	Centec Boulevard
Verizon Switching Station	Grafton Street

**Category 3 – Dams**

A list of dams in Shrewsbury is included in Chapter 4 under Dam Failure.

**Category 4 – Facilities/Populations to Protect**

**1. Special Needs Population/Elderly Housing/Assisted Living**

Shrewsbury Nursing and Rehab Center	40 Julio Drive
Southgate at Shrewsbury	35 Julio Drive
Benchmark Senior Living	311 Main Street
The Residence at Orchard Grove	258 Walnut Street

**2. Schools/Daycare**

*(Please note: The EMD has a list of current daycare facilities but these can change locations and addresses frequently, so this list should be revisited periodically.)*

Parker Road Preschool	15 Parker Road
Beal Early Childhood Center	1 Maple Avenue
Calvin Coolidge Elementary School	1 Florence Street
Floral Street School	57 Floral Street
Walter J Paton School	58 Grafton Street
Spring Street School	123 Spring Street
Sherwood Middle School	28 Sherwood Avenue
Oak Middle School	45 Oak Street
Shrewsbury High School	65 Holden Street
St. John's High School	378 Main Street
UMass Medical School (nursing)	222 Maple Avenue
St. Mary's School	16 Summer Street

**Daycares**

Al-Hamra	435 South Street
Ahstrand, Ann Marie	46 Shady Lane Avenue
Almousa, Basemah	3 Edgewood Road
Champagne, Diane	264 Maple Avenue
Crossman, Patricia	3 Karen Avenue
Dakkak, Ghazal	5 Colonial Drive
Deb Roy, Anupama	96 Cherry Street
Fernandes, Maria Candida	52 Ireta Road
Glynn, Carol A.	45 Tanager Drive
God's Little Children Preschool	574 Lake Street
Goncalves de Oliveira, Nuzia	8 Baldwin Circle
Gubbala, Lakshmi	94 Cherry Street
Hamilton, Virginia T.	1 Meadow Lane
Hamm, Alison	6 Walnut Street
Hogan, Nancy	25 Grove Street
Kindercare Learning Center	177 Main Street
Letendre, Heather	31 Worthington Avenue
Lililput Early Childhood Center	18 Grafton Street
Little Beginnings	30 Floral Street
Lopes, Cristiana	26 Janet Circle
LoPriore, Sandra	113 Holden Street
Malo, Liduvina	27 Rosedale Avenue
Morou Hima, Fatouma	9 State Street
Orrizzi, Vincenza	199 Main Street
Pedersen, Sandra	479 Oak Street

Plude, Cynthia A	56 Francis Avenue
Richman-Brady, Sheryl	5 Hearthside Circle
Rupolo, Lori A.	27 Oak Street
School is Cool Childcare DBA, Little Creek Childcare	314 Grafton Street
Shrewsbury Children's Center Inc	138 N. Quinsigamond Avenue
Thakuri, Rita	6 Heath Road
The Learning Experience @ Shrewsbury	889a Boston Turnpike
Up Up and Plan Academy	910 Boston Turnpike Road

### 3. Other Facilities

Putnam Veterinary Clinic	824 Main Street
Community Animal Hospital	15 Clews Street
Knights of Columbus	206 S. Quinsigamond Avenue
Hoagland-Pincus Conference Center	222 Maple Avenue

### 4. Historic Buildings/Sites

According to the Massachusetts Cultural Resources Information System (MACRIS) online database accessed in March 2018, within Worcester there are 6 Areas, 66 Buildings, 2 Burial Grounds 2 Objects, and 10 Structures listed on the National Register of Historic Places, and two National Historic Landmarks. It should be noted that MACRIS records are not up to date, and therefore do not reflect the total number of resources that are no longer extant. The Local Team noted a Local Historic District this district includes significant municipal, residential and commercial buildings concentrated around Main Street, they have been identified as areas of priority to protect from natural hazards. Also, of note, is the Artemas Ward Homestead located on Main Street.

### 5. Employment Centers

Based on data obtained from the Massachusetts Executive Office of Labor and Workforce Development (EOLWD), the following table shows the largest employers in Shrewsbury:

Table 6

Largest Employers in Shrewsbury - April 2017		
Company	Location	No. of Employees
Metso Automation USA Inc.	Bowditch Drive	500-999
Seagate Inc	South Street #1	500-999

<b>Largest Employers in Shrewsbury - April 2017</b>		
<b>Company</b>	<b>Location</b>	<b>No. of Employees</b>
Charles River Laboratories Inc	South Street	250-499
UMass Online	South Street #400	250-499
University of MA System	South Street # 4	250-499
A A Transportation Co.	Hartford Turnpike	100-249
Christmas Tree Shops	Boston Turnpike #10	100-249
Exsel Plastics	Boston Turnpike	100-249
Floral Street School	Floral Street	100-249
Hebert Confections LLC	Hartford Turnpike	100-249

Source: EOLWD

### **Other Businesses**

MK Battery	165-B Memorial Drive
Praxair, Inc. HDC-699	223 Hartford Turnpike
Aggregate Industries Northeast Region, Inc.	651 Lake Avenue
U.S. Postal Service Central MA (P&DC)	192 Main Street
Charles River Laboratories	334 South Street
Waves & Flames	10 Hartford Turnpike
United Rentals (North America), Inc.	169 A & B Memorial Drive
NITCO Materials Handling Solutions	230 Cherry Street
Supercon, Inc.	830 Boston Turnpike
Tri State Truck Center	411 Hartford Turnpike
AA Transportation Co., Inc.	605 Hartford Turnpike
Ferrari Pools & Patios, Inc.	895 Boston Turnpike Road
Industrial Polymers& Chemicals Inc.	508 Boston Turnpike
Metso Automation USA Inc.	44 Bowditch Drive
Flynns Truck Plaza	307 Hartford Turnpike
Wagner & Wagner Auto Sales, Inc.	770 Boston Turnpike
WAGNER AUTOMOTIVE ENTERPRISES LLC	730 Boston Turnpike
Knights Airport Limousine Service, Inc.	390 Hartford Turnpike
TangenX Technology Corporation	910 Boston Turnpike Road
VALVOLINE INSTANT OIL CHANGE	507 Boston Turnpike
W. D. Matthews Machinery Co	297 Hartford Turnpike
Independent Truck Service Inc.	481 Hartford Turnpike
YRC, Inc. (186)	464 Hartford Turnpike
Foley Motorsports	894 Boston Turnpike
Audi Shrewsbury	780 Boston Turnpike
Shrewsbury Landfill	620 Hartford Turnpike
B-XII Shrewsbury LLC.	311 Main Street

## 6. Environmental Justice and Vulnerable Populations

The US Environmental Protection Agency defines Environmental Justice (EJ) as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Within the context of natural hazards and their mitigation, potential EJ concerns may arise from income-related factors, discrimination (overt or institutional), cultural isolation and barriers, language isolation, lack of transportation access, and disability (especially among the elderly).

In 2015, as part of its Mobility 2040 long range transportation plan, CMRPC identified disproportionate concentrations of EJ and other vulnerable populations at the US Census block group level throughout Central Massachusetts. Thresholds used in this identification process included various metrics from the 2010 Census and 2013 American Community Survey:

- Lower income households (median income below \$50,259/year); or
- Minority residents (20.3% or more of population); or
- Hispanic or Latino residents (14.0% or more of population); or
- Language isolated households (9.45% or more of population); or
- Zero vehicle households (12.75% or more of population); or
- Households with persons 75+ years of age (18.8% or more of population); or

Shrewsbury is a diverse town with a number of concentrations of environmental justice populations. According to the Mobility 2040 Study, there are higher concentrations of households with population of 75 years of age or more and a couple sections of town have language isolated households. Also, a sizable portion of the town are minority residents. Awareness of these locations will be vital if there is an emergency in town and specialized response might be necessary

Effective communication regarding hazard mitigation to these populations should occur through active outreach efforts with the public, the academic community, other agencies, and non-federal governmental entities, to anticipate, understand, and resolve specific issues of concern. The town should provide resources and assistance to threatened neighborhoods and vulnerable populations to enhance their resilience during and after a disaster.

More information regarding the identification of Environmental Justice and Vulnerable populations in the Central Massachusetts region can be found online.

## 7. Development

Shrewsbury is a well-developed suburban town with large business districts along several major highways that intersect the town, notably, MA-9 and US-20. Development and redevelopment along these corridors and elsewhere is a priority in diversifying the tax base of the town. There are several areas of note that have recently that have either recently been completed or currently under construction. The site of the former Spag's retail store has been completely transformed, the buildings which once made up Spag's have been demolished and in its place, stands the Lakeway Commons, this mixed-use development includes a Whole Foods store, 250 apartments, and 14 townhouses. This location is expected to be less vulnerable to flooding since the drainage in this location was upgraded as part of construction and there is less impervious surface. Storefronts along the MA-9 corridor have in recent years been modernizing and seeing new tenants move in to existing structures, as these buildings are renovated they are modernized and brought up to current code. This modernization is expected to make the facilities more resilient with up to date electrical systems and modern fire suppression systems. CenTeck Park North, located off US-20, is an ongoing development on property, formally farmland, and currently owned by the Town of Shrewsbury. The property is zoned Office/Research and Flexible Overlay for best-fit uses of Office and Administration, Research and Development, Laboratory, Accessory Manufacturing, Training Centers, Healthcare, or Assisted Living. Any development in this location should take into account hazard mitigation ensuring the protection of the business and residents from potential threats. There are numerous subdivisions either currently or soon to be under construction. Pointe at Hills Farms will have 248 units, Summit Ridge Estates has 57 units, Lake Street Senior Housing has 33 units, and Nelson Point has 18 units. Each of these locations will built to all modern building codes, development standards, follow Site Plan Review, and other review by all pertinent boards, commissions and municipal officials as required by law.

The Town of Shrewsbury actively and thoroughly reviews all development and redevelopment in town. The policies, procedures and bylaws ensure modern building codes are followed and properly engineered drainage and other infrastructure are constructed. Even with the ongoing development open space and land preservation is a priority in town. The town will soon begin the update of its 2012 Open Space and Recreation Plan, incorporating hazard mitigation and protecting the land from various natural hazards should be incorporated in to the update.

As the population of the Shrewsbury continues to grow and more development occurs, officials should seek to integrate hazard mitigation into everyday planning strategies. The Town of Shrewsbury should incorporate Hazard Mitigation into its every day planning and regulatory process The Hazards identified within this Plan would impact the Town and Region except flooding, which usually occurs in more isolated areas. New and redevelopment requirements

include mitigating flooding and stormwater impacts.

## **6.0 EXISTING PROTECTION**

The Town of Shrewsbury currently makes use of most available locally-controlled tools to mitigate the consequences of natural hazards: zoning regulations, planning, and physical improvements. The town participates in the federal program StormReady, and it also plans to research the utility of more public awareness and education programs as a result of this planning process.

Shrewsbury has most of the no-cost or low-cost hazard mitigation capabilities in place. Land use zoning, subdivision regulations and an array of specific policies and regulations that include hazard mitigation best practices, such as limitations on development in floodplains, stormwater management, tree maintenance, etc. Shrewsbury also has appropriate staff dedicated to hazard mitigation-related work for a community of its size, including a Town Manager, an Emergency Management Director, a professionally run Department of Public Works, and a Tree Warden. Shrewsbury has several relevant plans in place, including a Comprehensive Emergency Management Plan, and a Master Plan. Not only does Shrewsbury have these capabilities in place, but they are also deployed for hazard mitigation, as appropriate. The town also has very committed and dedicated volunteers who serve on Boards, Commissions and Committees and in other volunteer positions. The town collaborates closely with surrounding communities through its Local Emergency Planning Committee and has opted in to fire protection mutual aid agreements through MEMA.

Shrewsbury is also an active member community of the Central Massachusetts Regional Planning Commission (CMRPC) and can take advantage of no cost local technical assistance as needed provided by the professional planning staff at CMRPC.

The table below describes existing mitigation protections in Shrewsbury. It includes a brief description of each activity as well as a subjective evaluation of its effectiveness and of any need for modifications.

## 6.1 Existing Protection Matrix

Table 7

Existing Measure	Description	Action	Effectiveness & Recommendations
Participation in National Flood Insurance Program (NFIP)	Provides flood insurance for structures located in flood-prone areas. Also, communities participating in the NFIP have adopted and enforce ordinances, bylaws and regulations that meet or exceed FEMA requirements to reduce the risk of flooding.	Shrewsbury monitors building activity within the flood plain to ensure compliance with provisions of state building code.	Effective  Shrewsbury should seek to further limit development in the 100-year flood zones. Shrewsbury should educate its residents about NFIP.
Floodplain Zoning District Bylaw in place	Requires all development to be in compliance with state building code requirements for construction in floodplains	Shrewsbury has a Floodplain District (Section VII, Chapter I) in its Zoning Bylaws.	Very effective  No changes recommended



Existing Measure	Description	Action	Effectiveness & Recommendations
Stormwater Management policy and regulations in place	Planning Boards or Conservation Commissions review projects for consistency with MA DEP standards. This helps ensure adequate on site retention and recharge.	Shrewsbury does not have a Stormwater Management Bylaw however, Zoning, Subdivision and Wetlands Regulations have different requirements for Stormwater Management.	Effective No changes recommended
Local Open Space and Recreation Plan	<p>Local plan identifying significant natural resources and identifying mechanisms to ensure their protection. Following Mass. Department of Conservation and Recreation guidance for development of OSRPs, this document does not focus on specific hazards.</p> <p>Open Space Plans can provide many tools. Towns must commit to making the land acquisitions and regulatory changes, giving increased attention to preserving undeveloped flood-prone areas and associated lands</p>	Shrewsbury Open Space and Recreation Plan Update was issued in 2012.	Effective  When the current plan expires, Shrewsbury should prepare plan update as per Mass. DCR guidance. Where allowable, Shrewsbury should use the update to integrate hazard mitigation activities and recommendations.

Existing Measure	Description	Action	Effectiveness & Recommendations
Local wetlands protection bylaw and regulations in place (Mass. Assoc. of Conservation Commissions, 2006 data)	Local bylaws building upon the State's Wetlands Protection Act and Regulations. These add regulatory oversight provisions for development within the jurisdictional buffer zone, adding increased attention to alteration of wetlands and the opportunity to preserve capacity and quality.	Shrewsbury does not have a wetlands bylaw in place.	Effective  Shrewsbury should implement a local wetlands bylaw and examine enhanced development controls at wetlands to sustain natural barriers to flooding
Drainage system maintenance and repair program	Plan to keep municipal drainage facilities (storm drains, culverts, etc.) in good order	Shrewsbury performs catch basin cleaning from every two years, problem locations more frequently	Effective  Shrewsbury should examine a public education program for residents on storm drain clearance and other best practices
Tree Trimming	Plan to ensure routine maintenance of trees to reduce likelihood of vegetative debris in response to storm events	Shrewsbury conducts roadside mowing from April-November to remove juvenile trees. Tree trimming (take-downs and clearing dead branches) takes place as needed.	Effective  Shrewsbury should work with its electrical utility to coordinate a more systematic tree trimming program
Street Sweeping	Sweep streets to increase stormwater management capacity; capture and dispose of debris appropriately.	All roads are swept at least once a year or more often as needed.	Very Effective  No changes recommended

Existing Measure	Description	Action	Effectiveness & Recommendations
Culvert Maintenance and Replacement	Maintain existing culverts through regular maintenance and (in some cases) beaver controls; replace/expand culverts where needed to allow for adequate stormwater flow.	Culverts are repaired or upgraded on an as needed basis. An inventory of problem culverts is maintained.	Somewhat effective  Current efforts are piecemeal and are limited by lack of resources and systematic approach. Shrewsbury should develop a policy to prepare for expected climate change related precipitation increase by upsizing culverts, especially in known problematic areas. Seek external financial support. Planning must comply with 2014 Mass. Wetlands Protection Act update; culverts may not be replaced in-kind.
CodeRED System	Emergency warning system that sends voicemail/text/email alerts to residents (text/email alerts are optional).	CodeRED enables the town to provide residents with critical information quickly in a variety of situations, such as severe weather, unexpected road closures, missing persons and evacuation of buildings or neighborhoods.	Very effective  Promote CodeRED so all residents are familiar with the program.

## 7.0 MITIGATION STRATEGY

The Shrewsbury hazard mitigation planning team developed a list of mitigation strategies (both new and previously identified by local officials) and prioritized them using the criteria described below. This list of factors is broadly derived from FEMA's STAPLE+E feasibility criteria.

### 7.1 Impact

The team's consideration of each strategy included an analysis of the mitigation impact each can provide, regardless of cost, political support, funding availability, and other constraints. The intent of this step is to separately evaluate the theoretical potential benefit of each strategy to answer the question: If cost were no object, what strategies have the most benefit? Factors considered in this analysis include the number of hazards each strategy helps mitigate (more hazards equal higher impact), the estimated benefit of the strategy in reducing loss of life and property (more benefit equals higher impact) based on the relevant hazard(s) as assessed in Chapter 4, and the geographic extent of each strategy's benefits (other factors being equal, a larger area equals higher impact).

- **High Impact** – Actions that help mitigate several hazards, substantially reduce loss of life and property (including critical facilities and infrastructure), and/or aid a relatively large portion of the community
- **Medium Impact** – Actions that help mitigate multiple hazards, somewhat reduce loss of life and property (including critical facilities and infrastructure), and/or aid a sizeable portion of the community
- **Low Impact** – Actions that help mitigate a single hazard, lead to little or no reduction in loss of life and property (including critical facilities and infrastructure), and/or aid a highly-localized area

### 7.2 Priority

Following the ranking of each strategy for its mitigation impact, real world considerations were brought back into the analysis to inform the priority ranking process. Factors considered in this step include costs and cost effectiveness (including eligibility and suitability for outside funding), timing, political and public support, and local administrative burden.

**Costs and 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 clear and viable potential funding streams, such as

FEMA's Hazard Mitigation Grant Program (HMGP), are also given higher priority.

**Time required for completion** - Projects that are faster to implement, either due to short work duration, current or near-term availability of funds, and/or ease of permitting or other regulatory procedures, are given higher priority.

**Political and public support** - Strategies that have demonstrated political and/or public support through positive involvement by the public or prioritization in previous regional and local plans and initiatives that were locally initiated or adopted are given higher priority.

**Administrative burden** – Strategies that are realistically within the administrative capacity of the town and its available support network (CMRPC, Shrewsbury local emergency planning committee, etc.) are prioritized. Considerations include grant application requirements, grant administrative requirements (including audit requirements), procurement, and staff time to oversee projects.

- **High Priority** – Strategies that have obvious mitigation impacts that clearly justify their costs and to a large degree can be funded, can be completed in a timely fashion, can be administered effectively, and are locally supported
- **Medium Priority** – Strategies that have some clear mitigation impacts that generally justify their costs and generally can be funded, can be completed in a timely fashion, can be administered effectively, and are locally supported
- **Low Priority** – Strategies that have relatively low mitigation impacts that do not necessarily justify their costs and that may have difficulty being funded, completed in a timely fashion, administered effectively, and locally supported

### 7.3 Estimated Cost

Each implementation strategy is provided with a rough cost estimate based on available third-party or internal estimates and past experience with similar projects. Each includes hard costs (construction and materials), soft costs (engineering design, permitting, etc.), and where appropriate town staff time (valued at appx. \$25/hour for grant applications, administration, etc.). Projects that already have secured funding are noted. Detailed and current estimates were not generally available, so costs are summarized within the following ranges:

- **Low** – less than \$50,000
- **Medium** – between \$50,000 – \$100,000
- **High** – over \$100,000

## Timeline

Each strategy is provided with an estimated length of time it will take for implementation. Where funding has been secured for a project, a specific future date is provided for when completion is expected. However, most projects do not currently have funding and thus it is difficult to know exactly when they will be completed. For these projects, an estimate is provided for the amount of time it will take to complete the project once funding becomes available. Strategies are grouped by 1-2-year timeframe, 3-5-year timeframe, 5+ year timeframe, and ongoing items.

## Strategy Types

Mitigation strategies were broken into four broad categories to facilitate local implementation discussions, especially regarding budget considerations and roles/responsibilities:

**Structure and Infrastructure Projects** - Construct “bricks & mortar” infrastructure and building improvements in order to eliminate or reduce hazard threats, or to mitigate the impacts of hazards. Examples include drainage system improvement, dam repair, and generator installation. Structure and infrastructure improvements tend to have the greatest level of support at the local level, but are highly constrained by funding limits.

**Preparedness, Coordination and Response Actions** - Ensure that a framework exists to facilitate and coordinate the administration, enforcement and collaboration activities described in this plan. Integrate disaster prevention/mitigation and preparedness into every relevant aspect of town operations, including Police, Fire, EMD, EMS, DPW, Town Manager’s Office, Planning Board, Conservation Commission and Board of Selectmen; coordinate with neighboring communities where appropriate. Recommendations in this category tend toward standardizing and memorializing generally-practiced activities.

**Education and Awareness Programs** - Integrate education and outreach into the community to raise awareness of overall or hazard-specific risk and generate support for individual or community-wide efforts to reduce risk.

Awareness and education seek to affect broad patterns of behavior, essentially altering a culture. Awareness-building activity tends to have a fairly slow effect, although in the end it can provide extraordinary benefits with relatively little cash outlay.

**Local Plans and Regulations** - Review and propose updates to local bylaws, ordinances and regulations to protect vulnerable resources and prevent further risk to those resources. Formally adopt these updates into the local regulatory framework. Review the effectiveness of past

mitigation projects, programs procedures and policies. Incorporate mitigation planning into master plans, open space plans, capital improvement plans, facility plans, and other planning.

Planning and regulatory activity tends to provide extraordinary benefits with relatively little cash outlay. However, in smaller communities where planning activities are largely the purview of volunteers, outside assistance from the state or regional levels may be required to maximize its benefits. Political support may be difficult to achieve for some planning and regulatory measures, especially those that place new constraints on land use.

In addition to describing action items in each of these categories, for each strategy we also identify what hazard(s) it is intended to address, as described in Chapter 4 of this plan. Each strategy also identifies the lead organization who serves as the primary point of contact for coordinating efforts associated with that item, and identifies potential funding sources for implementation. See Chapter 8 for more information on potential funding.

## Town of Shrewsbury Mitigation Strategies

OVERALL GOAL: Facilitate activity within the Town of Shrewsbury that reduces the loss, and risk of loss, to persons and property

Mitigation Strategy	Hazard(s) Addressed	Who?	Potential Funding Sources	Priority	Impact	Estimated Cost	Timeline
Description		Agencies involved		Political & economic viability: High/Med/Low	Mitigation impact: High/Med/Low	High (\$100k+)/ Med (\$50k- 100k)/ Low (<\$50k)	Time needed to complete
<b>A. Structure &amp; Infrastructure Strategies</b>							
Identify and prioritize capital/structural mitigation projects that are cost-effective and technically feasible (stormwater drainage, dam repairs, vegetative debris management, etc.).	All	All	Federal, State, Local	High	High	Low	Ongoing
Maintain fire road maintenance and clearing program.	WF	DPW	Local, State	High	High	Low	Ongoing
Sweep streets at least once per year, or more often per requirements of stormwater regulations, to increase stormwater management capacity; capture and dispose of appropriately.	FL, SS, ST, HU	DPW, DOT	Local, State	High	High	Low	Ongoing
Maintain current biennial program of cleaning and upkeep of stormwater structures and basins. Upkeep more often as needed.	FL, SS, ST, HU	DPW	Local, State	High	High	Low	Ongoing
Improve drainage at Lake Street and US-20.	FL, SS, ST, HU	DPW, DOT	Federal, State, Local	High	High	High	1-2 years
Monitor and improve conditions of Poor Farm Pond Dam	FL, SS, ST, HU, DF	DPW, Worcester	Federal, State, Local	High	High	N/A	1-2 years
Monitor Valvoline Instant Oil, ensure maintenance and repair of oil separator occurs to reduce risk of pollution.	FL, SS, ST, HU	CC, DPW	Local, State	High	High	Low	Ongoing



Mitigation Strategy  Description	Hazard(s) Addressed	Who?  Agencies involved	Potential Funding Sources	Priority  Political & economic viability: High/Med/Low	Impact  Mitigation impact: High/Med/Low	Estimated Cost  High (\$100k+)/ Med (\$50k- 100k)/ Low (<\$50k)	Timeline  Time needed to complete
Evaluate and access the town's water supply (source, quality, and quantity). Identify/evaluate water conservation/efficiencies (low impact development bylaw/regulations), secure alternate sources of water to mitigate water supply impacts, and review the town's Water Supply Protection Plan.	All	DPW	Local, State	High	High	Medium	Ongoing
As the primary power source in town, ensure continuity of services for Shrewsbury Electric Light and Cable Operations (SELCO) but assessing the need for backup fuel alternate interconnections.	All	SELCO	Federal, State, Local	High	High	Medium	1-2 years
<b>B. Preparedness, Coordination &amp; Response Action Strategies</b>							
Increase communication and improve coordination between federal, state, regional, county, municipal, private, and non-profit agencies and CRHSAC in the area of hazard mitigation. LEPC meets 4 times a year.	All	LEPC	Local	High	Medium	Low	Ongoing
Maintain and enhance working relationships with the utility companies to improve mitigation of threats, and improve communication during events; ensure satellite spaces within each community for temporary emergency headquarters. Continue to meet with Eversource annually or more often as needed. Coordinate with the Columbia Gas training facility.	All	Fire, LEPC, Utilities	Local	High	High	Low	Ongoing
Continue Unified Incident Command program in training municipal officials as appropriate.	All	All	Local	High	Medium	Low	Ongoing

Mitigation Strategy  Description	Hazard(s) Addressed	Who?  Agencies involved	Potential Funding Sources	Priority  Political & economic viability: High/Med/Low	Impact  Mitigation impact: High/Med/Low	Estimated Cost  High (\$100k+)/ Med (\$50k- 100k)/ Low (<\$50k)	Timeline  Time needed to complete
Inventory shelter/emergency resources. Identify what services are available at the different shelters (e.g. food preparation, potable water, back-up electrical power, heat, showers, etc.) and whether the location of different shelters will be impacted by different hazards (i.e. whether flooding will make the shelter inaccessible to some residents). This would help ensure that suitable shelters are available for different types of natural hazards	All	EMD	Local, State	Medium	Medium	Low	1 Year
Evaluate and revise as necessary the town's policies/procedures around emergency management and vulnerable populations. Specifically, consider adjusting academic calendars/schedules (based on projected temperature extremes), public education opportunities, and best management practices around effective communication (development of registries/distribution lists and language barriers that may affect Code RED).	All	EMD	Local	Medium	Medium	Low	Ongoing
Evaluate and assess existing (and projected) municipal staff levels and equipment (based on population projections) necessary for a range of emergency response procedures. Evaluate need and review municipal policies for mutual aid/memorandums of understanding, specifically related to police and fire.	All	EMD, TM	Local	Medium	Medium	Low	Ongoing

Mitigation Strategy	Hazard(s) Addressed	Who?	Potential Funding Sources	Priority	Impact	Estimated Cost	Timeline
Description		Agencies involved		Political & economic viability: High/Med/Low	Mitigation impact: High/Med/Low	High (\$100k+)/ Med (\$50k-100k)/ Low (<\$50k)	Time needed to complete
In light of increasing storm frequency and severity (as projected), and to ensure readiness, develop a plan that responds to a Category 4 hurricane event.	HU	EMD	Local	Medium	Medium	Low	1 Year
Improve emergency preparedness by evaluation/identifying alternative shelter locations with sustainable systems, planning for shelter upgrades, increasing education and outreach and planning for pets.	All	EMD	Local, State	Medium	Medium	Low	1 Year
<b>C. Education &amp; Awareness Strategies</b>							
Promote Code RED in Shrewsbury so citizens are aware of emergencies in town. Also, Grafton Code RED in case of emergency at the propane facility in Grafton.	All	EMD	Local	High	High	Low	Ongoing
Expand the Emergency Management Director's active public outreach plan, which currently includes regular broadcasts on the Local Cable Access station and booths at the annual Spirit of Shrewsbury Festival held each fall and postings on social media. The purpose of this outreach is to educate residents and business owners on the measures they can implement to mitigate disaster impacts to themselves and others.	All	EMD	Local	High	High	Low	Ongoing
Promote use of full range of federal and state resources related to disaster mitigation such as educational materials, training, and National Weather Service forecasts	All	EMD	Federal, State, Local	High	High	Low	Ongoing

Mitigation Strategy	Hazard(s) Addressed	Who?	Potential Funding Sources	Priority	Impact	Estimated Cost	Timeline
Description		Agencies involved		Political & economic viability: High/Med/Low	Mitigation impact: High/Med/Low	High (\$100k+)/ Med (\$50k-100k)/ Low (<\$50k)	Time needed to complete
Develop educational and outreach tools to reach typically marginalized populations, particularly in designated environmental justice areas. Develop relationship with the India Center.	All	EMD	Local	High	High	Low	Ongoing
Collaborate with others to undertake initiatives and achieve success. (Example: conservation or env. groups that support wetlands protection, river corridor acquisition, or reducing runoff may assist.) Coordinate with the Lake Quinsigamond Watershed Association	All	EMD, Lake Assoc., Other	Local	Medium	Medium	Low	Ongoing
Host an annual 'Emergency Preparedness Day' to raise awareness about the town's vulnerabilities and existing policies/procedures in the event of an emergency situation.	All	EMD	Local, State	Medium	Medium	Low	Annually
<b>D. Local Planning &amp; Regulatory Strategies</b>							
Implement a vegetative debris management program to reduce debris and thereby mitigate risk of stormwater flooding, riverine flooding, winter storm damage	All	DPW, EMD	Local, State	Medium	Medium	Low	1 Year
Maintain membership in the Central Mass. Mosquito Control Project	All	TM	Local	High	High	Low	Ongoing
Continue to pursue funding that builds local capacity and supports grant-writing for mitigation actions.	All	All	Federal, State, Local	High	High	Low	Ongoing
Continue NPDES requirements of new permit as of 7/2018 which will improve the function of drainage infrastructure and mitigate flood risks.	FL, SS, ST, HU	DPW	Federal, State, Local	High	High	Low	Ongoing
Continue to actively enforce and comply with State Building Code Requirements.	All	BI	Local	High	High	Low	Ongoing

<b>Mitigation Strategy</b>	<b>Hazard(s) Addressed</b>	<b>Who?</b>	<b>Potential Funding Sources</b>	<b>Priority</b>	<b>Impact</b>	<b>Estimated Cost</b>	<b>Timeline</b>
Description		Agencies involved		Political & economic viability: High/Med/Low	Mitigation impact: High/Med/Low	High (\$100k+)/ Med (\$50k-100k)/ Low (<\$50k)	Time needed to complete
Continue to actively enforce and comply with the Massachusetts Wetlands Protection Act. Implement a town wetlands bylaw.	All	CC	Local	High	High	Low	Ongoing
Continue to enforce seismic standards in the State's Building Code.	EQ	BI	Local	High	High	Low	Ongoing
Develop a means for sharing information on a regional basis about successful hazard mitigation planning and programs. Create a feedback loop to improve pre-disaster planning by establishing a formal post-disaster assessment process.	All	All	Local, State	Medium	Medium	Low	1-2 Years
Find funding to review and update the regional and local disaster mitigation plans on a five-year cycle	All	TM	Federal, State, Local	High	High	Low	1 Year
Incorporate disaster mitigation actions into appropriate local and regional plans – Master Plans, land use, transportation, open space, and capital programming	All	PB, TM	Local	High	High	Low	Ongoing
Integrate disaster mitigation concerns into transportation projects (e.g. drainage improvements, underground utilities, etc.).	All	DPW, DOT	Federal, State, Local	High	High	N/A	N/A
Expand the use and role of annual Capital Improvement Program	All	TM	Local	Medium	Medium	Low	Ongoing
Work with CMRPC's Transportation Department on computer modeling for evacuation planning & re-routing post-disaster	All	EMD, CMRPC	Federal, State, Local	Medium	Medium	Low	1-2 Years
Update the Open Space and Recreation Plan to mitigate the flood risk in town, plan will expire in 2019.	All	PB, TM	Local, State	Medium	Medium	Low	1-2 Years

Mitigation Strategy	Hazard(s) Addressed	Who?	Potential Funding Sources	Priority	Impact	Estimated Cost	Timeline
Description		Agencies involved		Political & economic viability: High/Med/Low	Mitigation impact: High/Med/Low	High (\$100k+)/ Med (\$50k-100k)/ Low (<\$50k)	Time needed to complete
Continue and enforce the underground utility requirements in local subdivision regulations, and retrofitting of existing infrastructure.	All	PB	Local	Medium	Medium	Low	Ongoing
Incorporate disaster mitigation concerns into the MEPA review process.	All	State	State	High	High	Low	Ongoing
Strengthen regulations in regards to the Stormwater bylaw to mitigate the frequency of flooding.	FL, SS, ST, HU	TM	Local, State	High	High	Low	1-2 Years

'Hazards Addressed' abbreviations:

DF	Dam Failure	DR	Drought
EQ	Earthquake	FL	Flooding
HU	Hurricane	OT	Other
SS	Severe Snowstorm/Ice storm/Nor'easter	ST	Severe Thunderstorm/Wind/Tornado
WF	Wildfire/Brushfire	XT	Extreme Temperatures

'Who? Agencies Involved' abbreviations:

BI	Building Inspector	CMRPC	Central Mass. Regional Planning Commission
CC	Conservation Commission	DOT	Mass. Department of Transportation
DPW	Department of Public Works	EMD	Emergency Management Director
LEPC	Local Emergency Planning Committee	PB	Planning Board
SELCO	Shrewsbury Electric & Cable Operations	TM	Town Manager

## 8. PLAN ADOPTION, IMPLEMENTATION, AND MAINTENANCE

### 8.1 Plan Adoption

A public meeting was held on September 26, 2018 as part of a Shrewsbury Board of Selectmen meeting in order detail the planning process to date and to solicit comments and feedback from the public on the draft Shrewsbury Hazard Mitigation Plan then being finalized. The draft plan was provided to the town for distribution and posted on CMRPC's website from September 27 for public review and input. The Plan was then submitted to the Massachusetts Emergency Management Agency October 19, 2018 and the Federal Emergency Management Agency (FEMA) for their review. Upon receiving conditional approval of the plan by FEMA, the final plan was presented to the Shrewsbury Board of Selectmen and adopted on January 22, 2019.

### 8.2 Plan Implementation

The implementation of this plan began upon its formal adoption by the Board of Selectmen and approval by MEMA and FEMA. Those town departments and boards responsible for ensuring the development of policies, ordinance revisions, and programs as described in Sections 5 and 6 of this plan will be notified of their responsibilities immediately following approval. The Hazard Mitigation Team will oversee the implementation of the plan.

#### *Incorporation with Other Planning Documents*

Existing plans, studies, reports and municipal documents were incorporated throughout the planning process. This included a review and incorporation of significant information from the following key documents:

- ***Shrewsbury Comprehensive Emergency Management Plan*** (particularly the Critical Infrastructure Section) – The Critical Infrastructure section was used to help identify infrastructure components in town that have been identified as crucial to the function of the town; this resource was also used to identify potentially vulnerable populations and potential emergency response shortcomings.
- ***Shrewsbury Open Space and Recreation Plan Update (2012)*** – This Plan was used to identify the natural context within which mitigation planning would take place. This proved useful insofar as it identified water bodies, rivers, streams, infrastructure components (i.e. water and sewer, or the lack thereof), as well as population trends. This was incorporated to ensure that the town's mitigation efforts would be sensitive to the surrounding environment. It should be noted that this plan will soon expire and will need to be updated.

- ***Shrewsbury Zoning Bylaw*** –Zoning was used to gather and identify those actions that the town is already taking that are reducing the potential impacts of a natural hazard (i.e. floodplain regulations) to avoid duplicating existing successful efforts.
- ***Shrewsbury Master Plan*** – The comprehensive plan was used to identify major topics and future development in Shrewsbury. The plan summarizes current conditions and outlines goals for land use, housing, economic development, natural/cultural resources, public facilities, and traffic/circulation. Based on substantial public input, the plan was valuable for identifying critical infrastructure and for understanding future goals and implementation timetables that relate in many case to natural hazards.
- ***Massachusetts State Hazard Mitigation Plan (2013)*** - This plan was used to ensure that the town’s HMP was consistent with the State’s Plan.

After the Shrewsbury Hazard Mitigation Plan has been approved by both FEMA and the local government, links to the plan will be emailed to all town staff, boards, and committees, with a reminder to review the plan periodically and work to incorporate its contents, especially the action plan, into other planning processes and documents. In addition, during annual monitoring meetings for the Hazard Mitigation Plan implementation process, the Hazard Mitigation Team will review whether any of these plans are in the process of being updated. If so, the Hazard Mitigation Team will remind people working on these plans, policies, etc., of the Hazard Mitigation plan, and urge them to incorporate the Hazard Mitigation plan into their efforts. The Hazard Mitigation Team will also review current town programs and policies to ensure that they are consistent with the mitigation strategies described in this plan. The Hazard Mitigation Plan will also be incorporated into updates of the town’s Comprehensive Emergency Management Plan.

### **8.3 Plan Monitoring and Evaluation**

The town’s Emergency Management Director will call meetings of all responsible parties to review plan progress as needed, based on occurrence of hazard events. The public will be notified of these meetings in advance through a posting of the agenda at Town Hall. Responsible parties identified for specific mitigation actions will be asked to submit their reports in advance of the meeting.

Meetings will involve evaluation and assessment of the plan, regarding its effectiveness at achieving the plan's goals and stated purpose. The following questions will serve as the criteria that is used to evaluate the plan:

#### *Plan Mission and Goal*



- Is the Plan's stated goal and mission still accurate and up to date, reflecting any changes to local hazard mitigation activities?
- Are there any changes or improvements that can be made to the goal and mission?

#### *Hazard Identification and Risk Assessment*

- Have there been any new occurrences of hazard events since the plan was last reviewed? If so, these hazards should be incorporated into the Hazard Identification and Risk Assessment.
- Have any new occurrences of hazards varied from previous occurrences in terms of their extent or impact? If so, the stated impact, extent, probability of future occurrence, or overall assessment of risk and vulnerability should be edited to reflect these changes.
- Is there any new data available from local, state, or Federal sources about the impact of previous hazard events, or any new data for the probability of future occurrences? If so, this information should be incorporated into the plan.

#### *Existing Mitigation Strategies*

- Are the current strategies effectively mitigating the effect of any recent hazard events?
- Has there been any damage to property since the plan was last reviewed?
- How could the existing mitigation strategies be improved upon to reduce the impact from recent occurrences of hazards? If there are improvements, these should be incorporated into the plan.

#### *Proposed Mitigation Strategies*

- What progress has been accomplished for each of the previously identified proposed mitigation strategies?
- How have any recently completed mitigation strategies affected the town's vulnerability and impact from hazards that have occurred since the strategy was completed?
- Should the criteria for prioritizing the proposed mitigation strategies be altered in any way?
- Should the priority given to individual mitigation strategies be changed, based on any recent changes to financial and staffing resources, or recent hazard events?

#### *Review of the Plan and Integration with Other Planning Documents*

- Is the current process for reviewing the Hazard Mitigation Plan effective? Could it be improved?
- Are there any town plans in the process of being updated that should have the content of this Hazard Mitigation Plan incorporated into them?

- How can the current Hazard Mitigation Plan be better integrated with other town planning tools and operational procedures, including the zoning bylaw, the Comprehensive Emergency Management Plan, and the Capital Improvement Plan?

Following these discussions, it is anticipated that the planning team 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. The team will review and update the Hazard Mitigation Plan every five years.

Public participation will be a critical component of the Hazard Mitigation Plan maintenance process. The Hazard Mitigation Team will hold all meetings in accordance with Massachusetts open meeting laws and the public invited to attend. The public will be notified of any changes to the Plan via the meeting notices board at Town Hall, and copies of the revised Plan will be made available to the public at Town Hall.

## **8.4 Potential Federal and State Funding Sources**

### **Federal Funding Sources**

The FEMA web pages identify a number of funding opportunities. Please refer to <https://www.fema.gov/grants>. Some programs are described briefly below:

### **Hazard Mitigation Assistance**

The HMA grant programs provide funding opportunities for pre- and post-disaster mitigation. While the statutory origins of the programs differ, all share the common goal of reducing the risk of loss of life and property due to Natural Hazards. Brief descriptions of the HMA grant programs can be found below. For more information on the individual programs, or to see information related to a specific Fiscal Year, please click on one of the program links.

### **Hazard Mitigation Grant Program (HMGP)**

HMGP assists in implementing long-term hazard mitigation measures following Presidential disaster declarations. Funding is available to implement projects in accordance with State, Tribal, and local priorities. Please refer to: <http://www.fema.gov/hazard-mitigation-grant-program> for additional information.

HMGP funds may be used to fund projects that will reduce or eliminate the losses from future disasters. Projects must provide a long-term solution to a problem, for example, elevation of a home to reduce the risk of flood damages as opposed to buying sandbags and pumps to fight the flood. In addition, a project's potential savings must be more than the cost of implementing the project. Funds may be used to protect either public or private property or to purchase property that has been subjected to, or is in danger of, repetitive damage. Examples of projects include, but are

not limited to:

- Acquisition of real property for willing sellers and demolition or relocation of buildings to convert the property to open space use
- Retrofitting structures and facilities to minimize damages from high winds, earthquake, flood, wildfire, or other natural hazards
- Elevation of flood prone structures
- Development and initial implementation of vegetative management programs
- Minor flood control projects that do not duplicate the flood prevention activities of other Federal agencies
- Localized flood control projects, such as certain ring levees and floodwall systems, that are designed specifically to protect critical facilities
- Post-disaster building code related activities that support building code officials during the reconstruction process

### **Pre-Disaster Mitigation Grant Program (PDM)**

The PDM Program, authorized by Section 203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, is designed to assist States, U.S. Territories, Federally-recognized tribes, and local communities in implementing a sustained pre-disaster natural hazard mitigation program. The goal is to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding in future disasters. This program awards planning and project grants and provides opportunities for raising public awareness about reducing future losses before disaster strikes. Please refer to <http://www.fema.gov/pre-disaster-mitigation-grant-program> for additional information.

### **Flood Mitigation Assistance (FMA)**

Flood Mitigation Assistance (FMA) provides funds on an annual basis so that measures can be taken to reduce or eliminate risk of flood damage to buildings insured under the National Flood Insurance Program. Please refer to the FMA website: <http://www.fema.gov/flood-mitigation-assistance-grant-program>.

Three types of FMA grants are available to States and communities:

- **Planning Grants** to prepare Flood Mitigation Plans. Only NFIP-participating communities with approved Flood Mitigation Plans can apply for FMA Project grants
- **Project Grants** to implement measures to reduce flood losses, such as elevation, acquisition, or relocation of NFIP-insured structures. States are encouraged to prioritize FMA funds for applications that include repetitive loss properties; these include structures with 2 or more losses each with a claim of at least \$1,000 within any ten-year period since 1978.
- **Technical Assistance Grants** for the State to help administer the FMA program and activities. Up to ten percent (10%) of Project grants may be awarded to States for Technical

## Assistance Grants

### **Repetitive Flood Claims (RFC)**

The Repetitive Flood Claims (RFC) grant program was authorized by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004 (P.L. 108–264), which amended the National Flood Insurance Act (NFIA) of 1968 (42 U.S.C. 4001, et al). Please refer to: <https://www.fema.gov/repetitive-flood-claims-grant-program-fact-sheet>

RFC provides funds on an annual basis to reduce the risk of flood damage to individual properties insured under the NFIP that have had one or more claim payments for flood damages. RFC provides up to 100% federal funding for projects in communities that meet the reduced capacity requirements.

### **Severe Repetitive Loss (SRL)**

The Severe Repetitive Loss (SRL) grant program was authorized by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004, which amended the National Flood Insurance Act of 1968 to provide funding to reduce or eliminate the long-term risk of flood damage to severe repetitive loss (SRL) structures insured under the National Flood Insurance Program (NFIP). Please refer to: <https://www.fema.gov/media-library/resources-documents/collections/14>

SRL provides funds on an annual basis to reduce the risk of flood damage to residential structures insured under the NFIP that are qualified as severe repetitive loss structures. SRL provides up to 90% federal funding for eligible projects.

**Definition:** The definition of severe repetitive loss as applied to this program was established in section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a. An SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- a) That has at least four NFIP claim payments (including building and contents) over \$5,000 each, and the cumulative amount of such claims payments exceeds \$20,000; or
- b) For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

**Purpose:** To reduce or eliminate claims under the NFIP through project activities that will result in the greatest savings to the National Flood Insurance Fund (NFIF).

Federal / Non-Federal cost share: 75/25%; up to 90% Federal cost-share funding for projects approved in States, Territories, and Federally-recognized Indian tribes with FEMA-approved Standard or Enhanced Mitigation Plans or Indian tribal plans that include a strategy for mitigating existing and future SRL properties.

### **Disaster Assistance**

Disaster assistance is money or direct assistance to individuals, families and businesses in an area whose property has been damaged or destroyed and whose losses are not covered by insurance. It is meant to help with critical expenses that cannot be covered in other ways. This assistance is not intended to restore damaged property to its condition before the disaster. While some housing assistance funds are available through our Individuals and Households Program, most disaster assistance from the Federal government is in the form of loans administered by the Small Business Administration.

#### Disaster Assistance Available from FEMA

In the event of a Declaration of Disaster, assistance from FEMA is grouped in 3 categories:

- A. Housing Needs
- B. Other than Housing Needs
- C. Additional Services

#### **A. Housing Needs**

- **Temporary Housing** (a place to live for a limited period of time): Money is available to rent a different place to live, or a government provided housing unit when rental properties are not available.
- **Repair**: Money is available to homeowners to repair damage from the disaster to their primary residence that is not covered by insurance. The goal is to make the damaged home safe, sanitary, and functional.
- **Replacement**: Money is available to homeowners to replace their home destroyed in the disaster that is not covered by insurance. The goal is to help the homeowner with the cost of replacing their destroyed home.
- **Permanent Housing Construction**: Direct assistance or money for the construction of a home. This type of help occurs only in insular areas or remote locations specified by FEMA, where no other type of housing assistance is possible.

#### **B. Other than Housing Needs**

Money is available for necessary expenses and serious needs caused by the disaster, including:

- Disaster-related medical and dental costs.
- Disaster-related funeral and burial cost.
- Clothing; household items (room furnishings, appliances); tools (specialized or protective clothing and equipment) required for your job; necessary educational materials (computers, school books, supplies)
- Fuels for primary heat source (heating oil, gas).
- Clean-up items (wet/dry vacuum, dehumidifier).
- Disaster damaged vehicle.
- Moving and storage expenses related to the disaster (moving and storing property to avoid additional disaster damage while disaster-related repairs are being made to the home).
- Other necessary expenses or serious needs as determined by FEMA.
- Other expenses that are authorized by law.

### **C. Additional Services**

- Crisis Counseling
- Disaster Unemployment Assistance
- Legal Services
- Special Tax Considerations

#### **Assistance to Firefighters Grants**

The FEMA Assistance to Firefighters Grants (AFG) program provides funds to equip and train emergency personnel to recognized standards, enhance operations efficiencies, foster interoperability, and support community resilience. Under AFG, funds may be available for equipment, vehicles and/or training that can be used to mitigate and/or respond to wildfire-related hazards. AFG also has a Fire Prevention and Safety (FPS) component which funds public outreach programs and prevention activities, which can emphasize wildfire mitigation. Please refer to: <https://www.fema.gov/welcome-assistance-firefighters-grant-program>.

#### **Disaster Loans Available from the Small Business Administration**

The U.S. Small Business Administration (SBA) can make federally subsidized loans to repair or replace homes, personal property or businesses that sustained damages not covered by insurance. The Small Business Administration can provide three types of disaster loans to qualified homeowners and businesses:

- Home disaster loans to homeowners and renters to repair or replace disaster-related damages to home or personal property (please refer to: <https://www.disasterassistance.gov/get-assistance/forms>)

- Business physical disaster loans to business owners to repair or replace disaster- damaged property, including inventory, and supplies (please refer to: <https://www.sba.gov/loans-grants/see-what-sba-offers/sba-loan-programs/disaster-loans/disaster-loan-data>); and
- Economic injury disaster loans, which provide capital to small businesses and to small agricultural cooperatives to assist them through the disaster recovery period (please refer to): <https://www.sba.gov/funding-programs/disaster-assistance>

For many individuals, the SBA disaster loan program is the primary form of disaster assistance.

### **Disaster Assistance from Other Organizations and Entities**

The website <https://www.disasterassistance.gov/> is a secure, user-friendly U.S. Government web portal that consolidates disaster assistance information in one place. If you need assistance following a presidentially declared disaster— which has been designated for individual assistance— you can now go to DisasterAssistance.gov to register online. Local resource information to help keep citizens safe during an emergency is also available. Currently, 17 U.S. Government agencies, which sponsor almost 60 forms of assistance, contribute to the portal.

DisasterAssistance.gov speeds the application process by feeding common data to multiple online applications. Application information is shared only with those agencies you identify and is protected by the highest levels of security. DisasterAssistance.gov will continue to expand to include forms of assistance available at the federal, state, tribal, regional and local levels, with a projected completion date of 2014. Through [www.DisasterAssistance.gov](http://www.DisasterAssistance.gov) you have the ability to:

- Determine the number and forms of assistance you may be eligible to receive by answering a brief series of questions or start the individual assistance registration process immediately
- Apply for FEMA assistance and be referred to the Small Business Administration for loans through online applications
- Choose to have your Social Security benefits directed to a new address
- Access your federal student loan account information
- Receive referral information on forms of assistance that do not yet have online applications
- Access a call center in the event you do not have Internet access to ensure you can still register for assistance
- Check the progress and status of your applications online.
- Identify resources and services for individuals, families and businesses needing disaster assistance during all phases of an emergency situation
- Identify resources to help locate family members and pets
- Access assistance from the Department of State if you are affected by a disaster while traveling abroad

- Find information on disaster preparedness and response

### **Federal Funding Summary Table**

The following is a summary of the programs which are the primary source for federal funding of hazard mitigation projects and activities in Massachusetts:

*Table 8*

Program	Type of Assistance	Availability	Managing Agency	Funding Source
<b>National Flood Insurance Program (NFIP)</b>	Pre-Disaster Insurance	Any time (pre & post disaster)	DCR Flood Hazard Management Program	Property Owner, FEMA
<b>Community Rating System (CRS) (Part of the NFIP)</b>	Flood Insurance Discounts	Any time (pre & post disaster)	DCR Flood Hazard Management Program	Property Owner
<b>Flood Mitigation Assistance (FMA) Program</b>	Cost share grants for pre- disaster planning & projects	Annual pre-disaster grant program	MEMA	75% FEMA/ 25% non- federal
<b>Hazard Mitigation Grant Program (HMGP)</b>	Post-disaster Cost-Share Grants	Post disaster program	MEMA	75% FEMA/ 25% non- federal
<b>Pre-Disaster Mitigation Program</b>	National, competitive grant program for projects & planning	Annual, pre-disaster mitigation program	MEMA	75% FEMA/ 25% non- federal
<b>Severe Repetitive Loss</b>	For SRL structures insured under the NFIP.	Annual	MEMA	Authorized up to \$40 million for each fiscal year 2005 through 2009
<b>Assistance to Firefighters Grants (AFG)</b>	Training & equipment for wildfire-related hazards	Annual	FEMA	FEMA
<b>Small Business Administration (SBA) Mitigation Loans</b>	Pre- & Post- disaster loans to qualified applicants	Ongoing	MEMA	Small Business Administration
<b>Public Assistance</b>	Post-disaster aid to state & local governments	Post Disaster	MEMA	FEMA/ plus a non-federal share

For a list of additional potential funding sources, please refer to Table 17-7 on Pages 545-8 of the 2013 State Hazard Mitigation Plan:



<http://www.mass.gov/eopss/docs/mema/resources/plans/state-hazard-mitigation-plan/massachusetts-state-hazard-mitigation-plan.pdf>.

### ***State Funding Sources***

The Commonwealth of Massachusetts provides matching FEMA assistance. This means that, following Presidential disaster declarations, the state may contribute a portion of the 25% non-federal share for federal Infrastructure Support funds. Since 1991, the state has contributed nearly \$20 million to match FEMA's funding following declared Presidential disasters. Other State funding sources include the following:

### ***Special Appropriations and Legislative Earmarks***

Although there is no separate state disaster relief fund in Massachusetts, the state legislature may enact special appropriations for those communities sustaining damages following a natural disaster that are not large enough for a Presidential disaster declaration. Since 1991, Massachusetts has issued 20 major disaster declarations. Additionally, individual legislators may seek specific project funding for projects through the legislative budgeting and appropriations process.

### ***State Revolving Fund***

This statewide loan program through the Executive Office of Environmental Affairs assists communities in funding local stormwater management projects which help to minimize and/or eliminate flooding in poor drainage areas.

### ***Chapter 90 Funds***

This statewide program reimburses communities for roadway projects, such as resurfacing and related work and other work incidental to the above such as preliminary engineering including State Aid/Consultant Design Agreements, right-of-way acquisition, shoulders, side road approaches, landscaping and tree planting, roadside drainage, structures (including bridges), sidewalks, traffic control and service facilities, street lighting (excluding operating costs), and for such other purposes as the Department may specifically authorize. Maintaining and upgrading critical infrastructure and evacuation routes is an important component of hazard mitigation.

### ***MVP Program***

Launched in 2017, the Municipal Vulnerability Preparedness (MVP) program provides support for cities and towns to begin or to supplement the process of planning for resiliency. The state awards communities with funding to complete vulnerability assessments and to develop action-oriented resiliency plans, with a special emphasis on the impacts climate change. Communities will be able to define extreme weather and natural and climate related hazards, identify existing and future vulnerabilities and strengths, develop and prioritize actions for the community, and identify opportunities to take action to reduce risk and build resilience. MVP activities can easily be integrated with updates to the local hazard mitigation plan. More information is available online

here:[www.mass.gov/eea/air-water-climate-change/climate-change/massachusetts-global-warming-solutions-act/municipal-vulnerability-preparedness-program.html](http://www.mass.gov/eea/air-water-climate-change/climate-change/massachusetts-global-warming-solutions-act/municipal-vulnerability-preparedness-program.html)

### ***Community Development Block Grant (CDBG)***

CDBG remains the principal source of revenue for communities to use in identifying solutions to address physical, economic, and social deterioration in lower-income neighborhoods and communities. While primarily a housing and community development program administered through the Executive Office of Housing and Community Development (EOHCD), the program can also fund the rehabilitation of municipal buildings such as town halls, which in many cases, also serve as Emergency Operations Centers for their communities.

### ***State Land Acquisition & Conservation Program***

Through the Massachusetts Executive Office of Energy and Environmental Affairs, this annual program purchases private property for open space, wetland protection and floodplain preservation purposes. For instance, in 1998, the state set an ambitious goal of protecting 200,000 acres of open space in the Commonwealth by 2010. In August 2001, less than three years later, the state announced that the Commonwealth and its land protection partners had reached the halfway mark in achieving that goal - 100,000 acres. Updated information may be found on the website of the Executive Office of Energy and Environmental Affairs Open Space Protection program at: <https://www.mass.gov/orgs/executive-office-of-energy-and-environmental-affairs>

### ***Dams & Levees Program***

EEA funds projects for the repair and removal of dams, levees, seawalls, and other forms of inland and coastal flood control. In FY 2016, the maximum award for any one application was \$1,000,000 for dams and levees and \$3,000,000 for seawalls and other coastal foreshore protection. A minimum financial match of 25% of total funds requested is required. For additional information, please refer to <http://www.mass.gov/eea/waste-mgmt-recycling/water-resources/preserving-water-resources/water-laws-and-policies/water-laws/draft-regs-re-dam-and-sea-wall-repair-or-removal-fund.html>.

### ***Major Flood Control Projects***

The state provides half of the non-federal share of the costs of major flood control projects developed in conjunction with the U.S. Army Corps of Engineers. This program is managed by DCR.

### ***Flood Control Dams***

Natural Resource Conservation Service (NRCS), manages the Flood Control Dams Program, (PL566), which funds states in the operation and maintenance of the 25 PL566 flood control dams located on state property. This program also includes technical assistance and other smaller services from the NRCS and partners.

### ***Flood Hazard Management Program Staff Funding***

The state provides the 25% non-federal share for FEMA's funding under the Community Assistance Program - State Support Services Element (CAP-SSSE). CAP-SSSE funding, and the state match supports the Flood Hazard Management Program (FHMP) within the Department of Conservation and Recreation. The FHMP works with FEMA to coordinate the National Flood Insurance Program throughout Massachusetts, providing technical assistance to participating communities and professionals.

### ***MassWorks Infrastructure Program***

The MassWorks Infrastructure Program provides a one-stop shop for municipalities and other eligible public entities seeking public infrastructure funding to support economic development and job creation. Although not specific to natural hazards per se, these infrastructure enhancements under MassWorks could also address identified needs for hazard mitigation. The MassWorks Infrastructure Program is administered by the Executive Office of Housing and Economic Development, in cooperation with the Department of Transportation and Executive Office for Administration & Finance. Please refer to:

<http://www.mass.gov/hed/economic/eohed/pro/infrastructure/massworks/> for additional information.

### ***Weatherization Assistance Program***

The Weatherization Assistance Program is funded each year by the U.S. Department of Energy's Office of Energy Efficiency & Renewable. The extent of services to be provided depends on available funding. The program is intended to help low-income homeowners and renters lower their energy cost and reduce the potential impact from severe weather events. Weatherization service agencies throughout Massachusetts run the Weatherization Assistance Program. Please refer to <http://energy.gov/eere/wipo/weatherization-assistance-program> for additional information.

## **APPENDICES**

- A. Maps**
- B. Public Survey Results**
- C. Planning Team & Public Meetings**
- D. Glossary**
- E. 2012/2018 Priorities Comparison**