# Natural Hazards Mitigation Plan

## City of Melrose, Massachusetts

Draft

CDM Smith

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# Section 1

# Introduction

## 1.1 Goal and Purpose of the Natural Hazards Mitigation Plan

This Natural Hazards Mitigation Plan (NHMP) provides documentation of a natural hazard mitigation planning process to immediately integrate community-derived priorities and identify actions to reduce risk and build resilience in the City of Melrose. According to the Federal Emergency Management Agency (FEMA)[1], a NHMP enables communities to:

- Increase education and awareness around threats, hazards, and vulnerabilities;
- Build partnerships for risk reduction involving government, organizations, businesses, and the public;
- Identify long-term, broadly-supported strategies for risk reduction;
- Align risk reduction with other state, tribal, or community objectives;
- Identify implementation approaches that focus resources on the greatest risks and vulnerabilities; and
- Communicate priorities to potential sources of funding.

The goal of this NHMP is to identify both known and potential risks from current and future natural hazards and to develop, through the community planning process, actions to reduce the risk from these hazards. Each of these hazard mitigation actions is intended to either mitigate the susceptibility of the community to a natural hazard or to better prepare the City of Melrose to protect and manage the community in the occurrence of a natural hazard. Implementing these actions can reduce the risk of loss of life and property in Melrose by lessening the impact of natural hazards. Further, having an up-to-date NHMP approved by FEMA for the City of Melrose makes the City eligible for non-disaster funding and assistance from FEMA to implement actions outlined in this NHMP. All hazard mitigation actions are contingent on funding and those identified as responsible for implementing actions are also responsible for obtaining funding.

The NHMP process was led by the Melrose Department of Public Works and included input from community representatives, the public, and regional partners (**Section 2**). The 2017 Master Plan, "Melrose Forward" specifically recommended updating the NHMP; this plan fulfills that action item[2]. This NHMP will serve as the primary resilience planning document for the City of Melrose.

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[1] These benefits are directly from FEMA's Hazard Mitigation Planning website: https://www.fema.gov/hazard-mitigation-planning
[2] Melrose Forward: A Community Vision and Master Plan. 2017. Available at: https://www.cityofmelrose.org/sites/melrosema/files/uploads/executive_summary_to_melrose_forward.pdf

### 1.1.1 Role of the 2004 Natural Hazards Mitigation Plan

Melrose last developed a NHMP in 2004. Many of the natural hazard mitigation actions from the 2004 plan have been implemented and have resulted in a reduced risk of flooding in certain parts of Melrose. The findings and lessons learned from the 2004 plan have been incorporated into this plan, as appropriate. Details on the status of actions from the 2004 plan are summarized in **Section 5.1**.

### 1.1.2 Overlap and Integration of the Municipal Vulnerability Preparedness Program

Massachusetts Executive Office of Energy and Environmental Affairs (EEA) launched the Municipal Vulnerability Preparedness (MVP) grant program in 2016. This program provides grants to cities and towns in Massachusetts to begin planning for climate change and taking action to increase resiliency. The City of Melrose was awarded a $19,000 MVP planning grant from EEA to conduct Community Resilience Building (CRB) workshops in the City. Conducting the workshops allowed Melrose to achieve “MVP” designation from the Commonwealth – a designation that gives the City access to further funding to implement resilient actions.

The City capitalized on the opportunity to integrate both the MVP and NHMP planning processes into one resilience document. This follows the Commonwealth’s lead of including the impacts from climate change as natural hazards. In September 2018, Massachusetts adopted a first of its kind State Hazard Mitigation and Climate Adaptation Plan (SHMCAP).

## 1.2 Brief History of Melrose

Melrose was originally called “Ponde Fielde” because of the many ponds and streams located around the region. It was considered part of Charlestown until the mid-1600s. As the 18th century progressed, the small village, then known as the North End of Malden (North Malden), began to grow as a prosperous farming community. After the American Revolution in 1776, trades people, merchants, shoe makers, and innkeepers began to settle in the village. North Malden remained a thinly populated area, despite the established trade market that emerged in neighboring Boston.

In 1845 the Boston and Maine Railroad built a track through North Malden. Overnight, the quiet village of North Malden became populated by those who worked in Boston but wanted to escape the crowded metropolis of the big city for fresh air and open spaces. The population boomed when three railroad stations (Wyoming, Cedar Park, and Melrose Highlands) were constructed allowing an easier commute for residents to the city.

North Malden, upon reaching a condition of self-sufficiency in 1889, established itself as the City of Melrose. Parks and schools were constructed, police and fire services were instituted, and three distinct shopping districts allowed the residents in the city to rely on the goods and services provided exclusively by locals.

Today Melrose prospers with its ideal location between Boston and Route 128. The City is now more self-sufficient than ever by providing what is necessary to support its residents’ housing, education, health care, employment, shopping, entertainment, recreation, and leisure needs.

## 1.3 Environmental Setting

Melrose is an idyllic, small New England city located 7 miles north of Boston. The City is approximately 4.76 square miles of total land area with nearly 28,000 residents.

Main Street in the heart of downtown Melrose has a Victorian feel with buildings dating back to the mid to late 1800s. Ell Pond dominates the landscape in the center of the City with a gazebo, walking trails and scenic views. The Massachusetts Department of Housing and Community Development calls Melrose a "garden city" since trees line its streets, and parks and open space are spread out through and around the City. The "green belt" of surrounding communities, including the Middlesex Falls Reservation to the west, provides a natural buffer from more urban communities beyond.

The residential areas of Melrose are diverse in both architectural style and in the density of its population. Historic neighborhoods are located in the more urban areas near downtown, with newer development near the Mount Hood golf course.

Culture and recreation play a role in the everyday lives of the citizens of Melrose. The City is proud of its 100-year old Melrose Symphony Orchestra, while its many parks and open spaces provide residents a place to exercise, play, or relax with friends.

## 1.4 Changes in Development since the 2004 Natural Hazard Mitigation Plan

Since the development of the 2004 Plan, Melrose has been featured as the "hottest ZIP code" in the United States and one of the "Best Small Cities in America." Melrose continues to be a desirable place to live, with a strong economic base, a multitude of transportation options, and valued parks and open space for all to enjoy.

These are positive advances for the City that come with challenges such as limited housing inventory and keeping housing costs affordable. The City is falling short on the amount of subsidized housing available, according to the Commonwealth's standards. Melrose continues to look at options for increasing housing production and reducing barriers to creating new housing units.

The City has placed a priority on improving facilities and infrastructure in Melrose, implementing many of the action outlined in the 2004 NHMP and improving operational facilities management. Melrose Veterans Memorial Middle School, the Melrose High School, the Milano Senior Center, and other facilities have been rebuilt or upgraded to better standards. The details of this progress is detailed in **Section 5**. The City has been designated a Green Community by the Commonwealth, has substantially reduced energy use and related greenhouse gas emissions, and has saved on energy costs.

# Section 2

# The Planning Process

## 2.1 Community Team

The NHMP team was led by the Public Works Department, with input and guidance from the Office of Planning and Community Development and support from the Mayor's Office. A Community Team consisting of public officials, regional organizations, neighboring communities and residents were engaged throughout the planning process and provided a broad spectrum of local knowledge and experience to inform this NHMP for the City of Melrose. Details on the Community Team participants (and those who were invited) and the methods for soliciting and receiving input from them are provided in the following sections.

## 2.2 Process for Public Input and Feedback

The public planning process was led by the Melrose Department of Public Works and their consulting firm, CDM Smith. There were four primary methods by which the City received input:

1. MVP Workshops held in April 2018 with community representatives with additional assistance of the Planning Department;
2. NHMP Community Input and MVP Public Listening Session held on June 21, 2018 for the general public;
3. Regional Input meeting held on September 25, 2018 with regional partners; and
4. Public meeting held on March 11, 2019, including the release of a draft of this plan a week prior to this meeting.

Details of each of these processes are below. Through this series of workshops and meetings, the public gave input to this NHMP on natural hazards, areas of concern, vulnerabilities and strengths in Melrose, and plans for future mitigation activities and priorities. The methods of soliciting feedback are described further below and results of feedback received from these public planning activities can be found in **Appendix A**.

The City requested participation from community representatives and regional partners via direct emails. Public participation was encouraged through meeting notices posted on the City's website and Mayor Infurna's blog.

### 2.2.1 Municipal Vulnerability Preparedness Workshops

The MVP workshops' central objectives were to:

- Define top local natural and climate-related hazards of concern;
- Identify existing and future strengths and vulnerabilities;
- Develop prioritized actions for the community; and

- Identify immediate opportunities to collaboratively advance actions to increase resilience.

Participates were asked to complete a brief online survey, which focuses on how the community currently perceives, assesses, and acts to reduce risks to which informed the workshops (see **Appendix A**). The workshops were held on April 5 and 11, 2018 from 8:45am – 1:00pm at Mount Hood Golf Course in Melrose. The first workshop began with a large group discussion on the hazards that face the community that will be impacted by climate change. Smaller multi-disciplinary groups then prioritized the top four hazards, identified and prioritized the societal, infrastructure and environmental vulnerabilities impacted by the hazards. At the second workshop, hazard mitigation actions were developed to address the vulnerabilities. This information was captured in risk matrices for each small group. Hazard mitigation actions were prioritized by small working group and were presented to the larger group for comprehensive prioritization, determined by participant voting. The priorities set during this process reflect the importance of the hazard, vulnerability, and mitigation strategy to participant's organization and the magnitude of the impacts to the society, infrastructure, and environmental assets in Melrose. Qualitative magnitude of benefits and costs were considered in the final prioritization of mitigation strategies. This information was captured by meeting scribes and summarized in the MVP plan in **Appendix A**. The leadership and core team members for planning and facilitating the MVP process were:

- Gail Infurna, Mayor of Melrose
- Martha Grover, Energy Efficiency Manager / Table Facilitator
- Elena Proakis Ellis, City Engineer / Table Facilitator
- John Scenna, Director of Public Works
- Lauren Miller, Lead Facilitator / Consultant Team, CDM Smith
- Lauren Klonsky, Table Facilitator / Consultant Team, CDM Smith
- Workshop scribes: Scott Dixon (Department of Public Works), Amy Heidebrecht (Department of Public Works), Lori Massa (Office of Planning and Community Development)

Community representatives that were invited via email by Mayor Infurna and participated in the process are shown in **Table 2-1**.

**Table 2-1. MVP Workshop Community Representatives**

| Name | | Department/Organization | |
|---|---|---|---|
| Brigid | Alverson | Mayor's Office | * |
| David | Ball | Fire Department | * |
| Joan | Bell | Parks Superintendent | * |
| Jim | Bennett | Melrose Historical Commission | |
| Paul | Brodeur | State Representative | * |
| Dan | Cameron | National Grid | * |
| Chris | Cinella | Chamber of Commerce | * |
| Ruth | Clay | Health Director, Emergency Management Director | * |
| Ed | Collina | Fire Department, Incoming Fire Chief | |
| Paul | Cote | EMARC | |
| Eric | Devlin | Conservation Agent | * |
| Neal | Ellis | Information Technology Director | * |
| Denise | Gaffey | Office of Planning and Community Development Director | * |
| George | Harrington | Melrose Housing Authority | * |
| Faith | Hassell | National Grid | * |
| Andy | Henkenmeier | Hallmark Emergency Preparedness | * |
| Jim | Holt | Melrose Housing Authority | |
| Adam | LaFrance | Human Rights Commission | |
| Gary | LaMothe | Melrose Energy Commission, First Congregational Church | * |
| Stacy | Lanier | First Methodist Church | |
| Chris | Leary | Fire Department, Fire Chief | |
| Jason | Lewis | State Senator | |
| Mike | Lindstrom | Mayor's Office | * |
| Mike | Lyle | Police Chief | * |
| Donna | Macdonald | Riverside Community Care | * |
| Mike | Main | MEMA Regional Manager, region 1 | |
| Katie | Moore | Pedestrian and Bicycle Advisory Committee, Melrose Energy Commission, Resident | * |
| Ron | Morin | Friends of the Fells | |
| Susan | Murphy | Conservation Commission, Melrose Energy Commission | * |
| Dan | O'Leary | Mystic Valley Elder Services | |
| Judy | Santa Maria | EMARC, Director of Family Support | * |
| Dominic | Taranowski | First Congregational Church | |
| Cyndy | Taymore | Melrose Public Schools | |
| Lori | Timmermann | Melrose Energy Commission, First Congregational Church | * |
| Ann | Waitt | Department of Public Works | * |
| David | Young | Consulting Engineer, CDM Smith | * |
| Erin | Zwirko | Office of Planning and Community Development | |
| Verizon | | | |
| Comcast | | | |

Note: *indicates attendance at the CRB Workshops. Others were invited to the meetings.

The full report and findings, including the maps used, pre-workshop survey, climate projections, final Risk Matrix, and meeting materials, may be found in **Appendix A**. This report and other resilience planning information may also be found at: https://www.cityofmelrose.org/home/events/10693. The MVP process and MVP final report were used to inform this NHMP by identifying and prioritizing: 1) natural hazards in Melrose, 2) the vulnerability of societal, infrastructure, and environmental assets in Melrose, and 3) hazard mitigation strategies to address vulnerabilities; this information is included in **Sections 3, 4, and 6** of this NHMP.

## 2.2.2 NHMP Community Input and MVP Public Listening Session

The City of Melrose held a public forum called "Preparing for Extreme Weather Events: A Listening Session" on June 21, 2018 from 7:00pm – 8:45pm at the Melrose Middle School. The purpose of the meeting was to present the City's readiness to handle climate-related events and emergencies, to discuss how we can become more prepared, and to hear suggestions and feedback from the community on this important topic. The meeting was open to the entire community and served as both a forum for the community to provide input on the development of this NHMP and the required MVP "public listening session." A notice for this meeting was published on the City's events calendar prior to the meeting here: https://www.cityofmelrose.org/home/events/10693. Mayor Infurna posted the notice in her blog at: https://mayorinfurna.wordpress.com/2018/06/14/preparing-for-extreme-weather-events-a-listening-session-on-june-21/

Community feedback was received from participants through a facilitated discussion of the MVP process and findings. Participants were also given the opportunity to submit their feedback in writing on hazards and actions to reduce vulnerabilities. Hazard mitigation strategies were prioritized by participant voting. This information was captured by meeting scribes and summarized in the MVP plan (**Appendix A**). Additional vulnerabilities and hazard mitigation strategies that were identified at this meeting has been incorporated into this plan and included in **Section 6**. Meeting materials may be found in **Appendix A**, including an agenda, list of attendees, populated feedback questionnaires, and results of participant voting**.**

## 2.2.3 NHMP Regional Input

The City held a regional input meeting for this NHMP to provide an opportunity for local and neighboring community partners to give input to the process. The City gained insight on regionally-focused hazard mitigation strategies and opportunities that could improve the City's resilience. The meeting was held on September 25, 2018 from 1:00pm-3:00pm at the Soldiers and Sailors Memorial Hall in Melrose. Verbal input from the group discussion was captured from meeting participants in the form of meeting notes, which may be found in Appendix A. Input from the regional stakeholders was incorporated into this plan by considering additional vulnerabilities and hazard mitigation strategies identified by participants and included in **Sections 4 and 6** of this document. Meeting materials such as the meeting agenda, presentation, sign-in sheet, and meeting notes may also be found in **Appendix A**. Regional and community representatives that were invited via email to or participated in the regional input meeting are shown in **Table 2-2**.

**Table 2-2. Regional Input Representatives**

| Name | | Department/Organization | | |
|---|---|---|---|---|
| Manisha | Bewtra | Melrose | Board of Aldermen | * |
| Paul | Broder | State Representative | | * |
| Dan | Cameron | National Grid | | |
| Ruth | Clay | Melrose | Health Director / Emergency Management Director | |
| Edward | Collina | Melrose | Fire Department | * |
| Glenn | Cronin | Malden | Police / Emergency Management Director | |
| Joy | Duperault | DCR | State coordinating office for FEMA | |
| Denise | Gaffey | Melrose | Office of Planning and Community Development | * |
| Matt | Grafton | Stoneham | Department of Public Works | * |
| Bob | Grover | Stoneham | City Engineer, Department of Public Works | |
| Faith | Hassell | National Grid | | |
| Jim | Holt | Melrose | Housing Authority | |
| James | Hughes | Saugus | Fire Department | * |
| Robert | Knox | Malden | Department of Public Works | |
| Mike | Lyle | Melrose | Police Department | |
| Mikael | Main | MEMA | Region 1 | |
| Denise | Mason | Comcast | | |
| Lauren | Miller | CDM Smith | Consultant Team | * |
| James | Mulrenan | Melrose | Police Department | * |
| Brendan | O'Regan | Saugus | Department of Public Works | |
| Scott | Phelan | Saugus | Emergency Management | |
| Peter | Pietrantonio | Melrose | Operations Manager, Department of Public Works | |
| Elena | Proakis Ellis | Melrose | City Engineer, Department of Public Works | * |
| John | Ray | | Massachusetts Bay Transportation Authority | |
| John | Scenna | Melrose | Director, Department of Public Works | * |
| Rick | Stinson | Wakefield | Department of Public Works | |
| Stanley | Usovicz | Verizon | | * |
| Robert | Van Campen | Melrose | City Solicitor | |
| Ann | Waitt | Melrose | Department of Public Works | |
| Thomas | Walsh | Wakefield | Emergency Management | |
| Mikchael | Zwirko | Melrose | Board of Alderman | |

Note: *indicates attendance at the Regional Input Meeting. Others were invited to the meetings.

## 2.3 Continuing Public Outreach and Involvement

There was a public forum on March 11, 2019 at the Melrose High School Learning Commons; a draft of this NHMP was posted a week prior to this forum, to allow time for public review. Feedback received at the forum has been incorporated into the plan.

The City is committed to keeping the public engaged in the ongoing process of natural hazard mitigation to improve resilience in Melrose.

# Section 3

# Natural Hazard Risks

## 3.1 Introduction to Natural Hazards

A natural hazard is defined by the World Bank as a physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.[1] Natural hazards can include atmospheric, hydrologic, geologic, and wildfire events whose incidence or intensity humans have little to no control over. However, humans play an important role in the preparation and response to various natural hazards, resulting in the potential reduction of losses and harmful impacts to human life and/or the physical environment. This section considers the natural hazards identified in the 2013 Massachusetts HMP[2] and discusses their applicability to Melrose. It also presents FEMA disaster declarations in Middlesex County since 2001 in each hazard category. In addition, projected climate change impacts have been incorporated into the hazards considered herein, expanding upon the work that was conducted in spring 2018 as part of the City's MVP process.

### 3.1.1 Climate Change Interaction with Natural Hazards

Climate change continues to be a contributing factor to the frequency and intensity of the natural hazards described below, with the exception of earthquakes and major urban fires.[3] As part of the MVP process, the EEA summarized the existing and expected future climate conditions by major watershed in the Commonwealth. Melrose falls into two watersheds; however, the majority of the City is in the Boston Harbor Basin. Therefore, projections from this basin were used as a basis for discussing future climate change in the City. The key takeaways[4] from the EEA on the future climate conditions are:

- Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth.
- Average, maximum, and minimum temperatures are expected to increase; seasonally, maximum summer and fall temperatures are expected to see the highest projected increase and minimum winter and fall temperatures are expected to increase.

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[1] Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0
[2] This NHMP was developed at the same time as the 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP). Melrose used draft information from its development to inform this plan. It may be found at: https://www.mass.gov/files/documents/2018/10/26/SHMCAP-September2018-Full-Plan-web.pdf
[3] Dam failures are not directly related to climate change; however, changes in precipitation patterns or storm events may impact a dam's ability properly function.
[4] These impacts are taken directly from the document provided by EEA to MVP communities in December 2017 entitled "Massachusetts Climate Change Projections."

- The number of days receiving precipitation over one inch are variable, fluctuating between loss and gain of days.
- Seasonal projections for total precipitation are also variable for the Boston Harbor basin. The winter season is expected to experience the greatest change with an increase of 0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable.
- Precipitation will be more variable. “Extreme” precipitation events are likely to occur more often.

## 3.2 Natural Hazards in Melrose

This NHMP update focuses on natural hazards of concern as identified through a review of previous City of Melrose and Commonwealth of Massachusetts HMPs, as well as through information collected via the MVP and public comment processes conducted during plan development. The identified hazards of concern are flooding, severe weather, fire, earthquake, and invasive species. **Table 3-1** below lists these natural hazards, along with subsections describing the detail of each hazard of concern and the source of identification for inclusion in this NHMP.

**Table 3-1. Summary of Natural Hazards of Concern in Melrose, MA**

| Natural Hazard of Concern in Melrose | Natural Hazard Detail | 2013 Massachusetts HMP | MVP Workshops 4/2018 | Public Meeting 6/21/18 |
|---|---|---|---|---|
| Flooding | Flooding (including inland, riverine, and ice jam flooding) | X | X | X |
| | Dam Failure | X | | X |
| | Landslide | X | | X |
| Severe Weather | High Wind | X | X | X |
| | Thunderstorm | X | X[a] | X |
| | Tornado | X | X[a] | X |
| | Hurricane and Tropical Storm | X | X[a] | X |
| | Snow & Blizzard | X | X[a] | X |
| | Nor’easter | X | X[a] | X |
| | Ice Storm | X | X[a] | X |
| | Extreme Temperatures | X | X | X |
| | Drought | X | | X |
| Fire | Major Urban Fire | X | | X |
| | Wildfire | X | | X |
| Earthquake | | X | | X |
| Invasive Species | | X[b] | | X |

Notes: a) The MVP Workshops identified major storms as a hazard but did not break down information by the type of storm. b) Invasive Species was a hazard in the draft 2018 Massachusetts HMP, not the 2013 Massachusetts HMP, by which this NHMP update is required to follow.

Risk is defined by the World Bank as the potential for consequences where something is at stake and where the outcome is uncertain.[5] The 2013 Massachusetts HMP categorizes natural hazards by the frequency of occurrence, severity, and area of impact, to understand the magnitude of risk posed by these natural hazards to the Commonwealth. It is assumed that these are the same in Melrose as they are for the Commonwealth under current conditions. However, due to climate change, the frequency and the likely severity of natural hazards may be impacted. This is summarized in **Table 3-2**.

These are defined as follows[6]:

- Frequency of Occurrence:
  - Very low: Events that occur less often than once in 100 years (less than 1% probability per year)
  - Low: Events that occur from once in 50 years to once in 100 years (1% to 2% probability per year)
  - Medium: Events that occur from once in 5 years to once in 50 years (2% to 20% probability per year)
  - High: Events that occur more frequently than once in 5 years (greater than 20% probability per year)
- Severity (or Impact):
  - Minor: Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted, limited injuries or fatalities.
  - Serious: Scattered major property damage, some minor infrastructure damage, essential services are briefly interrupted, some injuries and/or fatalities.
  - Extensive: Widespread major property damage, major public infrastructure damage (up to several days for repairs), essential services are interrupted from several hours to several days, many injuries and/or fatalities.
  - Catastrophic: Property and public infrastructure destroyed, essential services stopped, numerous injuries and fatalities.
- Area of Impact (extent of impact on any locality for a particular event):
  - Minor: Limited and scattered property damage, limited damage to public infrastructure and essential services not interrupted, limited injuries or fatalities.

[5] Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0
[6] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts. Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf

- Isolated: A single whole or partial community impacted
- Local: One community to several communities impacted
- Regional: Many communities to a county impacted
- Widespread: Multiple counties impacted

**Table 3-2. Hazard Risk Assessment in Melrose, MA**

| Natural Hazard of Concern | Natural Hazard Detail | Frequency of Occurrence | | Severity or Impact | | | Area of Impact |
|---|---|---|---|---|---|---|---|
| | | Current Probability | Impacted by Climate Change? | Likely Level (Current) | Worst-Case | Impacted by Climate Change? | |
| Flooding | Flooding | High | Yes | Serious | Catastrophic | Yes | Regional |
| | Dam Failure | Very Low | No | Extensive | Catastrophic | No | Local |
| | Landslide | Low | Yes | Minor | Extensive | Yes | Local |
| Severe Weather | High Wind | High | Potential | Minor | Extensive | Potential | Regional |
| | Thunderstorm | High | Yes | Minor | Extensive | Yes | Regional |
| | Tornado | Medium | Potential | Serious | Extensive | Potential | Local |
| | Hurricane and Tropical Storm | Medium | Yes | Serious | Catastrophic | Yes | Widespread |
| | Snow & Blizzard | High | Yes | Minor | Extensive | Yes | Widespread |
| | Nor'easter | High | Yes | Minor | Extensive | Yes | Widespread |
| | Ice Storm | Medium | Yes | Minor | Extensive | Yes | Regional |
| | Extreme Temperatures | Medium | Yes | Serious | Extensive | Yes | Widespread |
| | Drought | Low | Yes | Minor | Serious | Yes | Widespread |
| Fire | Major Urban Fire | Low | No | Minor | Serious | No | Isolated |
| | Wildfire | Medium | Potential | Minor | Extensive | Potential | Local |
| Earthquake | | Very Low | No | Serious | Catastrophic | No | Regional |
| Invasive Species [a] | | Ongoing | Yes | Serious | n/a | Yes | Widespread |

Note: a) Invasive Species was a hazard in the draft 2018 Massachusetts SHMCAP. The frequency is categorized in that plan as "ongoing" as invasive species do not occur at specific moments. The severity and area of impact were assigned to the best extent possible.

## 3.2.1 Flooding

Flooding, the overflow of large volumes of water beyond the usual boundaries, can be caused by various factors. The City of Melrose is most likely to experience floods related to inland riverine overflows, urban drainage issues, and infrastructure or ground failures. Severe weather largely coincides with significant flood events within the City of Melrose and surrounding areas. Heavy rainstorms, nor'easters, tropical storms, and hurricanes have the potential to cause overbank flooding or flash floods.

Areas most susceptible to flooding include riverine corridors and urban areas with natural and structural characteristics that reduce soil infiltration rates and increase surface runoff during significant precipitation events. Steep stream banks and urban drainage systems increase runoff rates and channel stormwater to area rivers and streams, resulting in the potential for flooding to occur more quickly and reach greater depths.[7] Finally, large rain events and the resulting inflow and infiltration into the sanitary sewer system have the potential to cause sanitary sewer overflows (SSOs) and sewer pump station failures.

The extent of the 100-year flood, 500-year flood, and other flood hazard areas are identified and discussed further in Sections 4 and 5 and on Figure 5-1.

#### 3.2.1.1 Dam Failure

Flooding can also be caused by significant structural catastrophes such as dam failure. A dam is a constructed barrier intended to obstruct or control the flow of water. Dam failures can be caused by a number of natural and non-natural factors including dam capacity exceedance, material or structural failure, foundation movement or cracking of concrete or embankment, piping or erosion issues, inadequate operation and maintenance, and/or deliberate acts of sabotage. Earthquakes, landslides, extreme storms, and massive snowmelt may also contribute to the occurrence of dam failures.[8]

There are two dam systems in Stoneham near the border of Melrose managed by the Massachusetts Water Resources Authority that pose a potential hazard to the City - Fells Reservoir Dams and the Spot Pond Dam. The Fells Reservoir Dams are considered high hazard and significant hazard dams by MWRA with 63 million gallons of storage. These classifications do not reflect the dam condition, rather the proximity to residents. The Spot Dams, considered as a significant hazard class by MWRA are earthen embankment with 2,500 million gallons of storage. If these dams were to fail, million gallons of water could inundate the and cause significant flood damage to City of Melrose.[9]

#### 3.2.1.2 Landslide

A landslide occurs when there is any type of ground movement along a steep gradient caused by falling rocks or increased driving forces. The cohesive strength of soils making up a steep slope can become unstable and fail for various reasons. The most common cause of landslide occurrences is the oversaturation of soils from precipitation and water level changes (groundwater or surface water). Flooding, for example, can result in the oversaturation of soils and raise groundwater and surface water levels in a short period of time. Water saturation along a steep gradient would add weight to the slope while pore pressure increases, resulting in the decreased strength of earth materials ultimately causing slope failure. Additional factors that may cause a landslide include undercutting due to high surface flows, construction related causes,

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[7] 2004 City of Melrose Natural Hazards Mitigation Plan, Section 2
[8] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts. Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf
[9] Massachusetts Water Resources Authority, Presentation to WSCAC Status of MWRA Water Systems Dams, 5/16/17.

earthquakes, or other adverse geologic conditions. This may occur throughout the City, however the Commonwealth categorizes this as a low probability and low impact hazard.

## 3.2.2 Severe Weather

Severe weather includes any critical or dangerous meteorological event that may potentially cause significant losses to public or private property, the environment, or human life. Some severe weather events may also result in flooding, as described in the previous section. Defined below are the severe weather events of concern for the City of Melrose.

### 3.2.2.1 High Wind

The National Weather Service (NWS)[10] defines high winds as sustained surface winds of 40 miles per hour (mph) or greater for at least one hour, or wind gusts of 58 mph or greater for any duration of time. The most common high wind impacts include surface damage to natural and manmade structures including downed trees and power lines and damaged roofs, windows, and siding. Power outages may occur during high wind events, especially after prolonged dry periods or periods of excessive rainfall as tree root systems are weakened and the occurrence of downed trees damaging power lines becomes more prominent.

High winds are generally a component of several other types of weather events including tornadoes, severe thunderstorms, hurricanes, tropical storms, and nor'easters. Historical occurrences of these other types of weather events associated with high winds are listed in **Section 3.4**.

### 3.2.2.2 Thunderstorm

Thunderstorms are rain- or hail-bearing storms that produce lightning and thunder. Thunderstorms are generally more common in spring and summer months as warmer temperatures allow for convection of hot air (the transfer of hot air to higher atmospheres). The moisture from rising hot air begins to cool at higher elevations in the atmosphere resulting in cloud development. As those clouds continue to rise and eventually reach below freezing conditions, water molecules continue to cool or freeze creating rain or hail. Interactions between cooled water molecules produce the electricity that forms lightning.[11]

Severe thunderstorms are defined by the NWS as any storm causing 58 mph winds or greater, a storm producing hail at least 1-inch in diameter, or a tornado-producing storm.[12] Heavy rainfall and high winds produced by a severe thunderstorm have the potential to cause flooding and high wind damages as discussed in sections 3.2.1 and 3.2.2.1.

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[10] National Weather Service Advisory Definitions. Website accessed on 08/13/2018; https://www.weather.gov/lwx/WarningsDefined

[11] NOAAs national Severe Storms Laboratory Severe Weather 101. Website accessed on 08/13/2018; https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

[12] National Weather Service Advisory Definitions. Website accessed on 08/13/2018; https://www.weather.gov/lwx/WarningsDefined

**Table 3-3** lists the occurrence of severe thunderstorms between 2004 and 2018 along with the resulting impacts on the Melrose area according to the NOAA storm events database.[13]

**Table 3-3. Severe Thunderstorm Events impacting Melrose between 2004-2018**

| Date | Event | Impacted Area | Description |
|---|---|---|---|
| May 13, 2006 ("Mother's Day Storm") | Thunderstorm (heavy rainfall, flooding) | Middlesex County | Widespread flooding caused by heavy rainfall over a 100-hour period. Governor declared a State of Emergency during time of event, and the President declared major disaster status for those affected. For some locations, this was the worst flooding recorded since the 1938 Hurricane and the great rain/snowmelt floods of 1936. A total of 8 to 12 inches of rainfall accumulated during this storm event. Property damages throughout the County were estimated to reach approximately $5M due to damages from this storm. |
| June 23, 2012 | Thunderstorm (damaging winds, large hail) | Melrose | An upper level disturbance and associated cold pool provided enough lift and instability to produce showers and sustained thunderstorms in the Melrose area. |
| October 25, 2017 | Thunderstorm (heavy rain, high wind, flooding) | Melrose | Storm front stalled over the region producing 2 to 6.5 inches of rainfall within 24 hours. Storm caused strong winds with speeds reaching 45-55 mph and widespread urban and poor drainage flooding. Most notable flooding in Melrose occurred at the intersection of Larchmont Road and Porter Street. |

### 3.2.2.3 Tornado

Tornadoes are considered the most violent of all atmospheric storms that have the potential to cause catastrophic damage in localized areas without significant warning. Tornadoes are formed if the following components are present[14]:

- Strong winds in the mid to upper levels of the atmosphere
- Clockwise turning of wind, visible from the dust and debris caught in the rotation
- Increasing wind speeds in the lowest 10,000 feet of the atmosphere
- Warm, moist air near the ground surface with unusually cool air above the surface
- A forcing mechanism such as a cold front or leftover weather boundary from a previous severe weather event

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[13] National Oceanic and Atmospheric Administration, Storm Events Database. Accessed on 09/05/2018; https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=25%2CMASSACHUSETTS
[14] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf

The Enhanced Fujita Tornado Scale (EF Scale) is used by the NWS to assign a tornado severity rating based on the damage caused on the ground and the associated estimated wind speeds. When tornado-related damage is surveyed, it is compared to a list of damage indicators (DIs) and degrees of damage (DoD) which help estimate the range of wind speeds the tornado likely produced. This is done for several structures, then a final rating from EF0 to EF5 is assigned. **Tables 3-4** and **3-5** list the EF Scale wind speeds and damage indicators.[15]

**Table 3-4. Enhanced Fujita Scale[16]**

| EF Number | 3-second gusts (mph) |
|---|---|
| 0 | 65-85 |
| 1 | 86-110 |
| 2 | 111-135 |
| 3 | 136-165 |
| 4 | 166-200 |
| 5 | 200+ |

**Table 3-5. Enhanced Fujita Scale Damage Indicators[17]**

| No. | Damage Indicator | No. | Damage Indicator |
|---|---|---|---|
| 1 | Small barns, frames outbuildings | 15 | School – 1 story elementary (interior or exterior halls) |
| 2 | One or two-family residences | 16 | School – junior or senior high school |
| 3 | Single-wide mobile home | 17 | Low-rise (1-4 story) building |
| 4 | Double-wide mobile home | 18 | Mid-rise (5-20 story) building |
| 5 | Apt, Condo, townhouse (3 stories or less) | 19 | High-rise (over 20 stories) |
| 6 | Motel | 20 | Institutional bldg. (hospital, govt. or university) |
| 7 | Masonry Apt or motel | 21 | Metal building system |
| 8 | Small retail building (fast food) | 22 | Service station canopy |
| 9 | Small professional (doctor office, bank) | 23 | Warehouse (tilt-up walls or heavy timber) |
| 10 | Strip mall | 24 | Transmission line tower |
| 11 | Large shopping mall | 25 | Free-standing tower |
| 12 | Large, isolated (big box) retail building | 26 | Free standing pole (light, flag, luminary) |
| 13 | Automobile showroom | 27 | Tree – hardwood |
| 14 | Automobile service building | 28 | Tree – softwood |

The threat for tornado development and touchdown in the City of Melrose is very low according to NOAA's storm event database.[18] Middlesex County has encountered a total of 18 tornadoes since 1950 with varying levels of intensity. None of the historically recorded tornadoes impacted the Melrose area.

[15] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf

[16] NOAA Storm Prediction Center Website. Accessed 09/12/2018. https://www.spc.noaa.gov/faq/tornado/ef-scale.html

[17] NOAA Storm Prediction Center Website. Accessed 09/12/2018. https://www.spc.noaa.gov/faq/tornado/ef-scale.html

[18] National Oceanic and Atmospheric Administration, Storm Events Database. Accessed on 09/05/2018; https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=25%2CMASSACHUSETTS

### 3.2.2.4 Tropical Storm and Hurricane

Tropical storms are defined as numerous thunderstorms with a low-pressure, warm center that produce strong winds and heavy rains, but at lower wind-speeds than a hurricane. Tropical storms are generally formed in tropical coastal areas where water evaporated from the ocean saturates the air, resulting in condensation of water vapor and the formation of tropical storm clouds. Both tropical storms and hurricanes have a cyclonic nature resulting from the Coriolis force, with counterclockwise wind flow in the Northern Hemisphere and clockwise wind flow in the Southern Hemisphere. The size of a tropical storm or cyclone is measured by the distance from its center of circulation to its outermost isobar and can range from very small (138 miles) to very large (552 miles).[19]

The greatest threats associated with tropical storms are impacts from heavy rainfall and flooding, as well as the potential for tornado formation and power outages. High winds are not as big of a threat but can still cause damage to a lesser degree. Generally, tropical storms lose strength as they move inland further from the ocean, which provides the primary source of energy for the storm. However, storm surges caused by tropical storms along the coastline can potentially reach up to 25 miles inland, putting the City of Melrose at risk.

Hurricanes are similar to tropical storms in their formation and movement patterns, however a hurricane has the potential to be much more powerful and damaging than a tropical storm due to higher wind speeds and the greater likelihood of flooding from storm surges and heavy rainfall. Hurricanes begin as tropical storms and are categorized as a hurricane once wind speeds reach a sustained speed of 74 mph or greater.[20] The Saffir-Simpson scale, shown in **Table 3-6**, ranks hurricanes on a scale of 1 to 5 based on wind speed.

**Table 3-6. Saffir-Simpson Hurricane Scale[21]**

| Category | Wind Speed (mph) | Potential Damage |
|---|---|---|
| 1 | 74 – 95 | Minimal: Damage is primarily to vegetation, mobile homes, and some signs. No real damage is done to larger structures. |
| 2 | 96 – 110 | Moderate: Some downed trees, damaged roof coverings, and major damage to mobile homes |
| 3 | 111 – 130 | Extensive: Large downed trees, some structural damage to roofs, destroyed mobile homes, and structural damage to small homes and utilities |
| 4 | 131 – 155 | Extreme: Extensive damage to roofs, windows, and doors, roof systems on small buildings completely fail, and some failed curtain walls |
| 5 | 155 + | Catastrophic: Considerable and widespread roof damage, severe damage to windows and doors, extensive glass failures, and potential for entire buildings to fail |

[19] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf
[20] National Weather Service Advisory Definitions. Website accessed on 08/13/2018; https://www.weather.gov/lwx/WarningsDefined
[21] NOAA National Hurricane Center Website. Accessed 09/12/2018; https://www.nhc.noaa.gov/aboutsshws.php

Tropical storms and hurricanes that develop in the Cape Verde Islands or in the Bahamas have the potential to reach coastal New England and impact the City of Melrose, which is near the coast of the Atlantic Ocean; Mount Hood Golf Course is located only 0.75 miles from Rumney Marsh Reservation and less than three miles from Revere Beach. Isolated tornadoes are also a threat during a hurricane as powerful funnel clouds can form along the outer bands of the hurricane as much as 15 hours prior to the landfall of the hurricane itself. Hurricane season for the City of Melrose and the New England region is from June to November; however, most hurricanes on record in the area have occurred between August and October.[22]

### 3.2.2.5 Snow and Blizzard

Snow is a form of frozen precipitation that requires atmospheric temperatures to be below freezing from the ground surface to the cloud level. A total of approximately ten inches of snow is equivalent to one inch of rain depending on the snow-liquid ratio of the snow. Snow storms producing sustained winds of 35 mph or greater with only a quarter-mile of visibility for at least 3 hours are considered blizzards.[23] Severe blizzards produce winds upwards of 45 mph at or below 10° F.[24] High winds during a severe blizzard blow falling snow or accumulated snow from the ground surface enough to reduce visibility to near zero. Hazards associated with snow storms and blizzards include potential flooding from snowmelt, dangerous travel conditions, and cold stress. The City of Melrose receives approximately 48 to 72 inches of snow annually.[25] According to NOAA, there have been 93 days with either blizzards, heavy snow, winter storms, or winter weather conditions between 2005 and the 2017-2018 winter season in Middlesex County.[26]

### 3.2.2.6 Nor'easter

Nor'easters are damaging and forceful winter storms that generally occur between October and May. A nor'easter is characterized as a large, counter-clockwise cyclonic storm with strong northeasterly winds ranging from 20 to 60 mph. These winter storms produce significant amounts of snow and/or rain with the potential for wind gusts exceeding hurricane force intensity. Nor'easter storms tend to remain stationary for several days and have historically occurred more frequently than hurricanes, intensifying the potential risks and impacts caused by heavy precipitation and high winds.[27] Powerful nor'easters could cause billions of dollars in damages along with severe economic, transportation, and human disruption from flooding, blocked roads, and unsafe travel conditions. Nor'easters progress in a northeastward direction

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[22] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf

[23] National Weather Service, Advisory Definitions. Website accessed on 8/13/18 https://www.weather.gov/lwx/WarningsDefined

[24] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf

[25] 2004 City of Melrose Hazard Mitigation Plan, Section 2

[26] National Oceanic and Atmospheric Administration, National Centers for Environmental Information. Website accessed on 9/17/18 https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=25%2CMASSACHUSETTS#

[27] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf

and typically attain maximum intensity near New England, putting the City of Melrose at risk of encountering multiple strong, damaging storms each year.[28]

### 3.2.2.7 Ice Storm

An ice storm is defined by the NWS as any storm accumulating a quarter-inch or more of ice due to freezing liquid rainfall forming ice sheets on cold objects.[29] Ice sheet formation on the ground surface poses dangerous road and walkway conditions. Additionally, trees and power lines may be pulled down due to the excess weight of ice accumulation. Freezing precipitation could also be in the form of sleet or ice pellets. Ice pellets are formed when a snowflake melts as it passes through warmer atmospheric air and then refreezes into ice as it approaches colder temperatures near the ground.[30] Table 3-7 includes information about the only ice storm on record in Middlesex County between 2004 and 2018 according to the NOAA storm events database.[31]

**Table 3-7. Ice storm events in Middlesex County between 2004 and 2018**

| Date | Event | Impacted Area | Description |
|---|---|---|---|
| December 11, 2008 | Ice Storm | Western and Northwest Middlesex County | Three quarters of an inch of ice accumulated on exposed surfaces across western and northwest Middlesex County. The hardest hit areas were the Monadnock region, Worcester Hills, and the east slopes of the Berkshires. Downed trees, power lines, and large limbs were common throughout the County due to ice accumulation, blocking many roads. One indirect death was reported due to extended outdoor exposure. |

### 3.2.2.8 Extreme Temperatures

Extreme temperatures are defined based on relative climatic averages for specific geographic locations. Temperatures that fall far outside the normal average ranges for a specific area would be considered a temperature extreme. **Table 3-8** shows average seasonal high and low temperatures for the City of Melrose.[32]

**Table 3-8. Average High and Low Temperatures in Melrose, MA**

| Season | Average Temperatures (high/low) |
|---|---|
| Spring (Mar-May) | 58°F / 36°F |
| Summer (Jun-Aug) | 80°F / 59°F |
| Fall (Sep-Nov) | 62°F / 41°F |
| Winter (Dec-Feb) | 38°F / 19°F |

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[28] National Weather Service, What is a Nor'easter? Website accessed on 08/14/2018 https://www.weather.gov/safety/winter-noreaster
[29] National Weather Service, Advisory Definitions. Website accessed on 8/13/18 https://www.weather.gov/lwx/WarningsDefined
[30] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf
[31] NOAA Storm Events Database accessed on 11/05/2018; https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=25%2CMASSACHUSETTS
[32] NOAA Climate Website accessed on 8/14/18 https://www.climate.gov/maps-data/data-snapshots/averagetemp-monthly-cmb-2018-06-00?theme=Temperature

Generally, temperatures equal to or greater than 90°F for 3 consecutive days in the New England region are considered extreme heat events. Heat advisories are administered by the NWS when the Heat Index is forecast to reach 100-104°F.[33]

Winter storms have the potential to develop extreme cold temperatures. Power outages from severe winter storm events put people at greater risk of developing cold stress related illnesses due to limited or inadequate indoor heating. For the City of Melrose and surrounding region, temperatures reaching 0°F or below are considered extreme cold temperatures. Table 3-9 lists the extreme temperature events on record for Middlesex County between 2004 and 2018 according to the NOAA storm events database.[34]

**Table 3-9. Extreme temperature events in Middlesex County between 2004-2018.**

| Date | Event | Impacted Area | Description |
|---|---|---|---|
| July 6-7, 2010 | Extreme Heat | Western Middlesex County | Temperatures nearing 100 degrees Fahrenheit with high humidity occurring in western Middlesex County. Heat index values ranged from 100 to 106 degrees Fahrenheit. |
| July 5, 2013 | Extreme Heat | Southeast Middlesex County | A long period of very hot and humid weather occurred across the region between July 3 and July 7, 2013. One heat related death was reported July 6 in Medford. Temperatures in the area had climbed above 90 degrees Fahrenheit for the third consecutive day on July 5. |
| February 15-16, 2015 | Extreme Cold/Wind Chill | Western, Northwest, and Southeast Middlesex County | Heavy snow, blizzard conditions, and coastal flooding occurred throughout areas of Middlesex County. Nearly 60 inches of snow accumulated in approximately three weeks causing significant transportation delays and closures through March of 2015. Roof collapses were a common occurrence due to heavy snow accumulation in both rural and urban areas. A fallen icicle ruptured a gas line in Duxbury, causing an explosion at an Alzheimer's care facility. Wind chills of 30 to 31 degrees below zero were reported throughout the area. A total of three deaths were reported from indirect causes. |
| February 14, 2016 | Extreme Cold/Wind Chill | Western Middlesex County | Arctic high pressure brought strong northwest winds and extremely cold wind chills to the area. Many locations reported wind chills between 25 and 35 degrees below zero. |

[33] National Weather Service, Heat Index. Website accessed on 08/14/18 https://www.weather.gov/safety/heat-index
[34] NOAA Storm Events Database website accessed 11/05/2018; https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=25%2CMASSACHUSETTS

### 3.2.2.9 Drought

Drought is defined as an extended period with below normal precipitation rates leading to dry conditions and the potential for water supply shortages. Impacts related to drought can affect potable water supply, as well as the agricultural sector and portions of the natural environment including aquatic ecosystems, wildlife, and plant life. Impacts can be far reaching and include wildfires and economic impacts related to reduced crop yields triggering increased prices for goods and services.

**Table 3-10** presents historical drought data for Middlesex County since 2004.

**Table 3-10. Historical Drought Conditions from 2004 to 2018 in Melrose, MA[35]**

| Date | Drought Designation | Description |
|---|---|---|
| Spring 2012 | Severe Drought (D2) | The U.S. Drought Monitor declared severe drought (D2) over southeastern Middlesex County from April 12 through May 15. This was deemed a meteorological drought due to precipitation levels approximately one half of normal. |
| Summer 2016 | Severe Drought (D2)<br>Extreme Drought (D3) | Severe drought designated for Middlesex County in July 2016. Continued dry conditions through the month of August extended the drought designation through the summer. The U.S. Drought Monitor continued the Severe Drought (D2) designation in southeastern Middlesex County through August 16th. It was upgraded to an Extreme Drought (D3) designation at that time, which continued through the end of August. |
| Fall 2016 | Extreme Drought (D3) | The U.S. Drought Monitor continued the Extreme Drought (D3) designation in southeastern Middlesex County from September - November. |
| Winter 2016-2017 | Extreme Drought (D3) Severe Drought (D2) Moderate Drought (D1) | The U.S. Drought Monitor continued the Extreme Drought (D3) designation in southeastern Middlesex County through December. Increased moisture levels lowered the designation to a Severe Drought (D2) by January. The U.S. Drought Monitor continued the Severe Drought (D2) designation in Southeast Middlesex County until January 24, when it was reduced to the Moderate Drought (D1) designation. |

While Melrose is susceptible to the impacts of drought conditions, the City's potable water supply is provided by the Massachusetts Water Resources Authority (MWRA), which can generally provide adequate water supply during drought conditions to a greater degree than non-MWRA communities in the region.

[35] National Oceanic and Atmospheric Administration, Storm Events Database. Accessed on 09/05/2018; https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=25%2CMASSACHUSETTS

## 3.2.3 Fire

There are two different types of fire events that may adversely impact the City of Melrose, 1) major urban fires, and 2) wildfires. Both types of fires are discussed in greater detail below.

### 3.2.3.1 Major Urban Fire

Major urban fires are defined as any type of large, uncontrollable fire that occurs in an urban area and causes significant destruction. The cause of major urban fires is more often related to other hazards such as storms, earthquakes, gas leaks, car accidents, hazardous material spills, terrorism, or criminal activity.[36] Smaller urban fires are generally related to cooking, smoking, or equipment/appliance malfunctions. The greatest risk related to any type of urban fire is the proximity to human life and the high cost of damage mitigation to the communities affected by the fire.

There have been recent examples of major urban fires in communities near Melrose over the past several years, although none within Melrose City limits. One of which was related the gas explosions in the Merrimack Valley in September 2018. This event led to extensive damage, 21 people transported to the hospital, and one death in Lawrence, North Andover, and Andover, Massachusetts; the event required mutual aid from surrounding municipalities and state[37].

### 3.2.3.2 Wildfire

Wildfires include fires that occur in undeveloped, vegetated or forested areas and are caused by natural events or by human activity. Wildfires generally begin small and unnoticed due to their rural location, but have the potential to spread quickly, especially during dry, high wind conditions. Wildfires are classified into three different categories[38]:

- Surface fire: Most common type that burns along the forest floor and moves slowly killing or damaging all trees it comes into contact with
- Ground fire: Usually occurs during drought conditions and burns the organic materials on the forest floor
- Crown fire: Spreads rapidly due to high winds causing flames to jump along treetops.

Wildfire season in the City of Melrose and surrounding areas is during the drier, spring and summer months. Snowpack levels and local weather conditions including droughts have a significant impact on the likelihood and intensity of wildfires in the area, though there have been no wildfires in Middlesex County since 2004.

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[36] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf
[37] National Transportation Safety Board, Preliminary Report Pipeline. Website Accessed on 10/30/18; https://www.ntsb.gov/investigations/AccidentReports/Pages/PLD18MR003-preliminary-report.aspx
[38] 2013 State Hazard Mitigation Plan, Commonwealth of Massachusetts Website Accessed on 10/2/18; https://www.mass.gov/files/documents/2017/01/mp/massachusetts-state-hazard-mitigation-plan.pdf

### 3.2.4 Earthquake

Earthquakes occur when tectonic plates on the earth's outer crust develop faults or fractures and slide against or into each other resulting in the movement and vibration of the earth's surface. Earthquakes can range from mild to very violent and destructive events that have the potential to cause significant structural damage and failure. Earthquake activity in the ocean may cause large waves or tsunamis that have the potential to flood adjacent coastal areas. Additionally, soft soils may intensify structural damage caused by inland earthquakes and increase the potential losses resulting from a strong quake. According to the US Geological Survey website, there have been two magnitude 2.5 earthquakes according the Richter Scale (see **Table 3-11**) in the state of Massachusetts since 2004, neither of which impacted the City of Melrose.[39] The Richter scale measures the strength of earthquakes based on the waves recorded by seismographs. A magnitude 2.5 earthquake is considered minor because they do not result in damage to buildings even if they are felt by people.

**Table 3-11. Richter Scale for Earthquake Magnitude[40]**

| Magnitude | Description |
|---|---|
| 1.0 - 3.0 | Not felt except by a very few under especially favorable conditions. |
| 3.0 - 3.9 | Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated. |
| 4.0 - 4.9 | Felt indoors by many during the day. At night, some or many are awakened. Dishes, windows, doors disturbed or broken; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. Unstable objects overturned. Pendulum clocks may stop. |
| 5.0 - 5.9 | Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. |
| 6.0 - 6.9 | Ranges in damage. May be negligible or slight in buildings of good design and construction; slight to moderate in well-built ordinary structures; great damage in poorly built or badly designed structures; some chimneys, factory stacks, columns, and monuments may be damaged for fall. Heavy furniture overturned. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. |
| 7.0 and higher | Damage ranges from slight to total collapse depending on the design of the building. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. Lines of sight and level may be distorted. Objects thrown into the air. |

[39] USGS Earthquake Hazards Program Website. Accessed 09/13/2018; https://earthquake.usgs.gov/earthquakes/search/

[40] USGS Earthquake Hazards Program Website. Magnitude and Intensity Comparison. Accessed 02/06/2019; https://earthquake.usgs.gov/learn/topics/mag_vs_int.php

### 3.2.5 Invasive Species

The draft 2018 SHMCAP identifies invasive species as a natural hazard for the first time.[41]- The City has chosen to include this natural hazard in the evaluation as it is a hazard of concern in Melrose. These effects may be City-wide, potentially covering all 3,036 acres of land.

The NOAA defines invasive species as any organism that can cause ecological or economic harm in a new environment where it is not native.[42] Invasive species are generally spread unintentionally through accidental transport on water vessels or on the clothing, shoes, or luggage of traveling individuals. Occasionally, invasive species are introduced intentionally for garden landscaping purposes or through disposal of unwanted aquatic pets in local waterways. Invasive plant, animal, or aquatic species have the potential to outcompete native organisms for nourishment and/or shelter, potentially causing significant ecosystem changes and reduced biodiversity. Invasive plant species from the list included in the SHMCAP have the potential to be found in the City of Melrose today and in the future. **Table 3-12** lists the SHMCAP invasive species that have the potential to impact the Melrose area according to the City's Conservation Commission Agent.

**Table 3-12. Invasive Species of Concern in Melrose, MA**

| Species Name | Common Name | Species Type | Current Concern | Future Concern |
|---|---|---|---|---|
| *Acer platanoides* | Norway maple | Tree | X | |
| *Adelges tsugae* | Hemlock woolly adelgid | Insect | | X |
| Agrilus planipennis | Emerald Ash Borer | Insect | | X |
| *Ailanthus altissima* | Tree of heaven | Tree | X | |
| *Alliaria petiolata* | Garlic mustard | Herb | X | |
| *Anoplophora glabripennis* | Asian long-horned beetle | Insect | | X |
| *Berberis thunbergii* | Japanese barberry | Shrub | X | |
| *Cabomba caroliniana* | Carolina fanwort; fanwort | Herb | X | |
| *Celastrus orbiculatus* | Oriental bittersweet; Asian or Asiatic bittersweet | Vine | X | |
| *Cynanchum louiseae* | Black swallow-wort; Louise's swallow-wort | Vine | X | |
| *Dreissena polymorpha* | Zebra mussel | Mollusk | | X |
| *Elaeagnus umbellata* | Autumn olive | Shrub | X | |
| *Frangula alnus* | European buckthorn, glossy buckthorn | Shrub | X | |
| *Lonicera x bella [morrowii x tatarica]* | Bell's honeysuckle | Shrub | X | |
| *Lymantria dispar* | Gypsy moth | Insect | | X |
| *Lysimachia nummularia* | Creeping jenny, moneywort | Herb | X | |

[41] 2018 Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan, Commonwealth of Massachusetts. Accessed 10/1/18; https://www.mass.gov/files/documents/2018/09/17/SHMCAP-September2018-Chapter4.pdf

[42] NOAA National Ocean Service Website accessed on 08/14/18 https://oceanservice.noaa.gov/facts/invasive.html

| Species Name | Common Name | Species Type | Current Concern | Future Concern |
|---|---|---|---|---|
| *Lythrum salicaria* | Purple loosestrife | Herb | X | |
| *Myriophyllum heterophyllum* | Variable water-milfoil; two leaved water-milfoil | Herb | X | |
| *Myriophyllum spicatum* | Eurasian or European watermilfoil; spike water- milfoil | Herb | X | |
| Operophtera brumata | Winter Moth | Insect | X | |
| *Phragmites australis* | Common reed | Grass | X | |
| *Polygonum cuspidatum / Fallopia japonica* | Japanese knotweed; Japanese or Mexican bamboo | Shrub | X | |
| *Polygonum perfoliatum* | Mile-a-minute vine or weed; Asiatic tearthumb | Vine | | X |
| *Potamogeton crispus* | Crisped pondweed, curly pondweed | Herb | | X |
| *Rhamnus cathartica* | Common buckthorn | Shrub | X | |
| *Robinia pseudoacacia* | Black locust | Tree | X | |
| *Rosa multiflora* | Multiflora rose | Vine/Shrub | X | |
| *Trapa natans* | Water chestnut | Herb | X | |

## 3.3 Omitted Hazards

The following hazards are not being evaluated further in this NHMP document, as they have been determined to not pose a significant threat to the City of Melrose.

### 3.3.1 Tsunami

A tsunami is a giant wave resulting from an earthquake or volcanic eruption in the ocean. The waves become larger as they approach landfall, potentially causing significant flooding and destruction to coastal areas. Extreme tsunami events could reach up to 10 miles inland depending on the shape and slope of the shoreline, as well as the elevation changes as you move further inland.

The probability of Melrose being impacted by a tsunami is very low. The City's distance from the coastline and fact that open space is the nearest point to the ocean (Mount Hood Golf course) provides a means of defense against the initial destructive impact of a tsunami wave. If Melrose were to be impacted, flooding would be minimal and could be addressed using the same mitigation strategies as for other flooding events.

### 3.3.2 Coastal Hazards

Coastal hazards include erosion and sea-level rise. High energy storms and flooding along the coast present a risk for land erosion over time depending on the intensity and frequency of storms. Additionally, climate change impacts will ultimately lead to changes in sea-levels, making coastal areas the most susceptible to inundation. However, the City of Melrose is 0.75 miles from Rumney Marsh Reservation and over two miles from the Revere Beach coastline, therefore any impacts from such hazards are not of great concern.

# 3.4 Recent Disaster Declarations

The City of Melrose and the surrounding communities of Middlesex County have experienced 23 FEMA-declared disaster events since 1991 from natural hazard events. Each event has caused significant damages to the affected communities and some events resulted in fatalities. A disaster declaration occurs when the Governor of the affected state requests federal assistance because a severe event exceeds the response capabilities and resources of the local and state governments. A preliminary damage assessment (PDA) is completed by jurisdictional officials to estimate the magnitude of the impact the disaster caused upon communities. The PDA provides supporting documentation that federal assistance is necessary for a specific event. **Table 3-13** identifies all declared disasters in Middlesex County since 1991. The table includes additional incident information such as the type of event, the duration, and a brief description. The majority of incidents impact multiple counties and states, and therefore the incident dates account for the entire time interval the disaster event occurs (not only the time it impacted Middlesex County).[43]

**Table 3-13 FEMA-Declared Disaster Events for Middlesex County (1991-2018)**

| Incident Type | Incident Dates | Incident Description | FEMA Disaster Number | FEMA Date Declared |
|---|---|---|---|---|
| Nor'easter | March 13, 2018 to March 14, 2018 | The third nor'easter to hit Massachusetts in a three-week timeframe, which produced up to two feet of snow. | 4379 | 7/19/2018 |
| Winter Storm | January 26, 2015 to January 28, 2015 | Winter storm Juno produced up to three feet of snow and set a record for total accumulation in areas of Massachusetts. | 4214 | 4/13/2015 |
| Winter Storm | February 8, 2013 to February 9, 2013 | Winter storm Nemo produced up to two feet of snow in areas of Massachusetts. Over 405,000 people were without power in Massachusetts due to the storm. | 4110 | 4/19/2013 |
| Hurricane | October 27, 2012 to November 8, 2012 | Damages caused by Hurricane Sandy amounted to $20.8M in Massachusetts. Hurricane Sandy produced wind gusts of 83mph and over 385,000 people were without power in Massachusetts. | 3350 | 10/28/2012 |
| Nor'easter | October 29, 2011 to October 30, 2011 | The Halloween nor'easter took the lives of six people in Massachusetts. Over 420,000 people lost power and 32 inches of snowfall impacted areas of Massachusetts. | 4051 | 1/6/2012 |
| | | | 3343 | 11/1/2011 |
| Hurricane Flooding | August 26, 2011 to September 5, 2011 | Hurricane Irene produced high winds and heavy rainfall, which caused significant flooding throughout Middlesex County. Over 400,000 people were without power in Massachusetts due to Hurricane Irene. | 3330 | 8/26/2011 |
| Blizzard | January 11, 2011 to January 12, 2011 | The North American Blizzard produced up to two feet of snow in areas of Massachusetts. | 1959 | 3/7/2011 |

[43] FEMA Disasters Website. Accessed on 9/10/2018; https://www.fema.gov/disasters.

| Incident Type | Incident Dates | Incident Description | FEMA Disaster Number | FEMA Date Declared |
|---|---|---|---|---|
| Hurricane | September 1, 2010 to September 4, 2010 | Hurricane Earl took one life in Massachusetts and produced $20,000 in damages. | 3315 | 9/2/2010 |
| Flooding | March 12, 2010 to April 26, 2010 | The St. Patrick's Day storm produced up to 10 inches of rain, along with melting snow, and caused severe flooding throughout Middlesex County and Massachusetts for weeks. | 1895 | 3/29/2010 |
| Winter Storm | December 11, 2008 to December 18, 2008 | Massachusetts experienced a severe ice storm that left up to one million people without power. | 1813 | 1/5/2009 |
| | | | 3296 | 12/13/2008 |
| Flooding | May 12, 2006 to May 23, 2006 | The Mother's Day storm produced enough rain to set historic rainfall and streamflow records in Middlesex County. | 1642 | 5/25/2006 |
| Flooding | October 7, 2005 to October 16, 2005 | A flooding event that caused $6.5M in damages across Massachusetts. | 1614 | 11/10/2005 |
| Winter Storm | January 22, 2005 to January 23, 2005 | A severe snow storm that produced 36 inches of snowfall in Melrose. | 3201 | 2/17/2005 |
| Flooding | April 1, 2004 to April 30, 2004 | Middlesex County experienced widespread flooding, which caused over $2M in damages across Massachusetts. | 1512 | 4/21/2004 |
| Winter Storm | December 6, 2003 to December 7, 2003 | A severe snow storm that produced over 30 inches of snow in areas of Massachusetts. | 3191 | 1/15/2004 |
| Winter Storm | February 17, 2003 to February 18, 2003 | The President's Day storm produced near record snowfall in Middlesex County, warranting the declaration of emergency assistance. | 3175 | 3/11/2003 |
| Severe Storms Flooding | March 5, 2001 to April 16, 2001 | Severe storms and flooding across Massachusetts caused over $6M in damages. | 1364 | 4/10/2001 |
| Heavy Rain Flooding | June 13, 1998 to July 6, 1998 | A severe storm produced over 10 inches of rain across eastern Massachusetts, which caused nearly $5M in flood damage. | 1224 | 6/23/1998 |
| Severe Storms Flooding | October 20, 1996 to October 25, 1996 | A severe storm produced over 10 inches of rain and caused flooding across eastern Massachusetts. | 1142 | 10/25/1996 |
| | | | 3119 | 10/23/1996 |
| Blizzard | January 7, 1996 to January 13, 1996 | The blizzard of 1996 produced 10 to 20 inches of snow across Massachusetts. | 1090 | 1/24/1996 |
| Blizzard | March 13, 1993 to March 17, 1993 | The blizzard produced high winds carrying snow and sleet across Massachusetts, with an accumulation of 12 inches. | 3103 | 3/16/1993 |
| Nor'easter | December 11, 1992 to | The nor'easter produced up to 27 inches of snow and a three-foot storm surge. | 975 | 12/21/1992 |

| Incident Type | Incident Dates | Incident Description | FEMA Disaster Number | FEMA Date Declared |
|---|---|---|---|---|
| | December 13, 1992 | | | |
| Hurricane | August 19,1991 | Hurricane Bob claimed the life of one person in Massachusetts and caused over $1B in damage. | 914 | 8/26/1991 |

Note: Incidents containing multiple disaster numbers and declarations received a disaster declaration and an emergency declaration, which made them eligible for different funding sources and are a method for FEMA to track different types of events.

# Section 4

# Vulnerability Assessment

## 4.1 Vulnerability Assessment Overview

Conducting a vulnerability assessment enables Melrose to preemptively identify how natural hazards may impact the City and take appropriate actions to reduce the severity of the impact. A qualitative vulnerability assessment for the purposes of this plan evaluated the natural hazard categories of flooding, severe weather, fire, earthquake, and invasive species in terms of the impacts to infrastructure, societal, and environmental assets to remain consistent with the MVP process. The assessment considers the exposure and sensitivity of an asset to the natural hazards to determine the vulnerability. The World Bank[1] defines these terms as:

- Exposure: The presence of people, livelihoods, infrastructure, species or ecosystems, environmental services and resources, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- Sensitivity: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- Vulnerability: The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

The feedback from the MVP workshops, the June 21, 2018 public meeting, and the September 25, 2018 regional stakeholder meeting have been incorporated into the findings in the Vulnerability Assessment in **Appendix B.** The findings are summarized below for each asset category by natural hazard, discussing the highest priority hazards first, then other hazard types. In addition, this section presents the results of a risk model used to evaluate vulnerability and also describes areas of Melrose that have been historically subject to multiple loss claims.

## 4.2 Priority Vulnerabilities in Melrose

Flooding and severe weather have been identified as priority hazards in Melrose through the public input process outlined in **Section 2**. The City has faced these hazards in the past like other Massachusetts communities, including flooding from the Mother's Day storm in 2006, overwhelming snowfall totals during the winter of 2015, and most recently impacts from the nor'easter events in January and March 2018. During the second of three March 2018 storms, Melrose City Hall lost power, which disabled the phone lines to emergency responders. These are examples of specific vulnerabilities that have already been caused by flooding and severe weather in Melrose.

[1] Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

The vulnerabilities these natural hazards cause to society, infrastructure, and the environment are summarized below; in many cases, the impacts are similar for fires and earthquakes as noted. The full details may be found in the Vulnerability Assessment in **Appendix B.**

### 4.2.1 Societal Vulnerability due to Flooding and Severe Weather

The following is a summary of the societal asset vulnerabilities in Melrose due to flooding and severe weather:

- **Emergency Management Planning**: The City of Melrose maintains emergency response and evacuation plans that emergency response personnel follow in the event of a natural disaster. Outdated emergency and evacuation plans that do not take into account increased frequency and intensity of climate change related natural disasters pose a risk to public health and safety.

- **Senior / Aging Population**: The senior/aging populations may have impaired mobility, diminished sensory awareness, chronic illness, and/or other social and economic limitations that make them particularly vulnerable to natural hazards. Power outages resulting from flood, severe weather, or earthquake events could cause inadequate indoor heating or air conditioning (A/C) as well as potential loss of important medical technologies and life-support equipment.  Loss of communication with public safety personnel during emergency events also presents immediate danger to the senior/aging population, whether they are in their own homes or in senior housing. Maintaining power and communication with emergency personnel, as well as providing access to emergency relief resources such as food, water, medical supplies, and transportation to nearby shelters or hospitals are important components of keeping senior populations safe during an emergency.

- **Chronically Ill / Disabled Population**: Chronically ill and disabled populations are particularly vulnerable to flooding and severe weather events as limited mobility, diminished sensory awareness, and/or reliance on medical equipment hinders their ability to seek shelter and stay safe during a natural disaster. This would include, but not be limited to, the mentally ill, pregnant women, and the physically disabled. Power outages resulting from natural disasters could cause inadequate indoor heating or A/C as well as the potential loss of important medical technologies and life-support equipment.

- **Non-English Speaking Population:** The inability to communicate or understand relevant emergency response or health and safety information puts the non-English speaking population at greater risk of life threatening circumstances during a natural hazard event.

- **Low-Income Population:** Low-income populations in Melrose face additional challenges in the event of a natural disaster. Low-income housing is generally less able to withstand disaster and may incur more damage than standard, newer homes, particularly during flood, severe weather, or earthquake events. Lower-income populations may also lack access to personal transportation and communications and may not have adequate access to healthcare.  In addition, low-income populations may be less able to purchase and replace damaged goods and property and resupply food. In addition to the details outlined in Section 4.2.1, during extreme temperature events, low-income populations may be unable to afford the cost of heating or cooling their homes.

- **Faith Based Organizations**: Faith based organizations play an important societal role in Melrose, including in the event of a natural disaster. They have the potential to provide shelter and a safe refuge away from the chaos and destruction of natural hazard events. Due to the important role faith based organizations play in post-disaster relief, ensuring accessibility and maintaining power and communication at such facilities is very important.

- **Pet Owners:** During an emergency that requires evacuation from one's home, pet owners may be reluctant to leave if they cannot take their pets with them. Many shelters cannot accommodate pets and kennel capacity may be limited (or impacted by the same event that requires evacuation). People's reluctance to leave their pets may increase their vulnerability to acute events.

## 4.2.2 Infrastructure Vulnerability due to Flooding and Severe Weather

The following is a summary of the infrastructure asset vulnerabilities in Melrose due to flooding and severe weather:

- **Transportation Infrastructure:** Natural disasters such as floods, severe weather events, and earthquakes make transportation services and public transit systems vulnerable to damages and potential service delays or shut downs. Transportation infrastructure, including public transit systems, play an important role in pre and post disaster mitigation by providing evacuation route services to vulnerable populations before a disaster hits, by distributing emergency relief resources (food, supplies, medical personnel), and by safely mobilizing vulnerable populations to local shelters or hospitals post disaster. Roadways and parking lots throughout the City of Melrose are primarily vulnerable to flood or snow related road closures that would present emergency response and accessibility issues. Blocked roadways that prevent access to evacuation routes or that block routes to hospitals, utility infrastructure, and emergency response facilities are of greatest concern. Roadways and parking lots that are particularly vulnerable to flooding include Lebanon St at Sylvan St, Derby Road, the rail bridge at Melrose St., the City Hall parking lot, Grove St, and Geneva Road at Upham Street.

- **Residential and Commercial Properties**: Residential and commercial properties throughout the City of Melrose are vulnerable to severe weather, floods, fire, and earthquake events. Properties that fall within flood prone areas are particularly vulnerable.

- **Fire and Police Stations**: The fire and police stations in Melrose currently have a lack of back-up power. Engines 2 and 3 do not have generators leaving these critical facilities vulnerable to power outages and communication losses during a severe storm, flood, or earthquake event. Police officers and firefighters offer important first response and rescue operations during an emergency. Power outages and loss of communication with such personnel could inhibit appropriate and timely response to those in need during a natural hazard event.

- **City Hall:** Melrose City Hall serves as the hub for the City's communications systems and has historically been home to the City's Emergency Management Command Center. The server room in the Information Technology Department at City Hall contains equipment that runs the City's phone systems for the Police and Fire Departments, along with the phones in City Hall and at most of the Melrose Public School buildings. Loss of communication with public safety personnel during emergency events presents immediate danger to public safety. Maintaining power at City Hall is of critical importance; it currently is particularly vulnerable due to the potential for power outages during flooding and severe weather events.

- **Emergency Shelters:** Melrose Middle School and Memorial Hall serve as the City of Melrose's designated emergency shelter locations. Both buildings are particularly vulnerable to severe weather (especially extreme heat) and flood. Melrose Middle School is located in a flood prone area, and both emergency shelter locations are in urban areas that experience elevated surface temperatures. Access to adequate emergency relief supplies as well as controlled indoor temperatures and working communication systems at emergency shelters are critically important to public health and safety. Increased temperatures make access to adequate A/C at these shelter locations important.

- **Schools / Child Care Facilities:** Schools and child care facilities are vulnerable to impacts associated with flooding, severe weather, earthquakes, or fire. Melrose High School and Melrose Middle School are at greater risk due to their being within the Ell Pond floodplain. Additionally, several schools including Melrose Middle School, Melrose High School, Lincoln Elementary School, Beebe School, and the Melrose Early Childhood Center are located in areas where elevated surface temperatures occur due to the heat island effect making access to adequate A/C more important. Maintaining communication with emergency personnel during a natural disaster is of critical importance for schools and child care facilities. In addition, Melrose schools are part of METCO, which allows children from Boston to attend Melrose Public Schools. Therefore, a disruption to the schools impacts children both in Melrose and regionally.

- **Melrose-Wakefield Hospital**: The Melrose-Wakefield Hospital (MWH) is the only hospital facility in the City of Melrose. Centrally located, the hospital may be vulnerable to impacts from floods, severe weather, fire, and earthquakes. Power loss is the greatest risk to MWH associated with these natural hazards. Flooded roadways throughout the City and region have the potential to block transportation routes to the hospital as well.

- **Pharmacies:** The availability of life saving medications and prescription drugs for vulnerable populations becomes of critical importance during a natural hazard event. In extreme circumstances, a severe storm, flood, fire, or earthquake could prevent the import of important medications to the local pharmacies in Melrose.

- **Gas Infrastructure:** Gas transmission systems are primarily vulnerable to floods, severe weather and earthquake events. Significant flooding in areas with underground gas lines may lead to gas transmission system failures due to increased hydrostatic pressure. Erosion from severe storms or flood events may even expose buried gas lines leaving them vulnerable to damages from flowing debris and disruption of supporting materials.

- **Electrical / Power Infrastructure**: Power lines and electrical substations are particularly vulnerable to floods, severe weather, earthquakes, and fire. High wind from severe storms and ground movement from earthquakes could cause downed power lines while extreme heat or drought conditions increase the likelihood of wildfires that may impact power lines or electrical substations. Electrical services for Melrose are provided by National Grid.

- **Fuel Sources:** Preparation for and mitigation of natural disasters are largely dependent on access to sufficient fuel sources, such as gasoline and diesel. Public preparedness for natural hazards such as severe storms and floods includes the acquisition and storage of propane, gasoline, or diesel for transportation vehicles in case there are long-term power outages.

- **Food Sources:** Preparation and mitigation of natural disasters are largely dependent on access to sufficient food sources. This would include grocery stores, community gardens, or partnerships with regional farms. Public preparedness for natural hazards such as severe storms and floods includes the acquisition and storage of non-perishable food and water in case there are long-term power outages.

- **Communications Infrastructure:** Properly working communication and information technology systems are of fundamental importance during an emergency event. Failure of these systems during a flood, severe weather event, or earthquake presents an immediate threat to public safety. Melrose relies on the City of Melrose IT Department, as well as Verizon and Comcast, to maintain communication pathways and IT systems during a natural hazard event.

- **Sewer Pumping Stations**: Sewer pumping stations are facilities that pump wastewater from low lying areas to higher elevations and eventually to the wastewater treatment plant where the water is treated before being discharged back into the environment. The five sewer pumping stations in the City of Melrose are at risk of power loss during flooding, severe weather, or earthquake events. Lift stations on Union Street by the middle school and high school and on the Lynn Fells Parkway in a residential area, are located in or near a 1% annual chance flood prone area and are at greater risk of failure due to flooding. The consequences of failure at the two larger lift stations (on the Lynn Fells Parkway and Upham Street) are of particular concern. Power loss and flooding of sewer pumping stations could cause significant sewer system outages and lead to sewer line backups and spills in localized areas that could pose a potential health and safety hazard to the public and the environment. The cost of cleanup and repair of sewer system pumping stations could be substantial.

- **Water Pumping Stations**: Melrose has two water booster stations to serve the "high service" neighborhoods. Both stations are in the good repair and have emergency back-up pumps in the event of failure of the main pumps or a need for additional pressure during a fire or other high water use event. These stations are critical facilities to fight fires in the high service neighborhoods.

- **Water and Sewer Pipelines**: Massachusetts Water Resources Authority (MWRA) provides drinking water and sanitary sewer services for the City of Melrose; water and sewer pipelines are owned and maintained by both the MWRA (transmission lines and interceptors) and the City (local water and sewer mains). Loss of clean drinking water and functioning sewer systems presents a significant danger to public health and the environment. Areas at greater risk of failure during a severe storm or flooding event include sanitary sewer overflows off Melrose Street next to Melrose High School, as well as off Grove Street, Tremont Street, Sylvan Street, and Melrose Towers.

- **Stormwater Drainage Infrastructure**: Stormwater drainage issues have the potential to cause significant flooding and damage to impacted areas. Debris from a storm event could clog storm drains and cause water to back-up with no place to drain. Furthermore, downstream drainage channels, both covered and open channels, must be kept clean in order to pass the large volumes of water resulting during storm events. Areas of concern include Geneva Road at Upham Street as well as the outfall and related upstream piping at Wyoming Cemetery.

### 4.2.3 Environmental Vulnerability due to Flooding and Severe Weather

The following is a summary of the environmental asset vulnerability in Melrose due to flooding and severe weather; note that air quality is only impacted by severe weather (extreme hot temperatures) and not by flooding:

- **Water Bodies: Lakes/Rivers/Reservoirs**: Water-bodies such as lakes, rivers, and reservoirs act as mechanisms of storm flow transmission and storage during flood or severe weather events. Drainage systems and flood management measures are designed to convey stormwater runoff to area waterways or floodplains. These measures help to minimize the potential for flooding in more populated areas that could cause significant structural damage or pose a risk to public safety. However, due to the stress imposed on water bodies from rapid flow increases or physical forces in the event of a severe storm, flood, or earthquake, erosion, landslides, and dam failures could be potential consequences. Drainage issues may result in the blockage and back-up of stormwater flows that may ultimately impact nearby communities or structures. Specific areas of concern in Melrose include areas around Ell Pond, the DCR property at the downstream end of Ell Pond Brook, outlet structures at Swains Pond, and the connection between Towners Pond and Swains Pond. Additionally, if either the High Service Reservoir Earthen Dam or the Spot Pond Dam in the Town of Stoneham were to fail, approximately 60 million gallons of water would rush into the City of Melrose. Finally, extreme temperatures may adversely impact the natural habitat of native aquatic organisms.

- **Parks/Natural Areas/Open Space**: Potential damages to parks and natural areas incurred from floods and severe storms could include downed trees, destroyed natural habitat, and diminished aesthetics. Extreme heat and periods of extended drought may also leave parks and natural areas more susceptible to fire and may adversely affect plant life. Invasive species also present a threat to native vegetation and wildlife. The primary parks in the City of Melrose include Melrose Common, Pine Banks Park, Conant Park, the Middlesex Fells Reservation, and the Mount Hood Golf Course. In addition, there are many acres of conservation land, with smaller neighborhood areas in the northern half of the City and more widespread conservation land in the southern half. Lastly, the City-owned Wyoming Cemetery is a significant open space asset in the community.

- **Tree Canopy:** Tree canopy is a measure of how much of the land surface is covered by tree leaves. Tree canopy is an important component of both urban and natural areas that provide shade, habitat, and aesthetic quality. Increased tree canopy also provides proven human health benefits such as improved cardiovascular, respiratory, and mental health. The tree canopy is vulnerable to all types of natural hazards - severe storms, floods, fires, and earthquakes - which may result in damaged and downed trees. Increasing the tree canopy also helps mitigate extreme heat impacts on natural habitats and reduces the heat island effect in urban areas.

- **Wildlife:** Damage to parks and natural areas from floods, severe weather, earthquakes, or fires, could harm or displace native wildlife populations. Changes in wildlife populations could cause shifts in ecosystem structure and diminish biodiversity.

- **Air Quality:** Temperature increases result in poor air quality which can impact public health and safety. On hot days, the level of air pollutants increases, making it difficult for vulnerable populations such as children, the elderly, and those with respiratory illnesses to spend time outdoors.

# 4.3 Additional Vulnerabilities in Melrose

As discussed in previous sections, fire, earthquake, and invasive species have varying degrees of likelihood of occurrence and impact in Melrose, however are included in this plan for completeness. Many of the vulnerabilities caused by these natural hazards are similar or the same as for flooding and severe weather. The impacts of these natural hazards on infrastructure, society, and the environment are summarized below. The full details may be found in the Vulnerability Assessment in **Appendix B.**

## 4.3.1 Vulnerability due to Fire

A unique society vulnerability for fire relates to the **Senior / Aging** and **Chronically Ill / Disabled** populations in Melrose. They are particularly vulnerable to fire as limited mobility, diminished sensory awareness, and/or reliance on medical equipment hinders their ability to evacuate and stay safe during a natural disaster. Societal vulnerabilities for **Emergency Management Planning**, **Non-English Speaking Population**, **Low-Income Population, Faith Based Organizations,** and **Pet Owners** are the same as outlined in Section 4.2.1.

**Fire and Police Stations** in Melrose have a unique infrastructure vulnerability in addition to the details outlined in Section 4.2.2; if these facilities are impacted by fire, it impacts the ability for emergency personnel in Melrose to respond to people's needs during fire events in the City. Infrastructure vulnerabilities for **Residential and Commercial Properties, City Hall**, **Emergency Shelters, Schools/Child Care Facilities, Melrose-Wakefield Hospital**, **Pharmacies**, **Fuel Sources**, and **Communications Infrastructure** are the same as outlined in Section 4.2.2.

For environmental vulnerabilities, **Air Quality** is adversely impacted by wildfire, which may be exacerbated due to extreme heat and drought conditions, in addition to the details outlined in Section 4.2.3. Environmental vulnerabilities for **Parks/Natural Areas/Open Space, Tree Canopy,** and **Wildlife** are the same as outlined in Section 4.2.3, with the added concerns of destruction of natural resources and the associated lengthy recovery due to fires.

### 4.3.2 Vulnerability due to Earthquake

As with the societal vulnerabilities to fire, unique vulnerabilities for earthquakes relate to the **Senior/Aging** and **Chronically Ill/Disabled** populations in Melrose. They are particularly vulnerable due to limited mobility, diminished sensory awareness, and/or reliance on medical equipment that hinders their ability to evacuate and stay safe during a natural disaster. Societal vulnerabilities for **Emergency Management Planning**, **Non-English Speaking Population**, **Low-Income Population, Faith Based Organizations,** and **Pet Owners** are the same as outlined in Section 4.2.1.

Earthquakes have the potential to cause wide-scale **Gas Infrastructure** and **Electrical/Power Infrastructure** failure in addition to the details outlined in Section 4.2.2. Infrastructure vulnerabilities to earthquakes for **Transportation Infrastructure, Residential and Commercial Properties**, **City Hall**, **Emergency Shelters, Schools/Child Care Facilities, Melrose-Wakefield Hospital**, **Pharmacies**, **Fuel Sources**, **Communications Infrastructure,** Sewer **Pumping Stations,** and **Water and Sewer Pipelines** are the same as outlined in Section 4.2.2.

Environmental vulnerabilities to earthquakes for **Water Bodies: Lakes/Rivers/Reservoirs, Tree Canopy,** and **Wildlife** are the similar to those outlined in Section 4.2.3.

### 4.3.3 Vulnerability due to Invasive Species

The following is a summary of the societal, infrastructure, and environmental vulnerabilities in Melrose due to invasive species:

- **Senior/Aging Population**: The senior/aging populations are particularly susceptible to vector borne diseases making mosquito control an important preparation and mitigation measure as new and different species of mosquitos carrying disease migrate to the region. The Milano Senior Center and non-profit organizations like Mystic Valley Elder Services are the primary entities that house and assist at risk senior populations in Melrose.

- **Food Sources:** Some invasive species may impact locally grown produce at community and home gardens or regional farms.

- **Water Bodies: Lakes/Rivers/Reservoirs**: The occurrence of invasive species and extreme temperatures may adversely impact the natural habitat of native aquatic organisms. Invasive plants, aquatic species, and animals could outcompete native organisms for food and/or shelter resulting in potential shifts in ecosystem structure and diminished biodiversity. Invasive insects such as some mosquito species may potentially spread disease. The ecosystems of the City's ponds, including Ell Pond, Swains Pond, Towners Pond, and the ponds at the Mount Hood Golf Course would be of particular concern.

- **Parks/Natural Areas/Open Space**: Invasive species also present a threat to native vegetation and wildlife. Invasive plants and animals could outcompete native organisms for food and/or shelter resulting in potential shifts in ecosystem structure and diminished biodiversity. Invasive insects such as some mosquito species may potentially spread disease.

- **Tree Canopy:** As described above, the tree canopy is important in Melrose as it provides shade, habitat, aesthetic quality, and improved air quality and human health. Invasive species could potentially impact the health and density of native tree species.

- **Wildlife:** Damage to parks and natural areas from invasive species could harm or displace native wildlife populations. Changes in wildlife populations could cause shifts in ecosystem structure and diminish biodiversity.

## 4.4 Impacts due to Disease

Disease is a secondary effect resulting from other natural hazards discussed in this plan and is not considered a natural hazard itself. However, because the interplay between natural hazards and disease was an area of concern at the MVP workshops and during the June 21, 2018 public meeting and has impacts on the people that live and work in Melrose, it is summarized below.

### 4.4.1 Flooding and Disease

Flood waters can transport harmful and hazardous materials that have the potential to cause human health issues. Specifically, floods in urban areas may be contaminated with high levels of harmful pathogens or chemical compounds originating from sewer overflows or nearby wastewater or industrial facilities. Exposure to such contaminants could cause short term gastrointestinal illness or other health concerns. Standing water and moist conditions following a flood event also have the potential to attract disease bearing insects like mosquitos. Mosquitos are vectors for the spread of diseases like H1N1, Zika, and other infectious diseases.

### 4.4.2 Extreme Temperatures and Disease

Extreme heat has the potential to cause heat stress related illnesses including heat rash, heat cramps, heat exhaustion, or heat stroke. Workers exposed to extreme heat are at the greatest risk for heat related illness, as well as other high-risk groups like the elderly or young children. Additionally, high heat conditions adversely impact air quality by increasing ground-level ozone, or “smog” levels. Hydrocarbon and nitrogen oxide pollution from things like vehicles and power plants combine with sunlight and heat resulting in elevated levels of air pollution on hot, sunny days. High smog levels can impact the elderly, infants, or individuals with existing respiratory illnesses like asthma and limit the amount of time they can safely stay outdoors. Additionally, changes in atmospheric conditions may favor the proliferation of particular disease-causing pathogens or, as noted above, vectors which carry these pathogens.

The potential to develop a cold stress related illness like frostbite is measured based on wind chill temperatures using the Wind Chill Temperature Index, which is shown in **Table 4-1**.

**Table 4-1 Wind Chill Temperature Index and Frostbite Risk[2]**

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

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

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

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

*Effective 11/01/01*

## 4.4.3 Fire and Disease

Smoke and air pollution resulting from urban or wildfires could pose a health risk to sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. Firefighters and first responders would also be at a greater risk when on the site of a fire. Smoke from wildfires contains emissions that include soot, tar, water vapor, minerals, carbon monoxide, carbon dioxide, nitrogen oxide, formaldehyde, and benzene – all of which can have harmful health impacts if inhaled.

## 4.4.4 Other Disease Vulnerabilities

Another disease risk from natural hazards is in the aftermath of a major natural disaster, when populations may not have access to clean, safe drinking water, proper nourishment, and hygienic living conditions. All types of natural hazards that may result in the need for emergency shelter use or that may impact the continued provision basic infrastructure services must be considered in relation to their potential to result in the spread of disease, especially to more vulnerable populations. Access to healthcare facilities, personnel, and medications may also be impeded during and after a major hazard event.

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[2] NWS Wind Chill/Temperature Index. Website accessed 08/14/18 https://www.weather.gov/oun/safety-winter-windchill

# 4.5 Loss Estimates

Part of the vulnerability assessment presented herein is evaluating the potential monetary losses that may result from natural hazards. Identifying and understanding the potential losses allow Melrose to further evaluate and prioritize where hazard mitigation projects may be of most use. For this plan, the losses were evaluated for flooding, hurricanes (wind damage), and earthquakes using a HAZUS model, as well as reviewing historical multiple loss properties in Melrose due to flooding.

## 4.5.1 HAZUS Methodology, Data Inputs, Assumptions, and Results

Hazards United States (HAZUS) is a natural hazard analysis tool developed by FEMA and the National Institute of Building Science (NIBS). The software package uses geographic information system (GIS) technology to calculate loss estimates and risk assessments. HAZUS estimates the cost of physical damage to buildings and contents due to floods, hurricanes, earthquakes, and tsunamis. High-risk locations due to these natural hazards are identified and geographically represented for users to visualize the spatial relationships between populations and other fixed geographic assets or resources. The results generated by HAZUS are used by federal, state, regional and local governments and private enterprises to help communities make informed resource expenditure decisions related to disaster mitigation and preparedness.

There are two analysis scenarios in HAZUS for hazard events: 1) probabilistic analysis or 2) deterministic analysis. The probabilistic analysis estimates average annual losses based on the probability of multiple events occurring during specific time periods; this means the loss estimate can be higher or lower in a given year. It also evaluates the statistical likelihood that a given event will occur. Since this plan incorporates the effects of climate change - which impact the probability of flooding and hurricane events - it was determined that the probabilistic analysis did not fit the needs of the plan. Therefore, the deterministic analysis was used, which evaluates losses based on specific events and does not evaluate the frequency or probability of the event. It gives a worst-case scenario of losses due to a natural hazard event.

### 4.5.1.1 HAZUS Flood Model

The HAZUS Flood Model is an integrated system for identifying and quantifying flood risks based on the Multi-Hazard Loss Estimation Methodology Flood Model. The HAZUS Flood Model methodology can be dissected into two processes: 1) the flood hazard analysis and 2) the flood loss estimation analysis. Frequency, discharge, and ground elevation are used to model the spatial variation in flood depth and velocity in the flood hazard analysis phase. In the loss estimation phases, vulnerability curves and the results of the flood hazard analysis are used to calculate structural and economic damage.[3]

HAZUS has two flood designations to choose from – coastal or riverine flood hazards. To estimate flood losses in Melrose, the riverine flood hazard designation was selected, which is used for non-coastal areas. Flood hazard is defined by the relationship between the depth of flooding and the

[3] Multi-hazard Loss Estimation Methodology Flood Model. Website accessed on 9/15/18; https://www.fema.gov/media-library-data/20130726-1820-25045-8292/hzmh2_1_fl_tm.pdf

annual chance of inundation to that depth.[4] In addition to the hazard designation, flood magnitude was also specified as an input within the HAZUS Flood Model. The FEMA 100-year and 500-year floodplains[5] were examined in this analysis, including use of the recently updated flood elevations for the Ell Pond watershed.

A total of six sets of flood model results were compared using each of the following methods of calculating the flood elevations for both the 100-year and 500-year floods: 1) Default Data, 2) FEMA's Effective Data, and 3) User Defined Facilities (UDF) with FEMA's effective data. Each of these categories is described below:

1. **Default Data:** 100- and 500-year floodplains are developed using elevation data and the default HAZUS flood model. HAZUS-generated flooding extent and depth is compared to default inventory data to create a loss estimate.
2. **FEMA Effective Data:** FEMA effective 100- and 500-year floodplains are compared to default inventory data to create a loss estimate.
3. **User Defined Facilities:** City-supplied data replaces the default inventory. FEMA effective 100- and 500-year floodplains are compared to local inventory data to create a loss estimate.

Note that FEMA's effective data for 500-year flood zones are only captured in detailed study areas. In an actual 500-year flood event, it is expected that the areas in the 100-year flood zone would also experience losses.

### 4.5.1.2 HAZUS Hurricane Model

The HAZUS Hurricane Model is used to estimate losses from hurricane winds and storm surge. For this plan, only wind effects from hurricanes were evaluated and not the potential storm surge flooding, given the distance from the coast. Inland flooding effects are captured in the flood module. The Hurricane Model uses a default terrain roughness founded on digitized Land Use and Land Cover (LULC) data. Ground roughness is a critical component for the modeling of wind effects, damage, and losses to buildings.[6] The rougher the ground surface becomes, the wind speeds near the ground decrease, while the upper level wind speeds remain the same. For example, a typical suburban or urban environment with trees experiences lower wind loads on structures than those experienced by buildings located in unobstructed regions such as waterfronts and open fields.

HAZUS contains a database of historical hurricanes. For this plan, the 1938 New England Hurricane was modeled with the default census data (tracts) for the inventory. The 1938 hurricane can be considered a worst-case scenario for the region (based on historical storms). It

[4] HAZUS Flood Model User Guidance. Website accessed on 9/15/18; https://www.fema.gov/media-library-data/1533922374030-bef65c876277ce763cf594f847cb86cd/HAZUS_4-2_Flood_User_Manual_August_2018.pdf

[5] FEMA Flood Insurance Study, Middlesex County, MA, Revised 7/06/2016. Website accessed on 10/2/18; https://msc.fema.gov/portal/home

[6] Multi-hazard Loss Estimation Methodology Hurricane Model. Website accessed on 9/15/18; https://www.fema.gov/media-library-data/20130726-1820-25045-9850/hzmh2_1_hr_tm.pdf

became a Category 5 hurricane before making landfall as a Category 3 hurricane on Long Island; the hurricane weakened while traveling inland through Connecticut and Massachusetts, and was still a Category 1 storm entering Vermont. While the storm center traveled roughly along the Connecticut River, about 80 miles west of Melrose, the damages within the city modeled with HAZUS were significant.

### 4.5.1.3 HAZUS Earthquake Model

As with the HAZUS Hurricane Model, the HAZUS Earthquake Model is a tool within HAZUS that generates results based on a database of historical earthquakes, which can be used to show the projected impact of a similar earthquake today. The 1755 earthquake was selected as the input scenario for this plan. Its epicenter was approximately 25 miles east-north-east of Cape Ann, MA, and it was an estimated 5.9 magnitude earthquake.

Note that a limitation of the Earthquake Model is that the methodology does not have the capacity to calculate the additional damage or loss due to flooding or fire that could potentially occur as a result of an earthquake.[7]

### 4.5.1.4 HAZUS Results

The HAZUS results show the total loss by census block for flooding and by census tract for hurricane and earthquake. Census blocks are the smallest entity for which the U.S. Census Bureau collects information. Typically, a census block is the equivalent of a city block bounded by streets on all sides. Block groups are made up of an average of 40 census blocks and typically contain between 600 and 3,000 people. Census tracts generally contain 1,500 to 8,000 people and are made up of on average four block groups.

The total losses for each of the six flooding scenarios show that the values are decreasing with each additional level of detail (i.e., the Default Data predicts the highest losses while the UDF predicts the lowest). The 100-year and 500-year UDF scenarios are showing the lowest total losses, likely because the analysis is only pulling parcels that intersect the floodplain, whereas the other flooding scenarios aggregated the default census data at the block level, which likely over estimates losses. These results are shown in **Figures 4-1 to 4-6**. **Table 4-2** distinguishes between 500-year total losses and additional 100-year losses because the FEMA 500-year flood zones are only captured in detailed study areas. In an actual 500-year flood event, it is expected that the areas in the 100-year flood zone would also experience losses. Hurricane and earthquake results can also be found in **Table 4-2**, **Figure 4-7**, and **Figure 4-8**.

[7] Multi-hazard Loss Estimation Methodology Earthquake Model. Website accessed on 9/15/18; https://www.fema.gov/media-library-data/20130726-1820-25045-6286/hzmh2_1_eq_tm.pdf

**Table 4-2 HAZUS Scenario Results: Total Losses**

| HAZUS Scenario | Losses | Additional 100-year Losses |
|---|---|---|
| Flood: Default Data, 100-yr[a] | $86,214,000 | n/a |
| Flood: Default Data, 500-yr[a] | $107,480,000 | n/a |
| Flood: FEMA Effective Data, 100-yr [a] | $38,538,000 | n/a |
| Flood: FEMA Effective Data, 500-yr [a, b] | $63,263,000 | $11,225,000 |
| Flood: UDF FEMA Effective Data, 100-yr | $3,440,000 | n/a |
| Flood: UDF FEMA Effective Data, 500-yr[b] | $12,816,000 | $2,887,000 |
| Hurricane [c] | $13,480,000 | n/a |
| Earthquake [c] | $11,919,000 | n/a |

Notes: a) Losses by census block; b) FEMA's effective data for 500-year flood zones are only captured in detailed study areas. In an actual 500-year flood event, it is expected that the areas in the 100-year flood zone would also experience losses. Therefore, additional 100-year flood model results are shown alongside the 500-year detailed study area flood model results. c) Losses by census tract.

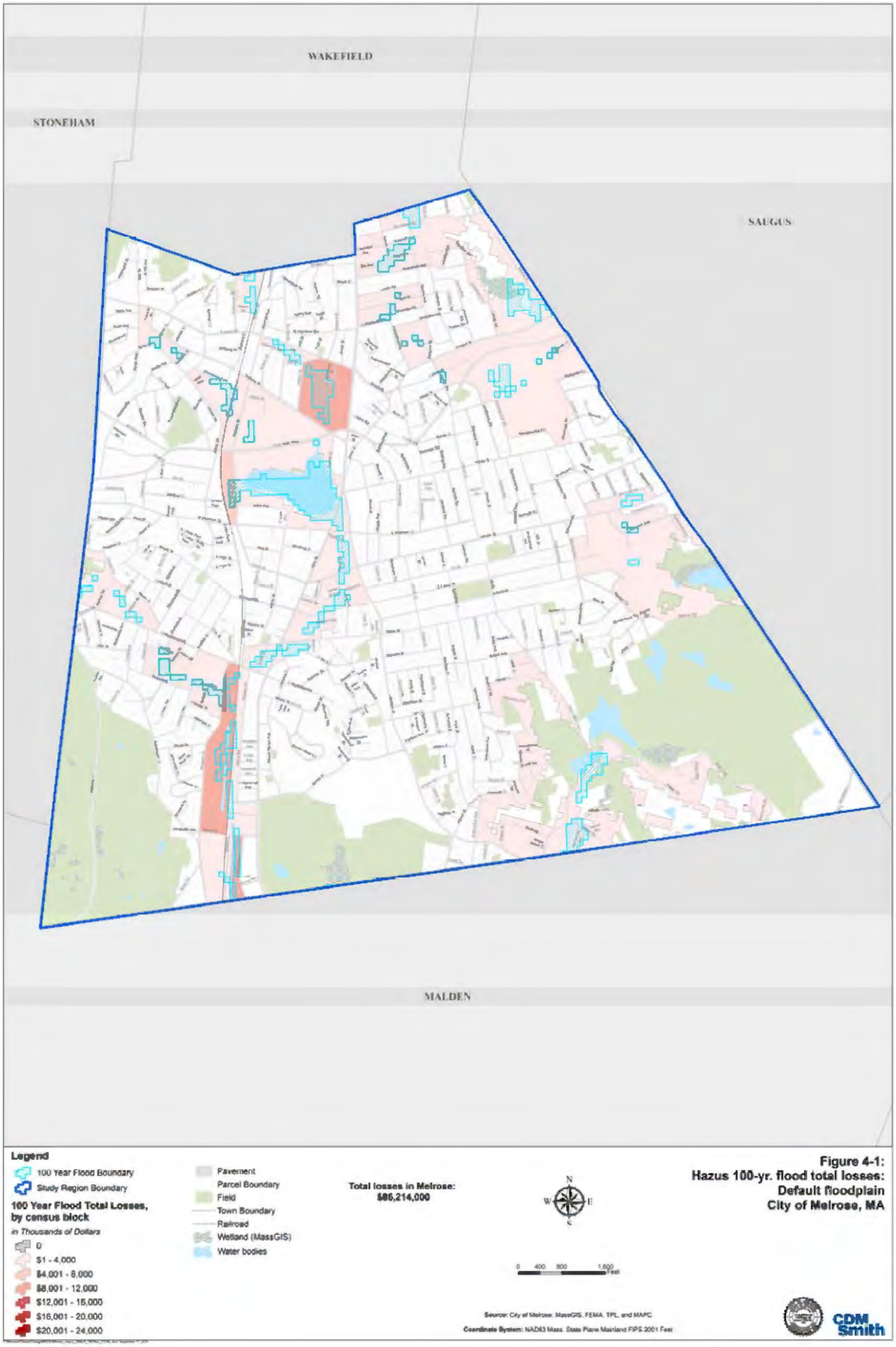
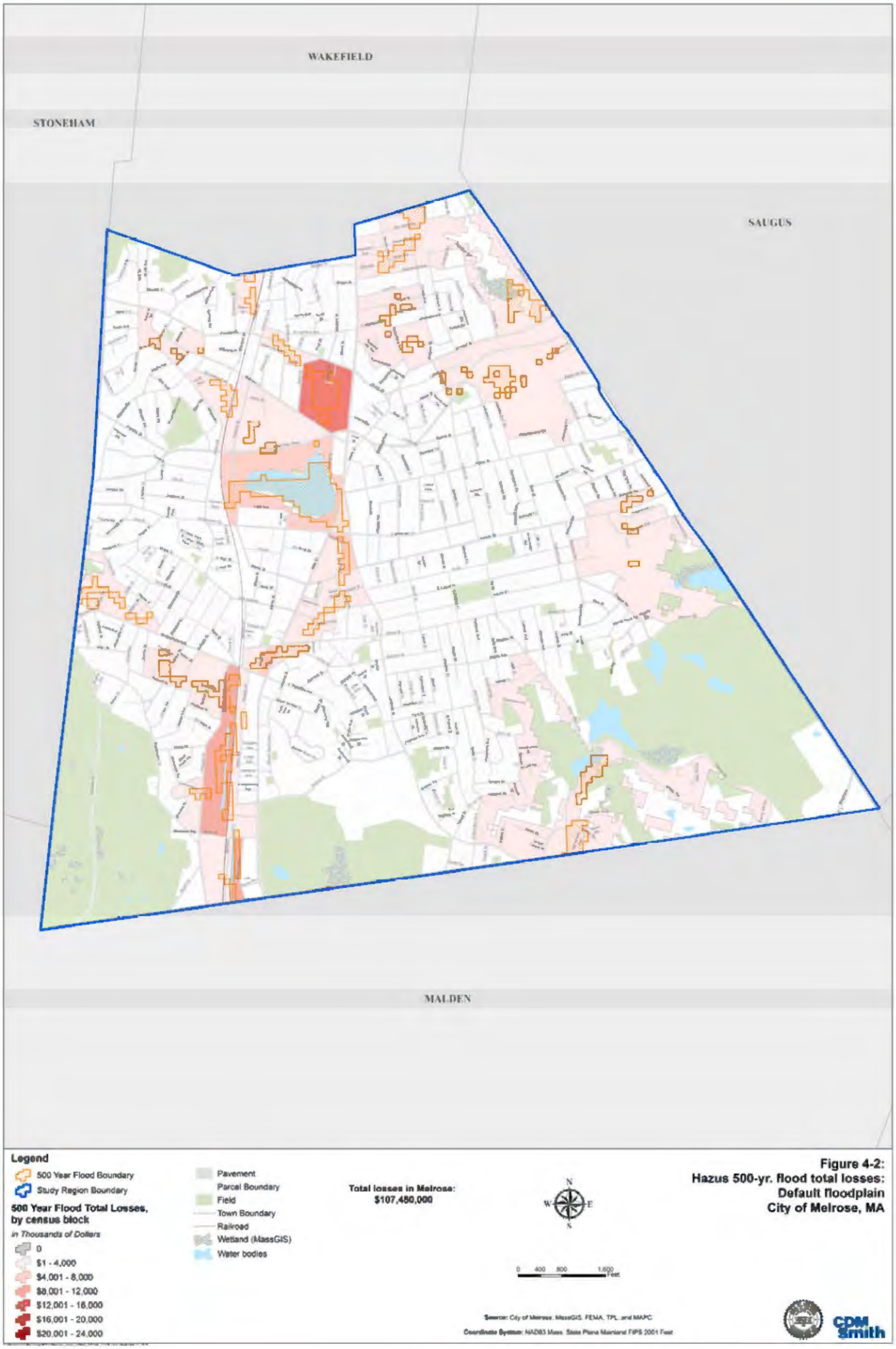



**Figure 4-1:**
**Hazus 100-yr. flood total losses:**
**Default floodplain**
**City of Melrose, MA**


WAKEFIELD
STONEHAM
SAUGUS
MALDEN
Legend
500 Year Flood Boundary
Study Region Boundary
500 Year Flood Total Losses, by census block
in Thousands of Dollars
0
$1 - 4,000
$4,001 - 8,000
$8,001 - 12,000
$12,001 - 16,000
$16,001 - 20,000
$20,001 - 24,000
Pavement
Parcel Boundary
Field
Town Boundary
Railroad
Wetland (MassGIS)
Water bodies
Total losses in Melrose: $107,480,000
N
W
E
S
0 400 800 1,600 Feet
Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet
Figure 4-2:
Hazus 500-yr. flood total losses:
Default floodplain
City of Melrose, MA

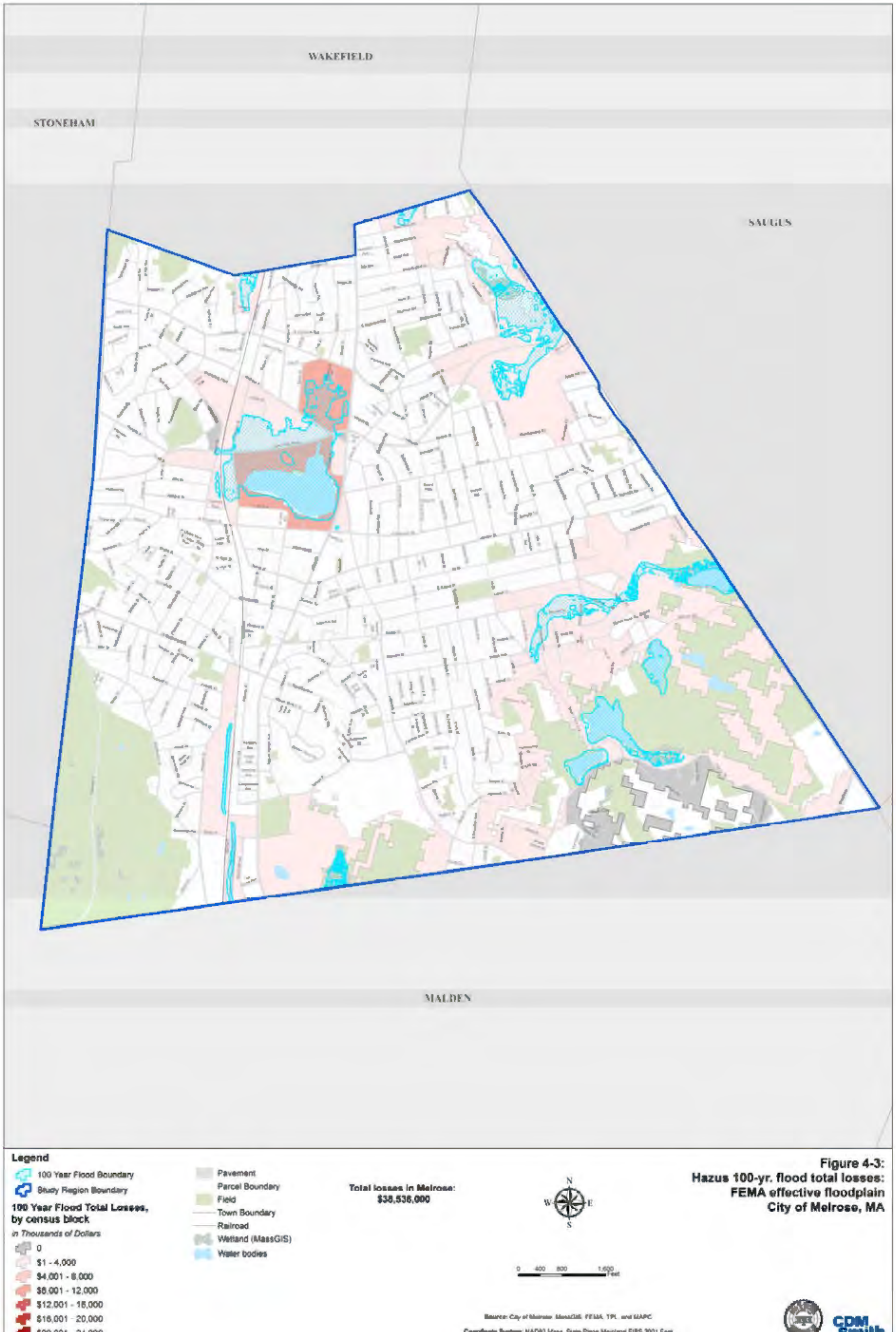



Figure 4-3: Hazus 100-yr. flood total losses: FEMA effective floodplain City of Melrose, MA

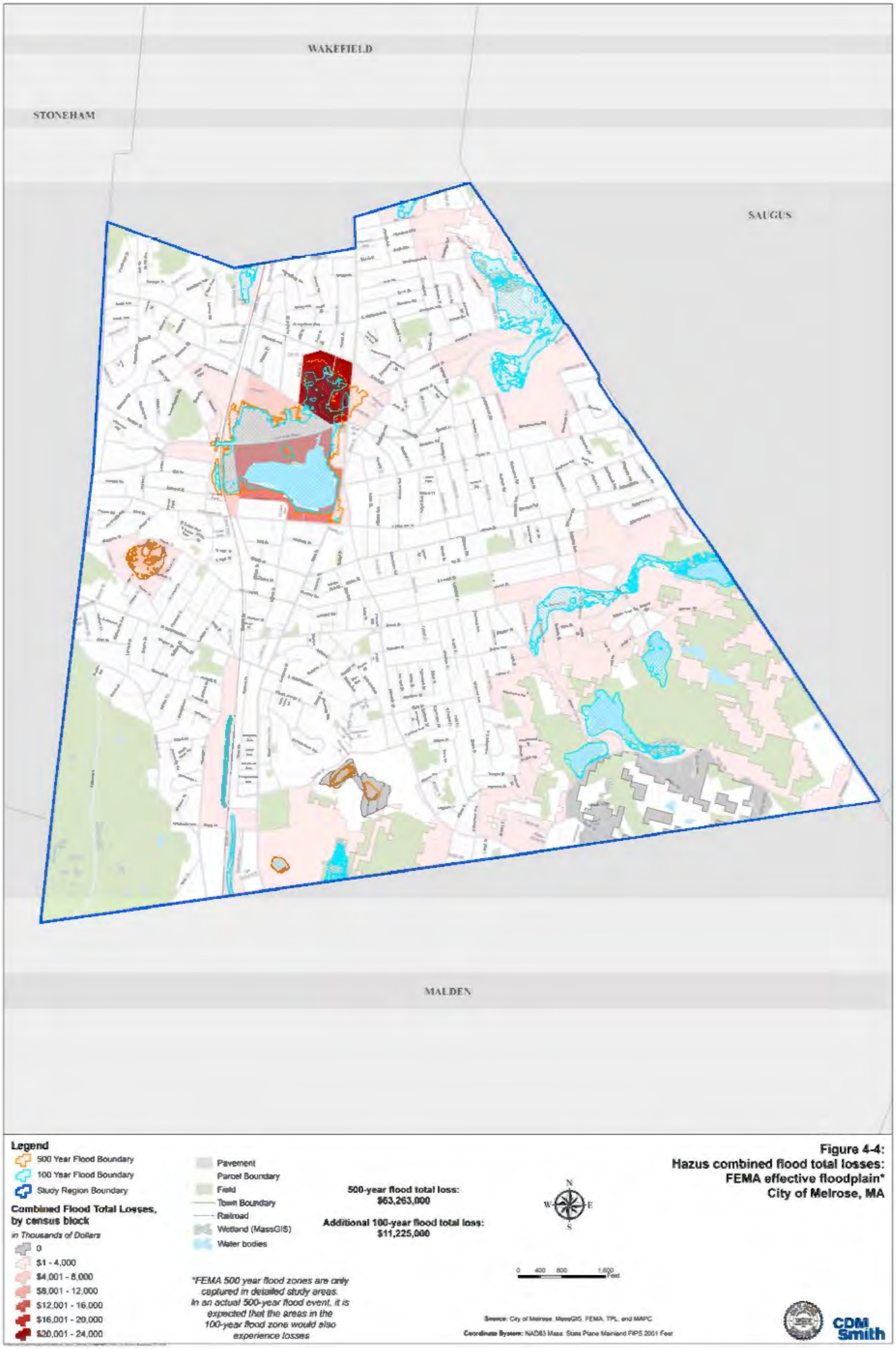



Figure 4-4:
Hazus combined flood total losses:
FEMA effective floodplain*
City of Melrose, MA

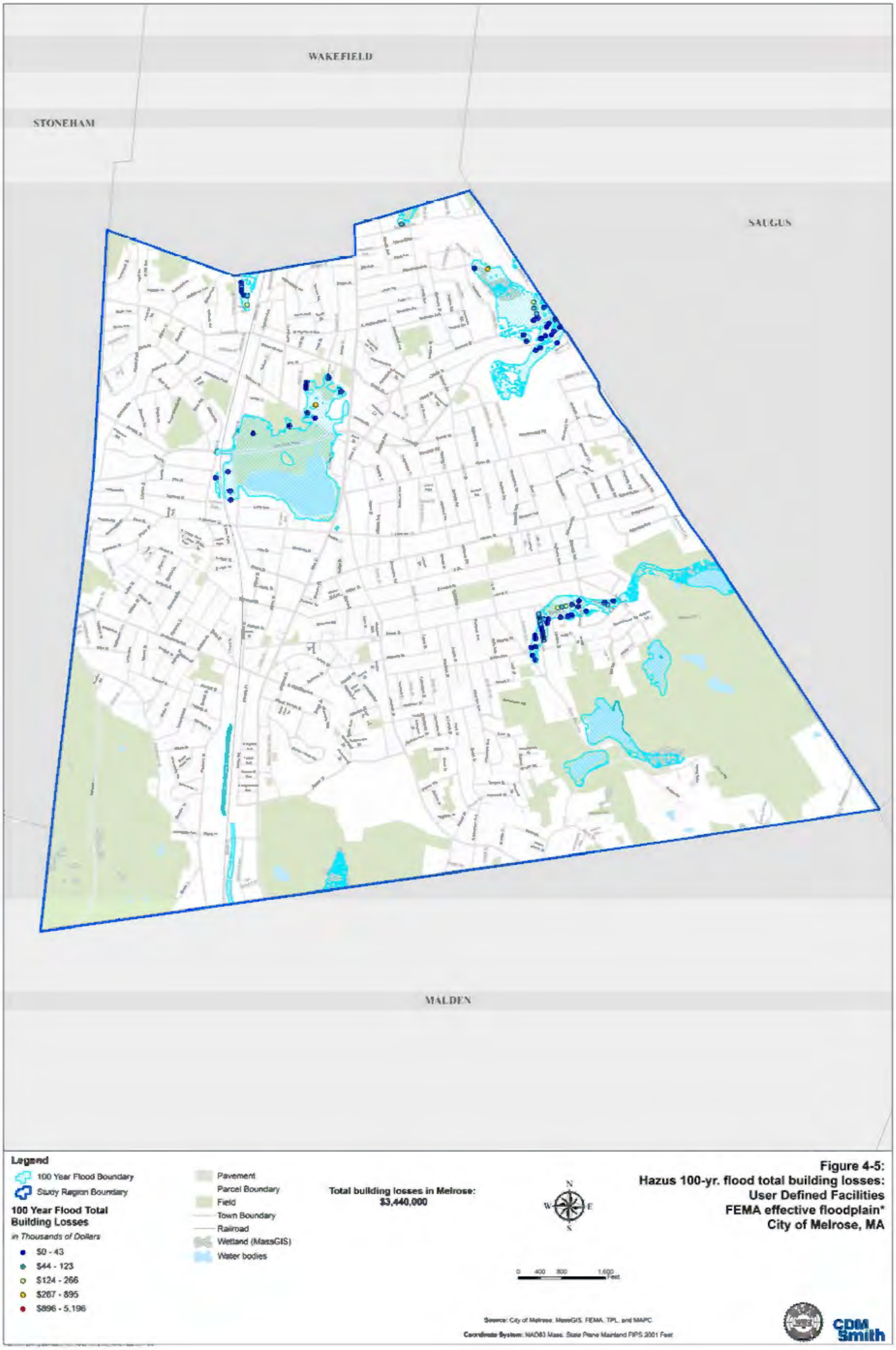



Figure 4-5:
Hazus 100-yr. flood total building losses:
User Defined Facilities
FEMA effective floodplain*
City of Melrose, MA

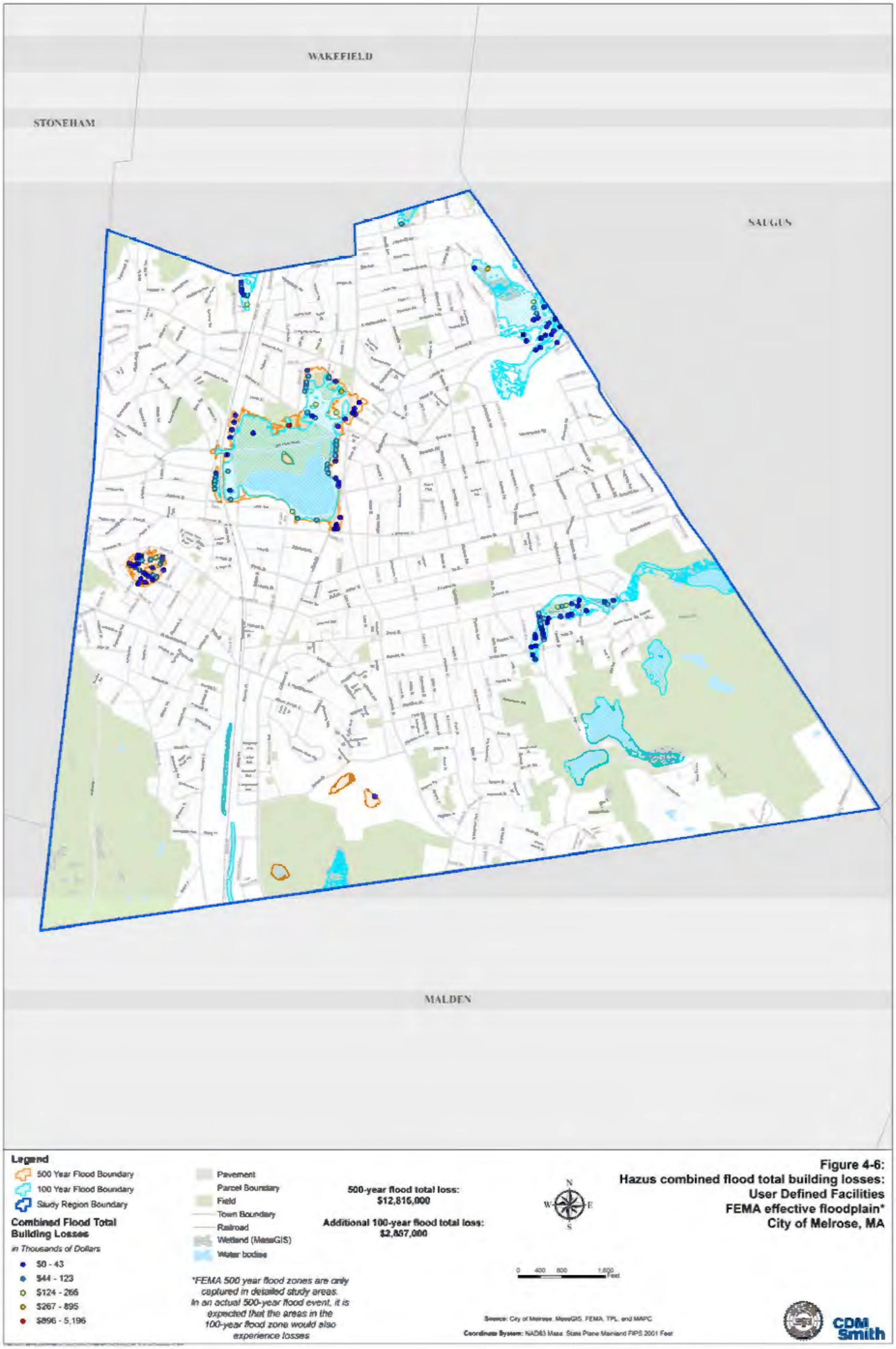



Figure 4-6:
Hazus combined flood total building losses:
User Defined Facilities
FEMA effective floodplain*
City of Melrose, MA


Figure 4-7:
Hazus Hurricane Total Losses*
City of Melrose, MA

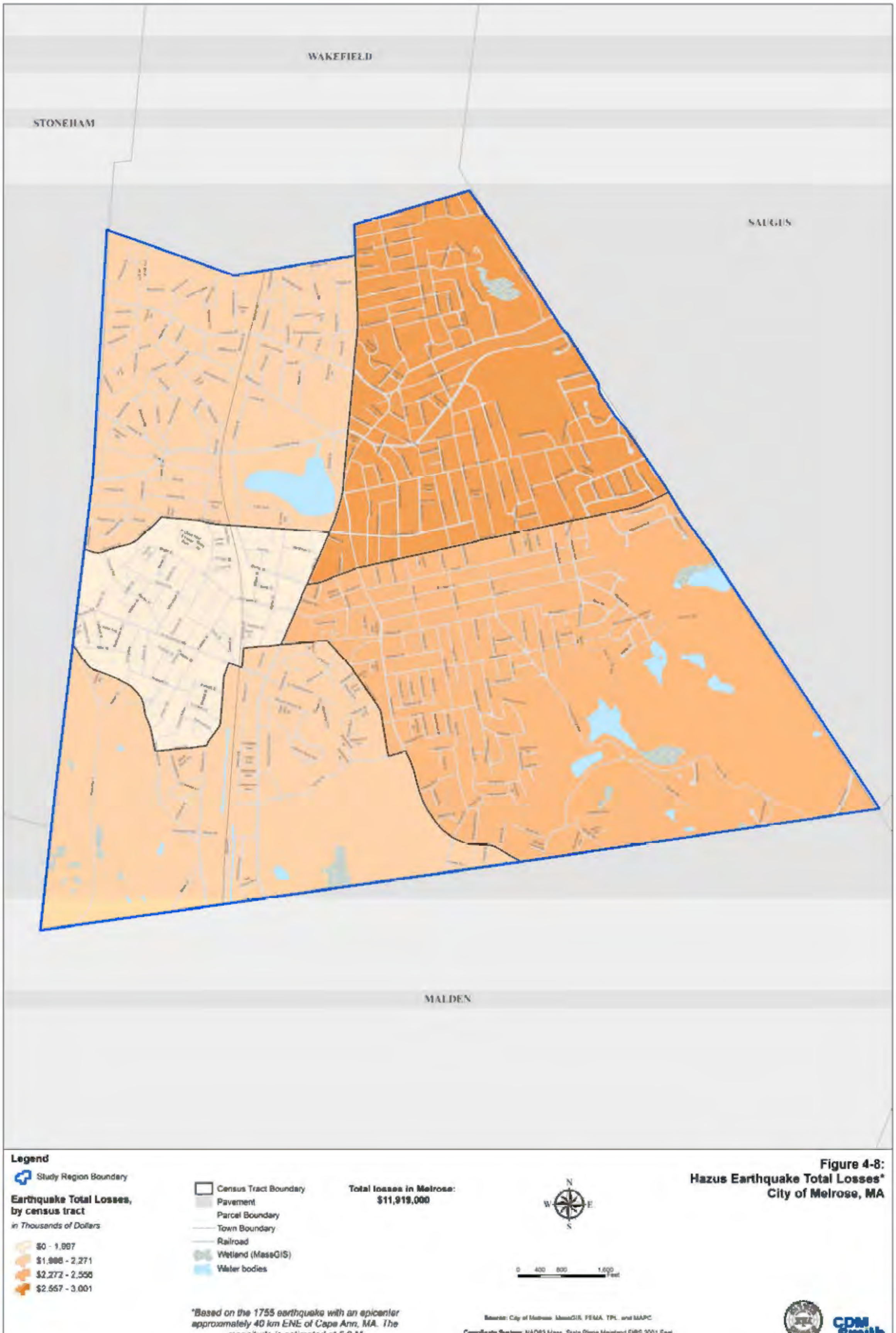



Figure 4-8: Hazus Earthquake Total Losses* City of Melrose, MA

### 4.5.2 Value of Frequently Flooded Areas

Prior to the MVP workshops, the City identified areas of concern due to potential hazards, including flooding. These areas are outside of the 100-year and 500-year floodplains, which indicates the flooding is likely due to stormwater drainage challenges. These areas are expected to continue to experience flooding if no hazard mitigation action is taken, especially with the expected changes in precipitation extremes due to climate change.

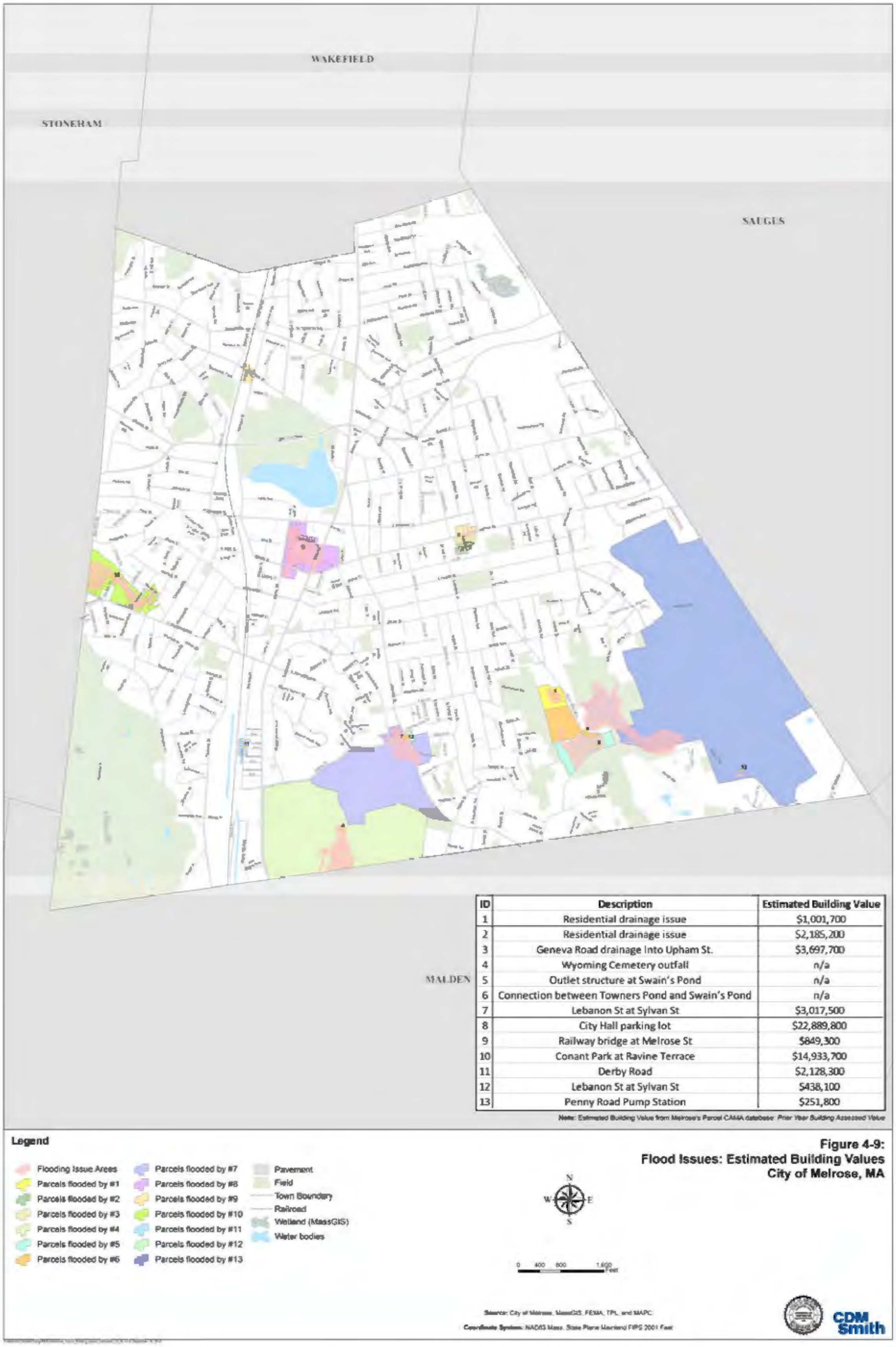
To estimate the approximate extent of flooding, elevation data and GIS hydrology tools were used to model corresponding flooding at these drainage issue areas. Each issue point was analyzed by intersecting parcels with the cloudburst depth grid[8] and calculating the total building assessed value for all parcels. These assessed building values do not accurately represent the damage from a flooding event but provide some insight to what may be damaged. Note that the Wyoming Cemetery outfall (4), Swain's Pond outlet (5), and connection between Towners Pond and Swain's Pond (6) do not have estimated building values because there are not any buildings within those parcels, or the parcel Computer Assisted Mass Appraisal (CAMA) database did not contain prior year building assessed value. However, the flooding at Lebanon Street and Sylvan Street (7) is directly caused by issues at the Wyoming Cemetery outfall. **Table 4-3** summarizes these thirteen frequently flooded areas and **Figure 4-9** provides a visualization of this analysis.

**Table 4-3 Building Values near Flooding Issues Areas**

| ID | Description | Estimated Building Value |
|---|---|---|
| 1 | Residential drainage issue | $1,001,700 |
| 2 | Residential drainage issue | $2,185,200 |
| 3 | Geneva Road drainage into Upham St. | $3,697,700 |
| 4 | Wyoming Cemetery outfall | n/a* |
| 5 | Outlet structure at Swain's Pond | n/a |
| 6 | Connection between Towners Pond and Swain's Pond | n/a |
| 7 | Lebanon St at Sylvan St | $3,017,500* |
| 8 | City Hall parking lot | $22,889,800 |
| 9 | Railway bridge at Melrose St | $849,300 |
| 10 | Conant Park at Ravine Terrace | $14,933,700 |
| 11 | Derby Road | $2,128,300 |
| 12 | Lebanon St at Sylvan St | $438,100 |
| 13 | Penny Road Pumping Station | $251,800 |

Note: Estimated Building Value from Melrose's parcel CAMA database: Prior Year Building Assessed Value.
*The Wyoming Cemetery outfall is the direct cause of flooding at Lebanon Street at Sylvan Street.

[8] Learn ArcGIS Website, Find Areas at Risk of Flooding in a Cloudburst. Website Accessed on 10/2/18; https://learn.arcgis.com/en/projects/find-areas-at-risk-of-flooding-in-a-cloudburst/




| ID | Description | Estimated Building Value |
|---|---|---|
| 1 | Residential drainage issue | $1,001,700 |
| 2 | Residential drainage issue | $2,185,200 |
| 3 | Geneva Road drainage Into Upham St. | $3,697,700 |
| 4 | Wyoming Cemetery outfall | n/a |
| 5 | Outlet structure at Swain's Pond | n/a |
| 6 | Connection between Towners Pond and Swain's Pond | n/a |
| 7 | Lebanon St at Sylvan St | $3,017,500 |
| 8 | City Hall parking lot | $22,889,800 |
| 9 | Railway bridge at Melrose St | $849,300 |
| 10 | Conant Park at Ravine Terrace | $14,933,700 |
| 11 | Derby Road | $2,128,300 |
| 12 | Lebanon St at Sylvan St | $438,100 |
| 13 | Penny Road Pump Station | $251,800 |

Note: Estimated Building Value from Melrose's Parcel CAMA database: Prior Year Building Assessed Value

**Figure 4-9:**
**Flood Issues: Estimated Building Values**
**City of Melrose, MA**

## 4.5.3 Repetitive Loss Properties

A Repetitive Loss Property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within a 10-year period since 1978. Severe Repetitive Loss Properties are residential properties with four or more NFIP claim payments of more than $5,000 each, with at least two of those payments occurring in a 10-year period, and with the total claims paid exceeding $20,000, or two or more claim payments that cumulatively exceeded the building's value.

FEMA reports that a total of 11 properties in Melrose are considered Repetitive Loss Properties, one of which is also a Severe Repetitive Loss Property. Details regarding these properties such as the exact addresses, number of losses per addresses, and claim amount per address are privileged and confidential information to protect the privacy of the owners.

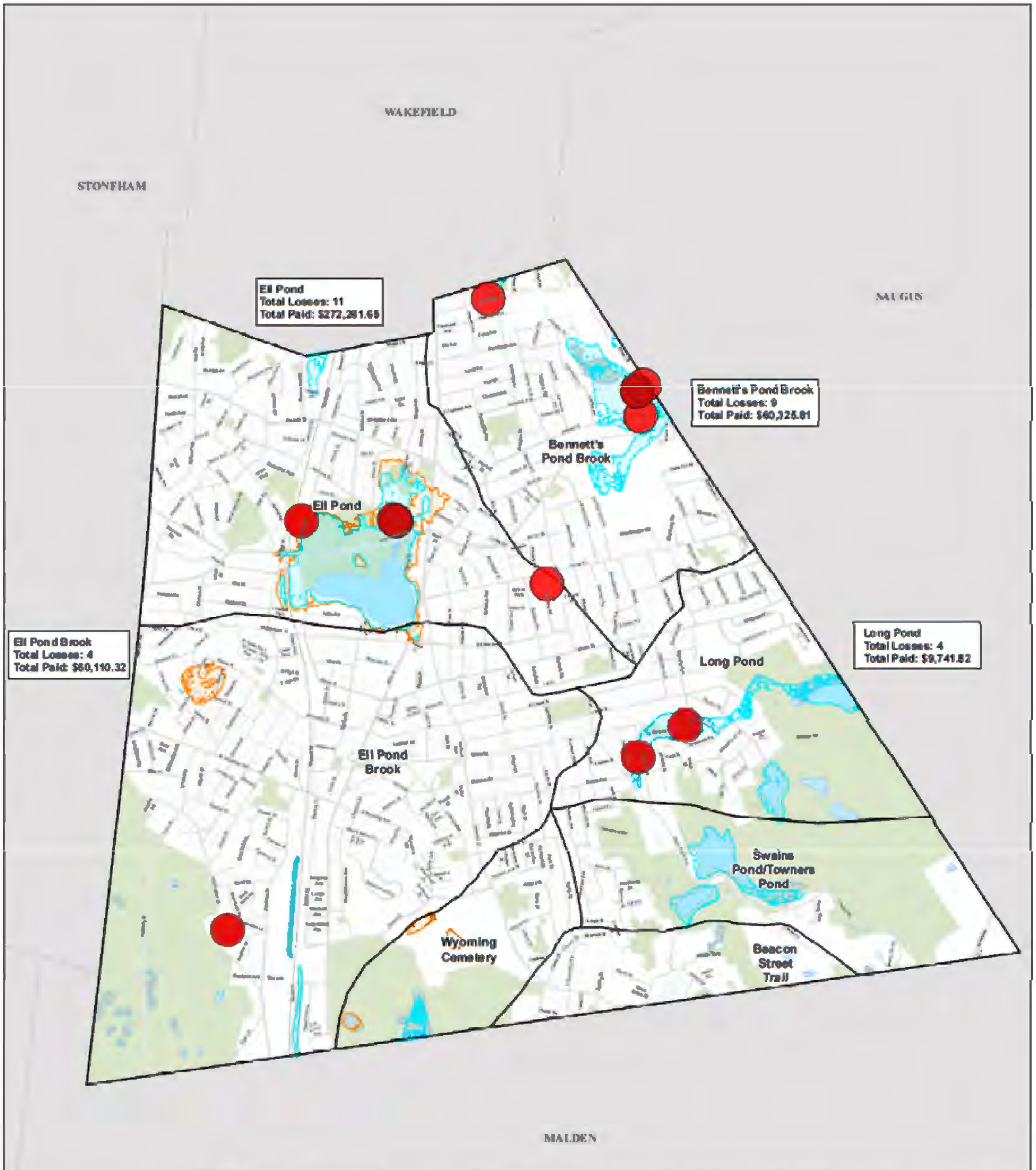
Reviewing this information in terms of the areas where these repetitive losses have occurred, as opposed to exact location, helps to inform the community of the areas where hazard mitigation assistance may be most warranted to prevent losses in the future, recognizing that additional properties may have also experienced repetitive losses, but did not necessarily have a flood insurance policy through the NFIP.

**Table 4-4** and **Figure 4-10** present a high-level summary of the total number of claims and amounts paid by drainage area to demonstrate the areas within Melrose that are impacted by repetitive losses.

**Table 4-4 Repetitive Loss Properties by Drainage Area in Melrose, MA**

| Drainage Area | Number of Properties | Number of Properties within FEMA Floodplain | Total Claims | Total Paid |
|---|---|---|---|---|
| Bennett's Pond Brook | 4 | 4 | 9 | $60,325.81 |
| Ell Pond [a] | 4 | 3 | 11 | $272,261.65 |
| Ell Pond Brook | 1 | 0 | 4 | $60,110.32 |
| Long Pond | 2 | 2 | 4 | $9,741.82 |
| Beacon Street Trail | - | - | - | - |
| Swains Pond / Towers Pond | - | - | - | - |
| Wyoming Cemetery | - | - | - | - |

Note: a) The severe repetitive loss property is located in the Ell Pond drainage area.
This information is from the FEMA NFIP Claim Data, the details of which are protected by Privacy Act of 1974, 5 U. S. C. section 552(a). It is accurate as of 4/30/18.




| Drainage Area | Number of Properties | Number of Properties within FEMA floodplain | Total Losses | Total Paid |
|---|---|---|---|---|
| Bennett's Pond Brook | 4 | 4 | 9 | $60,325.81 |
| Ell Pond | 4 | 3 | 11 | $272,261.65 |
| Ell Pond Brook | 1 | 0 | 4 | $60,110.32 |
| Long Pond | 2 | 2 | 4 | $9,741.82 |
| Beacon Street Trail | - | - | - | - |
| Swains Pond/Towners Pond | - | - | - | - |
| Wyoming Cemetery | - | - | - | - |

Legend
Area of Repetitive Loss Property
Drainage Area
100 Year Flood Boundary
500 Year Flood Boundary
Pavement
Parcel Boundary
Field
Town Boundary
Railroad
Wetland Boundary (City of Melrose)
Wetland (MassGIS)
Water Bodies

**Repetitive Loss Properties by Drainage Area, with FEMA floodplains City of Melrose, MA**

# Section 5

# Updated Hazard Areas from 2004 NHMP

## 5.1 High Hazard Area Profiles

During the development of the 2004 NHMP, the community team established geographic areas of the City as having the highest risk to natural hazards. These areas have been reviewed and reevaluated as part of this process; areas that continue to be of concern in Melrose are listed below.

Although these hazard areas are also susceptible to high winds and other natural hazards, the flooding in these areas has been determined to be the primary cause of risk to the community. In many of these areas, opportunities exist to modify or upgrade the City's stormwater collection and transport systems to minimize current flooding problems.

A description of each high flood hazard area is presented in the following sections along with some potential causes and mitigation measures. Each of these frequent flooding areas requires a more detailed engineering evaluation, beyond the scope of this study, to responsibly evaluate the cause and potential alternatives essential for more thorough mitigation recommendations. **Figure 5-1** shows the flood hazard regions which includes the one percent and 0.2 percent chance annual flood hazard areas and areas in Melrose prone to flooding. It also locates and identifies critical facilities in Melrose, including:

- Police and fire stations
- Emergency shelters and emergency generators
- City Hall and the historic district
- Water and wastewater pumping stations
- The Melrose-Wakefield hospital
- Schools and libraries
- Affordable housing
- Long term care facilities

Each flood hazard area is described in detail below.

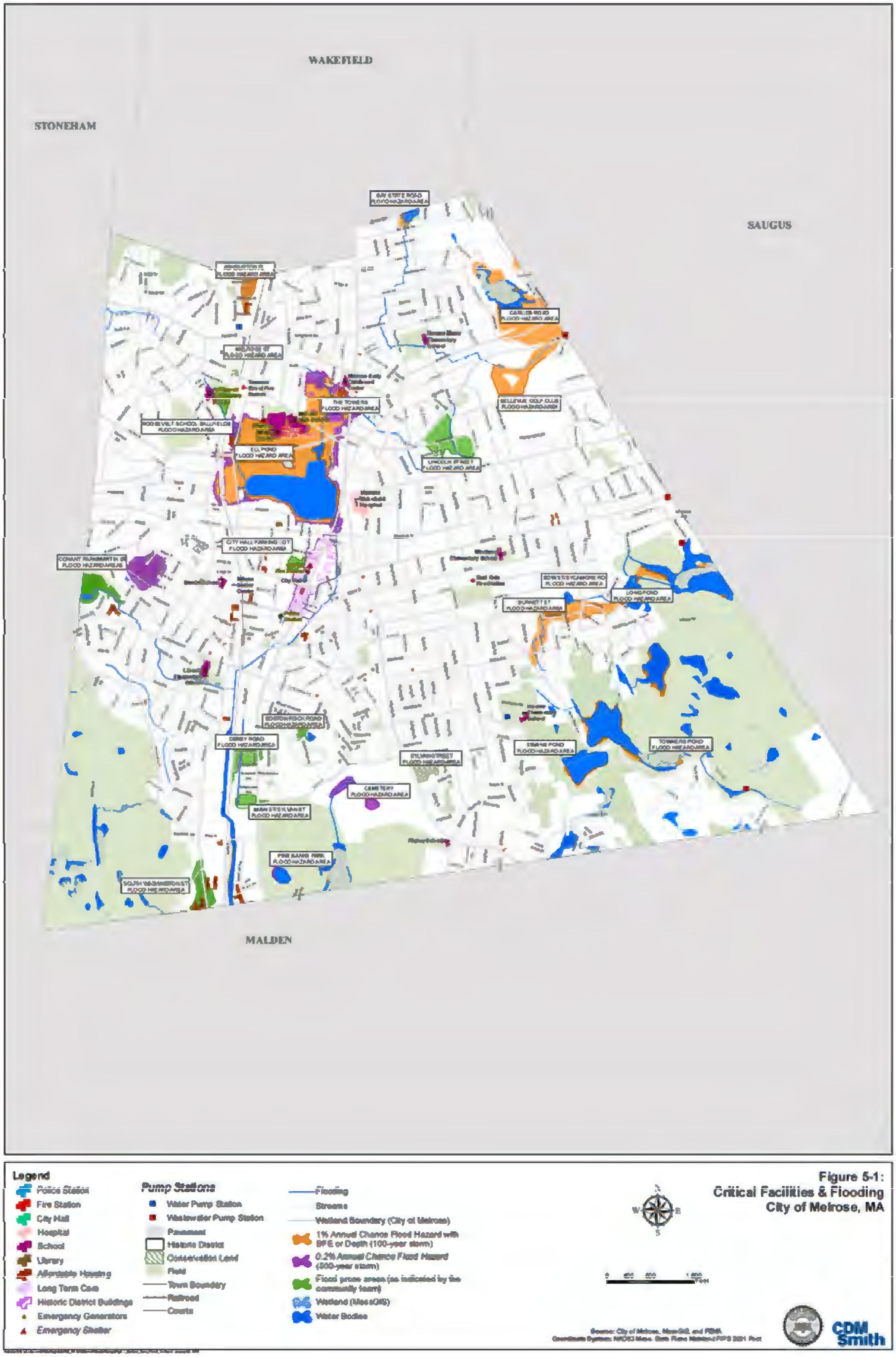



Figure 5-1: Critical Facilities & Flooding City of Melrose, MA



CDM Smith

## 5.1.1 Ell Pond Flood Hazard Region

When the 2004 analysis was performed, a large area around Ell Pond experienced significant flooding roughly every other year. There were also smaller portions of this area that experienced shallow flooding during a 100-year and 500-year flood in accordance with FEMA Flood Insurance Rate Maps. In general, a rainstorm with 3 to 4 inches of total rainfall used to result in significant flooding around Ell Pond.

Ell Pond receives flow from a large total drainage area including areas located adjacent to Ell Pond and flows from streams and culverts transporting flow from both Stoneham and Wakefield. Flow discharges from Ell Pond through an outlet located at the southeast corner of the Pond. Following the 2004 NHMP, the City, with assistance from FEMA, installed a new outlet from Ell Pond along with a crest gate that added flexibility in the ability to manipulate the pond's surface elevation. Both the new Ell Pond Drain and the prior discharge outlet transport water southward within or adjacent to Main Street. These flows eventually discharge near the Wyoming Hill commuter rail station to an open channel known as Lower Spot Pond Brook. The flows continue southward within Lower Spot Pond Brook through Malden and eventually reach a location upstream of the Amelia Earhart Dam located on the Mystic River in Boston.

As the issues surrounding Ell Pond were the most significant natural hazard within the City, solutions were immediately sought and implemented after completion of the 2004 report. While the solutions implemented have been very successful, large rain events with increasing volumes and intensities can still cause some degree of flooding in the vicinity of Ell Pond, as shown by the newly adopted floodplain elevations shown on Figure 5-1. Therefore, this area was maintained in this report as a focus area for monitoring potential future flooding impacts.

### 5.1.1.1 The Towers and Other Ell Pond Area Properties

Prior to the improvements described above to the Ell Pond outlet, the Towers, a residential high-rise located northeast of Ell Pond, experienced shallow flooding in the lower level parking area approximately every six months. Deeper flood waters totaling several feet in depth were also experienced within the parking garage about every other year. Other structures located in this flood hazard area include the Melrose High School and Melrose Veteran's Memorial Middle School campus, businesses, the Elmhurst Nursing Home, the Melrose DPW City Yard, and residential houses. While flooding in these areas has substantially improved as a result of the new Ell Pond outlet and crest gate installation, some issues still exist during large storms. One issue of note is wastewater backups that sometimes impact homes on Melrose Street when infiltration and inflow into the City's sewer system cause capacity restrictions within the City's sewer mains that run beneath the school campus. This issue relates to both the intensity of storm events and deficiencies in the City's sewer infrastructure.

### 5.1.1.2 Roosevelt School Athletic Fields

When the 2004 NHMP was developed, the athletic fields located behind the Roosevelt Elementary School on Vinton Street experienced flooding about four times per year. Since that time, the detention basin at the school has been improved, which has minimized flooding. These improvements have largely mitigated the associated flooding issues; however, their success is predicated on keeping the stormwater grate adjacent to the school clear of debris. Furthermore, improvements are recommended to the City's drainage system where it runs from Vinton Street, beneath the railroad tracks, through the property of a current auto body shop, discharging to Tremont Street (referred to herein as the "Tremont Street Drain"). This drainage pipe creates a bottleneck that sometimes results in backups onto the Roosevelt School property. The City should prioritize keeping the drainage grate clear and ensuring that it is accessible for periodic cleaning throughout the year. In addition, the Tremont Street Drain should be further evaluated to determine if improvements are feasible.

#### 5.1.1.3 Melrose Street

This small, community defined flood area is limited to the area beneath the Boston and Maine Railroad "overpass" bridge that crosses Melrose Street.

The cause of this flooding may be due to a combination of the low lying ground surface in this area and the flooding in the Ell Pond area. As explained previously, flooding in this neighborhood creates surcharge conditions in the subsurface culvert passing through the Roosevelt School property. The drainage system in the Melrose Street area discharges to the same culvert at a location adjacent to the Boston and Maine Railroad.

Previously, sewer backups within the MWRA transmission mains in this vicinity were also an issue during storm events. In response to this issue, the MWRA constructed a second transmission main in this area. As a mitigation measure to minimize capacity restrictions, the MWRA brings a bypass pump to Melrose Street when large storms are expected and pumps flow from one main into the other to equalize flows and minimize the risk of sewer overflows or backups.

### 5.1.2 Downtown Flood Hazard Region

The City of Melrose downtown district is located just south of Ell Pond. In 2004, three flood hazard areas were identified in this region: Felton Place, the Synagogue area, and the City Hall parking lot. The improvements to the Ell Pond outlet have resolved the flooding issues at the first two sites, having relieved the older granite Ell Pond outlet culvert of its capacity restrictions by providing a parallel outlet drain. The City Hall parking lot continues to be an area of concern.

#### 5.1.2.1 City Hall Parking Lot

The parking lot behind City Hall experiences flooding about four times per year. The catch basins and storm drainage that collect the storm water runoff from the parking lot discharges to the Ell Pond effluent culvert at a location near Felton Place. It is possible that surcharged water levels in the granite culvert near Felton Place cause the City Hall parking lot to surcharge above the elevation of the parking lot. However, with the other related flood areas having been alleviated by the installation of the new Ell Pond outlet, the problems causing the parking lot to flood may be more localized. It has been reported that the storm drains in the parking lot are pitched backwards, potentially exacerbating the flood problem.

Typical flooding in this area is shallow and limited to the parking lot area. However, it is sometimes significant enough that cars need to be relocated to avoid damage. The 2004 Community Team reported that one flood reached the roof level of cars parked in the lot, although this was prior to the Ell Pond outlet improvements.

The Soldiers and Sailors Memorial Hall is a critical facility located adjacent to the City Hall Parking lot that has been affected at times by the flooding in this area.

## 5.1.3 Lower Spot Pond Brook Flood Hazard Region

As explained previously, discharge from Ell Pond eventually flows to a large earthen open channel known as Lower Spot Pond Brook, running parallel to the Boston & Maine Railroad tracks on the southern end of Melrose.

The 2004 Community Team identified a relationship between the operation of the Amelia Earhart dam/pump station (located miles downstream in Boston) and the water level in the Lower Spot Pond Brook. It is believed that the operation of the dam includes free discharge of flow into Boston Harbor when the Harbor level is within non-storm surge conditions. The combination of damming and pumping of the flow to Boston Harbor occurs when the Harbor levels become surcharged during storm surge conditions. It is believed that the upstream water level of the dam during pumping creates a downstream water level that results in surcharge several miles upstream within the Lower Spot Pond Brook. This surcharge is believed to be to an elevation that impacts the capacity of the storm drainage systems located adjacent to the Brook resulting in flooding in each area. It is not known whether flow within the Brook backflows through any of the storm drainage systems to the flood areas.

The Derby Road and Main Street/Sylvan Street hazard areas described below were identified by the 2004 Community Team as being at least partially the result of surcharge levels in Lower Spot Pond Brook. These areas have also been noted more recently as priority areas for keeping catch basins clean, to ensure unrestricted localized flow during storm events. A third area in this region, Converse Lane, had also been identified in 2004 as having flooding problems. Drainage improvements have since been made to the Converse Lane neighborhood to alleviate flooding, therefore it is no longer included herein.

### 5.1.3.1 Derby Road

This older neighborhood located to the east of Lower Spot Pond Brook was reported in 2004 to experience flooding six to ten times per year. The storm drain system in this neighborhood discharges directly to Lower Spot Pond Brook. It is believed that as the Brook surcharges due to downstream conditions, the storm drainage system in the Derby Road area surcharges above the roadway level before the capacity required to transport the local runoff is achieved. This results in basement, yard, and street flooding.

To respond to frequent complaints from residents, the Melrose Public Works Department continues to clean the storm drains and catch basins in this area two to three times per year. The continued flooding that occurs even after the cleaning has been performed indicates the flood problem is due to the hydraulic deficiencies of the storm drainage in this area.

### 5.1.3.2 Main Street/Sylvan Street

Another 2004 Community Team defined flood hazard area is located directly south of the Derby Road flood hazard area. Basement, yard, and street flooding occur here almost every other month, especially at the intersection of Main Street and Sylvan Street. The Community Team believed the flooding in this area has similar origin to the Derby Road area in that the storm drainage system that discharges directly to Lower Spot Pond Brook has inadequate capacity when surcharge occurs in Lower Spot Pond Brook.

#### 5.1.3.3 Boston Rock Road

Small, local flooding was reported in 2004 to occur off of Boston Rock Road about four times per year. The flooding is limited to a handful of houses on Boston Rock Road and is a direct result of surcharge in the storm drain located within Boston Rock Road. It appears that this flood hazard area is caused by a combination of undersized drain piping and the low ground surface elevation within this area.

### 5.1.4 South Washington Street Flood Hazard Area

This flood hazard area located between the Middlesex Fells Reservation to the west and Lower Spot Pond Brook to the east was reported in 2004 as experiencing flooding about three times per year. It is believed that the flooding is caused by a blockage of the inlet structure, commonly referred to as the "trash grate," located at the boundary between Melrose and Malden. This inlet structure is within the jurisdiction of the Massachusetts Department of Conservation and Recreation (DCR), and the flooding is due to inadequate frequency of cleaning of the structure. This grate is often blocked with debris that washes out from the wooded area adjacent to it during storm runoff conditions.

The flooding typically requires the closing of one lane of traffic on South Washington Street and also floods adjacent parking lots. The City is continuing to work with the DCR to ensure that routine cleaning of the grate is performed.

### 5.1.5 Wyoming Cemetery Flood Hazard Region

Several identified flood hazard areas are located along a route of culverts that transport storm water from the area adjacent to Wyoming Cemetery, through the Cemetery, to a brook located within Pine Banks Park, where it flows into Malden. The following three flood hazard areas have been identified within this region.

#### 5.1.5.1 Pine Banks Park

Pine Banks Park is a densely wooded area located in the southwestern corner of the City of Melrose. It is believed that this area experiences shallow flooding similar to the FEMA designation for this area: 100-year and 500-year shallow flooding (less than one foot of depth). Flooding is limited to a portion of the park that is designated by the Commonwealth of Massachusetts as a wetland area.

#### 5.1.5.2 Cemetery

The flooding within Wyoming Cemetery is identified by FEMA to be within a 100-year and 500-year shallow flood zone (less than one foot of depth). The 2004 Community Team indicated a flood frequency of about six times per year within this area. Flooding has also been observed and reported in recent years. The flooding is caused by deficiencies within the drainage pipes through the cemetery and the adjacent Pine Banks Park, as well as the downstream outfall. The pipes through the cemetery do not have adequate pitch, and the outfall frequently has sediment deposits that back up at the outlet and restrict flow. Although the flooding within the cemetery is frequent, it is shallow and has little resulting impact because there are no buildings within this area. The main significance of the Cemetery flood area is the impact this flooding has on the upstream Sylvan Street flood area described below.

### 5.1.5.3 Sylvan Street

This flood hazard area is located adjacent to the northeast corner of Wyoming Cemetery and was reported in 2004 as flooding about six times per year. The storm drain system on Sylvan Street discharges through the Cemetery flood hazard area and typically floods during the same storm events as the Cemetery area. In the last two years, the City has performed extensive study of the pipes from this neighborhood, through the cemetery, to the outfall, and has identified a number of deficiencies. A preliminary plan for replacement/relocation of the drainage infrastructure downstream of this area has been developed for implementation when funding becomes available.

This area is also susceptible to sewer backups during storms, when infiltration and inflow overwhelm the adjacent sewer mains. This problem has exacerbated the impacts to the adjacent homes when combined with the stormwater flooding noted above.

## 5.1.6 Long Pond Flood Hazard Region

Long Pond receives storm water flow from a variety of neighborhoods located in the eastern area of Melrose. The following flood hazard areas have been identified: Long Pond, Bow Street/Sycamore Road, and Burnett Street Flood Hazard Areas. While flooding in these areas has improved as drainage system improvement projects have been implemented, this area is still susceptible to some level of flooding and is one the City continues to watch during storm events.

### 5.1.6.1 Long Pond

Long Pond is located on the eastern border of Melrose and is partly located within the adjacent Town of Saugus. The pond acts as a detention basin for storm water runoff from a large area of eastern Melrose.

The 2004 Community Team indicated that the area around the Pond flooded only once every few years with minimal resulting impact due to its location in undeveloped land.

Long Pond is partly located within the Mount Hood Memorial Park and Golf Course.  The Golf Course, although not specifically identified as a flood hazard area, was identified by the 2004 Community Team as an area that experiences flooding about once every two years.

### 5.1.6.2 Bow Street/Sycamore Road

This residential neighborhood, located about ¼ of a mile east of Melrose Common, was reported as flooding about once per year in 2004. Catch basins located in low areas in the backyards of houses on Bow Street surcharge, resulting in significant yard and basement/structural flooding especially between Bow Street and Slayton Road.

It is believed that flooding in this area is due to surcharge conditions in a subsurface culvert running between Bow Street and Slayton Street, possibly resulting from the downstream water level in the Long Pond area. Homes at the end of Laurel Street are also sometimes impacted by flooding in this area. Mitigation of this flooding is assisted by routine maintenance of the open channels downstream of the drainage in these neighborhoods, within the Mount Hood Golf Course.

#### 5.1.6.3 Burnett Street

The Burnett Street flood hazard area, located adjacent to the Bow Street area, was reported in 2004 to experience flooding about once a year, typically concurrent with flooding in the Bow Street area. The 2004 Community Team decided to distinguish this flood area separately from the adjacent Bow Street area because the extent and magnitude of the flooding in the Burnett area had been significantly mitigated prior to the 2004 NHMP, through a recently constructed detention pond located on the 1st hole of the Mount Hood Golf Course southeast of the Burnett Street area. The new storage within this basin appears to dampen out the peak flow of storm water runoff that the Golf Course previously contributed to the Burnett Street area. Since the basin was constructed, only small scale basement flooding in a few homes has occurred in this area about once per year.

### 5.1.7 Ashburton Place Flood Hazard Area

The Steele House senior center and a residential area located in the northwest corner of the Melrose Highlands (in northern Melrose) was reported in 2004 to experience flooding about once every nine months.

Flooding of basements, yards, and parking lots is common in this area and the Steele House, a critical facility, has required evacuation on at least one occasion. When flooding does occur, shallow water of 1 to 2 inches in depth appears within parking lots in this area.

## 5.2 Other Flood Hazard Area Profiles

In order to address all of the known flood hazard areas affecting the City, this subsection presents additional flood hazard areas that were either established by the 2004 Community Team or were identified by FEMA as located within the 100-year floodplain. Each of these delineated geographic areas has been determined to be at some level of risk for a future flood event; however, the level of risk to community assets is considered to be less than for those flood hazard areas presented above.

### 5.2.1 Bellevue Golf Club Flood Hazard Region

The area surrounding the Bellevue Golf Club, in the northeastern portion of the Melrose Highlands, has been defined by FEMA as being within the 100-year floodplain. This area has been divided into the Carlida Road area and the Bellevue Golf Club area.

#### 5.2.1.1 Carlida Road

This neighborhood located north of Howard Street and adjacent to the border with Saugus has experienced stormwater flooding in the past, however flooding has not occurred in recent years including during 100-year storm events.

Homeowners in this flood hazard area, mainly on Windsor Street, have petitioned FEMA with Letters of Amendment (LOA) to request a revised delineation of the 100-year floodplain in this area. Many of the residents in this area believe that their homes are not within the true 100-year floodplain, even though their property is located within the 100-year flood zone as defined on the current version of the FEMA Flood Insurance Rate Maps. These residents believe that they should not be required to carry flood insurance for their properties.

#### 5.2.1.2 Bellevue Golf Club

The Bellevue Golf Course was reported in 2004 as experiencing flooding about four times per year. However, the neighborhoods associated with this flood hazard area on Rivers Lane and Lynn Fells Parkway only experience flooding about once every four years. Flooding within the golf course is believed to be attributed to an undersized surface culvert that transports flow from Wakefield and the Melrose Highlands through the Golf Course to Saugus.

The Fellsway Wastewater Pump Station is a critical facility within this flood area that could experience damage or become disabled during a significant flood event in this area. The station is also susceptible to high flows during storm events due to inflow into the sewer system, which could result in sewer backups or overflows.

### 5.2.2 Swains Pond Avenue Flood Hazard Region

The Swains Pond Avenue region of Melrose, located just to the west of the Mount Hood Golf Course, is sparsely developed and covered with woodlands and ponds. The following flood hazard areas have been identified within this region and have each been identified as having minimal impact to the community.

#### 5.2.2.1 Swains Pond & Towners Pond

Swains Pond and Towners Pond experience noticeable flooding about once every ten years.

Although there was no experience by the 2004 Community Team of this flooding causing impacts to any structures, yards or streets, the defined 100-year floodplain does encroach on houses located on Swains Pond Avenue and the paved roadway in two locations. The 2004 Community Team indicated that no complaints had been received from property owners in this area. A headwall structure at the outlet from Swains Pond was damaged during a winter storm in 2015 and requires replacement in the near term.

### 5.2.3 Lincoln Street Flood Hazard Area

The Lincoln Street area located adjacent to the Lynn Fells Parkway and west of the Bellevue Golf Club has been determined as a flood hazard area that, in 2004, was reported to experience flooding about once every six months. The flooding historically experienced here was limited to the roadways and was the most severe at a low lying area of Lincoln Street. Members of the 2004 Community Team believed that the flooding on Lincoln Street may be mitigated with the construction of a few new catch basins within the low lying area of the street. Since that time, substantial drainage improvements (replacement and rerouting) have taken place in the neighborhoods of Stowecroft Road and Burrell Street, in this general vicinity. These improvements have mitigated backyard flooding issues on these streets. This area will continue to be watched during storm events, but the improvements in this area are believed to have alleviated the majority of the flooding in this neighborhood.

### 5.2.4 Conant Park/Martin Street Flood Hazard Area

This flood hazard area contains two distinct sub-areas; a residential area around Martin Street indicated by FEMA to be within the region of shallow flooding (less than one foot deep) during 100 and 500-year flood frequencies, and a flood prone sub-area mainly within Conant Park as indicated by the 2004 Community Team. The recurrence of flooding of the baseball fields located in Conant Park is about once a year, and the Martin Street area rarely (if ever) experiences flooding. This is still the case at this time.

The Melrose Care Center is a critical facility located on Martin Street within the FEMA designated shallow flood area.

### 5.2.5 Bay State Road Flood Hazard Area

The Bay State Road Flood Hazard Area, located in the northeast corner of the Melrose Highlands and adjacent to the Wakefield border, was reported in 2004 to experience flooding about once every two years. The flooding is mainly limited to undeveloped land, much of which is designated as a wetland resource area.

The extent of flooding decreased significantly prior to 2004 following construction of a new drain within Damon Avenue to transport a higher capacity of flow southward within the collection system. A headwall structure was also replaced, where only a pipe previously existed. It is believed that the basement, yard and street flooding on Bay State Road and Damon Avenue experienced in the past have been eliminated by these improvements, but this area is still watched by the City during storm events.

## 5.3 Update on Identified Actions in the 2004 Natural Hazard Mitigation Plan

The 2004 Natural Hazards Mitigation Plan identified 16 priority measures to reduce the risks posed by natural hazards. The City has completed five of these actions, has partially completed or is currently working on ten, and did not act on one. The status of these actions is listed in Table 5-1 below. For those not completed, the actions are further summarized with details on the current status and are carried into the later sections of this report.

**Table 5-1. Summary of the Status of 2004 Priority Mitigation Actions**

| Priority Mitigation Actions | Complete | Partial Completion | In Progress | No Action |
|---|---|---|---|---|
| Reconstruct DPW Maintenance and Repair Garage | | X | | |
| Reconstruct Middle School/High School Drain | X | | | |
| Reconstruct Roosevelt School Detention Basin | | X | | |
| Study/Implement Mitigation Measures for the Melrose Towers Condos | X | | | |
| Petition FEMA – include Converse Lane Community in 100-year floodplain | X | | | |
| Converse Lane Drainage Improvements | X | | | |
| Reconstruct Upstream Portion of Tremont Street Drain | | X | | |
| Study and Implement Mitigation Measures for Several Flood Hazard Areas | | | X | |
| Official City of Melrose Website – Increase Public Outreach | | | X | |
| Incident Command Course (ICS) | | | X | |
| Portable Generators | | X | | |
| Secure Important Records | | | X | |
| Direct-Connect for City Departments | X | | | |
| Reverse 911 | | X | | |
| Enroll in the Community Rating System | | | | X |
| South Washington Street Trash Grate | | | X | |

- **Reconstruct DPW Maintenance and Repair Garage (City Yard):** This facility, located within the 100-year flood area of Ell Pond at 72 Tremont Street, stores diesel fuel for the Fire, Police, School, Emergency Management and Public Works departments. Also, other hazardous materials such as oil, gasoline, solvents, etc. are stored here for both vehicle maintenance and emergency repair. The garage was to be reconstructed in a way to protect the active use of the garage during flood events (in Ell Pond) while avoiding hazardous contamination due to stored chemicals.

  ***Status:*** Partial Completion

  ***Action Update:*** The improvements to the outlet from Ell Pond have substantially decreased the frequency and magnitude of flooding within the Ell Pond watershed. This is reflected in the updated base flood elevation that was approved by FEMA on December 3, 2018. In addition, significant renovations have been made at the City Yard facility since 2004, and improvements have been made with regard to materials storage and organization such that operations have not been impeded in recent years by storm events. Since this facility is still within the 100-year floodplain to Ell Pond, opportunities for further improvements will continue to be sought as maintenance and upgrade projects are undertaken within the facility.

- **Reconstruct Roosevelt School Detention Basin:** This facility serves as the last detention basin prior to discharge of stormwater through the northwest tributary culvert to Ell Pond.

Several issues were identified in 2004 including the time of concentration that were believed to adversely impact flooding in the Ell Pond area. Also, it was acknowledged that wastewater overflows entered the detention basin and were then transported to Ell Pond through the northwest tributary culvert. There were also concerns for the safety of elementary school students at the Roosevelt School while the basin was holding water.

***Status:*** Partial Completion

***Action Update:*** The detention basin reconstruction has been completed. This area remains a location that requires routine maintenance. The City will continue to clean the grate that enters the drain beneath the railroad tracks and keep it accessible for routine maintenance.

- **Reconstruct Upstream Portion of Tremont Street Drain:** The deteriorating 30-inch corrugated metal (CM) pipe requires cleaning and lining. This segment of pipe is located upstream from the portions of the drain previously cleaned and lined or replaced with new 30-inch reinforced concrete pipe.

  ***Status:*** Partial Completion

  ***Action Update:*** The downstream portion of the Tremont Street drain was rehabilitated, and the upstream portion has been cleaned. Rehabilitation of the bottleneck between Tremont Street and Vinton Street is still recommended, although other improvements in the Ell Pond watershed have lessened the overall impacts of flooding in this area. This project remains on the list of projects for completion.

- **Study and Implement Mitigation Measures for Several Flood Hazard Areas:** In 2004, the NHMP recommended developing and implementing mitigation measures for flooding in the following flood hazard areas:

  - Derby Road
  - Main Street/Sylvan Street
  - Boston Rock Road
  - Sylvan Street
  - Wyoming Cemetery
  - Lincoln Street

  ***Status:*** In Progress

  ***Action Update:*** Several of these areas have been improved through minor improvements to the drainage system, along with increased frequency of routine maintenance such as catch basin and drain line cleaning. The City intends to continue with high frequency routine maintenance in the areas identified as benefiting from such work. At this time, the Wyoming Cemetery area and the related upstream flood hazard areas have been identified as the highest priority for infrastructure replacement of the flooding areas identified within Sections 5.1 and 5.2 above.

- **Official City of Melrose Website:** Increase public outreach on the website (www.cityofmelrose.org) with links to mitigation activities from this plan, FEMA 100-year floodplain maps, geographic information systems (GIS) data, and other natural disaster-related links such as hurricane preparation.

  ***Status:*** In Progress

  ***Action Update:*** The City's website has been improved with regard to the availability of information, including links to the documents produced during the MVP process that are available for public viewing. Information contained in this new NHMP report will be placed on the website along with other documents described above. A dedicated webpage will be created for the information related to this report and will be made public through the Mayor's Blog or other online media channels.

- **Incident Command Course (ICS):** Initiate this course through the Emergency Management Department to better prepare City personnel for emergency response.

  ***Status:*** In Progress

  ***Action Update:*** The FEMA Emergency Management Institute now has updated incident command and National Incident Management Systems (NIMS) training courses, which can be found at: https://training.fema.gov/nims/. The City will determine the most appropriate training opportunities for personnel to ensure training needs are being met. The City will ensure that the Emergency Management Director has adequate training and that other City personnel involved in emergency response are also trained as needed.

- **Portable Generators:** Purchase three portable generators for use in the following locations: one for City Hall, one for the City Yard on Tremont Street, and one to be shared among the five water and wastewater pump stations in the City.

  ***Status:*** Partial Completion

  ***Action Update:*** The City now owns three portable generators, as described above. However, as detailed elsewhere in this report, the generators are not sufficient to provide the needed backup power in emergency situations. The highest priority is to install a permanent generator at City Hall. The water and sewer pumping stations also require at least one more portable generator, along with modifications to ensure the ability to run all stations using the same portable equipment.

- **Secure Important Records:** Scan important records and documents stored in City Hall onto microfilm (or electronic form). Store the copy of the records at a secure off-site location away from the original records located at City Hall.

  ***Status:*** In Progress

***Action Update:*** Since 2004, the City has had some sets of documents scanned, such as the sewer and drainage plan sets. There are many more plans and documents that should be scanned with backups kept in an offsite storage location. The City intends to continue with this program until all critical records have been scanned. As new records are developed, electronic copies are created as a matter of routine protocol.

- **Reverse 911:** Employ the use of a reverse 911 system in the City of Melrose to better assist the elderly and hazard victims.

  ***Status:*** Partial Completion

  ***Action Update:*** The City uses Reverse 911 for emergency situations and also has implemented the Code Red service for other notifications to residents. The City is presently in the process of reevaluating the choice of systems and will be entering into a contract with a vendor in the near future to serve the needs for community outreach for both emergency and non-emergency situations. The Melrose Public Schools also use Direct Connect for contact with parents and guardians.

- **Enroll in the Community Rating System:** Fill out the FEMA Community Rating System application so citizens in the City of Melrose who own houses in the 100-year floodplain can qualify for discounts on flood insurance rate premiums.

  ***Status:*** No Action

  ***Action Update:*** City personnel are not aware of any action on this item, but it will be evaluated moving forward.

- **South Washington Street Trash Grate:** Advise the Massachusetts Department of Conservation and Recreation to perform regular cleaning of the trash grate structure located at South Washington Street that often becomes blocked with debris.

  ***Status:*** In Progress

  ***Action Update:*** The City is continually coordinating with the DCR to ensure that this structure is routinely cleaned. The last known cleaning was in October 2018. The City will continue to coordinate with the DCR to ensure this work is done, as it has the potential to have significant impacts on upstream properties if flows are restricted due to the build-up of debris.

In addition to these actions, a short list of secondary actions were identified in the 2004 NHMP, as well as a handful of mitigation measures that were already being performed and are still relevant today. These actions have been carried forward into the later sections of this report for continued implantation or future action. They are as follows:

- **Maintain Melrose Emergency Management Department:** The City has hired a new part-time Emergency Management Director in February 2019. This position should be maintained and continue to be funded.

- **Comprehensive Emergency Management Plan:** The CEMP is a detailed report documenting policies, procedures, responsibilities, and training for various departments within the City. There is also a section detailing specific hazards (e.g., flood, hurricane, fire, etc.) and protocols to deal with these hazards. This plan requires updating to meet current needs and training to ensure proper implementation in the event of an emergency.

- **Policies for New Construction:** The City has policies for new construction within the City ordinances that should be evaluated for opportunities to improve requirements, such as more emphasis on green infrastructure and other natural solutions that provide stormwater handling capacity and treatment and minimize impacts during storm events.

- **Emergency Shelter Areas:** As detailed elsewhere in this report, the City has a plan for emergency shelters that requires updating, and shelters need to be evaluated to ensure they have the required infrastructure to support their use during a variety of emergency conditions.

- **Winter Storm Snow and Ice Warning Program for Flat Roof Buildings:** The purpose of this program was to notify the owners of large flat roof properties of the potential for dangerous snow loads. It was suggested in 2004 to add to this list housing for mentally handicapped individuals and additional flat roof buildings which were not previously notified. This program has now been replaced with warnings placed on the Mayor's Blog during heavy snow load conditions. This practice is planned to continue, with select outreach from the Inspectional Services Department to particular properties of concern when deemed beneficial.

- **Blue Warning Lights:** In the 2004 NHMP, it was recommended that the City install warning lights at six to eight major intersections to alert citizens of an impending storm, the need for evacuation, or a parking ban. The effectiveness and applicability of these warning systems will be determined when considering whether to implement this type of system.

- **Wetlands Bylaw:** The 2004 NHMP recommended considering whether to expand the City's zero net runoff policy to all developments, rather than just small developments. This will continue to be considered, along with the policies for new construction noted above.

- **Fire Sprinkler System in City Hall:** The 2004 NHMP recommended installing a sprinkler system throughout City Hall to protect this historic landmark. This has not been implemented and will continue to be considered when upgrades are undertaken for the building.

# Section 6

# Natural Hazard Mitigation Strategies

## 6.1 Goals for Natural Hazard Mitigation Strategies

The goal of each of the hazard mitigation actions outlined in this section is intended to either mitigate the susceptibility of Melrose to a natural hazard or to better prepare the City to protect and manage the community in the occurrence of a natural hazard. This supports the overall goal of the NHMP to identify both known and potential risks from current and future natural hazards and to develop, through the community planning process, actions to reduce the risk from these hazards. Implementing these actions can reduce the risk of loss of life and property in Melrose.

## 6.2 Mitigation Strategies to Reduce Natural Hazard Risks

Mitigation strategies and actions have been developed to address the asset vulnerabilities identified in **Section 4.2** and in **Section 5**. The strategies presented within this section were identified based on overall best practices and through input from the MVP workshops held in April 2018, the MVP/NHMP public meeting held on June 21, 2018, the regional input meeting held on September 25, 2018, and further input from City staff. The City has already taken action on strategies identified, including hiring an Emergency Management Director in February 2019.

As with the vulnerabilities identified in **Section 4**, the hazard mitigation strategies are separated into societal, infrastructure, and environmental categories to address the specific vulnerable assets identified within each. The mitigation strategies presented in this section are described in further detail in **Appendix B**. The table in Appendix B includes the hazard and vulnerability it is intended to mitigate. The table also identifies the strategy planning and implementation details: the project stage, priority, timeframe for implementation, and responsible party for each mitigation strategy; these are defined in **Table 6-1**, below.

**Table 6-1. Summary of Mitigation Strategy Planning and Implementation Details**

| Category | Definition |
| --- | --- |
| Project Stage | The project stage identifies the type of mitigation strategy (e.g., training, public outreach) and/or when in a project phase the mitigation strategy should be implemented (e.g., planning, design, etc.). |
| Priority | The priorities are high, medium, and low, based on feedback from the planning process described in Section 2. |
| Timeframe | Timeframe indicates how long a strategy may take to implement:<br>• Ongoing timeframe: Part or all of the strategy is underway.<br>• Short: The strategy may be completed within a five year timeframe.<br>• Long: The strategy may take longer than five years to complete. |
| Responsible Party | The responsible party indicates which entity is responsible for the implementation of the strategy. It identifies specific organizations or City partnerships. Where the City is listed as the responsible party, the Public Works Department together with the Emergency Management Director will be responsible for working with relevant City departments on the implementation – including identifying and obtaining project funding sources, as appropriate. |

### 6.2.1 Societal Hazard Mitigation Strategies to Improve Resilience

The primary actions that can be taken to improve resiliency against flood, severe weather, and other natural hazard events for societal assets in Melrose are summarized below. Refer to **Sections 4.2.1, 4.3,** or **Appendix B** for the vulnerabilities that are addressed through these actions. The table in Appendix B also provides additional details that pertain to each mitigation action that should be referred to during their implementation.

- **Emergency Management Planning**: Update emergency and evacuation plans to consider the increased frequency and intensity of climate change related natural disasters and to make these plans consistent with current and/or improved practices and protocols. This includes community outreach to educate citizens about the City's emergency notification system, to increase the number of people signed up. An up-to date emergency and evacuation plan would reduce the potential risk posed to public health and safety by establishing standard preparedness and mitigation strategies that address modern day hazards. Additionally, promote the development of individual emergency and evacuation plans for every household and business in the area to ensure families and employers have an established plan of action in the event of an emergency. Continue to update, track progress, and participate in emergency management planning programs on a regular basis to ensure any appropriate changes are made when necessary.

- **Senior/Aging Population**: Implement an education and outreach program for the senior/aging population to increase awareness about emergency response and evacuation plans and greatly improve the resiliency of this vulnerable population through appropriate preparedness. National Grid maintains a utility life support contact list that is used to communicate emergency event information to senior/aging populations. Leverage, update, and or expand this utility life support list to better plan for adequate availability of power and/or emergency relief resources to senior/aging populations, and help to expedite power reconnection for those that need it most. Development of any education and outreach campaign should specifically and clearly address how individuals can be added to National Grid’s utility life support contact list. Install a back-up power generator at the senior center to ensure power and air conditioning is supplied to the senior/aging population in the event of a natural disaster.

- **Chronically Ill/Disabled Population**: Chronically ill and disabled populations of Melrose face similar vulnerabilities and risks as the senior/aging population, therefore, similar actions are recommended. Additional actions include an education and outreach program at local hospitals, or for the caregivers of chronically ill or disabled individuals, to learn more about appropriate emergency response and evacuation plans. Outreach should promote the addition of any chronically ill or disabled individual, especially those that rely on medical equipment that requires power supply, to the National Grid utility life support contact list. Install back-up generators at City shelters to provide reliable power and air conditioning at a place of refuge for chronically ill or disabled populations in Melrose, and ensure that designated shelters have appropriate accommodations for this population.

- **Non-English Speaking Population:** Evaluate the demographic information for the City of Melrose to determine the most prevalent non-English language(s) among Melrose residents. Information gathered through such efforts could be used to develop effective multi-lingual signage and education campaigns that provide clear and effective information about evacuation routes and emergency preparedness and response. Multi-lingual signage along roads and emergency shelter locations, as well as educational advertisements or announcements in local newspapers, tv stations, radio stations, or at faith-based organizations, can help inform the non-English speaking population and ultimately reduce the overall risks associated with the inability to appropriately communicate or understand relevant emergency response or health and safety protocols during an emergency.

- **Low-Income Population:** The City of Melrose and the Massachusetts Department of Housing and Community Development can work together to explore the possibility of developing a cooling assistance program to help low-income populations pay for air conditioning during extreme heat events. The City will identify public spaces with air conditioning that residents may go to during heat events to cool down and consider providing transportation to these locations. Additionally, potential methods, partnerships, and programs that would help low-income populations cover replacement costs for essential resources such as food, clothing, transportation, and temporary housing should be investigated. An education and outreach campaign targeting low-income populations about emergency response and evacuation plans, as well as resources available to them to prepare for and recover from incurred damages, would also be an important and effective means of improving the resiliency of low-income populations during and after a natural hazard event. The City will identify public spaces with air conditions

- **Faith Based Organizations**: Install back-up generators at faith-based organizations to maintain power supply during an outage and allow for the use of such facilities as a safe refuge for those in need during a natural disaster. Efforts that educate faith-based organization leaders about emergency response and evacuation plans, as well as on available resources that would provide food and water during an emergency, can help improve the City's resiliency by increasing methods of communication. Coordination with faith-based organizations may also provide additional shelter space and/or supplies to area residents during a natural hazard event.

- **Pet Owners:** The City should develop a list of possible locations for pets to go during an emergency event that pet owners can easily access. Additionally, the City and local animal shelters can work together to identify designated pet-friendly emergency shelter locations that would accommodate household pets in the event of a natural disaster. The Animal Control Officer will be included in appropriate hazard mitigation training and planning activities.

### 6.2.2 Infrastructure Hazard Mitigation Strategies to Improve Resilience

The actions that can be taken to improve resiliency against natural hazard events for infrastructure assets in Melrose are summarized below. Refer to **Section 4.2.2, 4.3,** or **Appendix B** for the specific hazards and vulnerabilities that are addressed through these actions, along with additional details for implementation.

- **Transportation Infrastructure:** Ensure that existing evacuation routes allow for fast movement and avoid locations prone to flooding, and that evacuation signage is clearly visible and easily understood by English and non-English speaking populations. Educate City emergency and DPW personnel on route locations and required maintenance, such as the regular removal of debris from storm drains located along evacuation routes. Design and construction efforts that improve the management of stormwater along important roadways can have significant beneficial impacts that would reduce the risk of road closures or damaged infrastructure as a result of flooding or severe weather events. Design and construction efforts include the implementation or expansion of green infrastructure in flood prone areas, as well as upgrades to drainage systems to manage a higher capacity of stormwater. The roadway areas noted in Section 5 require particular attention. An upgrade to the emergency communication and notification system would also ensure that travelers on transportation networks are aware of evacuation routes, delays, and availability of alternative travel routes in real-time. The City may be able to work with MassDOT, DCR and/or Verizon to identify and develop a standard protocol that would help to notify Melrose residents of evacuation procedures before or during a natural hazard event.

- **City Hall:** Installation of a back-up generator to provide power during an outage is of high priority to maintaining the City's communications systems and Emergency Management Command Center. The City should also elevate critical mechanical and electrical equipment above ground level where possible and incorporate dry and/or wet floodproofing techniques that would minimize potential flood damage. Incorporate green infrastructure practices such as bioretention ponds, bioswales, rain gardens, and/or pervious pavement to reduce potential flood impacts within the City Hall parking lot, and regrade the parking lot to accommodate such features. The City also needs to continue to secure critical records, by scanning and storing records in multiple locations including offsite electronic storage.

- **Fire and Police Stations**: Install back-up power generators at the fire and police stations to maintain power and critical emergency functions at these facilities during a power outage. Protect emergency response equipment and materials within these facilities against flood by relocating equipment, back-up power generators, and emergency response vehicles outside current and future flood prone areas. If relocation is not possible, materials and equipment can be elevated to the greatest extent practicable to reduce the potential risk of flood damage.

- **Residential and Commercial Properties**: Residential and commercial properties in flood prone areas would particularly benefit from the implementation of green infrastructure practices such as bioswales, rain gardens, rainwater harvesting, bioretention ponds, and pervious pavement. Develop and implement stricter ordinances for new and existing developments to help Melrose protect its residential and commercial buildings from flood damage. Train and/or certify contractors and developers on appropriate resilience measures and changes to ordinances to ensure all new developments are built with resilience to natural hazards in mind. Also continue to ensure that existing building codes are being strictly followed.

- **Memorial Hall**: Memorial Hall is designated as an emergency shelter but lacks emergency backup power and other infrastructure necessary to ensure appropriate lighting and temperatures can be maintained and that appropriate storage is available for food and other supplies. A backup generator should be installed at Memorial Hall if it will continue to be designated as a shelter location. Further measures should be taken to prevent emergency response equipment and supplies from damage by locating them at elevations outside of flooding areas and implementing floodproofing measures where applicable.

- **Emergency Shelters:** Install a back-up power generator at emergency shelters throughout the City to reliably supply power and heating, ventilation, and air-conditioning (HVAC) at locations that provide refuge to those in need. Develop an emergency shelter management plan that includes specific guidelines about adequate multi-lingual signage, as well as information about food supply and storage locations, resources for medications or medical emergencies, and information about water supply. Similar to other emergency response and communication facilities, important equipment and supplies should be protected from potential flood damage through relocation to non-flood prone areas or materials and equipment should be stored on elevated surfaces above ground level. Elevate existing transportation assets, utilize stormwater best management practices, and regularly clear debris or downed trees along roadways and sidewalks in areas near shelters to ensure easy access during emergencies.

- **Schools/Child Care Facilities:** Upgrade HVAC systems and implement green roofs or tree planting efforts. Implement green infrastructure such as bioretention ponds, bioswales, rain gardens, and/or pervious pavement at Melrose High School and Middle School, and incorporate dry and wet floodproofing techniques in buildings that fall within future flood prone areas. Enforce building codes on fire prevention and elevator maintenance, as well as regular drills and training for students and teachers. Improve school and child care facility preparedness for an emergency and help minimize potential impacts associated with natural hazard events. Installation of a generator at City Hall will also allow for uninterrupted communications at the school facilities which use the City Hall infrastructure for connectivity.

- **Melrose-Wakefield Hospital**: Coordinate and cross-train emergency management personnel from the City and the hospital so both are aware of emergency plans and protocols, including a plan to continuously and effectively communicate the Hospital's capacity and hazard exposure with emergency personnel and the media during an emergency event. Elevate existing transportation assets, use stormwater best management practices, and regularly clear debris or downed vegetation along roadways leading to the hospital. Dry and wet floodproofing techniques may also be implemented throughout the hospital to help improve resiliency against flood impacts. Investigate if the hospital could act as a 24-hour pharmacy to the public before, during, and/or after an emergency situation to serve as a location where the public may acquire needed medications when pharmacies may be closed or have inadequate supply.

- **Pharmacies:** Store in-demand or difficult to acquire medications outside future flood prone areas, or off the floor above possible flooding areas, to protect such valuable supplies from being inundated and lost during a severe flood. Extend hours of operation prior to an emergency to ensure the public has adequate opportunity to acquire needed medications as appropriate. Elevate existing transportation assets, use stormwater best management practices, and regularly clear debris or downed vegetation along roadways leading to the pharmacies.

- **Gas Infrastructure:** Regularly maintain and restore damaged gas line infrastructure, as well as the monitor waterways where buried gas lines are nearby for scour or erosion. Use appropriate resilient design and materials when upgrading or expanding gas pipelines. Regularly train and/or certify gas infrastructure contractors and National Grid personnel on resiliency protocols. Continue to aggressively work with the National Grid to have leak prone pipe materials replaced with more resilient materials.

- **Electrical/Power Infrastructure:** Implement microgrids where feasible to minimize the occurrence of wide scale power outages and expedite power reconnections. Maintain a buffer or clear zone between the edge of power lines and adjacent tree belts or woodland areas to minimize the potential for outages incurred as a result of falling trees or limbs. Elevate critical electrical equipment in future flood prone areas to protect against potential flood damages. Regularly maintain and repair damaged electrical systems and power infrastructure. Construct alternative energy systems and use renewable energy as the primary energy source where possible. Upgrade electric utility lines and/or install buried lines when feasible. Develop of a list of available "on call" electricians that can connect National Grid power lines from poles to the homes of at risk populations. Identify and repair locations where buried electrical infrastructure is prone to flooding and associated failure. Develop an ongoing training program to properly educate the City's labor force on appropriate emergency response actions and ensure National Grid has done the same. Develop procedures and plans for when peak power demand exceeds capacity during an extreme heat event and/or the develop and implement design standards for electrical equipment that can withstand higher maximum temperatures.

- **Fuel Sources:** Designate secure fuel storage locations for fuel reserves used during a natural disaster away from flood prone areas. Partner with gas stations across the City to extend hours of operation prior to an emergency event to ensure the public has access to adequate fuel supplies for long-term hazard events.

- **Food Sources:** Designate secure food storage locations away from flood prone areas to house food reserves that would be used in the event of a natural disaster. Partner with grocery stores to extend hours of operation prior to an emergency event to ensure the public has access to adequate supplies of food and water for long-term hazard events. Grocery stores and food pantries should also be involved in the development of emergency shelter management plans to ensure adequate food and water supplies are available to emergency shelters during a natural hazard event. In addition, food source and safety information will be provided in multiple languages.

- **Communications Infrastructure:** Close the City's fiberoptic loop to form a redundant pathway for information to get back through the network if there is a breach in the loop. A voice over internet protocol (VOIP) system could also be utilized to allow telephone networks to quickly be routed to another location which would allow City officials' phone numbers to travel with their cell phones. This would facilitate uninterrupted communication with City officials during the planning and coordination phase of emergency response and during and post disaster. Bury communication lines where possible. Maintain and restore damaged communication infrastructure. Upgrade emergency communication and real-time notification systems used by travelers on transportation networks. Elevate critical communication equipment, or relocate equipment away from future flood prone areas. Ensure access to portable cell towers and generator systems that can provide temporary communication and electrical services to areas that need it during an emergency event. Ensure information technology (IT) equipment has redundancy, uninterrupted power supply, and other precautions for unforeseen events where deemed beneficial. Develop ongoing training programs that properly educate the labor force on appropriate emergency response actions.

- **Sewer Pumping Stations**: Install back-up power (either onsite or portable) and bypass capability at the five sewer pumping stations. Elevate pumping station equipment located within flood prone areas, where possible. Regularly maintain and repair damaged infrastructure, and continue infiltration and inflow reduction measures in sewers to prevent backups and overflows during high flow events.

- **Water Pumping Stations**: Elevate water pumping station equipment located within flood prone areas, where possible. Regularly maintain and repair damaged infrastructure. Routinely maintain backup equipment to ensure its availability during emergency events.

- **Water and Sewer Pipelines**: Identify areas of concern and prioritize repair and replacement efforts through water and wastewater infrastructure condition assessments. Regularly maintain and repair damaged infrastructure, and develop ongoing training programs to properly educate the labor force on appropriate emergency response actions. Training should include updating water system emergency response plans and understanding MWRA emergency protocols. Coordinate with neighboring towns and cities with regard to mutual aid water connections and potential sewer surcharge conditions when sending wastewater downstream. Maintain the map of mutual aid connections in the Water System Emergency Response Plan.

- **Stormwater Drainage Infrastructure**: Conduct stormwater drainage studies to address flooding that results from insufficient capacity or other deficiencies in the drainage system, including the areas listed in Section 5. Results can be used to strategically repair deficiencies, increase capacity, or construct green infrastructure in areas that would benefit the most. Dredge stormwater outfalls in areas prone to flooding, as well as develop and implement a stormwater maintenance plan. Keep stormwater infrastructure mapping up-to-date. Coordinate with neighboring towns, cities, and state agencies when sending drainage downstream and monitor associated infrastructure issues.

### 6.2.3 Environmental Hazard Mitigation Strategies to Improve Resilience

The actions that can be taken to improve resiliency against flood, severe weather, and other natural hazard events for environmental assets in Melrose are summarized below. Refer to

**Section 4.2.3, 4.3,** or **Appendix B** for the vulnerabilities that are addressed through these actions and additional details for implementation.

- **Water Bodies: Lakes/Rivers/Reservoirs**: Investigate opportunities to install flood control gates that would better manage flows during a significant flood event. Increase channel capacity within streams and rivers by removing large obstacles within channels or through the dredging of water features in flood prone areas. Plant trees and vegetation to expand vegetative buffers and stabilize river and stream embankments to reduce erosion and scour during high flow events while also mitigating the impacts that high temperatures can have on aquatic habitats. Encourage green infrastructure through City policies, ordinances, and design standards to better manage stormwater runoff and potentially reduce impacts associated with flood events.

- **Parks/Natural Areas/Open Space**: Investigate and implement mosquito management measures, including ditch maintenance, to reduce the spread of disease from current and new mosquito populations, as appropriate. Protect and expand wetland areas, natural systems, and vegetative buffers where possible to improve flood management and conserve natural areas. Conduct routine maintenance of parks and natural areas to remove or relocate dead vegetation to reduce the risk of wildfire during drought or extreme heat conditions.

- **Tree Canopy:** Create a funded tree warden or certified arborist position, or train existing personnel to obtain certification, to advise on resilient tree species and provide tree canopy assessments. Consider public-private partnerships for funding tree planting and maintenance. Conduct routine monitoring of street trees and trees in parks and natural areas, to reduce the potential for wildfire, downed trees or limbs damaging communication, electrical, transportation, or other infrastructure assets. Efforts should focus on preserving and enhancing the tree canopy to reduce urban heat island effects and reduce emissions from cooling loads. Offer incentive programs or outreach targeting property owners to plant trees with higher survivability and resiliency against extreme conditions.

- **Wildlife:** Investigate mosquito management measures that would help reduce the spread of disease within the wildlife or human populations of Melrose. Protect, expand, or restore wetland areas, natural systems, and vegetative buffers and perform routine monitoring of those areas for potential threats to vegetation, including the identification and potential removal of invasive species. Promote green infrastructure that provides habitat value in addition to stormwater volume and quality mitigation where possible.

- **Air Quality:** Develop an air quality monitoring and alert system to notify the population of Melrose of poor air quality events and provide recommendations for safe levels of outdoor activity to reduce the risk of health impacts associated with air pollution, and provide a link on the City's website. Plant trees in urban areas. Continue to implement Complete Streets principles as well as the enforcement of anti-idling laws for vehicles. Create campaigns that encourage behaviors that decrease energy use and reduce emissions.

# 6.3 High Priority Hazard Mitigation Strategies

The high priority hazard mitigation actions are summarized in **Table 6-2.** These were identified through the planning process outlined in **Section 2** and reflect the priorities of the community. It is the City's intent to implement these prioritized actions to reduce risk and build resiliency within the community. The responsible parties identified for implementing these strategies are also responsible for obtaining funding to implement them. Funding may be from the City's annual budget or grants, including MVP action grants or FEMA funds for which the City will be eligible with the completion of this NHMP.  Other sources of funding will be identified as the City becomes aware of them. The timeframe for implementing these strategies is indicated in the table as ongoing (O), short term – within five years (S), or long term – more than five years (L). Refer to **Appendix B** of this report for more details and additional information about project stage, time frame, and responsible party.

**Table 6-2. High Priority Hazard Mitigation Strategies**

| Asset | Applicable Hazards | | | | | Priority Mitigation Strategy |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| **SOCIETAL** | | | | | | |
| Emergency Management Planning | X | X | X | X | | • Update Emergency Management Plan for the City of Melrose. (O / S)<br>• Develop and promote individual and family emergency plans that detail evacuation routes, needed supplies, and shelter locations. (O) |
| Senior / Aging Population | X | X | X | X | X | • Obtain the utility life support contact list from National Grid to communicate emergency event information to senior/aging populations. This would help plan for adequate availability of power and/or emergency relief resources and expedite power reconnection after an outage. (S) |
| Chronically Ill / Disabled Population | X | X | X | X | | • Develop a utility life support contact list that can be used to communicate with chronically ill/disabled populations during an emergency event to ensure adequate availability of power and/or emergency relief resources. (S) |
| **INFRASTRUCTURE** | | | | | | |
| City Hall | X | X | X | X | | • Install a back-up power generator at City Hall to provide power, lighting, and HVAC for the IT Department that directly controls communication systems with emergency personnel and Melrose Public Schools. (S)<br>• Regrade the ground surface and/or install green infrastructure such as bioretention ponds, bioswales, rain gardens, and/or pervious pavement, where technically feasible at the City Hall parking lot to minimize flooding. (S) |
| Memorial Hall | X | X | | X | | • Install a back-up power generator at Memorial Hall to supply power and HVAC at a shelter that provides refuge to those in need during or after an emergency event. (S) |
| Fire and Police Stations | X | X | X | X | | • Install a back-up power generator at the Engines 2 and 3 stations to maintain power and other critical infrastructure at these critical facilities during a power outage, as well as at Melrose City Hall as noted above for police and fire communications. (S) |

| Asset | Applicable Hazards | | | | | Priority Mitigation Strategy |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| Transportation Infrastructure | X | X | | X | | • Identify/confirm evacuation routes and ensure signage exists and routes avoid locations prone to flooding or other potential barriers. (S)<br>• Create multi-lingual evacuation route signage along roadways that clearly communicates emergency response information to the population of Melrose during a natural hazard event. (O/S)<br>• Develop and use redundant evacuation routes that allow for faster movement out of flooded areas. (S)<br>• Upgrade emergency communication and real-time notification of travelers on transportation networks to ensure timely notification of impending weather and climate events and awareness of evacuation routes, delays, and availability of alternate travel routes. Identify communication protocol for notification of evacuation procedures before or during an event. (S)<br>• Expand green infrastructure, including the use of bioretention ponds, bioswales, rain gardens, and pervious pavements at flood prone areas in Melrose to minimize potential flood impacts and road closures. (L)<br>• Upgrade road drainage systems to manage a higher capacity of stormwater in flood prone areas such as Lebanon St at Sylvan St, Derby Rd., rail bridge at Melrose St., Grove St., and Geneva Rd at Upham. (L) |
| Residential and Commercial Properties | X | X | X | X | | • Expand green infrastructure and green buildings to improve building resiliency. (L)<br>• Develop and implement stricter ordinances for new and existing developments that would help Melrose protect its residential and commercial buildings from flooding, wind, and prolonged power outage. Targeted strategies may include building code legislation changes, adjustments to zoning codes, development of a stormwater management ordinance, by law, or design standards, incentive programs, and best practices guides. The goal is to adopt new ordinances that would help prevent flooding or minimize flood damage. (S) |
| Emergency Shelters | X | X | X | X | | • Install a back-up power generator at emergency shelters to supply power and HVAC at locations that provide refuge to those in need. (S)<br>• Offer multi-lingual signage and information at shelters that clearly communicate emergency response information to the population of Melrose. (S)<br>• Elevate existing transportation assets, utilize stormwater BMPs, and/or ensure that roadways and sidewalks are clear of debris and downed vegetation that would block access to emergency shelter locations during an emergency event in flood prone areas. (L) |
| Schools / Child Care Facilities | X | X | X | X | | • Install green infrastructure such as bioretention ponds, bioswales, rain gardens, and/or pervious pavement at Melrose High School and Middle School to minimize roadway and parking lot flooding. (L) |
| Melrose-Wakefield Hospital | X | X | X | X | | • Coordinate and cross-train emergency management personnel from the City and MWH so both are aware of emergency plans and protocols. (S) |
| Gas Infrastructure | X | X | | X | | • Continue to aggressively work with National Grid to have leak prone pipe materials replaced. (O / L) |

| Asset | Applicable Hazards: Flooding | Severe Weather | Fire | Earthquake | Invasive Species | Priority Mitigation Strategy |
|---|---|---|---|---|---|---|
| Communications Infrastructure | X | X | X | X | | • Work with the transportation sector to upgrade emergency communication and real-time notification of travelers on transportation networks and evacuation routes. (S)<br>• Upgrade communication systems to provide real-time notifications of emergency events through access of cell phones and other portable devices. (S)<br>• Ensure IT equipment has redundancy, uninterrupted power supply, and other precautions for unforeseen events where deemed beneficial. (S) |
| Sewer Pumping Stations | X | X | | X | | • Install back-up power and bypass capability at sewer pumping stations, including exercising generators on a regular basis. Investigate renewable energy options where feasible. (S)<br>• Elevate pumping station equipment located in flood prone areas to minimize risk of flood damage and power failure during a flooding event. (S) |
| Water Pumping Stations | X | X | | X | | • Elevate pumping station equipment located in flood prone areas to minimize risk of flood damage and power failure during a flooding event. (S) |
| Stormwater Drainage Infrastructure | X | X | | | | • Conduct a stormwater drainage study to address flooding that results from insufficient capacity in the drainage system, with particular attention given to the areas identified in Section 5 as experiencing the most significant flooding. (S)<br>• Implement green infrastructure practices like bioretention ponds, bioswales, rain gardens, and pervious pavements to increase stormwater infiltration rates and minimize potential flood impacts at locations prone to flooding. (L)<br>• Dredge the stormwater outfalls in areas prone to flooding, including the outfall at Wyoming Cemetery, to reduce potential flood impacts downstream of outfall locations. (L)<br>• Develop a stormwater maintenance plan that requires routine maintenance of culverts, storm drains, and storm sewers to remove sediment/debris and improve stormwater conveyance. (S)<br>• Keep stormwater maps up to date and ensure operations personnel are aware of outfall locations. (O / S)<br>• Conduct site specific studies and designs in areas prone to flooding to allow for bidding and construction of associated improvements. (S) |
| **ENVIRONMENTAL** | | | | | | |
| Water Bodies: Lakes / Rivers / Reservoirs | X | X | | X | X | • Consider dredging water features in flood prone areas like Ell Pond, Swains Pond, and Towners Pond to aid in storage of stormwater runoff. (L)<br>• Investigate mosquito management measures that would help to reduce the spread of disease from current and new mosquito populations; implement as appropriate. (S)<br>• Expand green infrastructure strategies that retain and infiltrate precipitation near water features to better manage stormwater runoff. Encourage natural solutions through City policies, ordinances, and design standards. (L) |

<table>
<tr><th rowspan="2">Asset</th><th colspan="5">Applicable Hazards</th><th rowspan="2">Priority Mitigation Strategy</th></tr>
<tr><th>Flooding</th><th>Severe Weather</th><th>Fire</th><th>Earthquake</th><th>Invasive Species</th></tr>
<tr><td>Tree Canopy</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>• Create a funded tree warden (certified arborist) position or have existing staff become certified to advise on resilient tree species and consider public-private partnerships for funding of planting and maintenance.[1] (S)</td></tr>
<tr><td>Parks/Natural Areas/Open Space</td><td>X</td><td>X</td><td>X</td><td></td><td>X</td><td rowspan="2">• Investigate mosquito management measures as noted in the Water Bodies section.</td></tr>
<tr><td>Wildlife</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
</table>

# Section 7

# Implementation of the Natural Hazards Mitigation Plan

## 7.1 Implementation Process and Monitoring

The goal of this NHMP is to identify both known and potential risks from current and future natural hazards and to develop, through the community planning process, actions to reduce the risk from these hazards. This NHMP represents the culmination of a significant planning effort that involved stakeholders from across City government, the community, and regional partners. This NHMP is the primary resilience planning document in the City of Melrose, the findings of which will be incorporated into planning documents and processes including the City's Comprehensive Emergency Management Plan. The mitigation strategies to address hazards summarized in **Section 6** identify the responsible party for implementation along with the priority set by the community planning process. The implementation of high priority hazard mitigation strategies will be monitored by the responsible parties shown in **Section 7.3** unless otherwise noted in **Appendix B**. In general, implementation of the recommendations in this NHMP will be tracked by the Public Works Department together with the Emergency Management Director on an ongoing basis for the effectiveness of achieving the NHMP goals.

The NHMP will be available to the public on the City's website along with the primary contact information for the Department of Public Works (DPW), the City Engineer, and the Emergency Management Director, all of whom will be available to receive and respond to public input on this NHMP. The DPW Director, City Engineer, and/or Emergency Management Director will present on the NHMP's progress to the Board of Aldermen on an annual basis. Meetings with the Board of Aldermen are open to the public and broadcast on the City's local television station, MMTV. The Public Works Department will also bring outreach materials on preparedness and resilience that are developed as a result of this NHMP to the booth they host at the City's annual Victorian Fair every September – a popular, well-attended public event.

An Emergency Management team made up of the Police Department, Fire Department, Public Works Department, Emergency Management Department, Information Technology Department, and Mayor's Office meets on a regular basis. The Director of Public Works and the Emergency Management Director will use this forum as a platform to present hazards and vulnerabilities identified in this NHMP and update this group on the status of the prioritized mitigation strategies. They will also solicit additional feedback on this NHMP as needed from the Emergency Management team. In addition, this NHMP will be evaluated regularly and reevaluated following any natural disaster to ensure it remains up to date and useful by the DPW Director and the Emergency Management Director.

The Public Work Department will also oversee the formal adoption of the NHMP by the City – documentation of which is available in **Appendix C**.

## 7.2 Schedule for Updating the Plan

The City has committed to updating the NHMP every five years as required by the Disaster Mitigation Act of 2000. The Public Works Department will spearhead the next Melrose NHMP Update beginning no later than mid-2023. The update of the NHMP will meet the requirements in place at the time of its publication, including any public meetings, updates on the implementation of prioritized mitigation strategies, and an evaluation of further refined climate data, as available. Public meeting information will be widely publicized at least one week prior to each meeting.

## 7.3 Responsible Parties and Contacts

Multiple agencies within the City government, community members, and regional partners provided input into this NHMP. All are responsible for implementing actions to increase resilience to natural hazards in Melrose. The primary team responsible for implementation and addressing comments or suggestions are as follows:

- The Mayor's Office
  Address: City Hall, 562 Main Street, Melrose, MA 02176
  Phone: 781-979-4500
  Website: https://www.cityofmelrose.org/mayor
  Contact form: https://www.cityofmelrose.org/mayor/webforms/contact-mayor

- Public Works Department, Director, City Engineer:
  Address: City Hall, 562 Main Street, Melrose, MA 02176
  Phone: 781-665-0142
  Website: https://www.cityofmelrose.org/public-works
  Contact form: https://www.cityofmelrose.org/user/29/contact

- Emergency Management Department, Emergency Management Director:
  Address: City Hall, 562 Main Street, Melrose, MA 02176
  Phone: 781-979-4130
  Website: https://www.cityofmelrose.org/emergency-management
  Contact form: https://www.cityofmelrose.org/user/42/contact

- For state resources, contact the Massachusetts Emergency Management Agency:
  Address: 400 Worcester Road, Framingham, MA 01702-5399
  Phone: 508-820-2000 (MEMA Headquarters and Communications Center) or 978-328-1500 (MEMA Region 1 Office)
  Website: https://www.mass.gov/orgs/massachusetts-emergency-management-agency

- For federal resources, contact the Federal Emergency Management Agency:
  Address: 99 High Street, Boston, MA 02110
  Phone: 877-336-2734
  Email: fema-r1-info@fema.dhs.gov
  Website: https://www.fema.gov/region-i-ct-me-ma-nh-ri-vt

# Appendix A

MVP Report

MVP workshop materials

MVP and HMP public listening session meeting notice, materials, and notes

HMP regional team meeting materials and notes

HMP public meeting notice, materials, and notes (to be provided)

CDM Smith

# Community Resilience Building Workshop: Summary of Findings

# Municipal Vulnerability Preparedness (MVP)

# Melrose, Massachusetts

**April 5 & 11, 2018**

Prepared by:

CDM Smith

Citation: City of Melrose, (2018) Community Resilience Building Workshop Summary of Findings, Municipal Vulnerability Preparedness (MVP) Program. Melrose, Massachusetts.

# Summary of Findings

## 1.1 Overview

The City of Melrose was awarded a $19,000 grant from the Massachusetts Executive Office of Energy and Environmental Affairs to conduct Community Resilience Building (CRB) workshops in the City. This funding is through a new program called Municipal Vulnerability Preparedness (MVP). Conducting the workshops allows Melrose to achieve "MVP" designation from the Commonwealth – a designation that gives the City access to further funding to implement resilient actions. Melrose is also in the process of updating the Natural Hazards Mitigation Plan (HMP) and will incorporate the findings from the CRB workshops; the HMP will be the primary resilience planning document for the City of Melrose. The City engaged the consulting firm, CDM Smith, to assist with both efforts.

## 1.2 Community Resilience Building Workshops

In Melrose, the workshops held in conjunction with the MVP program were a new initiative to immediately integrate community-derived priorities into a natural hazard mitigation process and identify actions to build resilience in the community. The workshops' central objectives were to:

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

A core team was established for this process, which consisted of:

- Martha Grover, Energy Efficiency Manager
- Elena Proakis Ellis, City Engineer
- John Scenna, Director of Public Works

Prior to the workshops, the core team identified preliminary hazards and areas of concerns. These were mapped and presented at the workshops and included in a participatory mapping exercise (see Appendix A). The core team, along with the consultant, identified departments and organizations recommended to attend the workshops. These were: Chamber of Commerce, Comcast, Conservation Commission, Department of Public Works, EMARC, Emergency Management Department, Fire Department, First Congregational Church, First Methodist Church, Friends of the Fells, Hallmark Health Emergency Preparedness, Health Department, Human Rights Commission, Information Technology, Mayor's Office, Melrose Energy Commission, Melrose Historical Commission, Melrose Housing Authority, Melrose Public Schools, Massachusetts Emergency Management Agency, Mystic Valley Elder Services, National Grid, Office of Planning and Community Development, Parks Department, Pedestrian and Bicycle

Advisory Committee, Police Department, Riverside Community Care, State Representatives/ Senators, and Verizon. All were invited by the Mayor to participate; see section 1.3.3 for a specific list of workshop participants. The workshops were held on two days: Thursday, April 5, and Wednesday, April 11, 2018. Prior to attending the workshops, the participants were asked to fill out a survey, a copy of which can be found in Appendix B, along with the survey results.

### 1.2.1 Top Hazards and Vulnerable Areas

At the first workshop, participants were asked to identify connections between ongoing community issues, hazards, and local planning and actions in Melrose. They were also asked to identify and map vulnerabilities and strengths to develop infrastructure, societal, and environmental risk profiles for Melrose. Maps reflecting City landmarks and facilities, existing and potential areas of flooding concern, and possible heat impacts were prepared for discussion (see Appendix A). To facilitate this exercise, the following definitions from the World Bank[1] were discussed with participants:

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

As a brainstorming exercise, participants were asked the following triggering questions from the CRB Workshop Guide:

- What hazards have impacted Melrose in the past? Where, how often, and in what ways?
- What hazards are impacting your community currently?
- What effects will these hazards/changes have on Melrose in the future (3, 5, 10, 25 years)?
- What/who is exposed to hazards and climate threats within your community?
- Other concerns or considerations?

[1] Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

The hazards, risks, and vulnerabilities from this brainstorming session are presented in Figure 1-1.

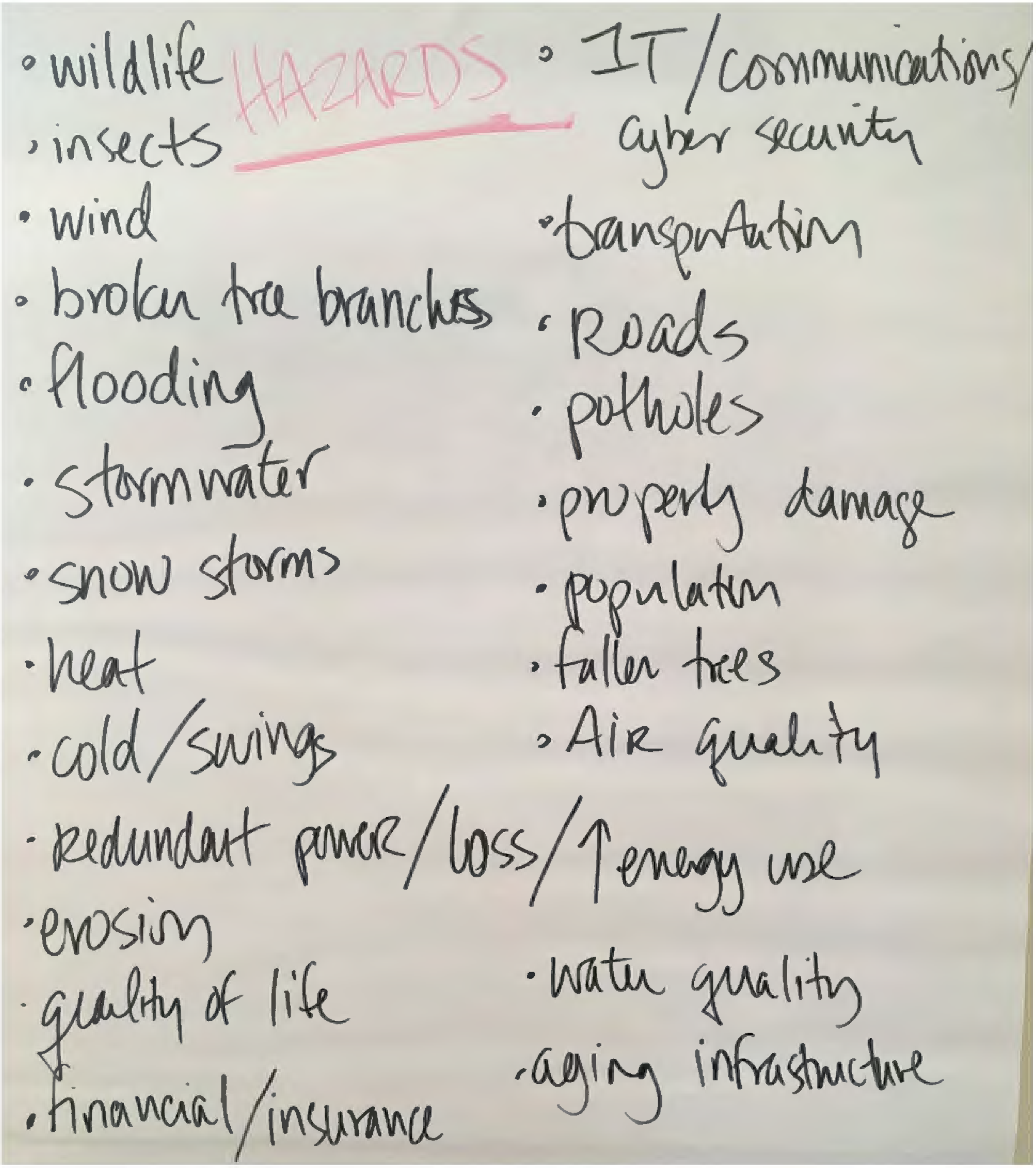



**Figure 1-1**
**Melrose Hazards, Risks, and Vulnerabilities (brainstorm results)**

### 1.2.1.1 Top Hazards

The Massachusetts Executive Office of Environmental Affairs (EEA) summarized the existing and expected future climate conditions by major watershed in the Commonwealth. Melrose falls into two watersheds; however, the majority of the City is in the Boston Harbor Basin. Therefore, projections from this basin were used as a basis for discussing future climate change in the City (see Appendix C). The key takeaways[2] from EEA on the future climate conditions are:

- Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth.
- Average, maximum, and minimum temperatures are expected to increase; seasonally, maximum summer and fall temperatures are expected to see the highest projected increase and minimum winter and fall temperatures are expected to increase.
- The number of days receiving precipitation over one inch are variable, fluctuating between loss and gain of days.
- Seasonal projections for total precipitation are also variable for the Boston Harbor basin. The winter season is expected to experience the greatest change with an increase of 0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable.
- Precipitation will be more variable. "Extreme" precipitation events are likely to occur more often.

With these climate change impacts in mind, the group was divided into three working groups, each of which was asked to identify the top four hazards from this list or others they felt were important to address. The Top Hazards were:

- Extreme temperature[3] (3 groups)
- Flooding (2 groups)
- Major Storms (2 groups)
- Wind (2 groups)
- Power Loss (2 groups)
- Disease (1 group)

[2] These impacts are direct from the document provided by EEA to MVP communities in December 2017 entitled "Massachusetts Climate Change Projections."
[3] One group identified extreme heat; two groups identified extreme temperatures which includes heat and cold.

#### 1.2.1.2 Areas of Concern Identified by Core Team

Prior to the meeting, the core team identified areas of concern due to potential hazards. They included sanitary sewer overflows, the ability to respond to large snowstorms, and the need for back-up power at sewer pump stations, cooling stations, and especially at City Hall. Additional areas with flooding concerns were noted to include:

- Geneva Road drainage that ties into Upham Street
- Outfalls at Wyoming Cemetery, downstream to Malden, and structure at Swain's Pond
- Connection between Towners Pond and Swain's Pond
- Lebanon Street at Sylvan Street
- City Hall parking lot
- Railway bridge at Melrose Street
- Conant Park at Ravine Terrace
- Derby Road

### 1.2.2 Current Concerns and Challenges Presented by Hazards

Melrose has faced natural hazards in the past like other Massachusetts communities, including flooding from the Mother's Day storm in 2006, overwhelming snowfall totals during the winter of 2015, and most recently the nor'easter events in January and March 2018. During the March 2018 storm, City Hall lost power, which disabled the phone lines to emergency responders.

In addition to the areas of concern raised by the core team, participants identified other concerns and challenges during the brainstorming session at the first workshop. These included:

- Maintaining and improving quality of life in Melrose
- Managing insects, pests, and wildlife with changes in precipitation patterns and increasing temperatures
- Ability to stay in good financial standing and obtain insurance despite climate stressors
- Cyber security concerns, maintaining communication pathways, and information technology systems (IT) during events
- Vulnerability of transportation systems to all hazards – including: 1) pothole maintenance from multiple freeze-thaw periods and 2) public transportation reliability
- Damage to property during events

- Population increases and the demands on public systems and housing availability
- Fallen trees during storms and the ability to remove them in a timely manner
- Poor air quality as temperatures rise, especially during heat waves
- Increasing energy use and strain on the electrical grid during heat waves
- Maintaining water quality through changing conditions
- Ability of aging infrastructure to withstand current and future hazards

### 1.2.3 Specific Categories of Concerns and Challenges

The working groups further discussed specific concerns and challenges in each of the categories of infrastructure, society, and environment. These findings, characterized as vulnerabilities, are presented in Appendix D in the Risk Matrix and in Table 1-1 below.

Of particular concern, as highlighted by every working group, was the lack of emergency generation capacity at City Hall. Melrose City Hall is the hub of communications in Melrose; calls to police, fire, ambulance, and schools are all routed through City Hall. During a power outage, like the one experienced during the March 2018 nor'easter, calls to these important services do not go through and calling out from land line phones is not feasible. This results in potential hazards of the highest magnitude through the lack of immediate communication during storm related events.

### 1.2.4 Current Strengths and Assets

The working groups discussed strengths and community assets in each of the categories of infrastructure, society, and environment during the latter half of the first workshop. These findings are presented in Appendix D in the Risk Matrix and in Table 1-1 below. Several strengths of note were discussed, including:

- Melrose has improved and upgraded stormwater systems to manage and mitigate existing flooding issues. These include drainage improvements to Ell Pond and have had a dramatically positive impact on the community.
- There are many faith-based organizations and associated places of worship in Melrose. These are a strength due to the community resilience they provide, the potential to use these organizations as a conduit for information to the public, and as a physical location of refuge and aid during or after an event.
- Melrose has an excellent team of first responders and emergency action plans. This coupled with a local hospital are community strengths; however, the emergency planning documents require updating, which is a vulnerability.
- Melrose has a Shelter Management Plan and identified shelters to provide for citizens during a time of need, which is a strength, although services at these locations require review (e.g., air conditioning, backup power, food availability and storage, etc.)

**Table 1-1 Vulnerabilities and Strengths in Melrose**

| Infrastructure Vulnerabilities and Strengths | V or S? |
|---|---|
| Roadways – evacuation routes, Melrose Street bridge | V |
| Technology – backup phones / public safety / servers | V |
| Drainage infrastructure / stormwater – parking lots | V/S |
| Sewer system / pump stations / MWRA | V |
| Power outages / power provider | V |
| City buildings / school facilities | V/S |
| New development | V/S |
| Generator capacity | V/S |
| Senior Center | V/S |
| Transportation network | V/S |
| Places of worship | S |
| Elderly and low-income housing | V |
| **Society Vulnerabilities and Strengths** | **V or S?** |
| Emergency responders | S |
| Emergency management plans / evacuation plans | V/S |
| MVP community / hazard mitigation plans | S |
| Public facilities | V/S |
| Hospital | S |
| Bus / transportation access | V/S |
| Seniors / aging population | V/S |
| Essential services to vulnerable populations | V |
| Communication (internal/to public) | V/S |
| Chronically ill / disabled | V |
| Managing public fear / anxiety | V |
| Security (cyber, physical, public safety) | V |
| Quality of life | V/S |
| Shelter management plan / shelters | S |
| Faith based organizations | S |
| **Environment Vulnerabilities and Strengths** | **V or S?** |
| Parks / open space / conservation land / Fells / Mt. Hood / trail network | V/S |
| Trees / canopy | V/S |
| Air quality | V |
| Heat islands | V |
| Local agriculture | V/S |
| Rodents / insects (vectors) | V |
| Mosquito management | V/S |
| Wildlife habitat | V/S |
| Water quality | V/S |
| Sewer overflow | V |
| Erosion | V |

Note: V = Vulnerability, S = Strength

## 1.2.5 Actions to Improve Resilience

The second workshop was focused on developing and prioritizing actions to improve resilience in the City. Each working group developed actions that would reduce vulnerability and enhance strengths for the features identified during the first workshop. The actions target one or multiple of the hazards in each of the categories of infrastructure, society, and environment. These actions were prioritized by each group as a high, medium, or low priority and assigned a timeframe for action of either short, long, or ongoing.  These findings are presented in Appendix D in the Risk Matrix.

### 1.2.5.1 Top Recommendations to Improve Resilience

Each working group identified the top five priority actions to improve resilience based on vulnerabilities and strengths identified by their group. These were presented to all workshop participants, who then voted on their top priorities from the aggregated list. The top action across every team was the need to install an emergency generator at City Hall. This project naturally rose to the top of the immediate needs list for the City of Melrose. The top five priority actions presented by the working groups were:

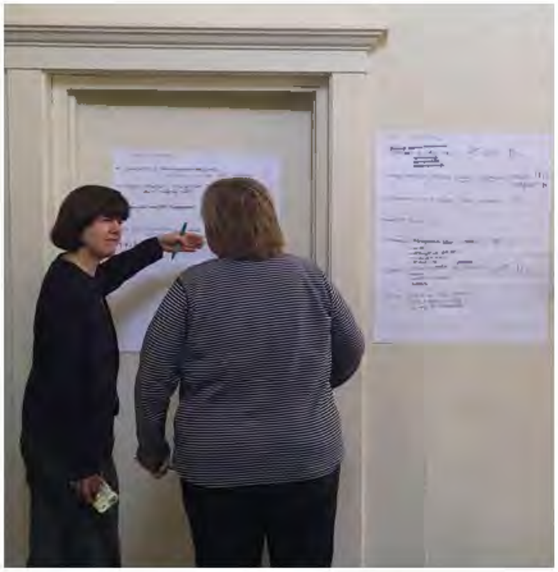
- Install a generator at critical public buildings and shelters[4] (1 group), specifically City Hall (3 groups)
- Install back-up power and bypass capability at water and sewer pump stations, including elevating infrastructure as appropriate (2 groups)
- Create a communications plan / conduct public outreach on hazards (2 groups)
- Update the emergency management plan which includes an evacuation plan, communication, and drills (2 group)

[4] One group generators at public buildings – including City Hall; two groups identified generators at City Hall specifically.

- Dredge stormwater outfalls, obtain a universal permit, and create a maintenance plan, which includes mosquito management (2 groups)
- Update the MS4 permit (1 group)
- Implement green infrastructure and green buildings, including zoning, stormwater, green energy, best management practices for developers, specific projects (1 group)
- Create a funded, dedicated emergency management director and a memorandum of understanding for emergency response (1 group)
- Create a funded tree warden position to advise on resilient tree species and consider public-private partnerships for funding for maintenance and planting (1 group)

After each team presented on their top five actions, each person was allowed three votes to allocate to any of the actions as show in Figure 1-2. This voting process determined the prioritized actions which are the Top Recommendations to Improve Resilience in Melrose. Furthermore, some sub-categories were established within these top priorities, as shown below:

1. Install an emergency generator at City Hall (17 votes)
2. Advance stormwater management actions including (9 votes):
    a. Dredge stormwater outfalls,
    b. Create a stormwater permit and maintenance plan, and
    c. Better manage mosquitos to reduce the spread of disease.
3. Improve emergency management including (9 votes):
    a. Update the emergency management plan, including evacuation routes and procedures,
    b. Improve outreach and communication to the public on emergency preparedness and climate hazards, and
    c. Create a dedicated/full-time emergency management director position.
4. Expand green infrastructure and green buildings, including (8 votes):
    a. Improving energy efficiency and expanding renewable energy throughout the City,



b. Implement best practices for stormwater management,

c. Update zoning codes and other regulatory mechanisms to facilitate green infrastructure and green buildings, and

d. Communicate and encourage best management practice implementation for developers.

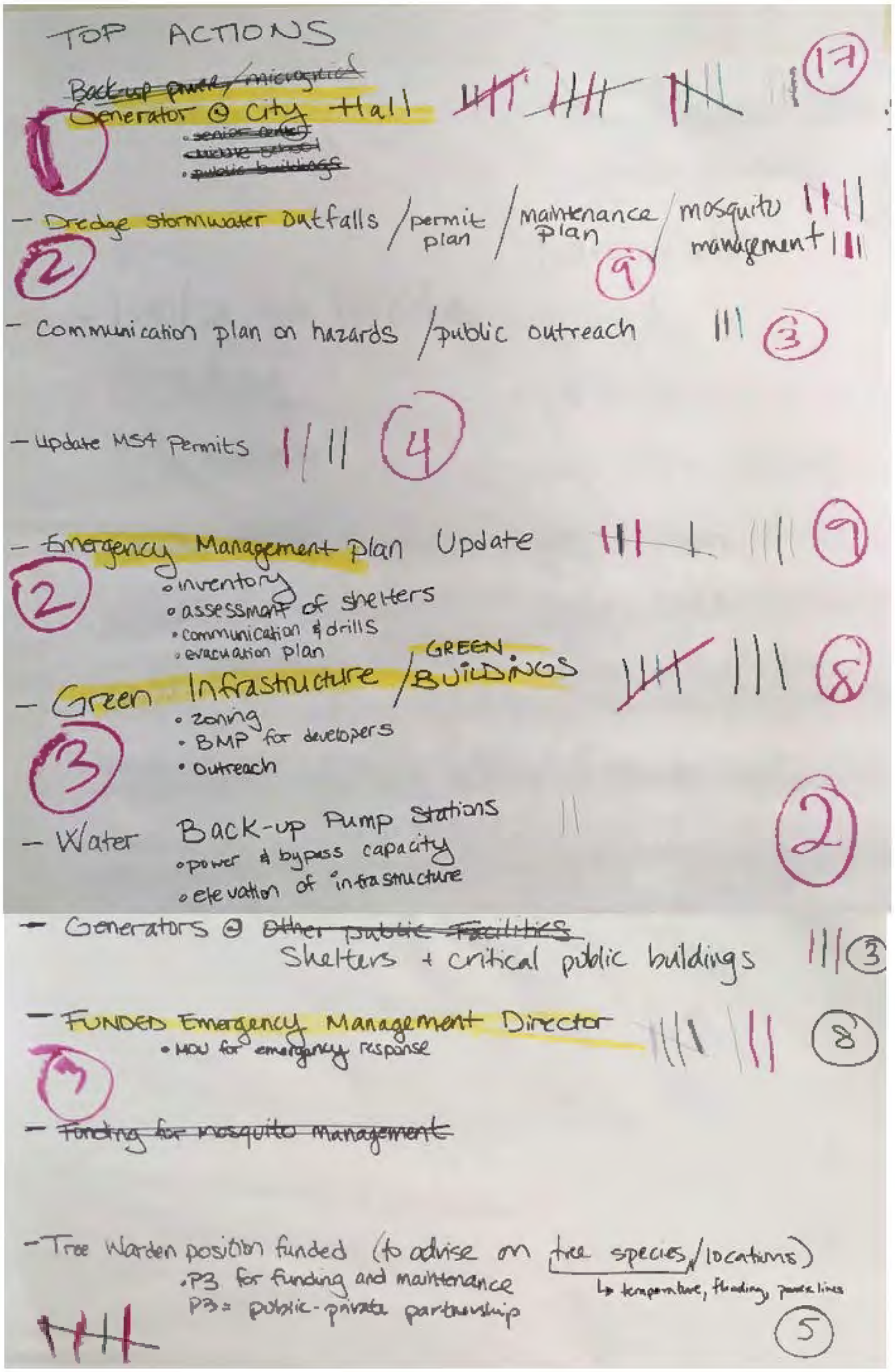



**Figure 1-2**
**Melrose Top Actions**

# 1.3 Acknowledgements


## 1.3.1 Leadership and Core Team Members

Thank you to the leadership and core team members for planning and facilitating the process described herein:

- Gail Infurna, Mayor of Melrose
- Martha Grover, Energy Efficiency Manager
- Elena Proakis Ellis, City Engineer
- John Scenna, Director of Public Works
- Lauren Miller, Lead Facilitator / Consultant Team, CDM Smith
- Lauren Klonsky, Table Facilitator / Consultant Team, CDM Smith
- Workshop scribes: Scott Dixon (Department of Public Works), Amy Heidebrecht (Department of Public Works), Lori Massa (Office of Planning and Community Development)

## 1.3.2 Funding and Facilities

Thank you to the Massachusetts Executive Office of Energy and Environmental Affairs for the funding to make these workshops possible.

Thank you to the Mount Hood Golf Club for providing the meeting space and refreshments.


## 1.3.3 Public Listening Session

The City of Melrose will hold a public listening session on June 21, 2018 open to the entire community to learn about the MVP process, next steps and actions, and how to implement resilience. The meeting will also discuss the Natural Hazards Mitigation Plan, which will identify actions to reduce the risk to the community from environmental hazards. The Natural Hazards Mitigation Plan will incorporate the findings from this report and will be the primary resilience planning document for the City of Melrose. This report and other resilience planning information may be found at: https://www.cityofmelrose.org/home/events/10693

### 1.3.4 Workshop Participants

Thank you to the community representatives that participated in the process, including:

| Name | | Department/Organization | |
|---|---|---|---|
| Brigid | Alverson | Mayor's Office | * |
| David | Ball | Fire Department | * |
| Joan | Bell | Parks Superintendent | * |
| Jim | Bennett | Melrose Historical Commission | |
| Paul | Brodeur | State Representative | * |
| Dan | Cameron | National Grid | * |
| Chris | Cinella | Chamber of Commerce | * |
| Ruth | Clay | Health Director, Emergency Management Director | * |
| Ed | Collina | Fire Department | |
| Paul | Cote | EMARC | |
| Eric | Devlin | Conservation Agent | * |
| Neal | Ellis | Information Technology Director | * |
| Denise | Gaffey | Office of Planning and Community Development | * |
| George | Harrington | Melrose Housing Authority | * |
| Faith | Hassell | National Grid | * |
| Andy | Henkenmeier | Hallmark Emergency Preparedness | * |
| Jim | Holt | Melrose Housing Authority | |
| Adam | LaFrance | Human Rights Commission | |
| Gary | LaMothe | Melrose Energy Commission, First Congregational Church | * |
| Stacy | Lanier | First Methodist Church | |
| Chris | Leary | Fire Department | |
| Jason | Lewis | State Senator | |
| Mike | Lindstrom | Mayor's Office | * |
| Mike | Lyle | Police Chief | * |
| Donna | Macdonald | Riverside Community Care | * |
| Mike | Main | MEMA Regional Manager, region 1 | |
| Katie | Moore | Pedestrian and Bicycle Advisory Committee, Melrose Energy Commission, Resident | * |
| Ron | Morin | Friends of the Fells | |
| Susan | Murphy | Conservation Commission, Melrose Energy Commission | * |
| Dan | O'Leary | Mystic Valley Elder Services | |
| Judy | Santa Maria | EMARC, Director of Family Support | * |
| Dominic | Taranowski | First Congregational Church | |
| Cyndy | Taymore | Melrose Public Schools | |
| Lori | Timmermann | Melrose Energy Commission, First Congregational Church | * |
| Ann | Waitt | Department of Public Works | * |
| David | Young | Consulting Engineer, CDM Smith | * |
| Erin | Zwirko | Office of Planning and Community Development | |
| | | Verizon | |
| | | Comcast | |

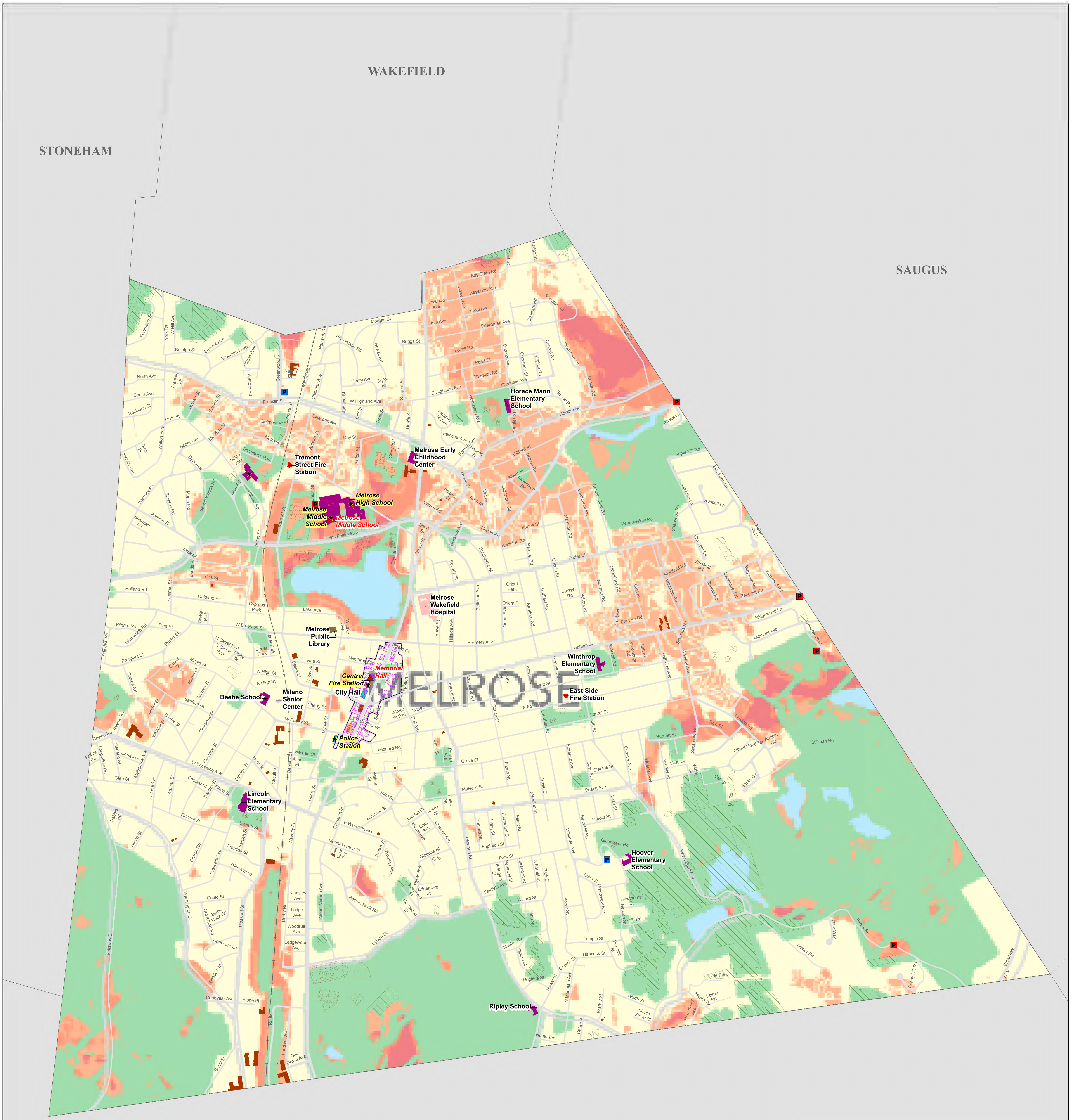
Note: *indicates attendance at the CRB Workshops. Others were invited to the meetings.

# Appendices

- Appendix A: Base Maps and Participatory Mapping Maps
- Appendix B: Pre-Workshop Survey Questions and Results
- Appendix C: Climate projections provided by the Executive Office of Energy and Environmental Affairs
- Appendix D: Melrose Risk Matrix
- Appendix E: Melrose MVP Meeting Materials

# Appendix A: Base Maps and Participatory Mapping Maps


Figure 1: Critical Facilities City of Melrose, MA




As the Metro Mayors region grows, changes in land use coupled with changing precipitation patterns are increasing the amount of stormwater runoff during rainfall events and altering the natural hydrologic regime. Increased stormwater leads to increased nuisance flooding, increased levels of pollutants entering the region's waterbodies, and higher demands on the combined sewer system. Stormwater also creates other challenges, including increased carbon emissions as water is pumped through sewer systems and then treated in treatment plants.

This map highlights areas that may be at risk of decreased water quality and increased flooding due to increased rainfall events and was created by combining the following criteria:

Current Flood Zones
Estimated Runoff Potential
Soil Permeability
Slope
Existing Wetlands
Coastal Adaption Areas
Sinks
Water Quality

**Legend**

**Climate-Smart Cities Layers**[1]

- Metro Mayors study area boundary
- Metro Area Planning Council (MAPC) town boundary
- Priority lands already under protection
- Parks, open space, or other protected land

Addressing stormwater challenges priorities
- Very high
- High
- Moderate

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library

- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

**Pump Stations**
- Water Pump Station
- Wastewater Pump Station

- Pavement
- Historic District
- Conservation Land
- Town Boundary
- Railroad
- Courts

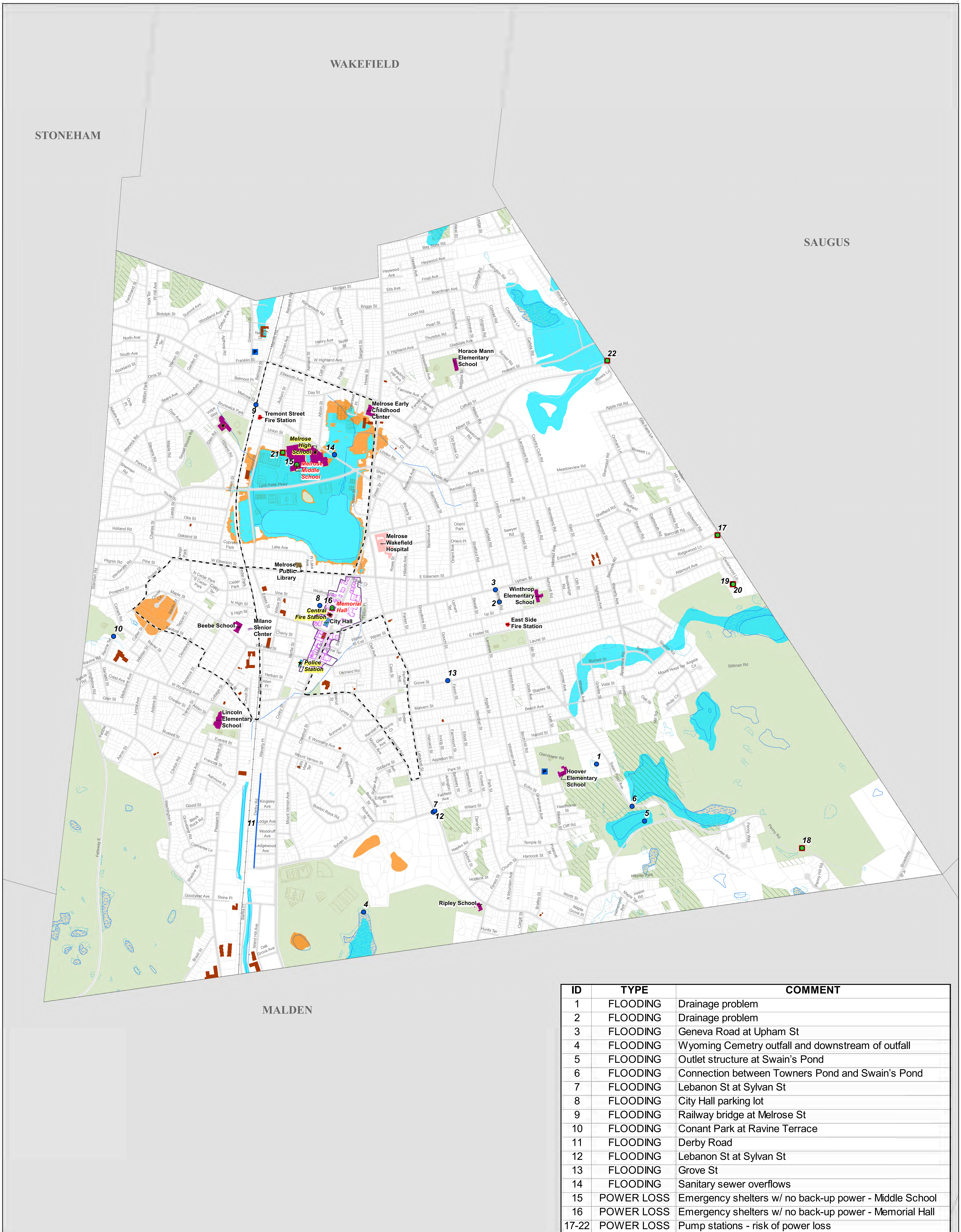
N W E S

0 400 800 1,600 Feet

# Figure 2: Metro Mayor's Stormwater Challenges City of Melrose, MA

**Source:** City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
**Coordinate System:** NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith




| ID | TYPE | COMMENT |
|---|---|---|
| 1 | FLOODING | Drainage problem |
| 2 | FLOODING | Drainage problem |
| 3 | FLOODING | Geneva Road at Upham St |
| 4 | FLOODING | Wyoming Cemetry outfall and downstream of outfall |
| 5 | FLOODING | Outlet structure at Swain's Pond |
| 6 | FLOODING | Connection between Towners Pond and Swain's Pond |
| 7 | FLOODING | Lebanon St at Sylvan St |
| 8 | FLOODING | City Hall parking lot |
| 9 | FLOODING | Railway bridge at Melrose St |
| 10 | FLOODING | Conant Park at Ravine Terrace |
| 11 | FLOODING | Derby Road |
| 12 | FLOODING | Lebanon St at Sylvan St |
| 13 | FLOODING | Grove St |
| 14 | FLOODING | Sanitary sewer overflows |
| 15 | POWER LOSS | Emergency shelters w/ no back-up power - Middle School |
| 16 | POWER LOSS | Emergency shelters w/ no back-up power - Memorial Hall |
| 17-22 | POWER LOSS | Pump stations - risk of power loss |

**Legend**

Police Station
Fire Station
City Hall
Hospital
School
Library
Affordable Housing
Long Term Care
Historic District Buildings
Emergency Generators
Emergency Shelter

**Type of Flooding Issue**

Flooding
Power Loss
Flooding
Cool & Climate Equity[1]

**Pump Stations**

Water Pump Station
Wastewater Pump Station

Pavement
Parcel Boundary
Historic District
Conservation Land
Field
Town Boundary
Railroad
Courts

Streams
Wetland Boundary (City of Melrose)
1% Annual Chance Flood Hazard with BFE or Depth (100-year storm)
0.2% Annual Chance Flood Hazard (500-year storm)
Wetland (MassGIS)
Water Bodies

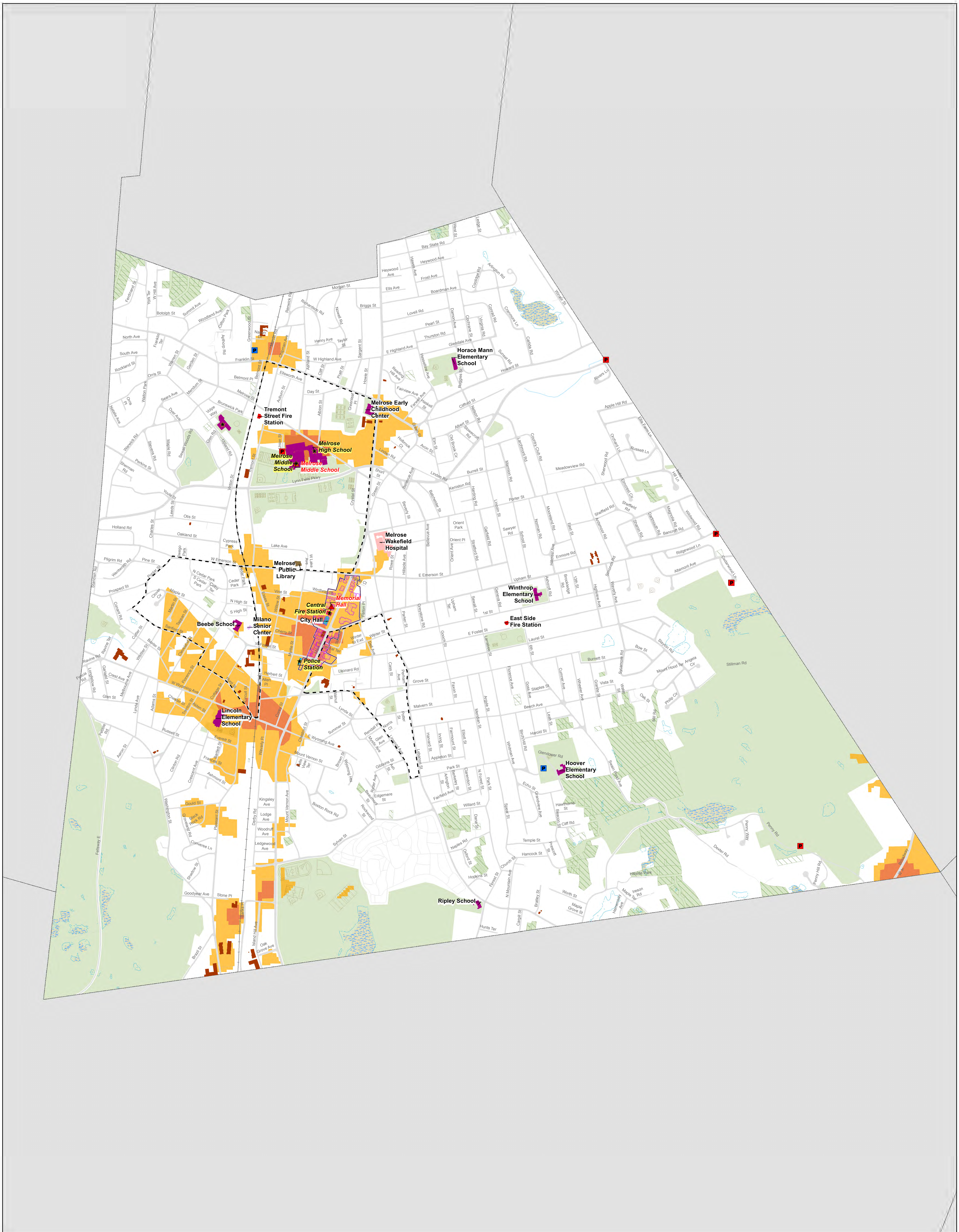
N W E S

0 400 800 1,600 Feet

# Figure 3: Critical Facilities & Flooding Vulnerable Population City of Melrose, MA

**Source:** City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
**Coordinate System:** NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith




## Legend

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

**Vulnerable Populations**

- Cool & Climate Equity[1]

**Elevated land surface temperature (July-Aug 2015)[1]**

- High
- Moderate

**Pump Stations**

- Water Pump Station
- Wastewater Pump Station

- Pavement
- Historic District
- Conservation Land
- Field
- Town Boundary
- Railroad
- Courts
- Streams
- Wetland Boundary (City of Melrose)
- Wetland (MassGIS)

0 400 800 1,600 Feet

# Figure 4: Urban Heat Islands & Vulnerable Population City of Melrose, MA

**Source:** City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
**Coordinate System:** NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith


| ID | TYPE | COMMENT |
|---|---|---|
| 1 | FLOODING | Drainage problem |
| 2 | FLOODING | Drainage problem |
| 3 | FLOODING | Geneva Road at Upham St |
| 4 | FLOODING | Wyoming Cemetry outfall and downstream of outfall |
| 5 | FLOODING | Outlet structure at Swain's Pond |
| 6 | FLOODING | Connection between Towners Pond and Swain's Pond |
| 7 | FLOODING | Lebanon St at Sylvan St |
| 8 | FLOODING | City Hall parking lot |
| 9 | FLOODING | Railway bridge at Melrose St |
| 10 | FLOODING | Conant Park at Ravine Terrace |
| 11 | FLOODING | Derby Road |
| 12 | FLOODING | Lebanon St at Sylvan St |
| 13 | FLOODING | Grove St |
| 14 | FLOODING | Sanitary sewer overflows |
| 15 | POWER LOSS | Emergency shelters w/ no back-up power - Middle School |
| 16 | POWER LOSS | Emergency shelters w/ no back-up power - Memorial Hall |
| 17-22 | POWER LOSS | Pump stations - risk of power loss |

**Legend**

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

**Type of Flooding Issue**

- Flooding
- Power Loss
- Flooding
- Cool & Climate Equity[1]

**Pump Stations**

- Water Pump Station
- Wastewater Pump Station

- Pavement
- Parcel Boundary
- Historic District
- Conservation Land
- Field
- Town Boundary
- Railroad
- Courts

- Streams
- Wetland Boundary (City of Melrose)
- 1% Annual Chance Flood Hazard with BFE or Depth (100-year storm)
- 0.2% Annual Chance Flood Hazard (500-year storm)
- Wetland (MassGIS)
- Water Bodies

N W E S

0 400 800 1,600 Feet

## Figure 3: Critical Facilities & Flooding Vulnerable Population City of Melrose, MA

RED

Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith


| ID | TYPE | COMMENT |
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| 8 | FLOODING | City Hall parking lot |
| 9 | FLOODING | Railway bridge at Melrose St |
| 10 | FLOODING | Conant Park at Ravine Terrace |
| 11 | FLOODING | Derby Road |
| 12 | FLOODING | Lebanon St at Sylvan St |
| 13 | FLOODING | Grove St |
| 14 | FLOODING | Sanitary sewer overflows |
| 15 | POWER LOSS | Emergency shelters w/ no back-up power - Middle School |
| 16 | POWER LOSS | Emergency shelters w/ no back-up power - Memorial Hall |
| 17-22 | POWER LOSS | Pump stations - risk of power loss |

**Legend**

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

**Type of Flooding Issue**

- Flooding
- Power Loss
- Flooding
- Cool & Climate Equity[1]

**Pump Stations**

- Water Pump Station
- Wastewater Pump Station

- Pavement
- Parcel Boundary
- Historic District
- Conservation Land
- Field
- Town Boundary
- Railroad
- Courts

- Streams
- Wetland Boundary (City of Melrose)
- 1% Annual Chance Flood Hazard with BFE or Depth (100-year storm)
- 0.2% Annual Chance Flood Hazard (500-year storm)
- Wetland (MassGIS)
- Water Bodies

N W E S

0 400 800 1,600 Feet

**Figure 3: Critical Facilities & Flooding Vulnerable Population City of Melrose, MA**

ORANGE

Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith


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| 11 | FLOODING | Derby Road |
| 12 | FLOODING | Lebanon St at Sylvan St |
| 13 | FLOODING | Grove St |
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| 16 | POWER LOSS | Emergency shelters w/ no back-up power - Memorial Hall |
| 17-22 | POWER LOSS | Pump stations - risk of power loss |

**Legend**

- Police Station
- Fire Station
- City Hall
- Hospital
- School
- Library
- Affordable Housing
- Long Term Care
- Historic District Buildings
- Emergency Generators
- Emergency Shelter

**Type of Flooding Issue**

- Flooding
- Power Loss
- Flooding
- Cool & Climate Equity[1]

**Pump Stations**

- Water Pump Station
- Wastewater Pump Station

- Pavement
- Parcel Boundary
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- Wetland (MassGIS)
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N W E S

0 400 800 1,600 Feet

**Figure 3: Critical Facilities & Flooding Vulnerable Population City of Melrose, MA**

Source: City of Melrose, MassGIS, FEMA, TPL, and MAPC
1) Climate-Smart Cities: Metro Mayor Climate-Smart Region, November 13, 2017
Coordinate System: NAD83 Mass. State Plane Mainland FIPS 2001 Feet

CDM Smith

# Appendix B: Pre-Workshop Survey Questions and Results

## Melrose Municipal Vulnerability Preparedness program

## Pre-Workshop Survey: March/April 2018

Thank you in advance for your involvement in the two-part Community Resilience Building Workshop series for Melrose's Municipal Vulnerability Preparedness (MVP) planning process and our upcoming Community Resilience Building workshops on April 5 and April 11, 2018.

We are excited to work with you to identify and prioritize actions to improve Melrose's resilience to climate change. These actions will aim to reduce impacts from climate-related hazards to infrastructural, societal, and environmental components to our community – today, and in the future. This information will also be used in conjunction with the on-going Hazard Mitigation Plan update which gives the City the opportunity to apply for grant funding from the Federal Emergency Management Agency (FEMA) for projects that are necessary to mitigate risks to the community from natural disasters.

We are asking participants to complete this brief survey, which focuses on how the community currently perceives, assesses, and acts to reduce risks. This will help us understand your concerns and priorities to make the most of our workshops.

We look forward to your feedback!

- Martha Grover, Energy Efficiency Manager, City of Melrose

- Elena Proakis Ellis, City Engineer, City of Melrose

- Lauren Miller, MVP Trained Facilitator / Consultant, CDM Smith

### 1. Enter your Name and Organization.

## * 2. Which of the following observed climate change impacts have already impacted your department / organization? Select all that apply.

- ☐ Increased frequency and magnitude of rain storms
- ☐ Increased frequency and magnitude of ice and snow storms
- ☐ Changes in precipitation patterns
- ☐ Increased seasonal / annual temperatures
- ☐ Temperature swings
- ☐ High wind events (including hurricanes, nor'easters, etc.)
- ☐ Other (please specify)

## * 3. What climate-related hazards is your department / organization most concerned about experiencing?

- ☐ Flooding
- ☐ Drought
- ☐ Power outages
- ☐ Wildfire
- ☐ Heat waves
- ☐ Vector-borne diseases
- ☐ Changes in growing season
- ☐ Decrease in snow cover
- ☐ Exacerbated respiratory conditions (i.e. asthma, allergies)
- ☐ Other (please specify)

* 4. From your department or organization’s opinion, which of the following is Melrose most vulnerable to as the result of climate change?  (Example climate change impacts are: Increased frequency and magnitude of rain, snow, or ice storms, Changes in precipitation patterns, Increased seasonal/annual temperatures, Temperature swings, Drought, High wind events)

Please rank based on order of vulnerability.
1 = Most vulnerable 8 = Least vulnerable.

Compromises to transportation infrastructure (roads, rail, bridges, trails, etc.)

Availability of utilities (water, wastewater, energy, communications, etc.)

Access to critical facilities (schools, libraries, emergency shelters, medical facilities, etc.)

Human injury, illness, or loss of life

Business interruptions (closures, economic losses, etc.)

Ability to maintain order and/or provide public amenities

Damage, contamination, or loss of ecosystems and natural resources (forests, wetlands, waterways, etc.)

Damage or loss of cultural resources (i.e. museums, historic properties, etc.)

## * 5. In your opinion, how prepared is your department / organization to address climate change vulnerabilities?

| Not Prepared: We expect operations would be significantly impacted by climate-related hazards. | | | | Prepared: We have plans, tools, and resources in place to be resilient to climate change hazards. |
|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ |

* 6. Please rank the importance of each statement to your department / organization to help us determine our collective priorities for reducing climate change vulnerabilities and work towards a more resilient Melrose.

| | Very Important | Somewhat Important | Neutral | Not Very Important | Not Important |
|---|---|---|---|---|---|
| Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) | Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Very Important | Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Somewhat Important | Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Neutral | Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Not Very Important | Protecting critical facilities (e.g. transportation networks, hospitals, fire stations, etc.) Not Important |
| Protecting and reducing damage to utilities | Protecting and reducing damage to utilities Very Important | Protecting and reducing damage to utilities Somewhat Important | Protecting and reducing damage to utilities Neutral | Protecting and reducing damage to utilities Not Very Important | Protecting and reducing damage to utilities Not Important |
| Protecting private property | Protecting private property Very Important | Protecting private property Somewhat Important | Protecting private property Neutral | Protecting private property Not Very Important | Protecting private property Not Important |
| Strengthening emergency services (e.g. police, fire, ambulance) | Strengthening emergency services (e.g. police, fire, ambulance) Very Important | Strengthening emergency services (e.g. police, fire, ambulance) Somewhat Important | Strengthening emergency services (e.g. police, fire, ambulance) Neutral | Strengthening emergency services (e.g. police, fire, ambulance) Not Very Important | Strengthening emergency services (e.g. police, fire, ambulance) Not Important |
| Promoting cooperation among public agencies, citizens, non-profits, and businesses | Promoting cooperation among public agencies, citizens, non-profits, and businesses Very Important | Promoting cooperation among public agencies, citizens, non-profits, and businesses Somewhat Important | Promoting cooperation among public agencies, citizens, non-profits, and businesses Neutral | Promoting cooperation among public agencies, citizens, non-profits, and businesses Not Very Important | Promoting cooperation among public agencies, citizens, non-profits, and businesses Not Important |

| | Very Important | Somewhat Important | Neutral | Not Very Important | Not Important |
|---|---|---|---|---|---|
| Preventing new or further development in hazard areas | Preventing new or further development in hazard areas Very Important | Preventing new or further development in hazard areas Somewhat Important | Preventing new or further development in hazard areas Neutral | Preventing new or further development in hazard areas Not Very Important | Preventing new or further development in hazard areas Not Important |
| Enhancing the function of natural features (e.g. streams, wetlands, etc.) | Enhancing the function of natural features (e.g. streams, wetlands, etc.) Very Important | Enhancing the function of natural features (e.g. streams, wetlands, etc.) Somewhat Important | Enhancing the function of natural features (e.g. streams, wetlands, etc.) Neutral | Enhancing the function of natural features (e.g. streams, wetlands, etc.) Not Very Important | Enhancing the function of natural features (e.g. streams, wetlands, etc.) Not Important |
| Protecting historical and cultural landmarks | Protecting historical and cultural landmarks Very Important | Protecting historical and cultural landmarks Somewhat Important | Protecting historical and cultural landmarks Neutral | Protecting historical and cultural landmarks Not Very Important | Protecting historical and cultural landmarks Not Important |
| Preserving natural ecosystems and biodiversity | Preserving natural ecosystems and biodiversity Very Important | Preserving natural ecosystems and biodiversity Somewhat Important | Preserving natural ecosystems and biodiversity Neutral | Preserving natural ecosystems and biodiversity Not Very Important | Preserving natural ecosystems and biodiversity Not Important |

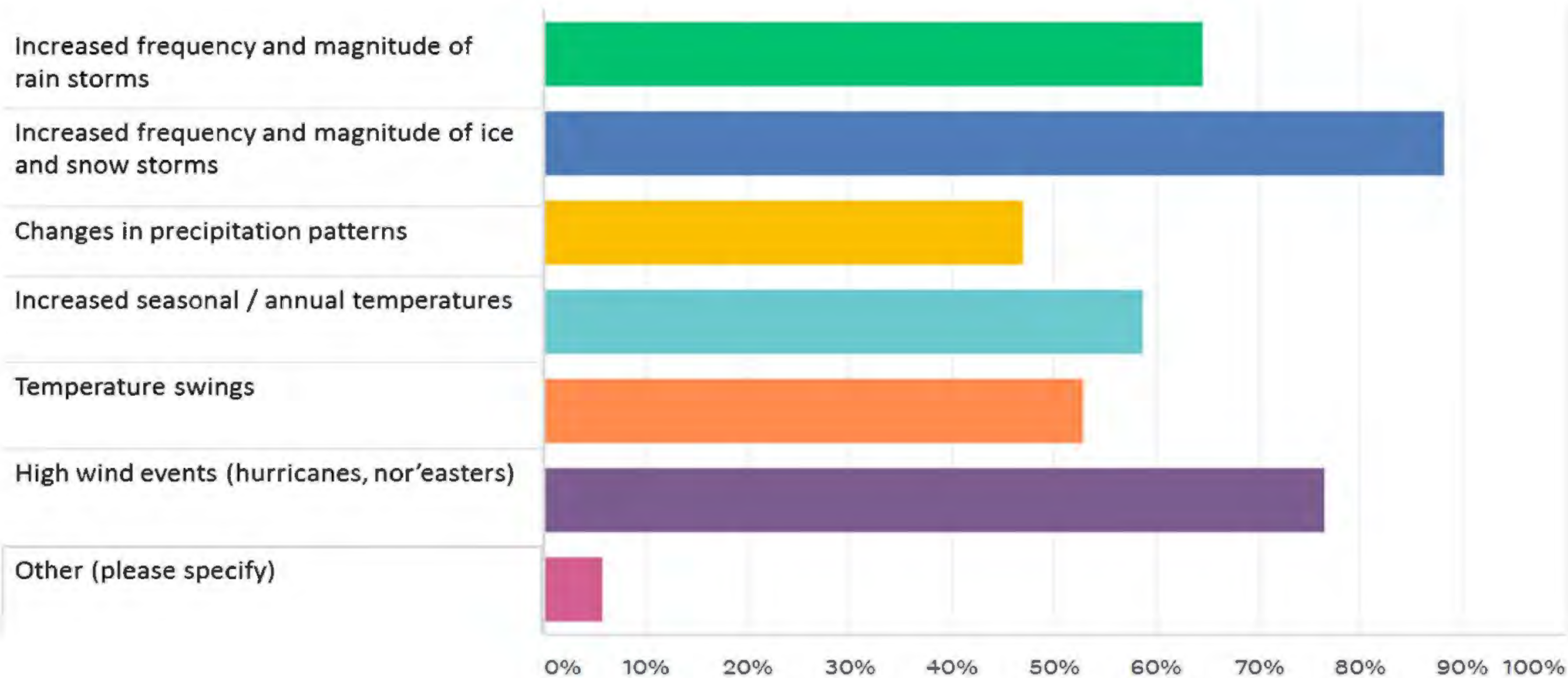
## 7. If you have additional comments you would like to share prior to the workshop, please provide them here.

DONE

Melrose Municipal Vulnerability Preparedness program

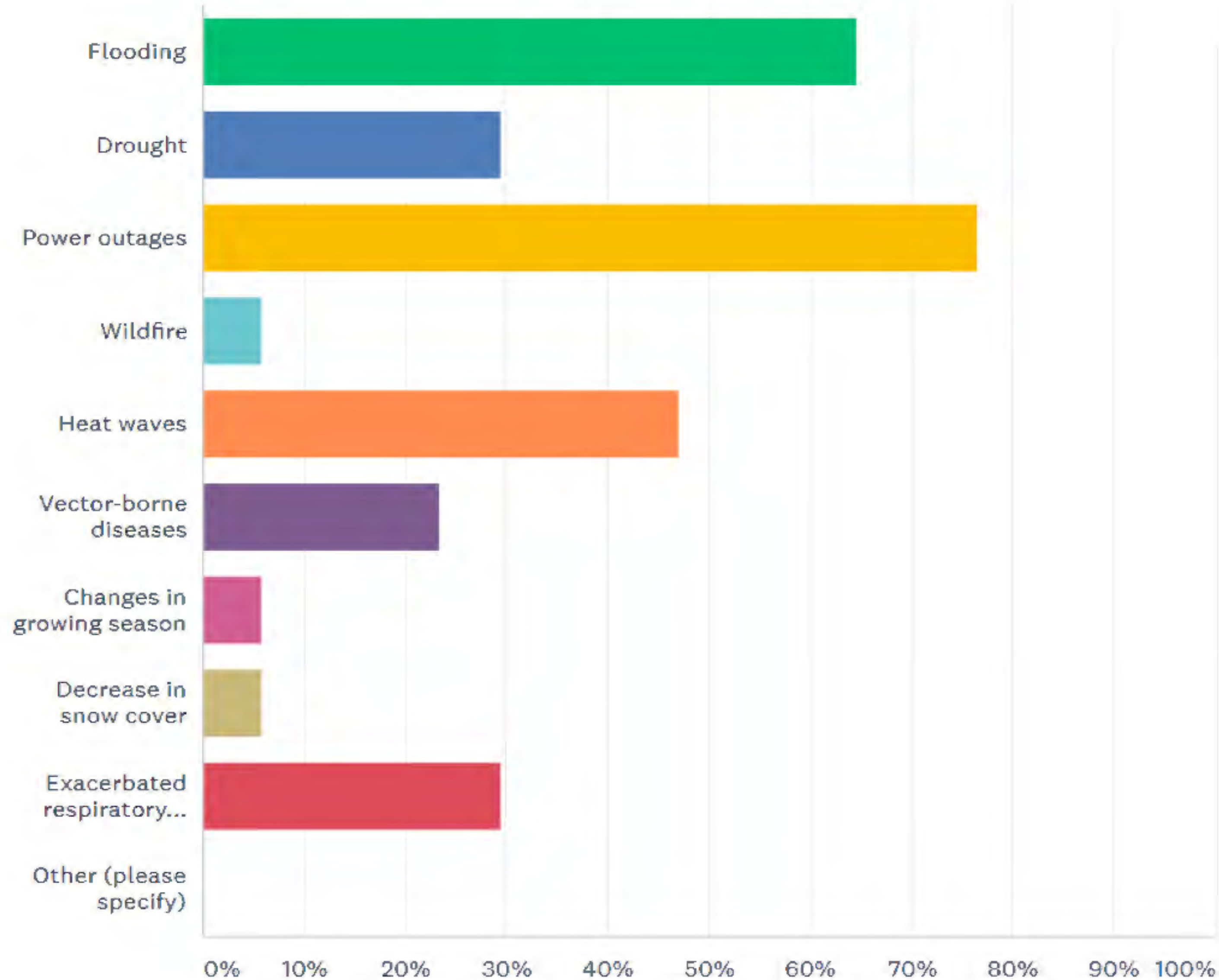
Pre-Workshop Survey Results

## 2. Which of the following observed climate change impacts have already impacted your department / organization? Select all that apply.




Other response: "Our Planning Board members are beginning to think about climate change when reviewing projects."

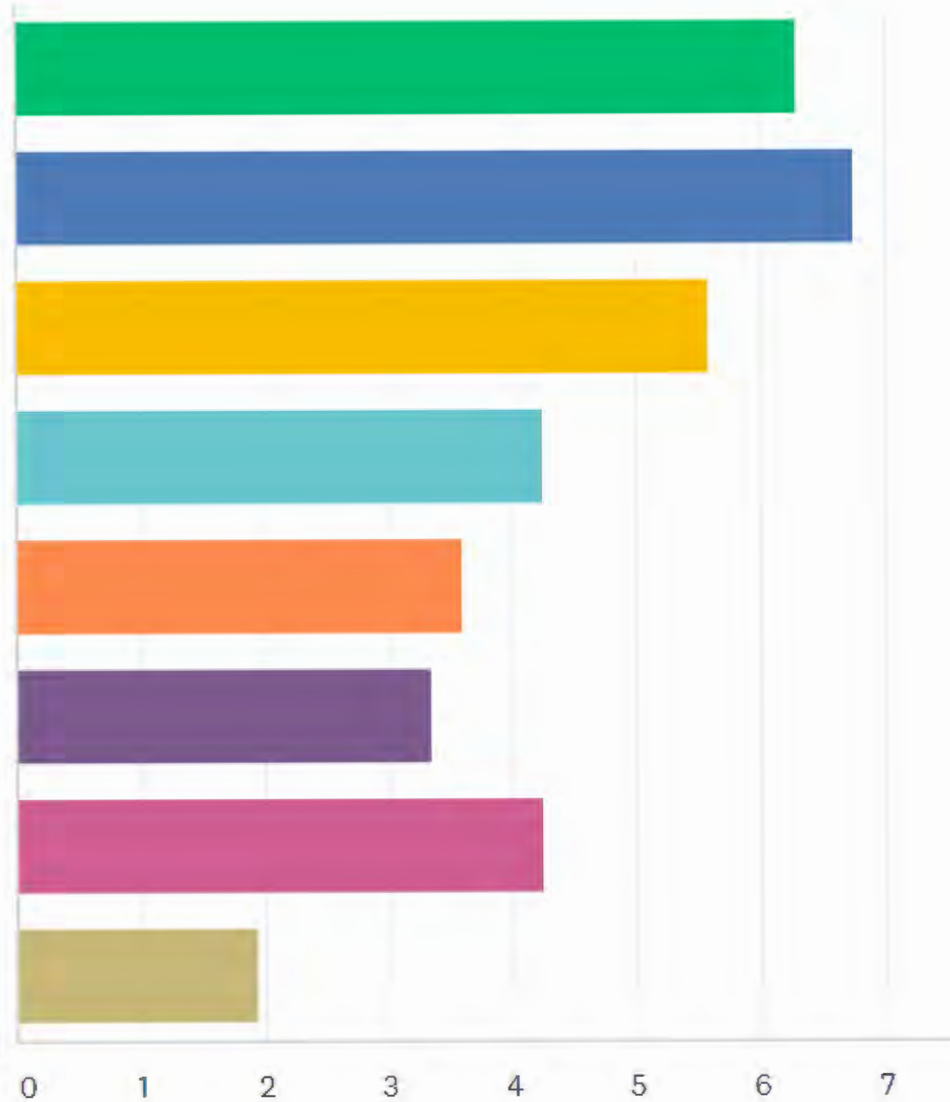
## 3. What climate-related hazards is your department / organization most concerned about experiencing?



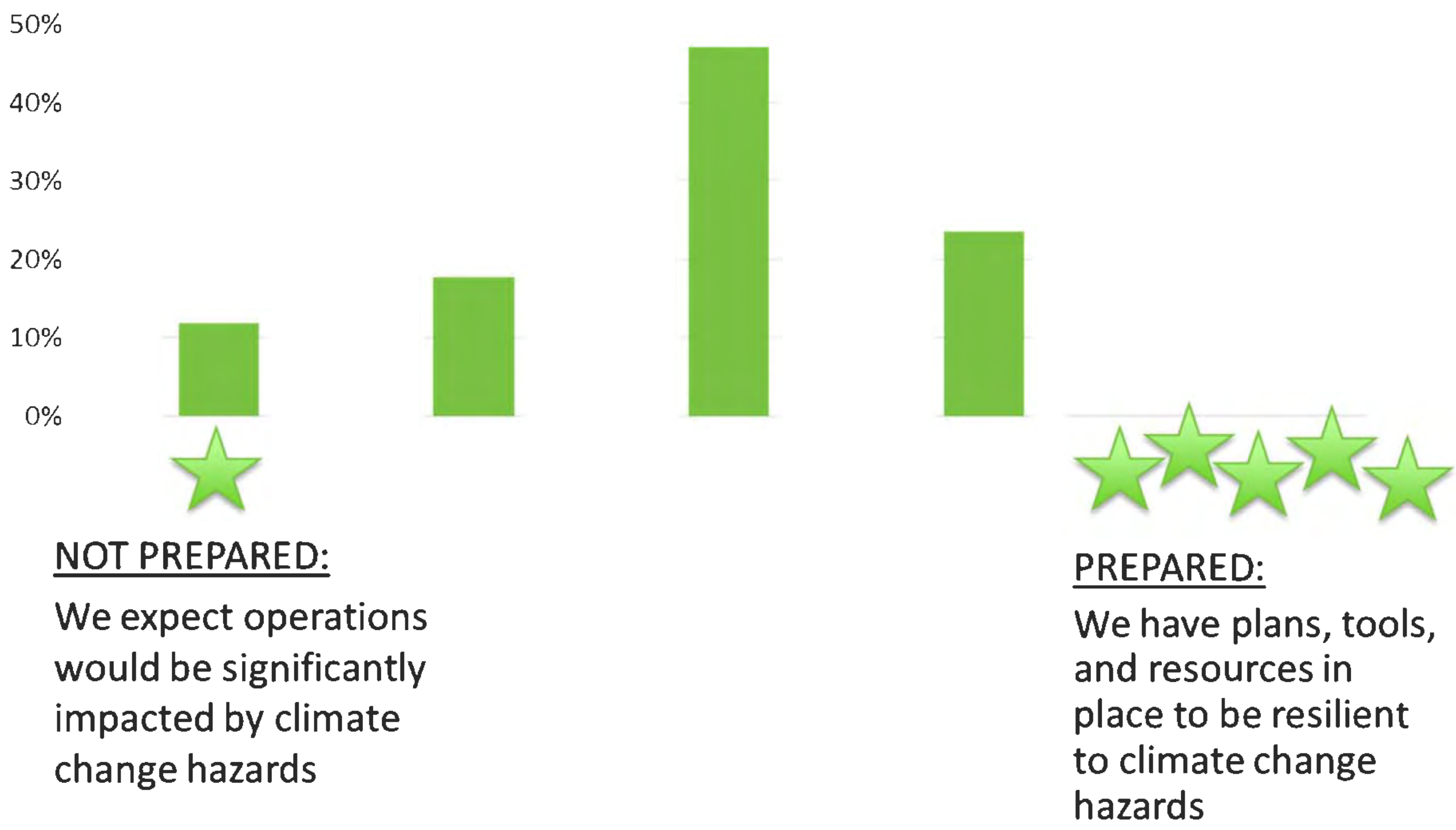

Other response: “Water quality impacts where storm water systems are undersized for more frequent extreme storms.”

4. From your department or organization’s opinion, which of the following is Melrose most vulnerable to as the result of climate change?  (Example climate change impacts are: Increased frequency and magnitude of rain, snow, or ice storms, Changes in precipitation patterns, Increased seasonal/annual temperatures, Temperature swings, Drought, High wind events)

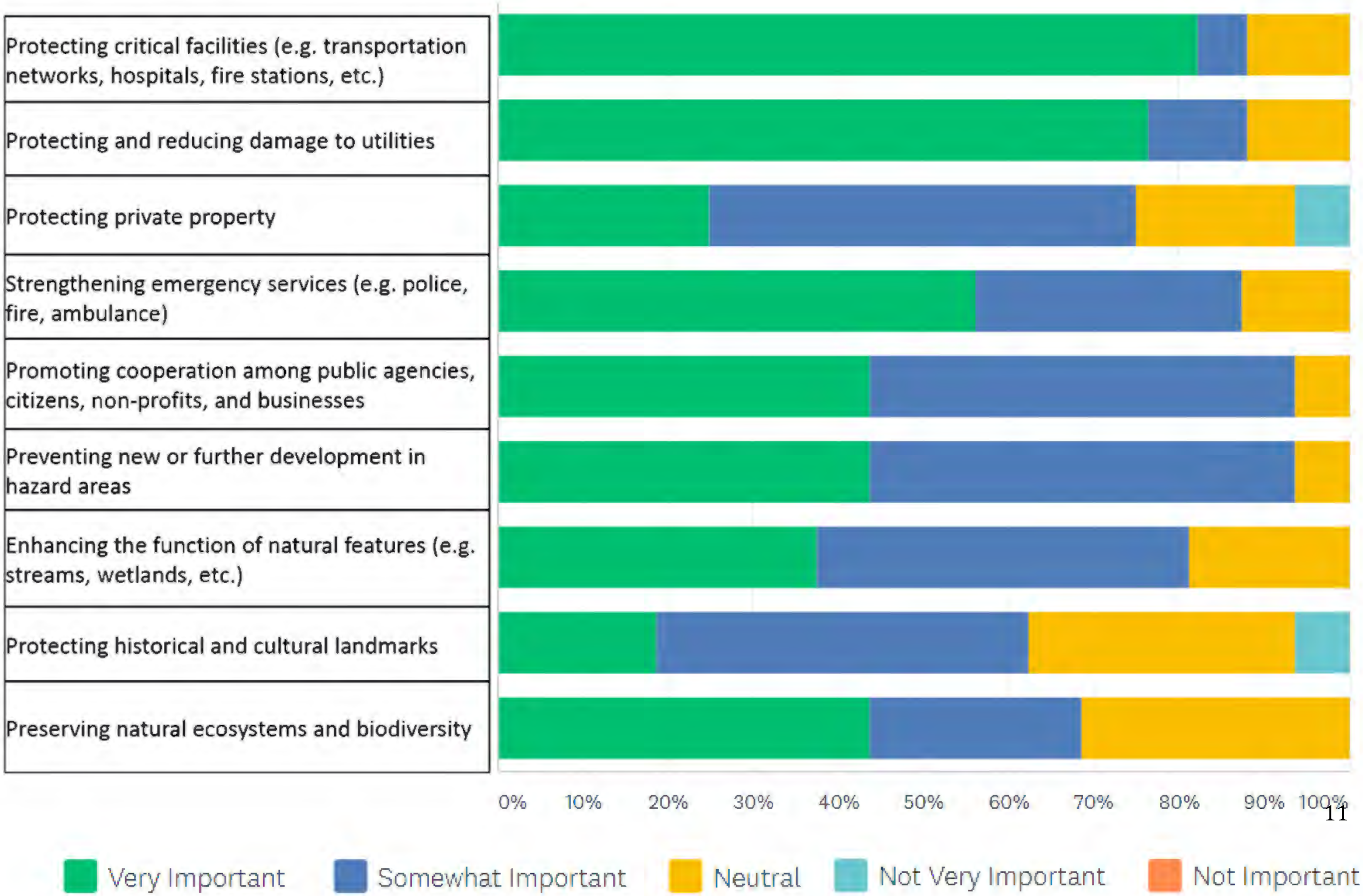
| | |
|---|---|
| Compromises to transportation infrastructure (roads, rail, bridges, trails, etc.) | 6.29 |
| Availability of utilities (water, wastewater, energy, communications, etc.) | 6.76 |
| Access to critical facilities (schools, libraries, emergency shelters, medical facilities, etc.) | 5.59 |
| Human injury, illness, or loss of life | 4.24 |
| Business interruptions (closures, economic losses, etc.) | 3.59 |
| Ability to maintain order and/or provide public amenities | 3.35 |
| Damage, contamination, or loss of ecosystems and natural resources (forests, wetlands, waterways, etc.) | 4.24 |
| Damage or loss of cultural resources (i.e. museums, historic properties, etc.) | 1.94 |



5. In your opinion, how prepared is your department / organization to address climate change vulnerabilities?



6. Please rank the importance of each statement to your department / organization to help us determine our collective priorities for reducing climate change vulnerabilities and work towards a more resilient Melrose.



## 7. If you have additional comments you would like to share prior to the workshop, please provide them here.

“My responses are based on Riverside involvement and not directly related to the city of Melrose depts.”

“So many comments... I'll wait for the workshop.”

# Appendix C: Climate projections provided by the Executive Office of Energy and Environmental Affairs

**MASSACHUSETTS CLIMATE CHANGE PROJECTIONS**

Researchers from the Northeast Climate Science Center at the University of Massachusetts Amherst developed downscaled projections for changes in temperature, precipitation, and sea level rise for the Commonwealth of Massachusetts. The Executive Office of Energy and Environmental Affairs has provided support for these projections to enable municipalities, industry, organizations, state government and others to utilize a standard, peer-reviewed set of climate change projections that show how the climate is likely to change in Massachusetts through the end of this century.

*Temperature and Precipitation Projections*

The temperature and precipitation climate change projections are based on simulations from the latest generation of climate models[1] from the International Panel on Climate Change and scenarios of future greenhouse gas emissions.[2] The models were carefully selected from a larger ensemble of climate models based on their ability to provide reliable climate information for the Northeast U.S., while maintaining diversity in future projections that capture some of the inherent uncertainty in modeling climate variables like precipitation. The medium (RCP 4.5) and high (RCP 8.5) emission scenarios were chosen for possible pathways of future greenhouse gas emissions. A moderate scenario of future greenhouse gas emissions assumes a peak around mid-century, which then declines rapidly over the second half of the century, while the highest scenario assumes the continuance of the current emissions trajectory.

Fourteen climate models have been run with 2 emission scenarios each, which lead to 28 projections. The values cited in the tables below are based on the 10-90$^{th}$ percentiles across the 28 projections, so they bracket the *most likely* scenarios. For simplicity, we use the terms "…expected to…," and "…will be…," but recognize that these are estimates based on model scenarios and are *not predictive forecasts*. The statewide projections comprising county- and basin-level information are derived by statistically downscaling the climate model results.[3] They represent the best estimates that we can currently provide for a range of anticipated changes in greenhouse gases. Note that precipitation projections are generally more uncertain than temperature.

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[1] These latest generation of climate models are included in the Coupled Model Intercomparison Project Phase 5 (CMIP5), which formed the basis of projections summarized in the IPCC Fifth Assessment Report (2013).

[2] Future greenhouse gas emissions scenarios are typically expressed as "Representative Concentration Pathways" (RCPs). They indicate emissions trajectories that would lead to certain levels of radiative forcing by 2100, relative to the pre-industrial state of the atmosphere; RCP4.5 equates to +4.5W $m^{-2}$, and RCP 8.5 would be +8.5W $m^{-2}$. In effect, they represent different pathways that society may or may not follow, to reduce emissions through climate change mitigation measures.

[3] The Local Constructed Analogs (LOCA) method (Pierce et al., 2014) was used for the statistical downscaling of the statewide projections.

The downscaled temperature and precipitation projections for the Commonwealth are provided at three geographic scales (Table 1) for annual and seasonal temporal scales (Table 2), and can be accessed through the Massachusetts Climate Change Clearinghouse website (www.massclimatechange.org). The statewide projections are included in this guidebook, but temperature and precipitation projections at each of the Commonwealth's major basins are accessible on the website and as a supplemental PDF to this guide.

These climate projections are provided to help municipal officials, state agency staff, land managers, and others to identify future hazards related to, or exacerbated by changing climatic conditions. For the Municipal Vulnerability Preparedness (MVP) program participants, we recommend using climate projections downscaled to the major basin scale (Table 1) as there are regional differences across several climate indicators (Table 3). These projections can help MVP communities to think through how future hazards in their community may change, given projected changes in temperature and precipitation.

Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century. A first step in becoming more climate-resilient is to identify the climate changes your community will be exposed to, the impacts and risks to critical assets, functions, vulnerable populations arising from these changes, the underlying sensitivities to these types of changes, and the background stressors that may exacerbate overall vulnerability.

**Table 1: Geographic scales available for use for Massachusetts temperature and precipitation projections**

| Geographic Scale | Definition |
|---|---|
| Statewide | Massachusetts |
| County | Barnstable, Berkshire, Bristol, Dukes, Essex, Franklin, Hampden, Middlesex, Nantucket, Norfolk, Plymouth, Suffolk, Worcester |
| Major basins[4] | Blackstone, Boston Harbor, Buzzards Bay, Cape Cod, Charles, Chicopee, Connecticut, Deerfield, Farmington, French, Housatonic, Hudson, Ipswich, Merrimack, Millers, Narragansett Bay & Mt. Hope Bay, Nashua, North Coastal, Parker, Quinebaug, Shawsheen, South Coastal, Sudbury-Assabet-Concord (SuAsCo), Taunton, Ten Mile, Westfield, and Islands (presented here as Martha's Vineyard basin and Nantucket basin) |

**Table 2: Definition of seasons as applied to temporal scales used for temperature and precipitation projections**

| Season | Definition |
|---|---|
| Winter | December-February |
| Spring | March-May |
| Summer | June-August |
| Fall | September-November |

[4] Many municipalities fall within more than one basin, so it is advised to use the climate projections for the basin that contains the majority of the land area of the municipality.

**Table 3: List and definitions of projected temperature indicators**

| Climate Variable | Climate Indicator | Definition |
|---|---|---|
| **Temperature** | Average temperature | Average annual or seasonal temperature expressed in degrees Fahrenheit (°F). |
| | Maximum temperature | Maximum annual or seasonal temperature expressed in degrees Fahrenheit (°F). |
| | Minimum temperature | Minimum annual or seasonal temperature expressed in degrees Fahrenheit (°F). |
| | Days with Tmax > 90 °F | Number of days when daily maximum temperature exceeds 90°F. |
| | Days with Tmax > 95 °F | Number of days when daily maximum temperature exceeds 95°F. |
| | Days with Tmax > 100 °F | Number of days when daily maximum temperature exceeds 100°F. |
| | Days with Tmin < 32 °F | Number of days when daily minimum temperature is below 32 °F. |
| | Days with Tmin < 0 °F | Number of days when daily minimum temperature is below 0 °F. |
| | Heating degree-days (base 65 °F) | Heating degree-days (HDD) are a measure of how much and for how long outside air temperature was lower than a specific base temperature. HDD are the difference between the average daily temperature and 65°F. For example, if the mean temperature is 30°F, we subtract the mean from 65 and the result is 30 heating degree-days for that day. HDD serves as a proxy that captures energy consumption required to heat buildings, and is used in utility planning and building design.[5] |
| | Cooling degree-days (base 65 °F) | Cooling degree days (CDD) are a measure of how much and for how long outside air temperature was higher than a specific base temperature. CDD are the difference between the average daily temperature and 65°F. For example, if the temperature mean is 90°F, we subtract 65 from the mean and the result is 25 cooling degree-days for that day. CDD serves as a proxy that captures energy consumption required to cool buildings, and is used in utility planning and building design. [6] |
| | Growing degree-days (base 50 °F) | Growing degree days (GDD) are a measure of heat accumulation that can be correlated to express crop maturity (plant development). GDD is computed by subtracting a base temperature of 50°F from the average of the maximum and minimum temperatures for the day. Minimum temperatures less than 50°F are set to 50, and maximum temperatures greater than 86°F are set to 86. These substitutions indicate that no appreciable growth is detected with temperatures lower than 50° or greater than 86°.[7] |

[5] For seasonal or annual projections, HDD are summed for the period of interest. For example, for winter HDD, one would sum the HDD for December 1 through February 28. Degree-days are not the equivalent of calendar days and thus why it is possible to have more than 365 degree-days.

[6] For seasonal or annual projections, CDD are summed for the period of interest. For example, for summer CDD, one would sum the CDD for June 1 through August 31. Degree-days are not the equivalent of calendar days and thus why it is possible to have more than 365 degree-days.

[7] Definition adapted from National Weather Service. Degree-days are not the equivalent of calendar days and thus why it is possible to have more than 365 degree-days.

**Table 4: List and definitions of projected precipitation indicators**

| Climate Variable | Climate Indicator | Definition |
|---|---|---|
| **Precipitation** | Total precipitation | Total annual or seasonal precipitation expressed in inches. |
| | Days with precipitation >1 inch | Extreme precipitation events measured in days with precipitation eclipsing one inch. |
| | Days with precipitation > 2 inch | Extreme precipitation events measured in days with precipitation eclipsing two inches. |
| | Days with precipitation > 4 inch | Extreme precipitation events measured in days with precipitation eclipsing four inches. |
| | Consecutive dry days | For a given period, the largest number of consecutive days with precipitation less than 1 mm (0.039 inches). |

*Impacts from Increasing Temperatures*

Warmer temperatures and extended heat waves could have very significant impacts on public health in our state, as well as the health of plants, animals and ecosystems like forests and wetlands. Rising temperatures will also affect important economic sectors like agriculture and tourism, and infrastructure like the electrical grid.

Annual air temperatures in the Northeast have been warming at an average rate of 0.5°F (nearly 0.26°C) per decade since 1970. Winter temperatures have been rising at a faster rate of 0.9°F[8] per decade on average. Even what seems like a very small rise in average temperatures can cause major changes in other factors, such as the relative proportion of precipitation that falls as rain or snow.

In Massachusetts, temperatures are projected to increase significantly over the next century. Winter average temperatures are likely to increase more than those in summer, with major impacts on everything from winter recreation to increased pests and challenges to harvesting for the forestry industry.

Beyond this general warming trend, Massachusetts will experience an increasing number of days with extreme heat in the future (Table 3). Generally, extreme heat is considered to be over 90 degrees F, because at temperatures above that threshold, heat-related illnesses and mortality show a marked increase.

Extreme heat can be especially damaging in urban areas, where there is often a concentration of vulnerable populations, and where more impervious surfaces such as streets and parking lots

[8] NOAA National Centers for Environmental information, Climate at a Glance: U.S. Time Series, Average Temperature, published December 2017, retrieved on December 21, 2017 from http://www.ncdc.noaa.gov/cag/

and less vegetation cause a “heat island” effect that makes them hotter compared to neighboring rural areas.
Urban residents in Massachusetts – especially those who are very young, ill, or elderly, and those who live in older buildings without air conditioning – will face greater risks of serious heat-related illnesses when extreme heat becomes more common. Extreme heat and dry conditions or drought could also be detrimental to crop production, harvest and livestock.

While warmer winters may reduce burdens on energy systems, more heat in the summer may put larger demands on aging systems, creating the potential for power outages. The number of cooling degree days is expected to increase significantly by the end of the century adding to this strain. In addition, heat can directly stress transmission lines, substations, train tracks, roads and bridges, and other critical infrastructure.

*Impacts from Changing Precipitation Conditions*

Rainfall is expected to increase in spring and winter months in particular in Massachusetts, with increasing consecutive dry days in summer and fall. More total rainfall can have an impact on the frequency of minor but disruptive flooding events, especially in areas where storm water infrastructure has not been adequately sized to accommodate higher levels. Increased total rainfall will also affect agriculture, forestry and natural ecosystems.

More intense downpours often lead to inland flooding as soils become saturated and stop absorbing more water, river flows rise, and the capacity of urban storm water systems is exceeded. Flooding may occur as a result of heavy rainfall, snowmelt, or coastal flooding associated with high wind and wave action, but precipitation is the strongest driver of flooding in Massachusetts. Winter flooding is also common in the state, particularly when the ground is frozen. The Commonwealth experienced 22 flood-related disaster declarations from 1954 to 2017 with many of these falling in winter or early spring, or during recent hurricanes.

The climate projections suggest that the frequency of high-intensity rainfall events will trend upward. Overall, it is anticipated that the severity of flood-inducing weather events and storms will increase, with events that produce sufficient precipitation to present a risk of flooding likely increasing. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure. The coast will experience the greatest increase in high-intensity rainfall days, but some level of increase will occur in every area of Massachusetts.

Intense rainfall in urbanized areas can cause pollutants on roads and parking lots to get washed into nearby rivers and lakes, reducing habitat quality. As rainfall and snowfall patterns change, certain habitats and species that have specific physiological requirements may be affected.

Climate projections for Massachusetts indicate that in future decades, winter precipitation could increase, but by the end of the century most of this precipitation is likely to fall as rain instead of snow due to warmer winters. There are many human and environmental impacts that could result from this change including reduced snow cover for winter recreation and tourism, less spring snow melt to replenish aquifers, higher levels of winter runoff, and lower spring river flows for aquatic ecosystems.

A small projected decrease in average summer precipitation in Massachusetts could combine with higher temperatures to increase the frequency of episodic droughts, like the one experienced across the Commonwealth in the summer of 2016.

Droughts will create challenges for local water supply by reducing surface water storage and the recharge of groundwater supplies, including private wells. More frequent droughts could also exacerbate the impacts of flood events by damaging vegetation that could otherwise help mitigate flooding impacts. Droughts may also weaken tree root systems, making them more susceptible to toppling during high wind events.

**Table 5: Statewide projected changes of temperature and precipitation variables by the middle and end of the century, based on climate models and the medium and high pathways of future greenhouse gas emissions. Projected changes for each climate indicator are given as a 30-year mean relative to the 1971-2000 baseline, centered on the 2050s (2040-2069) and the 2090s (2080-2099).[9] The values cited are the range of the most likely scenarios (10-90th percentile).**

| Climate Indicator | | Observed Value 1971-2000 Average | Mid-Century Projected and Percent Change in 2050s (2040-2069) | End of Century Projected and Percent Change in 2090s (2080-2099) |
|---|---|---|---|---|
| **Average Temperature** | Annual | 47.6 °F | Increase by 2.8 to 6.2 °F<br>Increase by 6 to 13 % | Increase by 3.8 to 10.8 °F<br>Increase by 8 to 23 % |
| | Winter | 26.6 °F | Increase by 2.9 to 7.4 °F<br>Increase by 11 to 28 % | Increase by 4.1 to 10.6 °F<br>Increase by 15 to 40 % |
| | Spring | 45.4 °F | Increase by 2.5 to 5.5 °F<br>Increase by 6 to 12 % | Increase by 3.2 to 9.3 °F<br>Increase by 7 to 20 % |
| | Summer | 67.9 °F | Increase by 2.8 to 6.7 °F<br>Increase by 4 to 10 % | Increase by 3.7 to 12.2 °F<br>Increase by 6 to 18 % |
| | Fall | 50 °F | Increase by 3.6 to 6.6 °F<br>Increase by 7 to 13 % | Increase by 3.9 to 11.5 °F<br>Increase by 8 to 23 % |
| **Maximum Temperature** | Annual | 58.0 °F | Increase by 2.6 to 6.1 °F<br>Increase by 4 to 11 % | Increase by 3.4 to 10.7 °F<br>Increase by 6 to 18 % |
| | Winter | 36.2 °F | Increase by 2.5 to 6.8 °F<br>Increase by 7 to 19 % | Increase by 3.5 to 9.6 °F<br>Increase by 10 to 27 % |
| | Spring | 56.1 °F | Increase by 2.3 to 5.4 °F<br>Increase by 4 to 10 % | Increase by 3.1 to 9.4 °F<br>Increase by 6 to 17 % |
| | Summer | 78.9 °F | Increase by 2.6 to 6.7 °F<br>Increase by 3 to 8 % | Increase by 3.6 to 12.5 °F<br>Increase by 4 to 16 % |
| | Fall | 60.6 °F | Increase by 3.4 to 6.8 °F<br>Increase by 6 to 11 % | Increase by 3.8 to 11.9 °F<br>Increase by 6 to 20 % |
| **Minimum Temperature** | Annual | 37.1 °F | Increase 3.2 to 6.4 °F<br>Increase by 9 to 17 % | Increase by 4.1 to 10.9°F<br>Increase by 11 to 29 % |
| | Winter | 17.1 °F | Increase by 3.3 to 8.0 °F<br>Increase by 19 to 47 % | Increase by 4.6 to 11.4 °F<br>Increase by 27 to 66 % |
| | Spring | 34.6 °F | Increase by 2.6 to 5.9 °F<br>Increase by 8 to 17 % | Increase by 3.3 to 9.2 °F<br>Increase by 9 to 26 % |
| | Summer | 56.8 °F | Increase by 3 to 6.9 °F<br>Increase by 5 to 12 % | Increase by 3.9 to 12 °F<br>Increase by 7 to 21 % |
| | Fall | 39.4 °F | Increase by 3.5 to 6.5 °F<br>Increase by 9 to 16 % | Increase by 4.0 to 11.4 °F<br>Increase by 10 to 29 % |

[9] A 20-yr mean is used for the 2090s because the climate models end at 2100.

Table 5 Continued

| Climate Indicator | | Observed Value<br>1971-2000 Average | Mid-Century<br>Projected and Percent Change in 2050s (2040-2069) | End of Century<br>Projected and Percent Change in 2090s (2080-2099) |
|---|---|---|---|---|
| **Days with Tmax > 90°F** | Annual | 5 days | Increase by 7 to 26 days | Increase by 11 to 64 days |
| | Winter | 0 days | No change | No change |
| | Spring | < 1 day[10] | Increase by 0 to 1 days | Increase by 0 to 4 days |
| | Summer | 4 days | Increase by 6 to 22 days | Increase by 9 to 52 days |
| | Fall | < 1 day[9] | Increase by 0 to 3 days | Increase by 1 to 9 days |
| **Days with Tmax > 95°F** | Annual | < 1 day[9] | Increase by 2 to 11 days | Increase by 3 to 35 days |
| | Winter | 0 days | No change | No change |
| | Spring | < 1 day[9] | No change | Increase by 0 to 1 days<br>Increase by |
| | Summer | < 1 day[9] | Increase by 2 to 10 days | Increase by 3 to 32 days |
| | Fall | < 1 day[9] | Increase by 0 to 1 day | Increase by 0 to 3 days |
| **Days with Tmax > 100°F** | Annual | < 1 day[9] | Increase by 0 to 3 days | Increase by 0 to 13 days |
| | Winter | 0 days | No change | No change |
| | Spring | 0 days | No change | No change |
| | Summer | < 1 day[9] | Increase by 0 to 3 days | Increase by 0 to 12 days |
| | Fall | 0 days | No change | Increase by 0 to 1 day |
| **Days with Tmin < 32°F** | Annual | 146 days | Decrease by 19 to 40 days | Decrease by 24 to 64 days |
| | Winter | 82 days | Decrease by 4 to 12 days | Decrease by 6 to 25 days |
| | Spring | 37 days | Decrease by 6 to 15 days | Decrease by 9 to 20 days |
| | Summer | < 1 day[9] | No change | No change |
| | Fall | 27 days | Decrease by 8 to 13 days | Decrease by 8 to 20 days |
| **Days with Tmin < 0°F** | Annual | 8 days | Decrease by 4 to 6 days | Decrease by 4 to 7 days |
| | Winter | 8 days | Decrease by 3 to 6 days | Decrease by 4 to 6 days |
| | Spring | < 1 day[9] | No change | No change |
| | Summer | 0 days | No change | No change |
| | Fall | < 1 day[9] | No change | No change |

[10] Over the observed period, there were some years with at least 1 day with seasonal Tmax over (or Tmin under) a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

**Table 5 Continued**

| Climate Indicator | | Observed Value<br>1971-2000 Average | Mid-Century<br>Projected and Percent Change in 2050s (2040-2069) | End of Century<br>Projected and Percent Change in 2090s (2080-2099) |
|---|---|---|---|---|
| **Heating Degree-Days (Base 65°F)** | Annual | 6839 degree-days | Decrease by 773 to 1627 degree-days<br>Decrease by 11 to 24 % | Decrease by 1033 to 2533 degree-days<br>Decrease by 15 to 37 % |
| | Winter | 3475 degree-days | Decrease by 259 to 681 degree-days<br>Decrease by 7 to 20 % | Decrease by 376 to 973 degree-days<br>Decrease by 11 to 28 % |
| | Spring | 1822 degree-days | Decrease by 213 to 468 degree-days<br>Decrease by 12 to 26 % | Decreases by 283 to 727 degree-days<br>Decrease by 16 to 40 % |
| | Summer | 134 degree-days | Decrease by 63 to 101 degree-days<br>Decrease by 47 to 76 % | Decrease by 76 to 120 degree-days<br>Decrease by 65 to 89 % |
| | Fall | 1407 degree-days | Decrease by 282 to 469 degree-days<br>Decrease by 20 to 33 % | Decrease by 289 to 752 degree-days<br>Decrease by 21 to 53 % |
| **Cooling Degree-Days (Base 65°F)** | Annual | 457 degree-days | Increase by 261 to 689 degree-days<br>Increase by 57 to 151 % | Increase by 356 to 1417 degree-days<br>Increase by 78 to 310 % |
| | Winter | 0 degree-days | Increase by 0 to 5 degree-days | Increase by 0 to 5 degree-days |
| | Spring | 17 degree-days | Increase by 15 to 48 degree-days<br>Increase by 88 to 277 % | Increase by 18 to 110 degree-days<br>Increase by 103 to 636 % |
| | Summer | 397 degree-days | Increase by 182 to 519 degree-days<br>Increase by 46 to 131 % | Increase by 260 to 1006 degree-days<br>Increase by 65 to 253 % |
| | Fall | 40 degree-days | Increase by 40 to 139 degree-days<br>Increase by 100 to 350 % | Increase by 69 to 297 degree-days<br>Increase by 175 to 750 % |
| **Growing Degree-Days (Base 50°F)** | Annual | 2344 degree-days | Increase by 531 to 1210 degree-days<br>Increase by 23 to 52 % | Increase by 702 to 2347 degree-days<br>Increase by 30 to 100 % |
| | Winter | 5 degree-days | Increase by 1 to 13 degree-days<br>Increase by 21 to 260 % | Increase by 4 to 27 degree-days<br>Increase by 74 to 563 % |
| | Spring | 259 degree-days | Increase by 88 to 226 degree-days<br>Increase by 34 to 87 % | Increase by 104 to 450 degree-days<br>Increase by 40 to 174 % |
| | Summer | 1644 degree-days | Increase by 253 to 618 degree-days<br>Increase by 15 to 38 % | Increase by 342 to 1124 degree-days<br>Increase by 21 to 68 % |
| | Fall | 429 degree-days | Increase by 172 to 394 degree-days<br>Increase by 40 to 92 % | Increase by 216 to 745 degree-days<br>Increase by 50 to 174 % |

**Table 5 Continued**

| Climate Indicator | | Observed Value<br>1971-2000 Average | Mid-Century<br>Projected and Percent Change in 2050s (2040-2069) | End of Century<br>Projected and Percent Change in 2090s (2080-2099) |
|---|---|---|---|---|
| **Days with Precipitation Over 1”** | Annual | 7 days | Increase by 1 to 3 days | Increase by 1 to 4 days |
| | Winter | 2 days | Increase by 0 to 1 days | Increase by 0 to 2 days |
| | Spring | 2 days | Increase by 0 to 1 days | Increase by 0 to 1 days |
| | Summer | 2 days | Increase by 0 to 1 days | Increase by 0 to 1 days |
| | Fall | 2 days | Increase by 0 to 1 days | Increase by 0 to 1 days |
| **Days with Precipitation Over 2”** | Annual | 1 day | Increase by 0 to 1 days | Increase by 0 to 1 days |
| | Winter | < 1 day[11] | Increase by < 1 day[10] | Increase by < 1 day[10] |
| | Spring | < 1 day[10] | Increase by < 1 day[10] | Increase by < 1 day[10] |
| | Summer | < 1 day[10] | Increase by < 1 day[10] | Increase by < 1 day[10] |
| | Fall | < 1 day[10] | Increase by < 1 day[10] | Increase by < 1 day[10] |
| **Days with Precipitation Over 4”** | Annual | < 1 day[10] | Increase by < 1 day[10] | Increase by < 1 day[10] |
| | Winter | 0 days | No change | Increase by < 1 day[10] |
| | Spring | 0 days | Increase by < 1 day[10] | Increase by < 1 day[10] |
| | Summer | < 1 day[10] | Increase by < 1 day[10] | Increase by < 1 day[10] |
| | Fall | < 1 day[10] | Increase by < 1 day[10] | Increase by < 1 day[10] |
| **Total Precipitation** | Annual | 47 inches | Increase by 1 to 6 inches<br>Increase by 2 to 13 % | Increase by 1.2 to 7.3 inches<br>Increase by 3 to 16 % |
| | Winter | 11.2 inches | Increase by 0.1 to 2.4 inches<br>Increase by 1 to 21 % | Increase by 0.4 to 3.9 inches<br>Increase by 4 to 35 % |
| | Spring | 12 inches | Increase by 0.1 to 2 inches<br>Increase by 1 to 17 % | Increase by 0.4 to 2.7 inches<br>Increase by 3 to 22 % |
| | Summer | 11.5 inches | Decrease by 0.4 to Increase by 2 inches<br>Decrease by 3 % to Increase by 17 % | Decrease by 1.5 to Increase by 1.9 inches<br>Decrease by 13% to Increase by 16 % |
| | Fall | 12.2 inches | Decrease by 1.1 to Increase by 1.4 inches<br>Decrease by 9 to Increase by 12 % | Decrease by 1.7 to Increase by 1.4 inches<br>Decrease by 14 to Increase by 11 % |
| **Consecutive Dry Days** | Annual | 17 days | Increase by 0 to 2 days | Increase by 0 to 3 days |
| | Winter | 11 days | Decrease by 1 to Increase by 1 days | Decrease by 1 to Increase by 2 days |
| | Spring | 11 days | Decrease by 1 to Increase by 1 day | Decrease by 1 to Increase by 1 day |
| | Summer | 12 days | Decrease by 1 to Increase by 2 days | Decrease by 1 to Increase by 3 days |
| | Fall | 12 days | Increase by 0 to 3 days | Increase by 0 to 3 days |

[11] Over the observed period, there were some years with at least 1 day with seasonal precipitation over a certain threshold while in all the other years that threshold wasn’t crossed seasonally at all.

## BOSTON HARBOR BASIN

**MUNICIPALITIES WITHIN BOSTON HARBOR BASIN:**

Abington, Arlington, Avon, Belmont, Boston, Braintree, Brockton, Burlington, Cambridge, Canton, Chelsea, Cohasset, Dedham, Dover, Everett, Foxborough, Hingham, Holbrook, Hull, Lexington, Malden, Melrose, Medfield, Medford, Milton, Norwell, Norwood, Quincy, Randolph, Reading, Revere, Rockland, Sharon, Somerville, Stoneham, Stoughton, Wakefield, Walpole, Watertown, Westwood, Weymouth, Wilmington, Winchester, Winthrop, and Woburn


Many municipalities fall within more than one basin, so it is advised to use the climate projections for the basin that contains the majority of the land area of the municipality.

## BOSTON HARBOR BASIN

| Boston Harbor Basin | | Observed Baseline 1971-2000 (°F) | Projected Change in 2030s (°F) | Mid-Century<br>Projected Change in 2050s (°F) | Projected Change in 2070s (°F) | End of Century<br>Projected Change in 2090s (°F) |
|---|---|---|---|---|---|---|
| Average Temperature | Annual | 50.13 | +2.07 to +3.99 | +2.73 to +6.07 | +3.18 to +8.92 | +3.46 to +10.84 |
| | Winter | 29.84 | +2.17 to +4.55 | +2.87 to +6.89 | +3.50 to +8.88 | +3.87 to +10.34 |
| | Spring | 47.65 | +1.69 to +3.44 | +2.34 to +5.41 | +2.58 to +8.02 | +3.13 to +9.79 |
| | Summer | 70.07 | +1.79 to +3.95 | +2.34 to +6.52 | +2.78 to +9.77 | +3.39 to +12.11 |
| | Fall | 52.58 | +2.03 to +4.69 | +3.52 to +6.53 | +3.30 to +9.31 | +3.78 to +11.60 |
| Maximum Temperature | Annual | 59.55 | +1.90 to +3.85 | +2.56 to +6.00 | +2.92 to +8.94 | +3.19 to +10.74 |
| | Winter | 38.38 | +1.85 to +4.32 | +2.46 to +6.44 | +3.02 to +8.26 | +3.42 to +9.56 |
| | Spring | 57.46 | +1.50 to +3.39 | +2.03 to +5.42 | +2.56 to +8.23 | +3.08 to +9.66 |
| | Summer | 80.04 | +1.69 to +3.99 | +2.23 to +6.41 | +2.70 to +9.90 | +3.22 to +12.21 |
| | Fall | 61.93 | +2.09 to +4.52 | +3.30 to +6.66 | +3.21 to +9.40 | +3.63 to +11.78 |
| Minimum Temperature | Annual | 40.7 | +2.17 to +4.24 | +2.91 to +6.22 | +3.45 to +8.91 | +3.75 to +10.95 |
| | Winter | 21.31 | +2.45 to +5.00 | +3.24 to +7.34 | +4.04 to +9.47 | +4.33 to +10.91 |
| | Spring | 37.84 | +1.75 to +3.47 | +2.64 to +5.71 | +2.62 to +7.81 | +3.25 to +9.76 |
| | Summer | 60.11 | +1.89 to +3.94 | +2.44 to +6.76 | +2.85 to +9.63 | +3.56 to +12.02 |
| | Fall | 43.22 | +1.99 to +4.81 | +3.49 to +6.45 | +3.39 to +9.29 | +3.92 to +11.41 |

- The Boston Harbor basin is expected to experience increased average temperatures throughout the 21st century. Maximum and minimum temperatures are also expected to increase throughout the end of the century. These increased temperature trends are expected for annual and seasonal projections.
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase throughout the 21st century.
    - Summer mid-century increase of 2.2 °F to 6.4 °F (3-8% increase); end of century increase of 3.2 °F to 12.2 °F (4-15% increase).
    - Fall mid-century increase of 3.3 °F to 6.7°F (5-11% increase); end of century increase by and 3.6 °F to 11.8 °F (6-19% increase).
- Seasonally, minimum winter and fall temperatures are expected to increase throughout the 21st century.
    - Winter mid-century increase of 3.2 °F to 7.3 °F (15-34% increase); end of century increase by 4.3 °F to 10.9 °F (20-51% increase).
    - Fall mid-century of 3.5 °F to 6.5 °F (8-15% increase); end of century increase of 3.9 °F to 11.4 °F (9-26% increase).

## BOSTON HARBOR BASIN

| Boston Harbor Basin | | Observed Baseline 1971-2000 (Days) | Projected Change in 2030s (Days) | Mid-Century Projected Change in 2050s (Days) | Projected Change in 2070s (Days) | End of Century Projected Change in 2090s (Days) |
|---|---|---|---|---|---|---|
| Days with Maximum Temperature Over 90°F | Annual | 7.85 | +5.60 to +15.57 | +7.75 to +29.07 | +9.46 to +49.32 | +11.54 to +66.93 |
| | Winter | 0.00 | +0.00 to +0.00 | +0.00 to +0.00 | +0.00 to +0.00 | +0.00 to +0.00 |
| | Spring | 0.5 | +0.20 to +0.77 | +0.37 to +1.35 | +0.40 to +2.36 | +0.29 to +3.97 |
| | Summer | 7.04 | +4.66 to +13.40 | +6.18 to +24.21 | +8.05 to +39.68 | +10.28 to +51.95 |
| | Fall | 0.31 | +0.51 to +2.14 | +0.73 to +4.89 | +0.91 to +8.34 | +1.19 to +10.97 |
| Days with Maximum Temperature Over 95°F | Annual | 1.08 | +1.77 to +6.53 | +2.01 to +12.66 | +2.92 to +26.38 | +4.55 to +40.58 |
| | Winter | 0.00 | +0.00 to +0.00 | +0.00 to +0.00 | +0.00 to +0.00 | +0.00 to +0.00 |
| | Spring | 0.01 | +0.02 to +0.20 | +0.02 to +0.35 | +0.08 to +0.70 | +0.03 to +1.51 |
| | Summer | 1.05 | +1.55 to +5.99 | +1.89 to +11.24 | +2.70 to +23.32 | +4.34 to +35.56 |
| | Fall | 0.02 | +0.06 to +0.67 | +0.08 to +1.55 | +0.16 to +3.53 | +0.26 to +4.83 |
| Days with Maximum Temperature Over 100°F | Annual | 0.05 | +0.24 to +1.40 | +0.32 to +3.81 | +0.47 to +8.58 | +0.55 to +15.67 |
| | Winter | 0.00 | +0.00 to +0.00 | +0.00 to +0.00 | +0.00 to +0.00 | +0.00 to +0.00 |
| | Spring | 0.00 | +0.00 to +0.02 | +0.00 to +0.06 | +0.00 to +0.11 | +0.00 to +0.36 |
| | Summer | 0.05 | +0.21 to +1.24 | +0.26 to +3.60 | +0.45 to +7.71 | +0.52 to +14.23 |
| | Fall | 0.00 | +0.00 to +0.13 | +0.00 to +0.28 | +0.00 to +0.70 | +0.01 to +1.21 |

- Due to projected increases in average and maximum temperatures throughout the end of the century, the Boston Harbor basin is also expected to experience an increase in days with daily maximum temperatures over 90 °F, 95 °F, and 100 °F.
    - Annually, the Boston Harbor basin is expected to see days with daily maximum temperatures over 90 °F increase by 8 to 29 more days by mid-century, and 12 to 67 more days by the end of the century.
    - Seasonally, summer is expected to see an increase of 6 to 24 more days with daily maximums over 90 °F by mid-century.
    - By end of century, the Boston Harbor basin is expected to have 10 to 52 more days.

## BOSTON HARBOR BASIN

| Boston Harbor Basin | | Observed Baseline 1971-2000 (Days) | Projected Change in 2030s (Days) | | | Mid-Century Projected Change in 2050s (Days) | | | Projected Change in 2070s (Days) | | | End of Century Projected Change in 2090s (Days) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days with Minimum Temperature Below 0°F | Annual | 2.58 | -0.73 | to | -1.72 | -0.86 | to | -2.01 | -1.02 | to | -2.05 | -0.92 | to | -2.1 |
| | Winter | 2.57 | -0.70 | to | -1.68 | -0.85 | to | -1.96 | -1.01 | to | -2.01 | -0.91 | to | -2.06 |
| | Spring | 0.01 | -0.08 | to | +0.01 | -0.09 | to | +0.00 | -0.11 | to | -0.00 | -0.11 | to | -0.00 |
| | Summer | 0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 |
| | Fall | 0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 |
| Days with Minimum Temperature Below 32°F | Annual | 119.21 | -11.79 | to | -27.09 | -17.05 | to | -42.10 | -21.02 | to | -54.79 | -22.54 | to | -65.69 |
| | Winter | 76.48 | -4.35 | to | -10.46 | -5.24 | to | -17.45 | -7.50 | to | -26.48 | -8.93 | to | -34.12 |
| | Spring | 26.51 | -3.44 | to | -10.21 | -6.02 | to | -14.01 | -6.70 | to | -18.17 | -7.95 | to | -19.54 |
| | Summer | 0.00 | -0.03 | to | -0.00 | -0.04 | to | -0.00 | -0.04 | to | -0.00 | -0.03 | to | -0.00 |
| | Fall | 16.19 | -4.11 | to | -8.13 | -5.81 | to | -10.18 | -6.64 | to | -12.56 | -5.80 | to | -14.06 |

- Due to projected increases in average and minimum temperatures throughout the end of the century, the Boston Harbor basin is expected to experience a decrease in days with daily minimum temperatures below 32 °F and 0 °F.
- Seasonally, winter, spring and fall are expected to see the largest decreases in days with daily minimum temperatures below 32 °F.
  - Winter is expected to have 5 to 17 fewer days by mid-century, and 9 to 34 fewer by end of century.
  - Spring is expected to have 6 to 14 fewer days by mid-century, and 8 to 20 fewer by end of century.
  - Fall is expected to have 6 to 10 fewer days by mid-century, and 6 to 14 fewer days by end of century.

## BOSTON HARBOR BASIN

| Boston Harbor Basin | | Observed Baseline 1971-2000 (Degree-Days) | Projected Change in 2030s (Degree-Days) | | | Mid-Century Projected Change in 2050s (Degree-Days) | | | Projected Change in 2070s (Degree-Days) | | | End of Century Projected Change in 2090s (Degree-Days) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heating Degree-Days (Base 65°F) | Annual | 6078.6 | -500.54 | to | -1035.05 | -672.05 | to | -1473.30 | -798.29 | to | -1955.65 | -899.41 | to | -2343.46 |
| | Winter | 3182.27 | -190.90 | to | -420.59 | -250.52 | to | -633.54 | -311.79 | to | -805.90 | -358.50 | to | -949.08 |
| | Spring | 1623.3 | -132.42 | to | -284.51 | -190.37 | to | -446.56 | -215.51 | to | -630.49 | -277.90 | to | -742.49 |
| | Summer | 77.66 | -28.69 | to | -48.6 | -34.41 | to | -61.51 | -40.23 | to | -71.65 | -43.54 | to | -74.94 |
| | Fall | 1190.96 | -142.96 | to | -330.92 | -248.43 | to | -418.08 | -232.46 | to | -591.26 | -253.57 | to | -668.90 |
| Cooling Degree-Days (Base 65°F) | Annual | 636.02 | +216.50 | to | +443.48 | +281.45 | to | +763.73 | +326.69 | to | +1205.65 | +381.04 | to | +1558.59 |
| | Winter | nan | +0.30 | to | +4.18 | -0.20 | to | +5.14 | -0.53 | to | +3.30 | -0.20 | to | +5.28 |
| | Spring | 26.94 | +13.42 | to | +33.49 | +23.11 | to | +63.87 | +25.82 | to | +103.20 | 23.93 | to | +143.38 |
| | Summer | 544.48 | +135.55 | to | +320.64 | +175.30 | to | +541.04 | +212.87 | to | +828.15 | +260.68 | to | +1041.01 |
| | Fall | 60.45 | +37.41 | to | +101.70 | +57.30 | to | +191.31 | +67.33 | to | +289.12 | +94.46 | to | +375.83 |
| Growing Degree-Days (Base 50°F) | Annual | 2733.34 | +393.15 | to | +798.33 | +538.44 | to | +1251.18 | +605.73 | to | +1995.52 | +691.87 | to | +2508.24 |
| | Winter | 7.42 | +1.44 | to | +16.84 | +2.52 | to | +19.76 | +7.07 | to | +36.68 | +7.25 | to | +46.66 |
| | Spring | 326.56 | +76.91 | to | +152.27 | +101.00 | to | +261.65 | +105.69 | to | +408.29 | +122.03 | to | +527.10 |
| | Summer | 1846.85 | +164.09 | to | +362.91 | +214.53 | to | +599.63 | +255.19 | to | +898.50 | +311.56 | to | +1114.22 |
| | Fall | 547.36 | +108.67 | to | +298.71 | +198.14 | to | +441.05 | +185.73 | to | +654.54 | +236.44 | to | +817.90 |

- Due to projected increases in average, maximum, and minimum temperatures throughout the end of the century, the Boston Harbor basin is expected to experience a decrease in heating degree-days, and increases in both cooling degree-days and growing degree-days.
- Seasonally, winter historically exhibits the highest number of heating degree-days and is expected to see the largest decrease of any season, but spring and fall are also expected to see significant change.
    - The winter season is expected to see a decrease of 251 to 634 degree-days by mid-century (a decrease of 8-20%), and a decrease of 359 to 949 degree-days by the end of century (a decrease of 11-30%).
    - The spring season is expected to decrease in heating degree-days by 12-28% (190-447 degree-days) by mid-century, and by 17-46% (278-742 degree-days) by the end of century.
    - The fall season is expected to decreases in heating degree-days by 21-35% (248-718 degree-days) by mid-century, and by and 21-56% (254-669 degree-days) by the end of century.
- Conversely, due to projected increasing temperatures, summer cooling degree-days are expected to increase by 32-99% (175-541 degree-days) by mid-century, and by 48-191% (261-1041 degree-days) by end of century.

- Seasonally, summer historically exhibits the highest number of growing degree-days and is expected to see the largest decrease of any season, but the shoulder seasons of spring and fall are also expected to see an increase in growing degree-days.
    - The summer season is projected to increase by 12-32% (215-600 degree-days) by mid-century, and by 17-60% (312-1114 degree-days) by end of century.
    - Spring is expected to increase by 31-80% (101-262 degree-days) by mid-century and 37-161% (122.-527 degree-days) by end of century.
    - Fall is expected to increase by 36-81% (198-441 degree-days) by mid-century and 43-149% (236-818 degree-days) by end of century.

## BOSTON HARBOR BASIN

| Boston Harbor Basin | | Observed Baseline 1971-2000 (Days) | Projected Change in 2030s (Days) | | | Mid-Century Projected Change in 2050s (Days) | | | Projected Change in 2070s (Days) | | | End of Century Projected Change in 2090s (Days) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days with Precipitation Over 1” | Annual | 9.06 | +0.37 | to | +2.16 | +0.78 | to | +3.05 | +1.00 | to | +3.17 | +1.28 | to | +4.43 |
| | Winter | 2.4 | -0.02 | to | +0.97 | +0.14 | to | +1.17 | +0.30 | to | +1.57 | +0.41 | to | +2.20 |
| | Spring | 2.04 | -0.04 | to | +0.82 | +0.00 | to | +1.08 | +0.18 | to | +1.30 | +0.23 | to | +1.33 |
| | Summer | 1.96 | -0.10 | to | +0.54 | -0.08 | to | +0.79 | -0.14 | to | +0.68 | -0.17 | to | +0.61 |
| | Fall | 2.64 | -0.21 | to | +0.69 | -0.11 | to | +0.99 | -0.29 | to | +0.76 | -0.33 | to | +1.01 |
| Days with Precipitation Over 2” | Annual | 1.27 | +0.05 | to | +0.58 | +0.10 | to | +0.74 | +0.11 | to | +0.88 | +0.27 | to | +1.19 |
| | Winter | 0.2 | -0.02 | to | +0.17 | -0.01 | to | +0.22 | +0.00 | to | +0.30 | +0.02 | to | +0.34 |
| | Spring | 0.21 | -0.07 | to | +0.17 | -0.01 | to | +0.24 | -0.02 | to | +0.24 | +0.01 | to | +0.36 |
| | Summer | 0.41 | -0.08 | to | +0.23 | -0.03 | to | +0.23 | -0.09 | to | +0.15 | -0.07 | to | +0.13 |
| | Fall | 0.44 | -0.06 | to | +0.29 | -0.04 | to | +0.26 | +0.01 | to | +0.32 | -0.08 | to | +0.45 |
| Days with Precipitation Over 4” | Annual | 0.08 | -0.03 | to | +0.15 | -0.01 | to | +0.13 | -0.03 | to | +0.16 | -0.03 | to | +0.20 |
| | Winter | 0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 | -0.00 | to | -0.00 |
| | Spring | 0.00 | -0.01 | to | +0.04 | -0.00 | to | +0.03 | -0.01 | to | +0.04 | -0.00 | to | +0.06 |
| | Summer | 0.03 | -0.03 | to | +0.07 | -0.02 | to | +0.06 | -0.03 | to | +0.06 | -0.02 | to | +0.10 |
| | Fall | 0.05 | -0.02 | to | +0.07 | -0.01 | to | +0.08 | -0.02 | to | +0.10 | -0.02 | to | +0.12 |

- The projections for expected number of days receiving precipitation over one inch are variable for the Boston Harbor basin, fluctuating between loss and gain of days.
    - Seasonally, the winter season is generally expected to see the highest projected increase.
    - The winter season is expected to see an increase in days with precipitation over one inch of 0-1 days by mid-century, and by 0-2.days by the end of century.
    - The spring season is expected to see an increase in days with precipitation over one inch of 0-1 days) by mid-century, and by 0-1 days) by the end of century.

## BOSTON HARBOR BASIN

| Boston Harbor Basin | | Observed Baseline 1971-2000 (Inches) | Projected Change in 2030s (Inches) | | | Mid-Century Projected Change in 2050s (Inches) | | | Projected Change in 2070s (Inches) | | | End of Century Projected Change in 2090s (Inches) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Precipitation | Annual | 46.07 | +0.02 | to | +4.67 | +0.30 | to | +6.20 | +1.19 | to | +7.67 | +1.09 | to | +9.03 |
| | Winter | 11.82 | -0.41 | to | +1.88 | -0.02 | to | +2.35 | +0.37 | to | +3.01 | +0.37 | to | +4.07 |
| | Spring | 11.59 | -0.10 | to | +2.24 | +0.03 | to | +2.18 | +0.14 | to | +2.71 | +0.30 | to | +2.83 |
| | Summer | 10.51 | -0.49 | to | +1.56 | -0.41 | to | +1.86 | -1.01 | to | +2.77 | -1.66 | to | +2.23 |
| | Fall | 12.18 | -0.92 | to | +1.18 | -1.02 | to | +1.60 | -1.74 | to | +2.08 | -1.64 | to | +1.78 |

- Similar to projections for number of days receiving precipitation over a specified threshold, seasonal projections for total precipitation are also variable for the Boston Harbor basin.
    - The winter season is expected to experience the greatest change with an increase of 0-20% by mid-century, and 3-34% by end of century.
    - Projections for the summer and fall seasons are more variable, and could see either a drop or increase in total precipitation throughout the 21st century.
        - The summer season projections for the Boston Harbor basin could see a decrease of 0.4 to an increase of 1.9 inches by mid-century (decrease of 4% to increase of 18%), and a decrease of 1.7 to an increase of 2.2 inches by the end of the century (decrease of 16% to increase of 21%).
        - The fall season projections for the Boston Harbor basin could see a decrease of 1.0 to an increase of 1.6 inches by mid-century (decrease of 8% to increase of 13%), and a decrease of 1.6 to an increase of 1.8 inches by the end of the century (decrease of 13% to increase of 15%).

| Boston Harbor Basin | | Observed Baseline 1971-2000 (Days) | Projected Change in 2030s (Days) | | | Mid-Century Projected Change in 2050s (Days) | | | Projected Change in 2070s (Days) | | | End of Century Projected Change in 2090s (Days) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Consecutive Dry Days | Annual | 17.46 | -0.29 | to | +1.41 | -0.41 | to | +2.17 | -0.93 | to | +2.88 | -0.59 | to | +3.64 |
| | Winter | 11.09 | -0.72 | to | +1.44 | -0.52 | to | +1.59 | -0.69 | to | +2.08 | -1.00 | to | +2.01 |
| | Spring | 11.37 | -1.05 | to | +0.55 | -1.10 | to | +1.24 | -1.44 | to | +1.47 | -1.31 | to | +1.27 |
| | Summer | 12.58 | -1.16 | to | +1.27 | -0.95 | to | +2.27 | -1.26 | to | +3.05 | -1.44 | to | +2.41 |
| | Fall | 12.78 | -0.20 | to | +2.02 | -0.18 | to | +2.66 | -0.40 | to | +3.08 | -0.45 | to | +3.00 |

- Annual and seasonal projections for consecutive dry days, or for a given period, the largest number of consecutive days with precipitation less than 1 mm (~0.04 inches), are variable throughout the 21st century.
    - For all the temporal parameters, the Boston Harbor basin is expected to see a slight decrease to an increase in consecutive dry days throughout this century.
    - Seasonally, the fall and summer seasons are expected to continue to experience the highest number of consecutive dry days.
        - The fall season is expected to experience an increase of 0-3 days in consecutive dry days by the end of the century.

**Community Resilience Building Risk Matrix** RED TEAM www.CommunityResilienceBuilding.org

**H-M-L** priority for action over the **S**hort or **L**ong
**V** = Vulnerability **S** = Strength

**Top Priority Hazards** (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

| Features | Location | Ownership | V or S | Major Storms: Rain and Snow | Extreme Temperature: Hot and Cold | Wind | Power Loss | Priority H - M - L | Time Short Long Ongoing |
|---|---|---|---|---|---|---|---|---|---|
| **Infrastructural** | | | | | | | | | |
| Roadways - Melrose Street Bridge - Evacuation Routes | | City/DCR | V | Signage regarding evacuation routes, interdepartmental commercial | | | | H | O |
| Technology - Backup Public Safety - Phone Servers (cooling) | | City | V | City Hall generator and generator battery backup<br>VOIP System | | | Close fiber optic loop | H | S |
| Stormwater - Parking Lots - Evacuation Routes | City Hall lots/ School lots | City | S/V | Lebanon/Sylvan outfall dredging - multi-year permit to dredge<br>City Hall Lot - Rain gardens | | | | H<br>M | S<br>L |
| Sewer System (pump stations) | | City/MWRA | V | Backup generator for pump stations<br>Elevate pump access | | | | H | S |
| Power - outages | | Ngrid/City | V | | Air conditioning for IT | | | H | S |
| Buildings (schools, pumps) | | City | V | Penney Road/Fellsway/Upham Pump Hardening | | | | H | S |
| **Societal** | | | | | | | | | |
| Senior and Aging Population | Homes/Senior Housing | City/COA | V/S | In the event of any hazard above, need to communicate emergency plan, outreach to vulnerable population, utility life support contact list, access to emergency funds, translation services, access to meals and food for under-served populations in emergencies. | | | | H | S |
| Essential Services to Vulnerable Populations | Grocery Rx Gas | City/Private | V | | | | | | |
| Communication - Internal - to public | | City | V/S | | | | | | |
| Chronically ill - Disable | | City/MWH | V | | | | | | |
| Managing Public Fear, Anxiety | | City | V | | | | | | |
| Severity (cyber, physical, public safety) | | City | V | | | | | | |
| **Environmental** | | | | | | | | | |
| Lakes/Ponds Erosion | Throughout | City | V | | | | | | |
| Parks/Open Space/Fells/Mt. Hood | Throughout | City/DCR | V | | | | | | |
| Trees/canopy | Throughout | City/DCR | S/V | Plant trees that are drought, flood, disease resistant and appropriate to locations | | | | | H/S |
| Air Quality | Throughout | All | V | | Anti-idling ordinance and technology education | | | | |
| Heat Islands | Near Schools/ downtown | City | V | | Plant more trees | | | | |
| Local Agriculture | Regional | Private Business | V/S | | | | | | |
| Rodents/Insets | Regional throughout | City/Regional | V/S | | More bats | | | | |

## Community Resilience Building Risk Matrix

ORANGE TEAM

www.CommunityResilienceBuilding.org

**H-M-L** priority for action over the **S**hort or **L**ong
**V** = Vulnerability **S** = Strength

**Top Priority Hazards** (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

| Features | Location | Ownership | V or S | Flooding | Power | Disease | Extreme Temperatures | Priority H - M - L | Time Short Long Ongoing |
|---|---|---|---|---|---|---|---|---|---|
| **Infrastructural** | | | | | | | | | |
| City Hall | City Hall Lot | City | V | ■ Prioritize to design green infrastructure and drainage opportunities ■ Secure funding for construction | | | ■ Tree warden to help encourage canopy | L | O/L |
| Drainage Infrastructure | Ell Pond and other | City/DPW | V/S | ■ Funding for Mosquito Control<br>n Drainage Evaluation Plan<br>n Maintain drainage infrastructure culverts by developing plans | ■ Remedy Funding of Power Systems | ■ Funding for Mosquito Control | | M | O/L |
| New Development - Spread disease with increasing population / alleviated flooding | Boardment | Residential | V/S | ■ Elevate electrical systems in new building ■ Build higher not wider<br>UPDATE NEW DEVELOPMENT DESIGN REQUIREMENTS | ■ Underground power lines for new development | | ■ Tree warden<br>UPDATE DESIGN REQUIREMENTS | M | L |
| Generator Capacity - Several large in development, need more | Several | Existing & Private need Public | V/S | | ■ Funding for new generators at municipal facilities | | | H | S |
| Power Provider | N/A | National Grid | V/S | | ■ Education/communication of National Grid policies programs and practices | | | M | O/L |
| Senior Center | Several Milano center | City Council on Aging | V/S | | ■ Funding for generator<br>COMMUNICATION PLAN | | | M | L |
| **Societal** | | | | | | | | | |
| Emergency Responders & MOU Capacity & EDS | Several | City/Community based/private | S | ■ Maintain an emergency management director and get funding to support identify emergency management center | | | | H | S |
| Evacuation Plans (have for some locations but not all) | School and Other | Public School & Emergency Management | V/S | ■ Update and communicate evaluation plans (website/meetings, etc. DRILLS !!!!) | | | | H | O |
| MVP Community and Hazard Mitigation Plans | Melrose | Public Planning/ DPW Management | S | ■ Continue to update, track progress, and participate in these types of programs | | | | H | O |
| Public Facilities (Library, Schools, Milano Center, Memorial Hall) | Several | Public DPW Facilities | V/S | ■ Food and supply storage of emergency supplies at public facilities | | | | L | O |
| Hospital | Downtown Lebanon & Main | Tufts Well source | S | ■ Communicate capacity in times of need/hazard exposure | | | | M | O |
| Bus/Transportation Access | N/A | MBTA | V/S | | ■ Develop MOU for power access<br>REGIONAL COORDINATION COMMUNICATION PLANS | | | M | O |
| **Environmental** | | | | | | | | | |
| Water bodies (Irrigation, storage capacity, flood management) (wetland) | Mt. Flood Ponds Ell Pond High School Stream Pierson | City, GMC, Mt Hood, Conservation | V/S | ■ Look for other opportunities for gates to control floods via plan | | ■ Funding for mosquito control | ■ Funding for dredging | M | O |
| Wildlife/Insects | Everywhere | N/A | V/S | | | ■ Education<br>■ Continue Conservation<br>■ Fund insect management program | | M | O |
| Mosquito Management (under funded) | Everywhere | E. Middlesex Mosquito Control Project | S/V | ■ Fund program | | ■ Fund program | | H | O/V/S |
| Air Quality | Everywhere | DEP Health Dept. | V | | | ■ Complete streets program continue | | M | O |
| Fells: Strength for community but vulnerable | IEMS | DCR | V/S | ■ Collaborate maintain partnerships with DCR | | | | L | O |
| Trees | | DPW | V/S | ■ Tree warden position funded, public/private partnerships for funding and investigate appropriate species | | | | M/H | O/L/S |

## Community Resilience Building Risk Matrix

**GREEN TEAM**

www.CommunityResilienceBuilding.org

**Top Priority Hazards** (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

**H**-**M**-**L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
**V** = Vulnerability **S** = Strength

| Features | Location | Ownership | V or S | Heat (H) | Flooding (F) | Snow Storms (S) | Wind (W) | Priority H - M - L | Time Short Long Ongoing |
|---|---|---|---|---|---|---|---|---|---|
| **Infrastructural** | | | | | | | | | |
| School facilities | Citywide | City | V&S | ■ Upgrade HVAC at Schools (H, S) | | | | H | S |
| City buildings | Citywide | City | V&S | ■ Generator at City Hall (all) | | | | H | S |
| Transportation network | Citywide | City & MBTA & MDOT & DCR | V&S | ■ Communicate with MBTA on emergency plan (all) | | | | M | O |
| Places of worship | Citywide | Private | S | | | | | M | O |
| Elderly housing | Scattered | Public/Private | V | | | | | | |
| Low income housing | Scattered | Public/Private | V | | | | | | |
| Water-sewer infrastructure/MWRA | Citywide | Public | V | ■ Install generators and bypass capacity at water sewer pump stations (F, W) | | | | H | S |
| Gas infrastructure | Citywide | Public | V | ■ Continue work with National Grid leak prone pipes out of ground (current and conditions) | | | | H | O |
| Electrical substations | Howard St | National Grid | V&S | ■ Work with National Grid on flood mitigation at Howard Street Substation buildings (F) | | | | M | O |
| Drainage system | Citywide | Public | V | ■ Investigate ways of getting info on green infrastructure to public and implement at municipal land (H,F) | | | | M<br>H | O<br>S |
| Vehicle fuel/home fuel | Citywide | Public/Private | V | | | | | | |
| Communication network | Citywide | Public/Private | V&S | | | | | | |
| **Societal** | | | | | | | | | |
| Quality of life | Citywide | Public/Private | V&S | ■ Make sure food pantries are well stocked (H, F, S, W) | | | | M | O |
| Essential services | Citywide | Public/Private | V&S | ■ Encourage local agriculture (F) | | | | M | O |
| Elderly Facilities<br>Shelter management plan | Citywide | Public/Private | V&S | | | | | | |
| Elderly Facilities<br>Shelter management plan | Citywide | Public/Private | V&S | | | | | | |
| Emergency management plan | Citywide | Public | V | ■ Update plan including inventory and assessment of emergency shelters and non shelters of refuge (M,F,S,W) | | | | H | S&O |
| Evacuation plan | Citywide | Public | V | ■ Public outreach (all) | | | | H | S&O |
| Faith based organizations<br>Emergency shelters | Citywide | Private | S | | | | | | |
| Faith based organizations<br>Emergency shelters | Citywide | Public | V&S | | | | | | |
| Lower household expenses<br>Low-income population | Citywide | Public/Private | V | ■ Investigate ways to encourage help a neighbor program (all) | | | | H | O |
| Non-English speaking population | Citywide | Public/Private | V | | | | | | |
| Hospital population | Wakefield Melrose Hospital | Private | S&V | | | | | | |
| **Environmental** | | | | | | | | | |
| Ell Pond | Ell Pond | Public | S&V | | | | | | |
| Trees | Citywide | Private/Public | S&V | | | | | | |
| Conservation land and parks | Conservation land | Public | S&V | | | | | | |
| Insects and vectors | Citywide | Public | V | | | | | | |
| Wildlife habitat | Citywide | Public | S&V | ■ Tree foreman becomes certified arborist (H,F,W) | | | | L | S |
| Wetlands | Citywide | Public | S&V | ■ Encourage native plantings (F,H.W) | | | | M | S&O |
| Trail network | Citywide | Public | S&V | | | | | | |
| Air quality | Citywide | Public | S&V | ■ Anti idling campaign (H) | | ■ Plant city trees in prioritized heat islands (H,F) | | M | S&O |
| Water Quality | Citywide | Public | S&V | | | | | | |
| Sewer overflow | Citywide | Public | V | | | | | | |
| Erosion | Citywide | Public & Private | V | | | | | | |

# Appendix E: Melrose MVP Meeting Materials

# Melrose
# Municipal Vulnerability Preparedness

**Agenda: Community Resilience Building Workshop #1**

**April 5, 2018**

| | |
|---|---|
| 8:45 – 9:00 | Registration and Refreshments |
| 9:00 – 9:10 | Welcome and Introductions |
| 9:10 – 9:20 | Workshop goals and Community Resilience in Melrose |
| 9:20 – 9:40 | Science and resources: Climate change projections in Melrose |
| 9:40 – 9:45 | Coffee break |
| 9:45 – 11:45 | Small Team Exercise (Led by the table facilitators)<br>• Team introductions / identify a spokesperson<br>• Characterize the hazards<br>• Identify community vulnerability and strengths for infrastructure, society, and environment |
| 11:45 – 12:00 | Break / Collect lunch |
| 12:00– 12:30 | Small Team report out – present findings to the full group |
| 12:30 – 12:45 | Summary Discussion / Wrap up |
| 12:45 - 1:00 | Introduce Workshop #2 on April 11 |

# Melrose
# Municipal Vulnerability Preparedness

**Community Resilience Building Workshop #1**

**April 5, 2018**

**Small Team Exercise Instructions**

1. Team introductions: Name, organization/department
2. Identify the spokesperson (not the facilitator or scribe)
3. Characterize the **TOP 4** the hazards in Melrose. **20 minutes**
   - Climate change projections
   - GIS maps (flooding, Metro Mayor's stormwater risk, heat)
   - Your experience
4. Identify Community Vulnerabilities and Strengths
   - "Features" in each category of infrastructure, society, and environment. Includes mapping and identifying ownership where possible. **1 hour (20 minutes on each feature)**
   - Identify each "Features" as a Vulnerability or Strength. **20 minutes**

**Definitions**

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

**A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.**

**Community Resilience Building Risk Matrix** www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Step 1. 20minutes

Step 2. 20 minutes on each section (1 hour total)

Step 3. 30 minutes

| | | | | Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.) | | | | Priority | Time |
|---|---|---|---|---|---|---|---|---|---|
| Features | Location | Ownership | V or S | | | | | H - M - L | Short Long Ongoing |
| **Infrastructural** | | | | | | | | | |
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| **Societal** | | | | | | | | | |
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| **Environmental** | | | | | | | | | |
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# Melrose Municipal Vulnerability Preparedness

Workshop #1

*April 5, 2018*

CDM Smith

# Welcome and Introductions

# Agenda

- 9:00 – 9:10 Welcome and Introductions
- 9:10 – 9:20 Workshop goals and Community Resilience in Melrose
- 9:20 – 9:40 Science and resources: Climate change projections in Melrose
- 9:40 – 9:45 Coffee break
- 9:45 – 11:45 Small Team Exercise (Led by the table facilitators)
  - *Team introductions / identify a spokesperson*
  - *Characterize the hazards*
  - *Identify community vulnerability and strengths for infrastructure, society, and environment*
- 11:45 – 12:00 Break / Collect lunch
- 12:00– 12:30 Small Team report out
- 12:30 – 12:45 Summary Discussion / Wrap up
- 12:45 - 1:00 Introduce Workshop #2 on April 11

# Workshop Goals and Community Resilience in Melrose

# GOAL of the MVP Workshops:

*"The Workshops are a new initiative to immediately integrate community-derived priorities into a natural hazard mitigation process and identify actions to build resilience in the community."*

This will allow Melrose to:

1. Become a "Massachusetts Municipal Vulnerability Preparedness (MVP)" rated City
2. Incorporate findings into Natural Hazards Mitigation Plan

- *Funding availability/implications*

# At these Workshops we will:

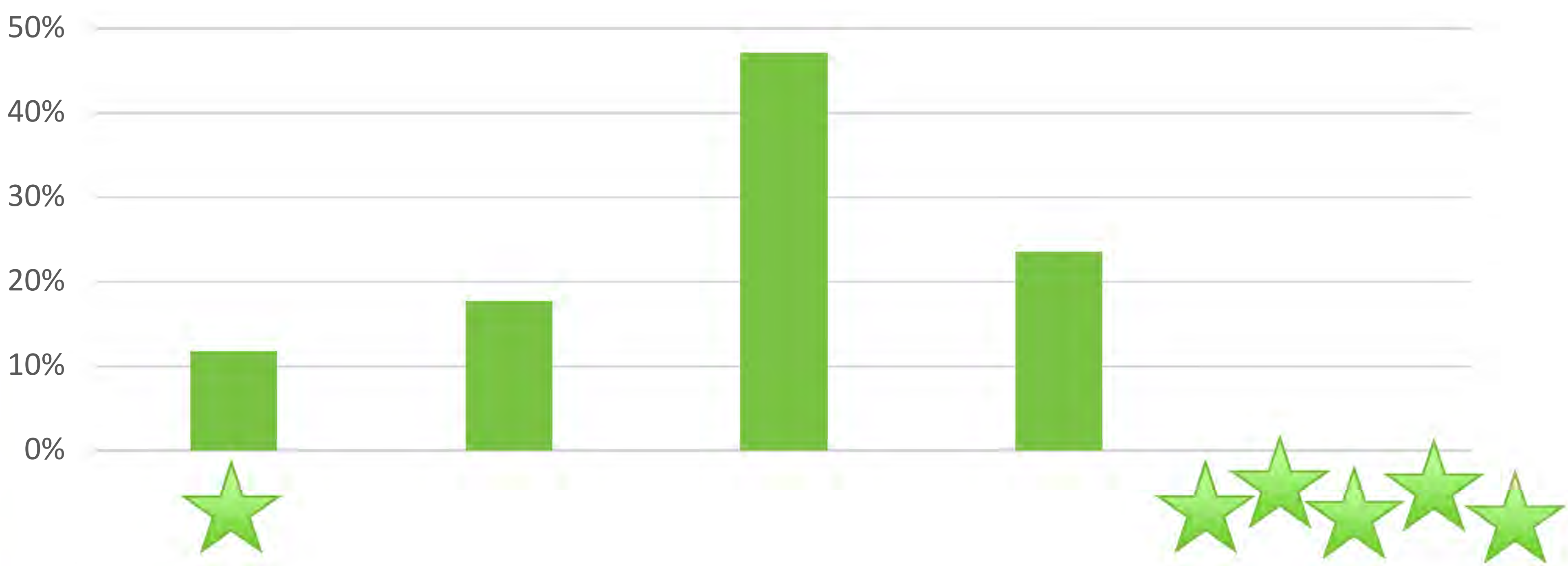
Workshop #1 (today):

- Understand connections between ongoing community issues, **hazards**, and local planning and actions in Melrose.
- Identify and map **vulnerabilities and strengths** to develop infrastructure, societal, and environmental **risk** profiles for Melrose.

Workshop #2 (April 11, 2018):

- Develop and prioritize actions and clearly delineated next steps.
- Identify opportunities to advance **actions** that further reduce the impact of hazards and increase resilience across and within Melrose.

# Survey Result: How prepared is your department / organization to address climate change vulnerabilities?




NOT PREPARED:

We expect operations would be significantly impacted by climate change hazards

PREPARED:

We have plans, tools, and resources in place to be resilient to climate change hazards

# Definitions

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
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A ***hazard*** is like the sun. The ***risk*** is sunburn. The ***vulnerability*** includes the length of ***exposure*** to the sun, how ***sensitive*** the skin is to it.

Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

# Climate Change Projections in Melrose

# Background on Climate Data

- Summarized by the MA Executive Office of Energy and Environmental Affairs
- Based on the latest Global Climate Models (GCM) from the International Panel on Climate Change (IPCC)
  - Medium and high greenhouse gas emission scenarios
  - Bracket the “most likely” scenarios
- “Downscaled” to major watershed basin (majority of Melrose is in the Boston Harbor watershed)
  - Temperature (e.g. average/maximum/minimum temperatures annual/seasonal days over 90, 95, 100$^{o}$F)
  - Precipitation (e.g. total annual, seasonal, days over 1, 2, 4 inches)
  - Temperature projections are more certain than precipitation

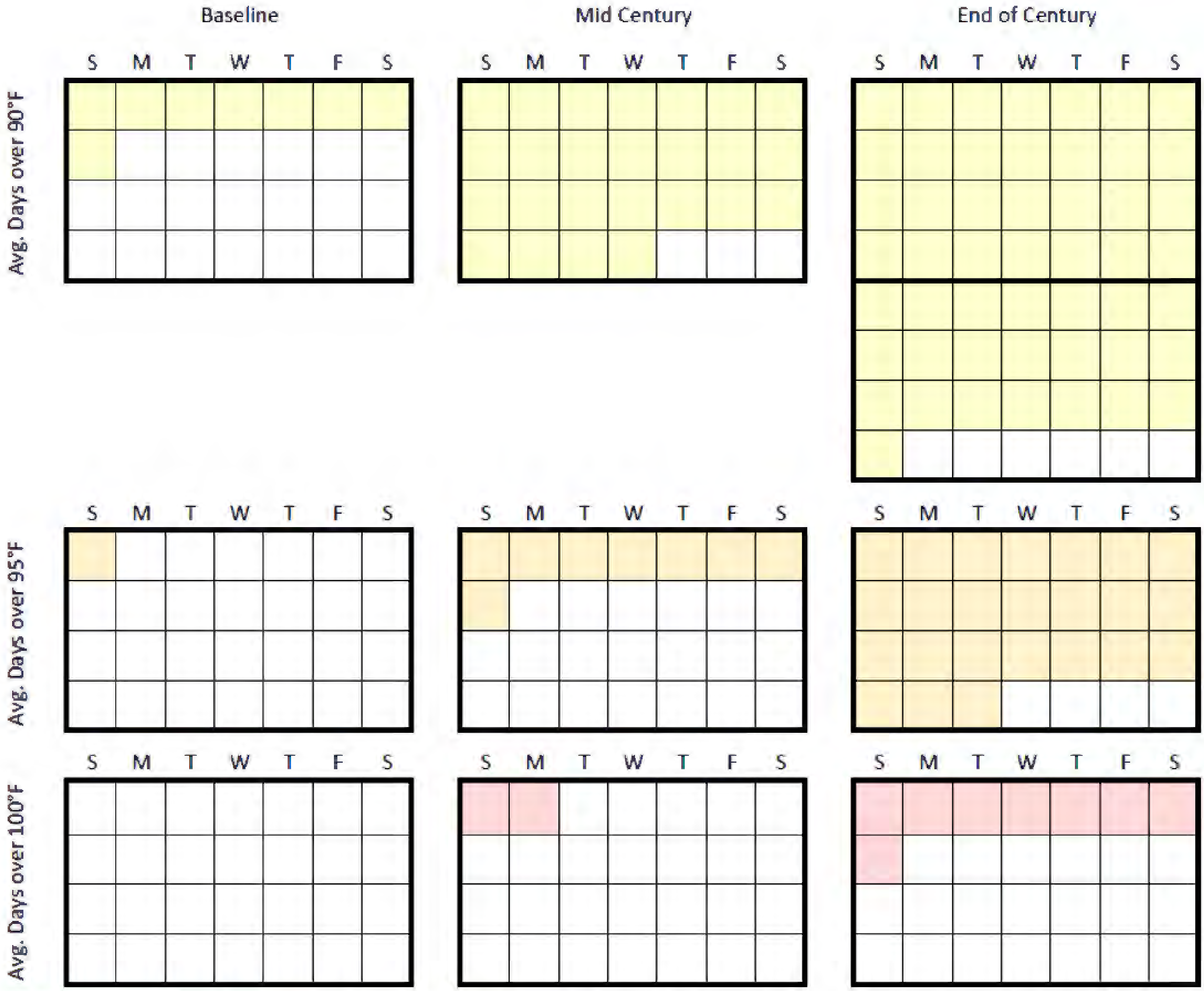
*Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century.*

# Temperature Impacts in Melrose

- Average, maximum, and minimum temperatures are expected to increase
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase
- Seasonally, minimum winter and fall temperatures are expected to increase throughout the 21st century.

| Boston Harbor Basin | | Observed Baseline 1971-2000 (°F) | Mid-Century 2050 (°F) | | | End of Century 2090's (°F) | | |
|---|---|---|---|---|---|---|---|---|
| Average | Annual | 50.13 | 52.86 | to | 56.2 | 53.59 | to | 60.97 |
| Maximum Temperature | Summer | 80.04 | 82.27 | to | 86.45 | 83.26 | to | 92.25 |
| | Fall | 61.93 | 65.23 | to | 68.59 | 65.56 | to | 73.71 |
| Minimum Temperature | Annual | 40.7 | 43.61 | to | 46.92 | 44.45 | to | 51.65 |
| | Winter | 21.31 | 24.55 | to | 28.65 | 25.64 | to | 32.22 |
| | Fall | 43.22 | 46.71 | to | 49.67 | 47.14 | to | 54.63 |

# Representation of Hot Days



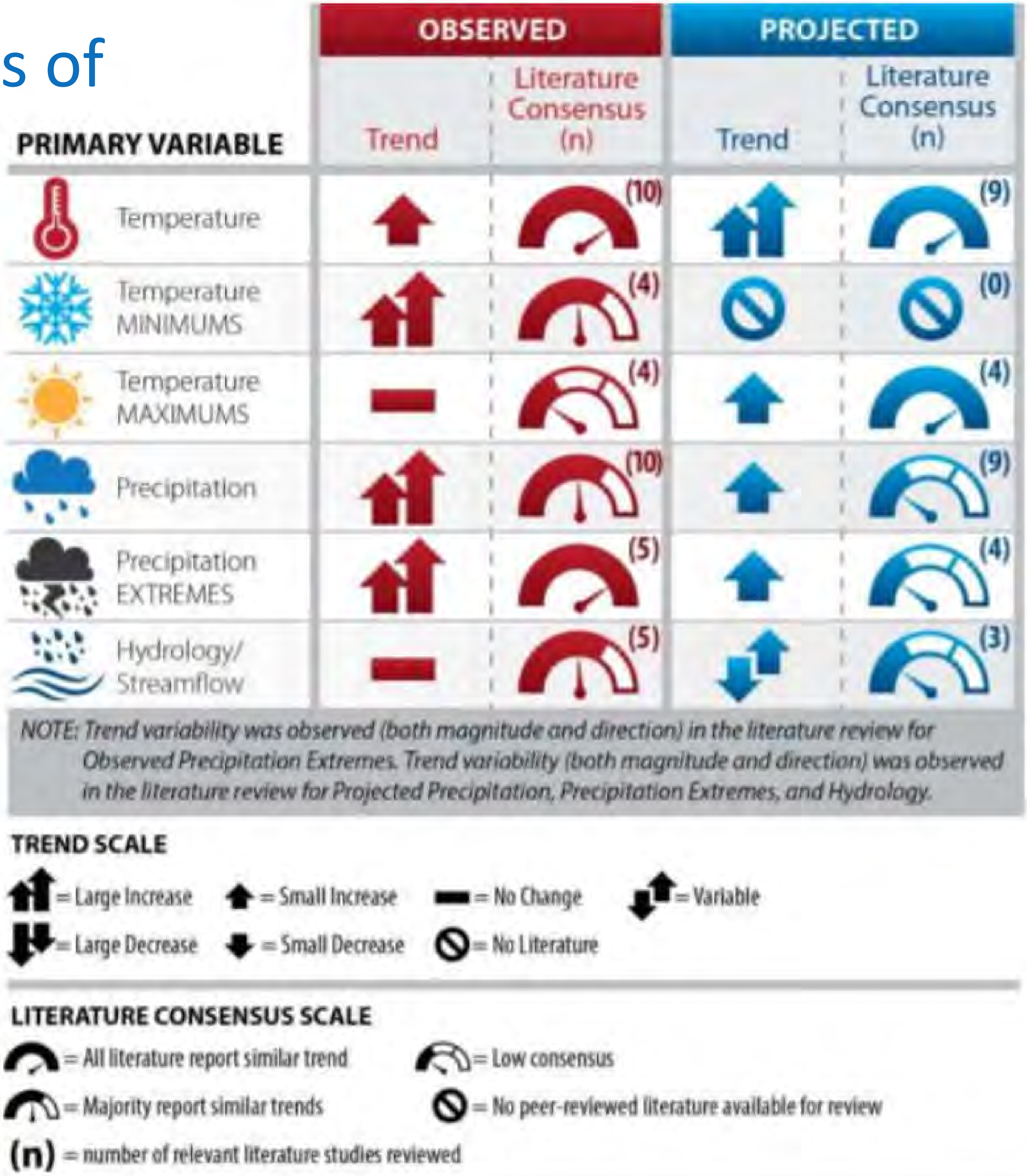
# Precipitation Impacts in Melrose

- Number of days receiving precipitation over one inch are variable, fluctuating between loss and gain of days.
- Seasonal projections for total precipitation are also variable for the Boston Harbor basin.
  - The winter season is expected to experience the greatest change with an increase of  0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable throughout the 21$^{st}$ century.

*Take away: Precipitation will be more variable. “Extreme” precipitation events are likely to occur more often.*

# U.S. Army Corps of Engineers

- Temperatures are rising
- Precipitation is increasing, especially extreme precipitation
- Hydrology and streamflow

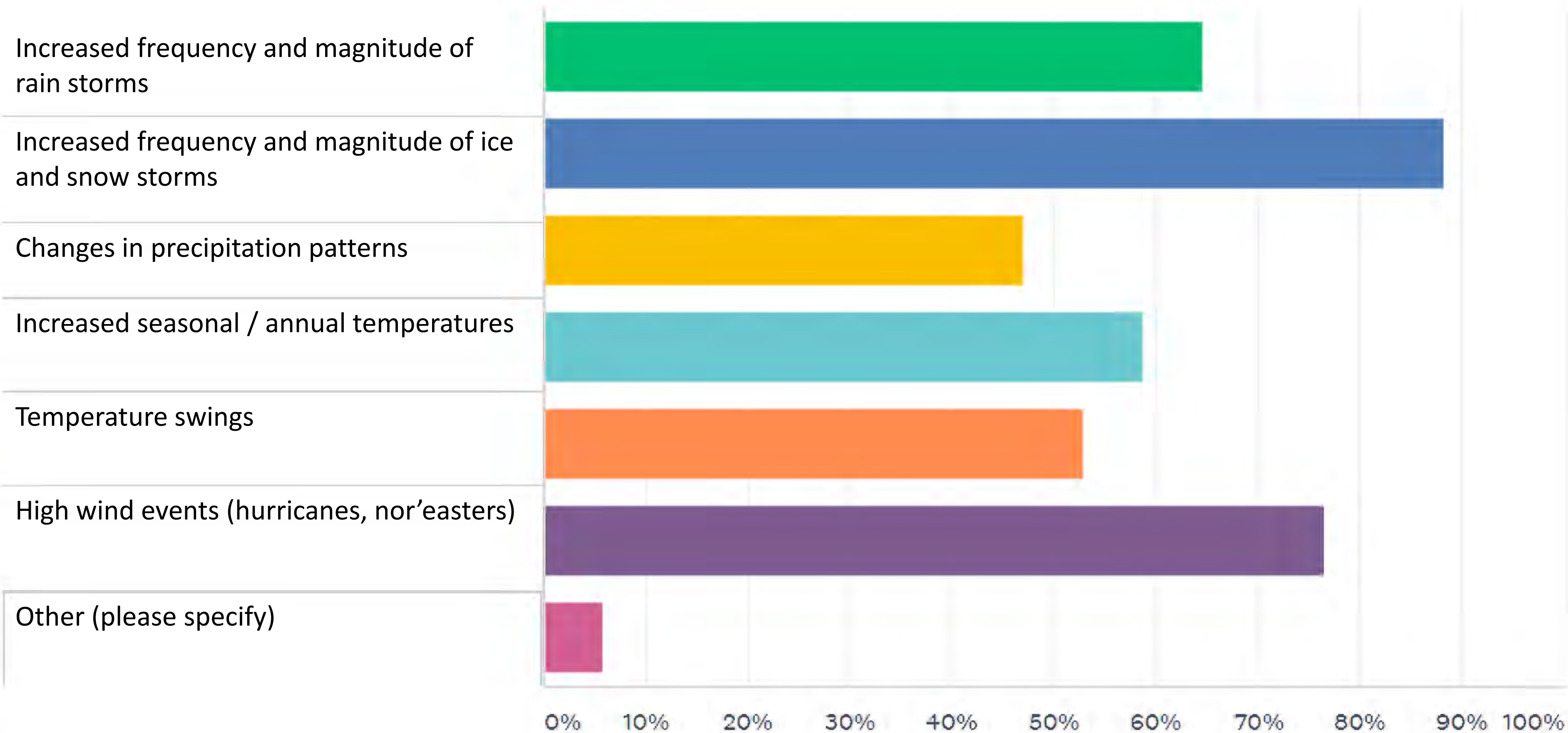



Source: USACE IWR: http://www.corpsclimate.us/docs/rccvarreports/USACE_REGION_01_Climate_Change_Report_CWTS-2015-20_Lo.pdf

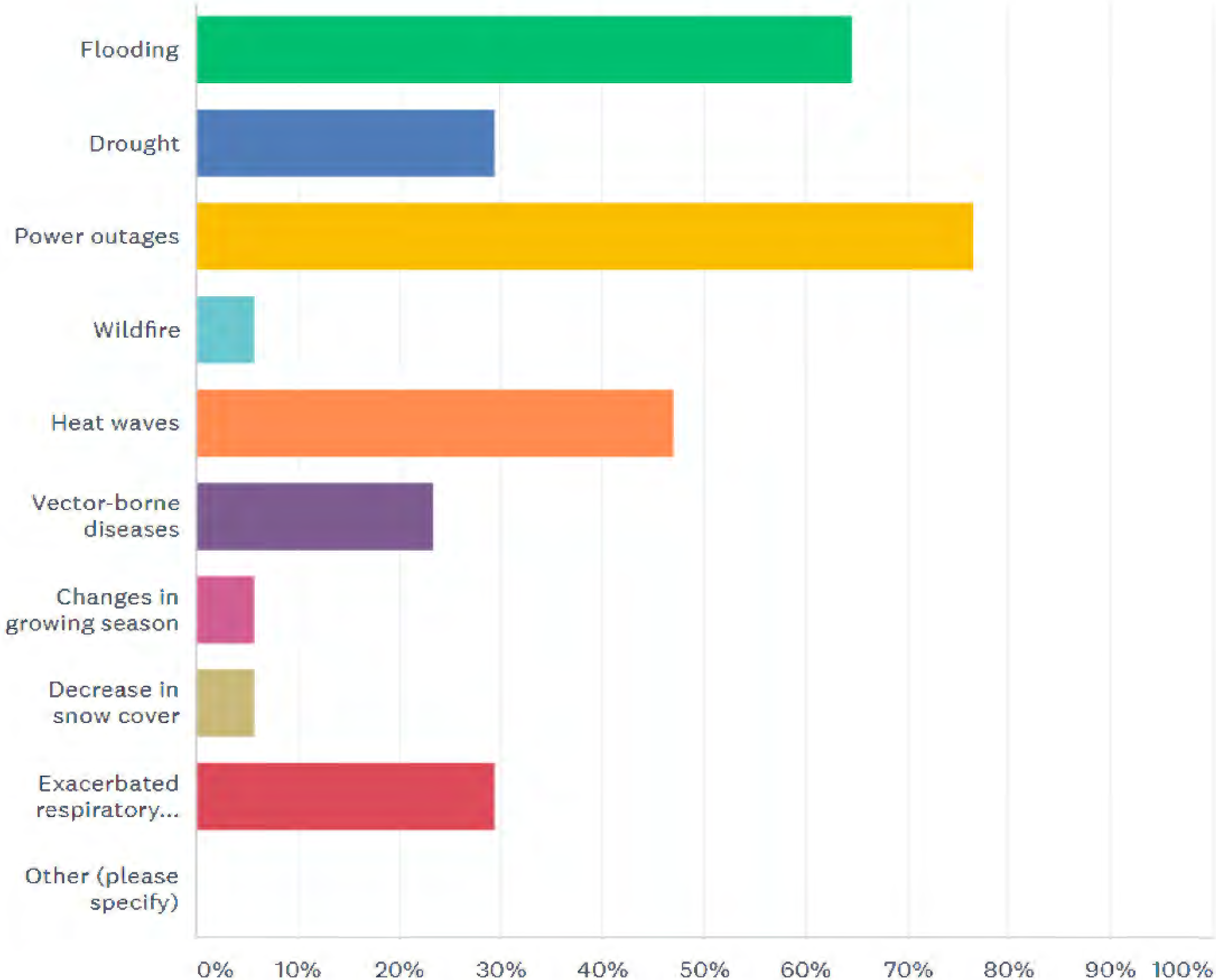
# Characterize Hazards

- What hazards have impacted Melrose in the past? Where, how often, and in what ways?
- What hazards are impacting your community currently?
- What effects will these hazards/changes have on Melrose in the future3 (5, 10, 25, years?)
- What is exposed to hazards and climate threats within your community?
- Other concerns or considerations?

# Which observed climate change impacts have already impacted your department/organization?



# What climate-related hazards is your department / organization most concerned about experiencing?



# Small Team Exercise Instructions

# Small Team Exercise Instructions

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2. Identify the spokesperson (not the facilitator or scribe)
3. Characterize the **TOP 4** the hazards in Melrose. **20 minutes**
   - Climate change projections
   - GIS maps (flooding, Metro Mayor's stormwater risk, heat)
   - Your experience
4. Identify Community Vulnerabilities and Strengths
   - "Features" in each category of infrastructure, society, and environment. Includes mapping and identifying ownership where possible. **1 hour (20 minutes on each feature)**
   - Identify each "Features" as a Vulnerability or Strength. **20 minutes**

# Hazards - examples

- Wind
- Flooding/Stormwater
- Rain storms
- Intense rainfall
- Heat waves
- Cold
- Temperature swings
- Major storms (Hurricane, nor'easter)
- Disease

**Community Resilience Building Risk Matrix**

www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

Step 1. 20minutes

Step 2. 20 minutes on each section (1 hour total)

Step 3. 30 minutes

| Features | Location | Ownership | V or S | | | | | Priority H - M - L | Time Short Long Ongoing |
|---|---|---|---|---|---|---|---|---|---|
| **Infrastructural** | | | | | | | | | |
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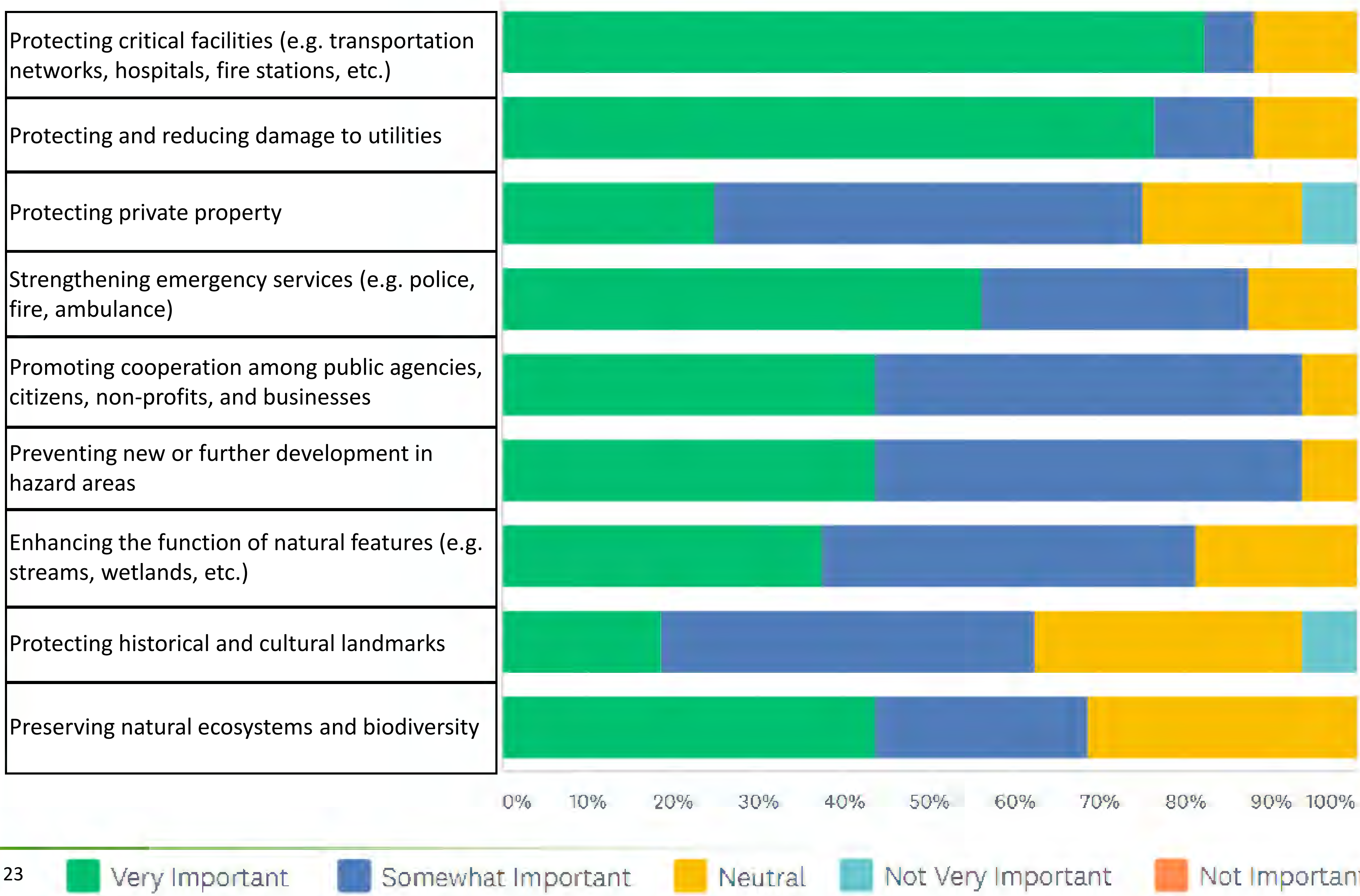
# Which of the following is Melrose most vulnerable to as the result of climate change?

| | |
|---|---|
| Compromises to transportation infrastructure (roads, rail, bridges, trails, etc.) | 6.29 |
| Availability of utilities (water, wastewater, energy, communications, etc.) | 6.76 |
| Access to critical facilities (schools, libraries, emergency shelters, medical facilities, etc.) | 5.59 |
| Human injury, illness, or loss of life | 4.24 |
| Business interruptions (closures, economic losses, etc.) | 3.59 |
| Ability to maintain order and/or provide public amenities | 3.35 |
| Damage, contamination, or loss of ecosystems and natural resources (forests, wetlands, waterways, etc.) | 4.24 |
| Damage or loss of cultural resources (i.e. museums, historic properties, etc.) | 1.94 |

# Collective priorities: rank the importance of each statement to your department / organization



## Community Resilience Building Workshop Risk Matrix

**H-M-L** priority for action over the **Short** or **Long** term (and **Ongoing**)
**V** = Vulnerability **S** = Strength

**Top 4 Hazards** (tornado, floods, wildfire, hurricanes, snow/ice, drought, sea level rise, heat wave, etc.)

| Features | Location | Ownership | V or S | Coastal Flooding SLR/Storm Surge | Inland Flooding and Rain Events | Ice and Snow | Wind | Priority H - M - L | Time Short Long Ongoing |
|---|---|---|---|---|---|---|---|---|---|
| **Infrastructural** | | | | | | | | | |
| Town Campus | Specific | Town | V | | | | | | |
| Evacuation Routes - Roads | Town-wide | Town/State | V | | | | | | |
| Electrical Distribution System | Multiple | CL&P/Town | V | | | | | | |
| Dams (inland and coastal) | Multiple | Private | V | | | | | | |
| Railway and State Bridges | Multiple | Amtrak/State | V | | | | | | |
| **Societal** | | | | | | | | | |
| Elderly Citizens (facilities) | Multiple | Private | V | | | | | | |
| Neighborhood Cooperation | Town-wide | Private | V | | | | | | |
| Faith-based Organizations | Multiple | Private | V | | | | | | |
| Homeless Population | Town-wide | Town | V | | | | | | |
| Vulnerable Neighborhoods | South side | Town/Private | V | | | | | | |
| Coordinated Evacuation Plan | Town-wide | Town/State | V | | | | | | |
| Sheltering Facility (upgrades) | Town/Region | Town/State | V | | | | | | |
| Shelter Management Plan | Town-wide | Town | S | | | | | | |
| Lower Household Expenses (flood insurance) | Town-wide | Town | S | | | | | | |
| **Environmental** | | | | | | | | | |
| Beaches & Dunes | Multiple | State-Town-Private | V/S | | | | | | |
| Forest (uniform age structure) | Town-wide | Town/State | V | | | | | | |
| Salt Marsh | Multiple | State/Private | V/S | | | | | | |
| Open Space Acquisition (for flood impact reduction) | Town-wide | Town-State-Private | V | | | | | | |
| State Parks | Specific | State | V | | | | | | |
| Rippowam River | Specific | State/Town | V | | | | | | |
| Drinking Water Reservoir | Multiple | State-Private | V | | | | | | |
| Protected Open Space | Multiple | State-Town-Private | S | | | | | | |

# Introduction to Workshop #2

# Workshop #2 Agenda

**Wednesday April 11, 2018**

- Workshop goals and desired outcomes
- Review Findings from Workshop #1
- Small Team Exercise (Led by the table facilitators)
  - Identify actions to address community vulnerabilities and reinforce strengths for infrastructure, society, and environment
  - Prioritize actions
  - Report out to the full group
- Finalize top priorities
- Wrap up and Next Steps

# Melrose
# Municipal Vulnerability Preparedness

**Agenda: Community Resilience Building Workshop #2**

**April 11, 2018**

| | |
|---|---|
| 8:45 – 9:00 | Registration and Refreshments |
| 9:00 – 9:05 | Welcome and Introductions |
| 9:05 – 9:15 | Workshop goals and desired outcomes |
| 9:15 – 9:30 | Review Findings from Workshop #1 |
| 9:30 – 11:30 | Small Team Exercise (Led by the table facilitators)<br>• Team introductions / identify a spokesperson<br>• Revisit Small Team hazards, vulnerability, and strengths from Workshop #1<br>• Identify actions to address community vulnerabilities and reinforce strengths for infrastructure, society, and environment<br>• Prioritize actions |
| 11:30 – 11:45 | Break / Collect lunch |
| 11:45– 12:15 | Small Team report out – present findings to the full group |
| 12:15 – 12:45 | Finalize top priorities |
| 12:45 - 1:00 | Wrap up and Next Steps |

# Melrose
# Municipal Vulnerability Preparedness

CDM Smith

**Community Resilience Building Workshop #2**

**April 11, 2018**

**Small Team Exercise Instructions**

1. Identify the spokesperson (not the facilitator or scribe)
2. Revisit team findings from Workshop #1 **15 minutes**
   - TOP 4 the hazards in Melrose
   - Community Vulnerabilities and Strengths" for infrastructure, society, and environment
3. Identify actions to address community vulnerabilities and reinforce strengths for in each category of infrastructure, society, and environment. **1 hour (20 minutes on each category)**
4. Prioritize actions for each feature; Includes mapping and identifying timeframe (Short, Long, Ongoing). **30 minutes (10 minutes on each category)**
5. Identify the top 3-4 priority actions for the Report Out **15 minutes**

**New defintions:**

- **Actions** reduce vulnerability or reinforce strengths.
- **Prioritized actions** take into account the importance of addressing the vulnerability / reinforcing the strength to the community

**A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.**

**The *actions* to address vulnerability of a sunburn include staying in the shade or wearing sunblock.**

Prioritizing Considerations

- Funding availability and terms
- Agreement on outstanding impacts from recent hazard events
- Necessity for advancing longer-term outcomes
- Contribution towards meeting existing local/regional planning objectives

Timeframe/Urgency Examples

- Current projects to reduce flooding = **ongoing (O)**
- Update the Hazard Mitigation Plan = **short term (S)**
- Reducing housing stock in high-risk areas = **long term (L)**

**Community Resilience Building Risk Matrix**

www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

**Top Priority Hazards** (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.)

| Features | Location | Ownership | V or S | | | | | Priority H - M - L | Time Short Long Ongoing |
|---|---|---|---|---|---|---|---|---|---|
| **Infrastructural** | | | | | | | | | |
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| **Societal** | | | | | | | | | |
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| **Environmental** | | | | | | | | | |
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Step 1 (Review). 15 minutes

Step 2. 20 minutes on each section (1 hour total)

Step 3. 45 minutes

# Melrose Municipal Vulnerability Preparedness

Workshop #2

April 11, 2018

CDM Smith

# Welcome and Introductions

# Agenda

- 9:00 – 9:05 Welcome and Introductions
- 9:05 – 9:15 Workshop goals and desired outcomes
- 9:15 – 9:30 Review Findings from Workshop #1
- 9:30 – 11:30 Small Team Exercise (Led by the table facilitators)
  - *Team introductions / identify a spokesperson*
  - *Revisit team findings from Workshop #1*
  - *Identify actions to address community vulnerabilities and reinforce strengths*
  - *Prioritize actions and identify timeframes*
- 11:30 – 11:45 Break / Collect lunch
- 11:45 – 12:00 Small Team report out
- 12:00 – 12:30 Finalize top priorities
- 12:30 - 12:45 Wrap up / Next Steps

# Workshop Goals and Desired Outcomes

# GOAL of the MVP Workshops:

*"The Workshops are a new initiative to immediately integrate community-derived priorities into a natural hazard mitigation process and identify actions to build resilience in the community."*

<u>This will allow Melrose to:</u>

1. Become a "Massachusetts Municipal Vulnerability Preparedness (MVP)" rated City
2. Incorporate findings into Natural Hazards Mitigation Plan

- *Funding availability/implications*

# At Today's Workshop, we will:

- **Develop and prioritize actions** and clearly delineated next steps.
- **Identify opportunities to advance actions** that further reduce the impact of hazards and increase resilience across and within Melrose.
- **Finalize top priorities**

# Review Findings from Workshop #1

# Definitions

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

- **Actions** reduce vulnerability or reinforce strengths.
- **Prioritized actions** take into account the importance of addressing the vulnerability / reinforcing the strength to the community

A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.

**The *actions* to address vulnerability of a sunburn include staying in the shade or wearing sunblock.**

# Review of Climate Data

- Summarized by the MA Executive Office of Energy and Environmental Affairs
- Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century.

**TEMPERATURE KEY TAKE-AWAY**

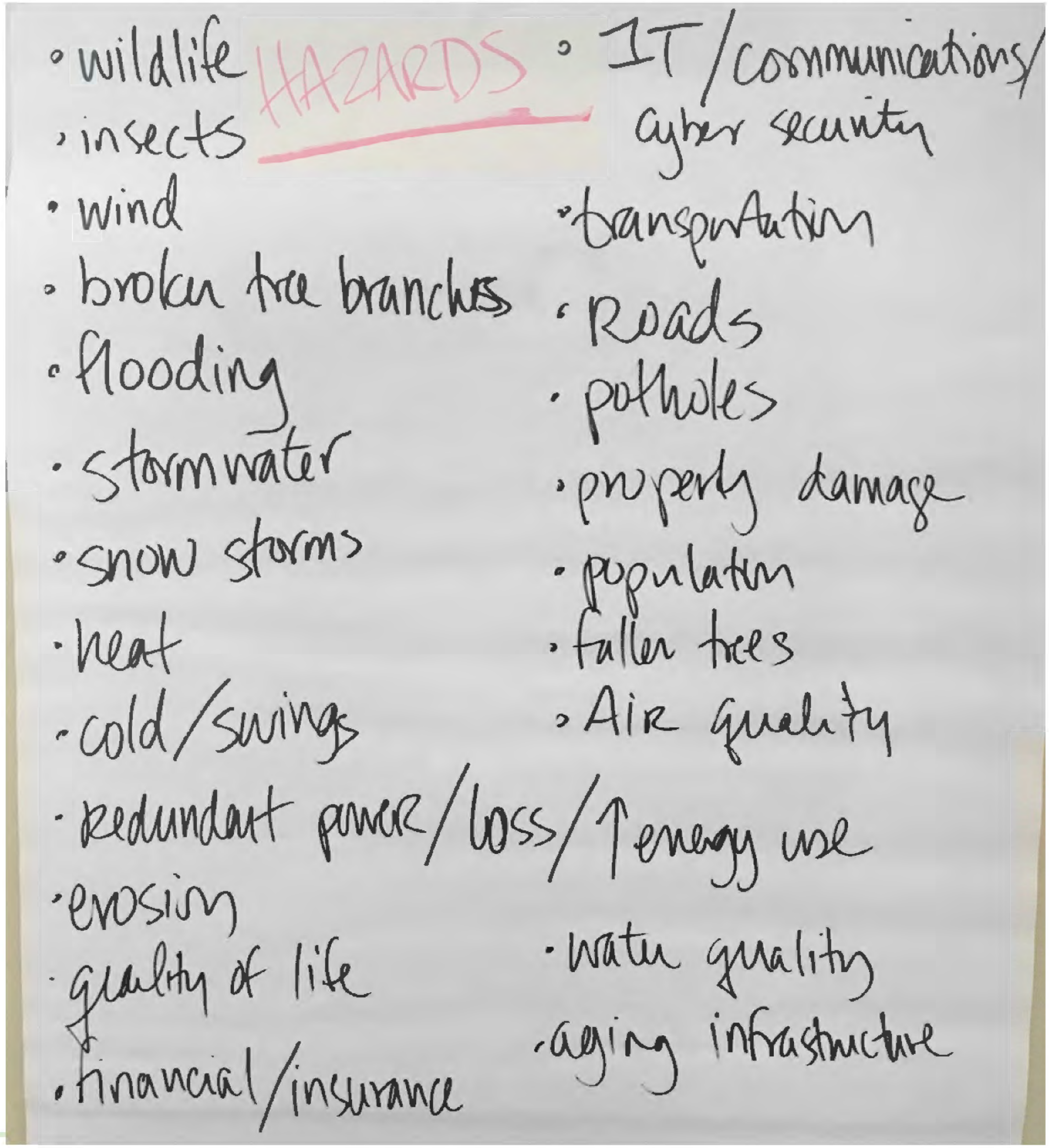
- Average, maximum, and minimum temperatures are expected to increase
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase

**PRECIPITATION KEY TAKE-AWAY**

- Precipitation will be more variable. "Extreme" precipitation events are likely to occur more often.

# Hazards in Melrose

- Extreme temperatures
- Heat
- Flooding
- Major storms (rain and snow)
- Wind
- Power loss
- Disease



# Vulnerabilities and Strengths in Melrose

| Infrastructure | V or S |
|---|---|
| Roadways – Evacuation routes, Melrose St. Bridge | V |
| Technology – Backup Phones/Public Safety/Servers | V |
| Drainage infrastructure / Stormwater – Parking lots | V/S |
| Sewer system / pump stations / MWRA | V |
| Power outages / power provider | V |
| City Buildings / School facilities | V/S |
| New development | V/S |
| Generator capacity | V/S |
| Senior Center | V/S |
| Transportation network | V/S |
| Places of worship | S |
| Elderly and low income housing | V |

# Vulnerabilities and Strengths in Melrose

| Society | V or S |
|---|---|
| Emergency Responders | S |
| Evacuation Plans | V/S |
| MVP Community / Hazard Mitigation Plans | S |
| Public Facilities | V/S |
| Hospital | S |
| Bus/Transportation Access | V/S |
| Seniors/Aging Population | V/S |
| Essential Services to Vulnerable Populations | V |
| Communication (internal/to public) | V/S |
| Chronically ill/disabled | V |
| Managing public fear/anxiety | V |
| Security (cyber, physical, public safety) | V |
| Quality of Life | V/S |
| Shelter Management Plan / Shelters | S |
| Faith based organizations | S |

# Vulnerabilities and Strengths in Melrose

| Environment | V or S |
|---|---|
| Water bodies (irrigation, storage capacity, flood management) | V/S |
| Parks/Open Space/Conservation Land/Fells/Mt. Hood/Trail Network | V/S |
| Trees/Canopy | V/S |
| Air Quality | V |
| Heat Islands | V |
| Local Agriculture | V/S |
| Rodents/Insects (vectors) | V |
| Mosquito Management | V/S |
| Wildlife habitat | V/S |
| Water quality | V/S |
| Sewer overflow | V |
| Erosion | V |

# Small Team Exercise Instructions

# Small Team Exercise Instructions

1. Identify the spokesperson (not the facilitator or scribe)
2. Revisit team findings from Workshop #1 **15 minutes**
   - Top 4 the hazards in Melrose
   - Community Vulnerabilities and Strengths for infrastructure, society, and environment
3. Identify actions to address community vulnerabilities and reinforce strengths **1 hour (20 minutes on each category)**
   - For in each category of infrastructure, society, and environment.
4. Prioritize Actions for each feature **30 minutes (10 minutes on each category)**
   - Includes mapping and identifying timeframe (Short, Long, Ongoing).
5. Identify the top 3-4 Priority Actions for the Report Out **15 minutes**

## Community Resilience Building Risk Matrix

www.CommunityResilienceBuilding.com

H-M-L priority for action over the Short or Long term (and Ongoing)
V = Vulnerability S = Strength

Step 1 (Review). 15 minutes

Step 2. 20 minutes on each section (1 hour total)

Step 3. 45 minutes

| | | | | Top Priority Hazards (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.) | | | | Priority | Time |
|---|---|---|---|---|---|---|---|---|---|
| Features | Location | Ownership | V or S | | | | | H - M - L | Short Long Ongoing |
| **Infrastructural** | | | | | | | | | |
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| **Societal** | | | | | | | | | |
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| **Environmental** | | | | | | | | | |
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# Prioritizing and Timeframes

Prioritizing Considerations

- Funding availability and terms
- Agreement on outstanding impacts from recent hazard events
- Necessity for advancing longer-term outcomes
- Contribution towards meeting existing local/regional planning objectives

Timeframe/Urgency Examples

- Current projects to reduce flooding = **ongoing (O)**
- Update the Hazard Mitigation Plan = **short term (S)**
- Reducing housing stock in high-risk areas = **long term (L)**

# Identifying/prioritizing actions - examples

| <u>H</u>-<u>M</u>-<u>L</u> priority for action over the <u>S</u>hort or <u>L</u>ong term (and <u>O</u>ngoing)<br><u>V</u> = Vulnerability <u>S</u> = Strength | | | | **Top Priority Hazards** (tornado, floods, wildfire, hurricanes, earthquake, drought, sea level rise, heat wave, etc.) | | | | **Priority** | **Time** |
|---|---|---|---|---|---|---|---|---|---|
| **Features** | **Location** | **Ownership** | **V or S** | Flooding | ALL (Major storms/Extreme temps/wind /power loss) | Heat | | <u>H</u> - <u>M</u> - <u>L</u> | <u>S</u>hort <u>L</u>ong <u>O</u>ngoing |
| **Infrastructural** | | | | | | | | | |
| City hall lot is subject to flooding | City Hall | City | V | -Repave with permiable pavement<br>-Install "green infrastructure" features in parking lot | | | | M | L |
| **Societal** | | | | | | | | | |
| Managing public fear/anxiety | Citywide | Public/ City | V | | -Increase two-way preparedness communication to citizens<br>-Host a series on emotional well-being | | | H | O/S |
| **Environmental** | | | | | | | | | |
| Air quality | Citywide | Public | S/V | | | -Increase the tree canpoy near vulnerable populations<br>-Create an anti-idling campaign | | M | S/L |

# Community Resilience Building Workshop Risk Matrix

**H-M-L** priority for action over the **S**hort or **L**ong term (and **O**ngoing)
**V** = Vulnerability **S** = Strength

**Top 4 Hazards** (tornado, floods, wildfire, hurricanes, snow/ice, drought, sea level rise, heat wave, etc.)

| Features | Location | Ownership | V or S | Coastal Flooding SLR/Storm Surge | Inland Flooding and Rain Events | Ice and Snow | Wind | Priority H-M-L | Time Short Long Ongoing |
|---|---|---|---|---|---|---|---|---|---|
| **Infrastructural** | | | | | | | | | |
| **Town Campus** | Specific | Town | V | Verify risk from flooding events; Identify alternative locations during peak flooding; Verify maintenance plan annually | | | | H | S |
| **Evacuation Routes - Roads** | Town-wide | Town/State | V | Install highly visible signage for evacuation routes; Develop and implement communication program | | | | H | S |
| **Electrical Distribution System** | Multiple | CL&P/Town | V | Within floodplain area, establish plan to address protection and long-term relocation of equipment | | Upgrade transformers; Maintain power line protection zone (tree trimming) | | H | O-L |
| **Dams (inland and coastal)** | Multiple | Private | V | Prevent possibility of catastrophic dam failure; Identify and remove dams to minimize downstream flooding due to failure | | | | H | L |
| **Railway and State Bridges** | Multiple | Amtrak/State | V | Improve communications between parties; Expand green/gray infrastructure and improve bridge structures; Assess vulnerability and prioritize infrastructure improvement list | | | | M | S |
| **Societal** | | | | | | | | | |
| **Elderly Citizens (facilities)** | Multiple | Private | V | Assess and identify vulnerabilities to determine residents needs during emergencies; Coordinate emergency planning efforts; Conduct routine evacuation drills | | | | H | S |
| **Neighborhood Cooperation** | Town-wide | Private | V | Assist associations in identifying and conducting best practices to reduce risk; Advance a "Neighbor helping Neighbor" Program through Community Center training | | | | H | S |
| **Faith-based Organizations** | Multiple | Private | V | Coordinate organizations in identifying and conducting best practices amongst members to reduce risk | | | | H | S |
| **Homeless Population** | Town-wide | Town | V | Extreme weather flyers and communications about available services | | | | M | S |
| **Vulnerable Neighborhoods** | South side | Town/Private | V | Identify level and location of vulnerable units; Develop longer term plan to reduce vulnerability | | | | M | L |
| **Coordinated Evacuation Plan** | Town-wide | Town/State | V | Reconfigure evacuation routes; Update signage along critical routes | | | | L | S |
| **Sheltering Facility (upgrades)** | Town/Region | Town/State | V | Conduct feasibility analysis for regional sheltering facility; Seek to construct over next 15 years. | | | | L | L |
| **Shelter Management Plan** | Town-wide | Town | S | Review and update as needed on annual basis; More resources required (cots, shampoo, etc.) | | | | | Ongoing |
| **Lower Household Expenses (flood insurance)** | Town-wide | Town | S | Continue enrollment in FEMA Community Rating System (CRS);Reduced number flood insurance rate payers through volunteer buyouts/relocation | | | | | Ongoing |
| **Environmental** | | | | | | | | | |
| **Beaches & Dunes** | Multiple | State-Town-Private | V/S | Maintain existing beaches & dunes; Assess values and key locations relative to people and property | | | | H | S |
| **Forest (uniform age structure)** | Town-wide | Town/State | V | Seeks management that diversifies the age structure of forests in Town; Assess and identify key vulnerabilities from tree fall | | | | H | S |
| **Salt Marsh** | Multiple | State/Private | V/S | Maintain existing marsh; Consider additional regulatory protection (increased setbacks) to prevent impacts to resource; Assess risk reduction potential from existing and future wetlands | | | | H | S |
| **Open Space Acquisition (for flood impact reduction)** | Town-wide | Town-State-Private | V | Secure state funding; Salt marsh advancement zones | Secure state/federal funding | Include land protection needs Master Plan | | H | S-L |
| **State Parks** | Specific | State | V | Encourage the State to work more closely with Town to comprehensively maintain town-wide natural resources, amenities, and water quality; Coordinate with state regarding evacuation procedures | | | | M | S |
| **Rippowam River** | Specific | State/Town | V | | Improve risk reduction characteristics of waterway through natural infrastructure & riparian buffer enhancements | | | M | S-L |
| **Drinking Water Reservoir** | Multiple | State-Private | V | Conduct assessment to comprehensively identify vulnerabilities and develop action plans to increase resilience of natural resources and long term water quality/quantity; Implement improvements | | | | L | L |
| **Protected Open Space** | Multiple | State-Town-Private | S | Maintain existing open space to help reduce risk to Town; Seek to increase open space with the highest risk reduction characteristics | | | | | Ongoing |

# Report Out / Final Priority Actions

# Small Team Priority Actions (Top 3-5 per Team)

**RED**

1. Generator at City Hall
2. Dredge SW outfalls/universal permit/maintenance plan
3. Communication plan on hazards
4. Update MS4 permit
5. Water/sewer back-up pump stations (power and bypass capability) and elevation

**GREEN**

1. Generator at City Hall
2. Update emergency mgmt. plan (inc. Inventory/assessment of shelters
3. Public outreach on hazards
4. Green infrastructure and green buildings (zoning, BMP for developers, specific projects)
5. Water/sewer back-up pump stations (power and bypass capability)

**ORANGE**

1. Generator at other public buildings
2. Dedicated emer. Mgmt director /MOU for emergency response
3. Update evacuation plan/communication/drills
4. Mosquito mgmt – disease and flooding
5. Trees – warden position/P3 for funding and maintenance

# Final Priority Actions (Goal: Top 3-5)

- City Hall generator
- Dredge stormwater outfalls/permit plan/maintenance plan/ mosquito management
- Emergency management:
  - plan update
  - outreach/communication
  - Emergency management director
- Green infrastructure and green buildings
  - Energy management (efficiency and renewable)
  - Stormwater management
  - Zoning/Regulatory
  - BMP
  - Communication

# Next Steps

# Next Steps

- Master Risk Matrix
- MVP Findings Report
- MVP listening session / Hazard mitigation plan public meeting – end of May/early June
- Natural Hazard Mitigation Plan (with climate change effects) – end of 2018

GREAT JOB!

THANK YOU!

# Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan

**Agenda**

**September 25, 2018**

*<u>Meeting Purpose:</u> An opportunity for local and neighboring community partners to provide input to Melrose's Natural Hazard Mitigation Plan process. Your input will assist Melrose by facilitating regionally-focused hazard mitigation strategies and opportunities*

| | |
|---|---|
| 1:00 – 1:15 | Welcome, introductions, review the meeting purpose |
| 1:15 – 1:45 | Review the natural hazards and key vulnerability assessment findings |
| 1:45 – 2:00 | Solicit feedback on the risks and vulnerabilities identified in Melrose |
| 2:00 – 2:45 | Brainstorm actions that reduce regional risks, including how we can work collaboratively to implement them<br>▪ Emergency management<br>▪ Public health<br>▪ Utility networks<br>▪ DPW |
| 2:45 – 3:00 | Summary discussion, next steps |

# Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan

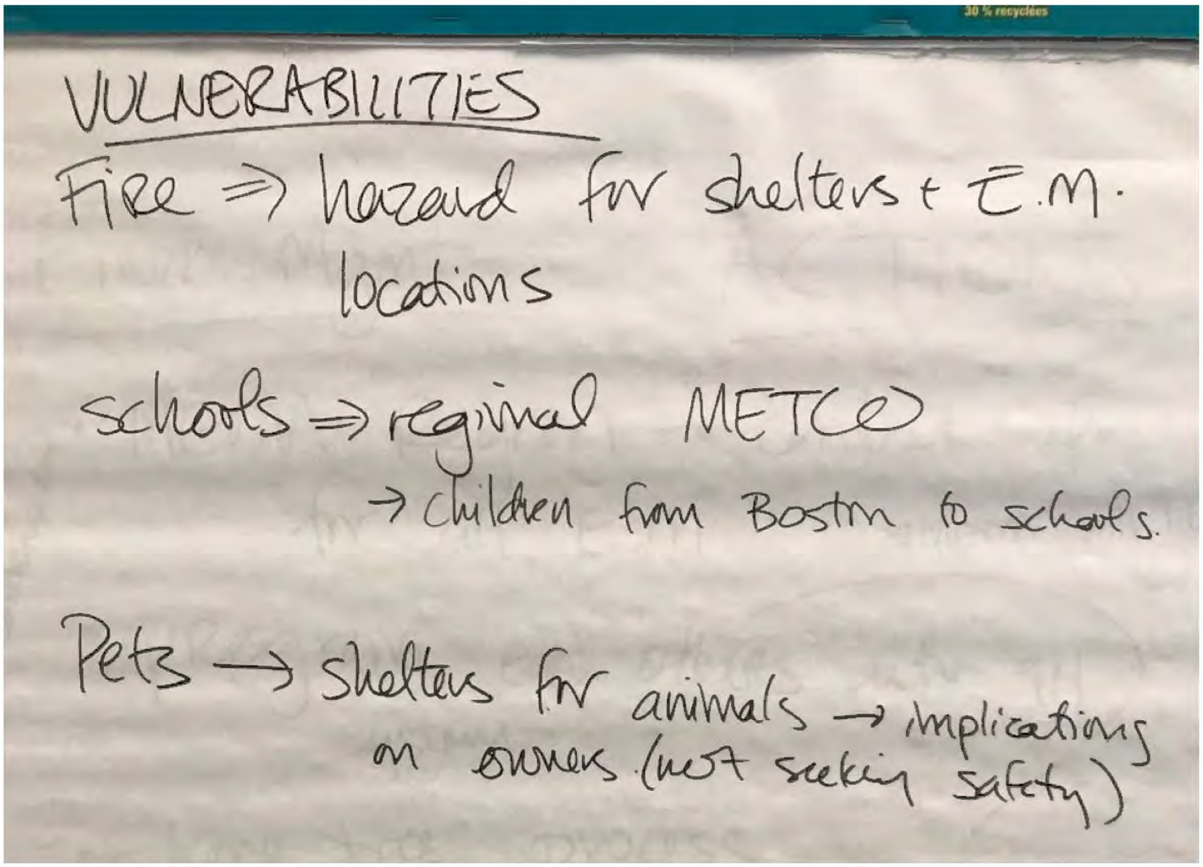
**Sign-In Sheet**

**September 25, 2018**

| Name | Organization/Role |
|---|---|
| James Hughes | Saugus EM |
| Stan Usovicz | Verizon |
| LT JAMES MULRENAN | MELROSE POLICE |
| Manisha Bewtra | Board of Aldermen |
| Matt Grafton | Stoneham Fire / EMD |
| JOHN SCENNA | Public Works, Melrose |
| John Ray | MBTA - Commuter Rail |
| Denise Gaffey | DGaffey@cityofmelrose.org |
| Paul Brodeur | State Rep. |
| Ed Collina | FIRE Chief melrose |
| Elena Proakis Ellis | City Engineer, Melrose |
| Lauren Miller | CDM Smith - consultant. |

# Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan

**Meeting Notes**



# Emer. Mgmt ACTIONS

communication

- MEMA Region → contact info for all E.M. *MEMA will likely step in.
- Program ~~[illegible]~~ others into 911 system
- ID "phone tree" process → responsibility?
- access to translators
- Regionalized training + tabletop exercises
- have a CODERED ⇒ need more people to sign-up...
- protocol for communications/plan

*① communication btwn EM
② com. to public/cohesive

- Officials → use official info. from utilities. Failure may come from NOT using these channels

all city understand protocol.

- usually same #

crews have been dispatched.

Public health

- pharmacy hrs ~~plan~~
- grocery hrs

extend before emergency

- Regional coordinated evac. plan → share info among towns
- if local evac → up to community
- current evac are local incidents

↳ need Regional

regional resources

MBTA → commuter rail "goes" to get people... up to com. rail. engineer

- how often are evac. plans updated?
  (Boston, etc?)
- Communicate evac. plans.
- Nat'l Grid → list of who needs power...
  - Better communicate HOW to get on list
  - communicate this list to Em Mgmt.
    <Eversource does this w/ Stoneham>
- ~~need~~ know where/who needs help
  + for downed wires.
- Can hospital act as 24/hr pharmacy as needed
  → supply
- on/off? access to view N.G. issues/work orders. (
  - N.G. has triage + phone # for police/fire
- NG can't connect from pole to house (maybe if police request...) → can we have LIST of avail. "emer. electricians"

## Utilities

MWRA emer. plan / coordination ☆
↳ annual emer. training. (take)

Boil orders (2010 ~ 5 days; Distribute bottled water)

mutual aid interconnection w/ water (have valves) w/ other towns.

Verizon - has emer. power / fewer capacity issues now
* Melrose → have Robust wireless + fiberoptics
Can Melrose have access to resident phones

GAS → Regional staging areas.
* ↳ where to centrally locate?
Operate at a central location
↳ how to create staging area

people available that can help in CRISIS
- trained in human capacity aspect.

DPW.

Informal "mutual aid" (have) equipment
→ only if we can.

Compatible emer. generators (portable). + other equipment.

MEMA has mutual aid for public works

Verizon has "cell on wheels" + generators.

MBTA has resources (via MEMA → they decide who has greatest need)

Quicker DPW, police, + fire can coordinate the better

↳ currently meet before a storm.

DPW - lead snow

- Clarity around who to call + when (Mayor? social media? direct #?)
  - ↳ training for public officials

# Regional Collaboration Meeting

Melrose Natural Hazard Mitigation Plan

*September 25, 2018*

CDM Smith

# Welcome and Introductions

# Agenda

- 1:00 – 1:15 Welcome, introductions, review meeting purpose
- 1:15 – 1:45 Review the natural hazards and key risk assessment findings
- 1:45 – 2:00 Solicit feedback on the risks identified in Melrose
- 2:00 – 2:45 Brainstorm actions that reduce regional risks, including how we can work collaboratively to implement them
    - Emergency management
    - Public health
    - Utility networks
    - DPW
- 2:45 – 3:00 Summary discussion, next steps

# Purpose of Tonight's Meeting

- Receive input to the Melrose Natural Hazards Mitigation Plan process from local and neighboring community partners to identify regionally-focused hazard mitigation strategies and opportunities

# Introductions

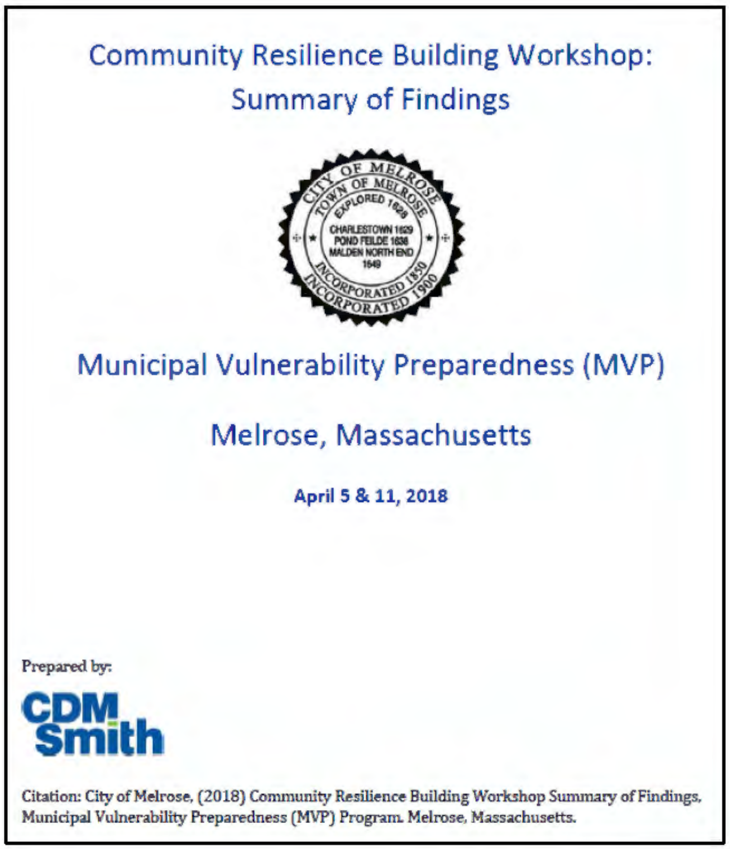
1. Name
2. Department
3. Title/Role
4. *If you're aware of any* - what related plans (formal or informal) does your organization have place?

   <u>Examples:</u>

   - Hazard mitigation plans
   - Emergency management plan
   - Evacuation plans
   - Climate change plans
   - Others?

# Resilience Programs in Melrose

- Massachusetts Municipal Vulnerability Preparedness (MVP) Program (complete)



Community Resilience Building Workshop:
Summary of Findings

Municipal Vulnerability Preparedness (MVP)

Melrose, Massachusetts

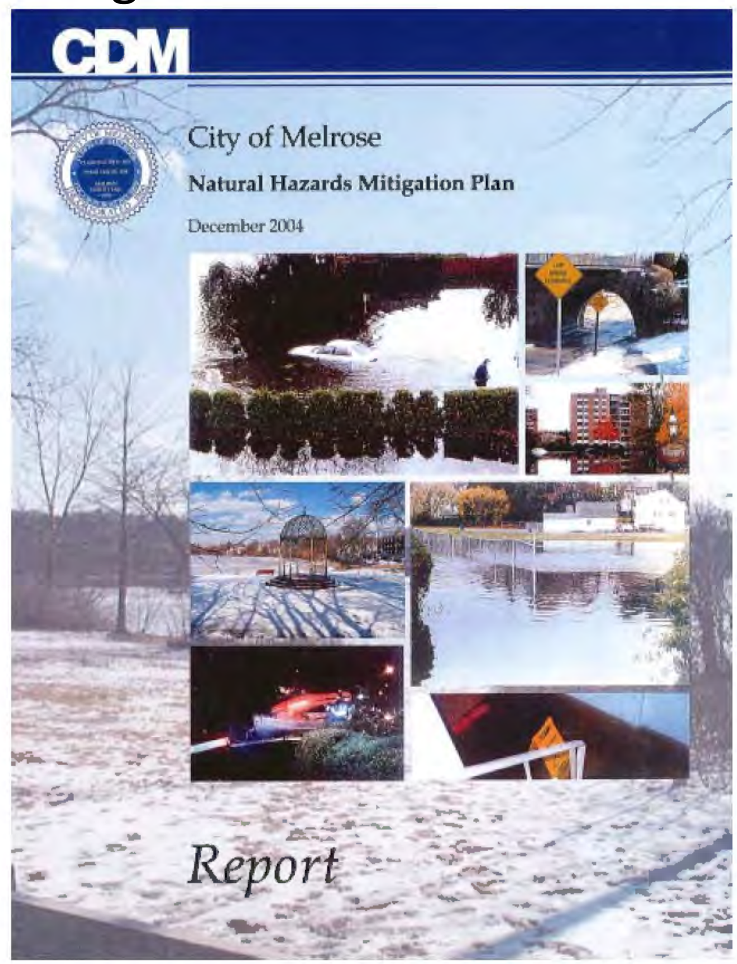
April 5 & 11, 2018

Prepared by:

CDM Smith

Citation: City of Melrose, (2018) Community Resilience Building Workshop Summary of Findings, Municipal Vulnerability Preparedness (MVP) Program. Melrose, Massachusetts.

- Natural Hazards Mitigation Plan (updating) – will include climate change



# Natural Hazard Mitigation Plan

- Planning process to reduce the risk of loss of life and property by lessening the impact of disasters
- Developing hazard mitigation plans enables state, tribal, and local governments to:
  - Increase education and awareness around threats, hazards, and vulnerabilities;
  - Build partnerships for risk reduction involving government, organizations, businesses, and the public;
  - Identify long-term, broadly-supported strategies for risk reduction;
  - Align risk reduction with other state, tribal, or community objectives;
  - Identify implementation approaches that focus resources on the greatest risks and vulnerabilities; and
  - Communicate priorities to potential sources of funding.

Source: Federal Emergency Management Agency https://www.fema.gov/hazard-mitigation-planning

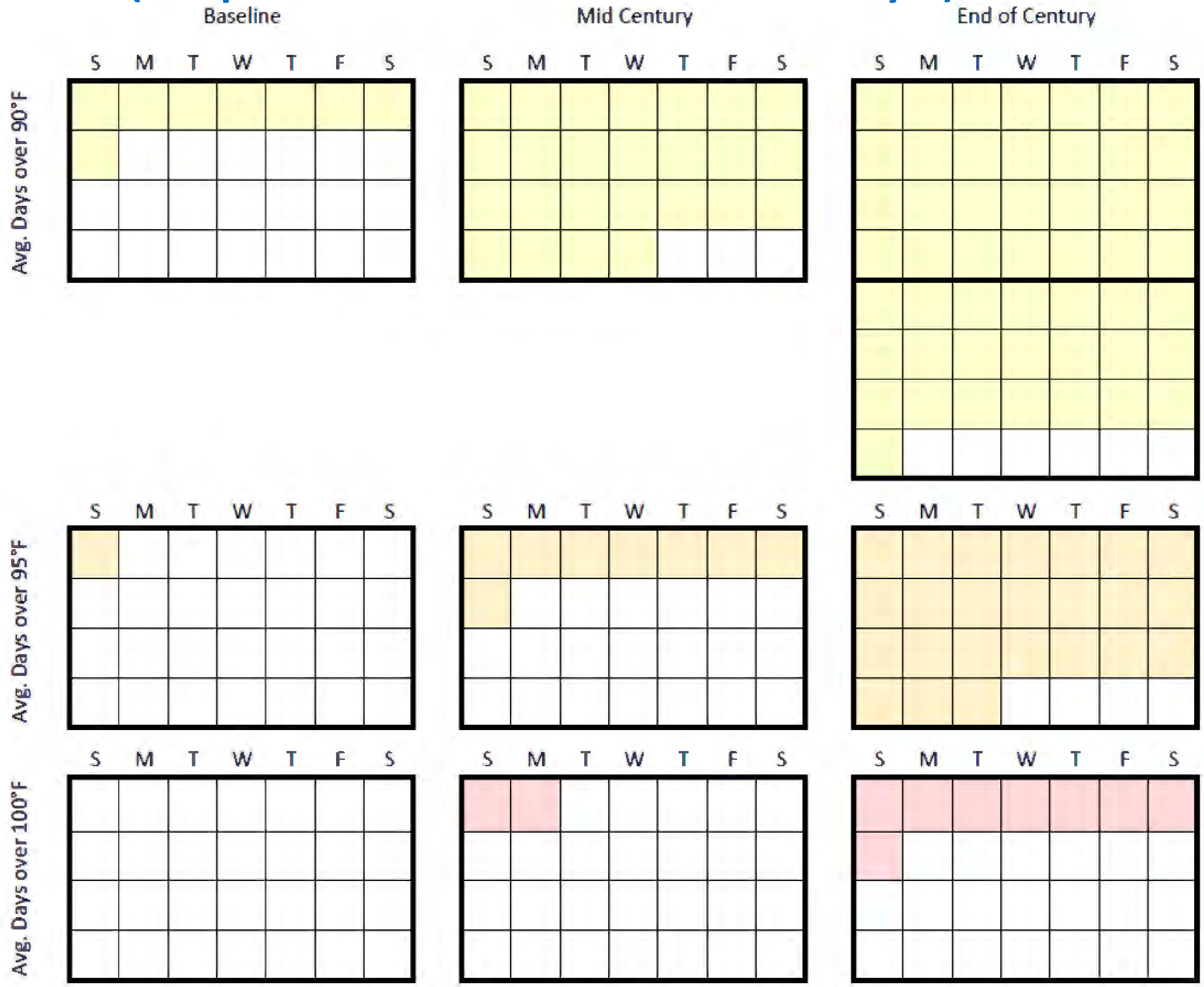
# Natural Hazards in Melrose

# Hazards in Melrose

- Flooding*
  - Dam failure
  - Landslide
- Fire
  - Major Urban Fire
  - Wildfire
- Earthquake
- Invasive Species
- Severe Weather
  - High Wind*
  - Thunderstorm*
  - Tornado
  - Hurricane / Tropical storm*
  - Snow & Blizzard*
  - Nor'easter*
  - Ice Storm*
  - Extreme Temperature (hot and cold)*
  - Drought

*Indicates the hazard was also identified during the MVP process

# Climate Change Temperature Impacts in Melrose (Representation of Hot Days)



# Climate Change Precipitation Impacts in Melrose

- Number of days receiving precipitation over one inch are variable, fluctuating between loss and gain of days.
- Seasonal projections for total precipitation are also variable for the Boston Harbor basin.
  - The winter season is expected to experience the greatest change with an increase of 0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable throughout the 21st century.

**Take away:** *Precipitation will be more variable. “Extreme” precipitation events are likely to occur more often.*

# Review & Feedback: Vulnerability Assessment

# Vulnerabilities (Society)

| Vulnerable Asset | Applicable Hazards | | | | | Regional Impacts |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| **SOCIETY** | | | | | | |
| **Emergency Response / Evacuation Plan** | X | X | X | X | | **X** |
| **Senior / Aging Population** | X | X | X | X | X | **X** |
| **Chronically Ill / Disabled Population** | X | X | X | X | | **X** |
| **Non-English Speaking Population** | X | X | X | X | | **X** |
| **Low-Income Population** | X | X | X | X | | **X** |
| **Faith Based Organizations** | X | X | X | X | | |

# Vulnerabilities (Infrastructure)

| Vulnerable Asset | Applicable Hazards | | | | | Regional Impacts |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| **INFRASTRUCTURE** | | | | | | |
| **Transportation Infrastructure** | X | X | | X | | **X** |
| **Residential and Commercial Properties** | X | X | X | X | | |
| **Fire and Police Stations** | X | X | | X | | **X** |
| **City Hall** | X | X | X | X | | |
| **Memorial Hall** | X | X | | X | | |
| **Emergency Shelters** | X | X | | X | | **X** |
| **Schools / Child Care Facilities** | X | X | X | X | | |
| **Melrose-Wakefield Hospital** | X | X | X | X | | **X** |
| **Pharmacies** | X | X | X | X | | **X** |
| **Gas Infrastructure** | X | X | | X | | **X** |
| **Electrical / Power Infrastructure** | X | X | X | X | | **X** |
| **Fuel Sources** | X | X | X | X | | **X** |
| **Food Sources** | | | | | | **X** |
| **Communications Infrastructure** | X | X | X | X | | **X** |
| **Sewer Pump Stations** | X | X | | X | | |
| **Water and Sewer Pipelines** | X | X | | X | | **X** |
| **Stormwater Drainage Infrastructure** | | | | | | **X** |

# Vulnerabilities (Environment)

| Vulnerable Asset | Applicable Hazards | | | | | Regional Impacts |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| **ENVIRONMENT** | | | | | | |
| **Water Bodies: Lakes / Rivers / Reservoirs** | X | X | | X | X | **X** |
| **Parks / Natural Areas / Open Space** | X | X | X | | X | |
| **Tree Canopy** | X | X | X | X | X | |
| **Wildlife** | X | X | X | X | X | **X** |
| **Air Quality** | | X | X | | | **X** |

# Group Exercise

# Actions to Reduce Risks from Hazards

- What Regional Action should Melrose take?
  - What Hazard(s) does the action apply to?
  - Who are the Responsible Parties?
  - What is needed for the action to be successful?
  - Is this a Priority?

**Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan**

CDM Smith

**September 25, 2018**

**Name/City or Town/Department:**

*What Regional Action should be taken to make Melrose and the Region more prepared for hazards?*

***ACTION TITLE:***

***ACTION DESCRIPTION:***

***RESPONSIBLE PARTIES (Check all that apply):***

☐ Melrose DPW ☐ Neighboring City/Town: ☐ Federal Government ☐ Utility (specify):_____
☐ Melrose Police ☐ DPW ☐ State Government ☐ Public Health Organization
☐ Melrose Fire ☐ Police ☐ Regional Government(s)
☐ Fire ☐ Other (specify):_______________

***APPLICABLE HAZARD:***

☐ Flood (including ice jam) ☐ Landslide ☐ Thunderstorm
☐ Dam failure ☐ Snow & blizzard ☐ High wind
☐ Hurricane / Tropical storm ☐ Ice storm ☐ Tornado
☐ Nor'easter ☐ Wildfire ☐ Extreme Temperature:
☐ Earthquake ☐ Major Urban Fire ☐ Hot ☐ Cold
☐ Other hazard (please specify): _______________

***PRIORITY OF THIS ACTION:***

☐ Very high ☐ High ☐ Moderate ☐ Low

# Thank you for your input!

# Definitions

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

- **Actions** reduce vulnerability or reinforce strengths.
- **Prioritized actions** take into account the importance of addressing the vulnerability / reinforcing the strength to the community

A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.

**The *actions* to address vulnerability of a sunburn include staying in the shade or wearing sunblock.**

# Background on Climate Data

- Summarized by the MA Executive Office of Energy and Environmental Affairs
- Based on the latest Global Climate Models (GCM) from the International Panel on Climate Change (IPCC)
  - Medium and high greenhouse gas emission scenarios
  - Bracket the "most likely" scenarios
- "Downscaled" to major watershed basin (majority of Melrose is in the Boston Harbor watershed)
  - Temperature (e.g. average/maximum/minimum temperatures annual/seasonal days over 90, 95, 100$^{o}$F)
  - Precipitation (e.g. total annual, seasonal, days over 1, 2, 4 inches)
  - Temperature projections are more certain than precipitation

*Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21$^{st}$ century.*

# Temperature Impacts in Melrose

- Average, maximum, and minimum temperatures are expected to increase
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase
- Seasonally, minimum winter and fall temperatures are expected to increase throughout the 21st century.

| Boston Harbor Basin | | Observed Baseline 1971-2000 (°F) | Mid-Century 2050 (°F) | | | End of Century 2090's (°F) | | |
|---|---|---|---|---|---|---|---|---|
| Average | Annual | 50.13 | 52.86 | to | 56.2 | 53.59 | to | 60.97 |
| Maximum Temperature | Summer | 80.04 | 82.27 | to | 86.45 | 83.26 | to | 92.25 |
| | Fall | 61.93 | 65.23 | to | 68.59 | 65.56 | to | 73.71 |
| Minimum Temperature | Annual | 40.7 | 43.61 | to | 46.92 | 44.45 | to | 51.65 |
| | Winter | 21.31 | 24.55 | to | 28.65 | 25.64 | to | 32.22 |
| | Fall | 43.22 | 46.71 | to | 49.67 | 47.14 | to | 54.63 |

Welcome to Melrose MASSACHUSETTS

Published on *Melrose MA* (https://www.cityofmelrose.org)



# Municipal Vulnerability Preparedness/Natural Hazard Mitigation Plan Public Listening Session

Melrose Veteran's Memorial Middle School Cafeteria
**Event Date:**
Thursday, June 21, 2018 - 7:00pm

**Preparing for Extreme Weather Events: A Listening Session**

At 7 p.m. on Thursday, June 21st, the City of Melrose will hold a public meeting to discuss our readiness to handle climate-related events and emergencies and how we can become more prepared. We want to hear suggestions and feedback from the entire community on this important topic. The meeting will be held in the Melrose Veterans Memorial Middle School Cafeteria.

In recent weeks, the City of Melrose has been holding internal discussions regarding which potential hazards to address first, and how to make Melrose more resilient as we expect more extreme weather in the future. This listening session is an important part of that process, and it leads directly to the next step, which is updating the Melrose Natural Hazards Mitigation Plan. This plan is our blueprint for reducing the risk to the community from environmental hazards and improving our ability to recover from the stronger storms that we expect as the impacts of global warming continue to increase.

Please join us to learn more about Melrose’s efforts to date and to provide your input.

View CDM Smith's Municipal Vulnerability Preparedness Report for Melrose.

Questions? Contact Energy Efficiency Manager Martha Grover at mgrover@cityofmelrose.org or 781-979-4195.

**Source URL:** https://www.cityofmelrose.org/home/events/10693

**Miller, Lauren M.**

**From:** Grover, Martha <mgrover@CityofMelrose.org>
**Sent:** Wednesday, June 20, 2018 2:32 PM
**To:** Martha Grover
**Subject:** REMINDER: Preparing for Extreme Weather Events - The Public Listening Session
**Attachments:** Melrose HMP-MVP agenda_062118.docx

**Preparing for Extreme Weather Events: A Listening Session** (agenda attached)

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Please join us on June 21st at 7 p.m. to learn more about Melrose's efforts to date and to provide your input. A full copy of the Summary of Findings from the preliminary Municipal Vulnerability Preparedness workshops can be viewed here:
https://www.cityofmelrose.org/home/events/10693

*Martha Grover*
*Energy Efficiency Manager*
*Office of Planning and Community Development*
*City of Melrose*
*562 Main Street, Melrose, MA 02176*
*781-979-4195*
*MGrover@cityofmelrose.org*

# ‘Preparing for Extreme Weather Events: A Listening Session’ on June 21

~~June 14, 2018June 13, 2018~~ ~~Mayor Infurna~~

At 7 p.m. on Thursday, June 21st, the City of Melrose will hold a public meeting to discuss our readiness to handle climate-related events and emergencies and how we can become more prepared. We want to hear suggestions and feedback from the entire community on this important topic. The meeting will be held in the Melrose Veterans Memorial Middle School Cafeteria.

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# Preparing for Extreme Weather Events: A Listening Session

**Agenda**

**June 21, 2018**

*Meeting Purpose:* *To discuss our City's readiness to handle climate-related events and emergencies and how we can become more prepared and to hear suggestions and feedback from the entire community on this important topic.*

7:00 – 7:15 Welcome and review the meeting purpose

7:15 – 7:50 Presentation on resilience programs in Melrose

- Discuss the Municipal Vulnerability Preparedness program and results
- Review the Hazard Mitigation Plan process
- Discuss actions Melrose has undertaken

7:50 – 8:20 Community feedback:

- What additional hazards may be experienced in Melrose?
- What additional actions could Melrose take to reduce hazards?

8:20 – 8:30 Group Exercise: Vote on the hazards and actions in Melrose

8:30 – 8:45 Summary discussion on outcome of votes / comments

**Preparing for**
**Extreme Weather Events:**
**A Listening Session**
**June 21, 2018**

**Sign-in Sheet**

| | |
|---|---|
| Dan + Cindy OLeary | 5 Whitwell St + Mystic Valley Elder SVS |
| Julie DeLillo | 13 Circuit St. |
| Bob Smith | 40 Irving St. |
| David Ball | Melrose FD |
| Bob Haney | Derby Rd |
| Eli U. Naeda | 174 Melrose St |
| Hollie Marston | Pearl St. |
| Jeana McNeil | Maple St. |
| Salil + Susan Bhole | |
| Lori Timmermann | 264 1st St |
| Gary Lamothe | 264 1st St. |
| Janine Venuti | Altamont Ave |
| Jim Donohue | 31 Gooch St. |
| Katie Moore | 35 Laurel St. |
| Aaron Weieneth | 94 Howard St |

# Preparing for Extreme Weather Events: A Listening Session

**Feedback from the Community**

**June 21, 2018**

*Community feedback and prioritization on the question: What actions could Melrose take to reduce hazards?*

| **Actions (from Community input)** | **Votes received** |
|---|---|
| Community empowerment / ownership / action: Everyone can play a role (ex. Community Emergency Response Team (CERT) training and workshops) | 14 |
| Emergency generator at City Hall | 9 |
| Programs / plans for private facilities / smart building; examples include solar readiness and stormwater programs (relates to concern about over-building and too many impervious surfaces) | 9 |
| Investigate / coordinate infrastructure projects across utilities to lesson disruption | 9 |
| Tree canopy assessment by a registered arborist to help property owners identify “problem trees” / incentive programs (relates to maintaining and adapting tree cover to resilient species) | 7 |
| Tie resilience into the bigger picture: reduce resource use (ex. greenhouse gases, recycling) | 7 |
| Microgrids | 6 |
| Communications: cell towers and landline poles | 5 |
| Long term planning and resources for emergency management / get community trained and maintain in emergency management to take direction from the City (Fire, DPW, etc.). – people become resources | 5 |
| Catch water from rooftops for irrigation | 4 |
| Coordinate with neighboring towns / cities / state when sending drainage downstream (outfalls) and monitor infrastructure issues (ex. Oak Grove flooding) | 4 |
| Emergency planning: evacuation (shelter and supplies); individual and family emergency plans | 4 |
| Utility coordination: includes poles (no more double poles); get all utilities to the table | 3 |
| Be cognizant of vulnerable populations (ex. snowy bump pads impact the blind population) | 3 |
| Hospital resilience to hazards | 2 |
| Upgrade electric utility lines / bury lines (investigate) | 2 |
| Sustainability / resilience training / certification for contractors | 2 |
| Fuel / energy supply and security | 1 |
| Upgrade state-owned lights (petition legislature) | 1 |
| Weiss Farm development stormwater concerns | 1 |
| Gray water opportunities | 0 |
| Water supply | 0 |
| Back-up systems for elevators in high rise buildings | 0 |
| Structured community engagement forum | 0 |

# Preparing for Extreme Weather Events: A Listening Session

CDM Smith

June 21, 2018

Name: Dan O Leary EMAIL: doleary@mves.org
5 Whitwell St + Mystic Valley Elder Services. Inc.

1. *What hazards are you concerned about in Melrose? (Check all that apply and/or add your own)*

- [x] Flood (including ice jam)
- [ ] Landslide
- [ ] Thunderstorm
- [ ] Dam failure
- [x] Snow & Blizzard
- [ ] High Wind
- [x] Hurricane / Tropical storm
- [x] Ice Storm
- [x] Tornado
- [x] Nor'easter
- [ ] Wildfire
- [x] Drought
- [ ] Earthquake
- [x] Major Urban Fire
- [x] Extreme Temperature
  - [x] Hot
  - [ ] Cold
- [ ] Other hazard (please specify):

2. *What action can the City take to make Melrose more prepared for the hazards you are concerned about?*

*ACTION TITLE:*

*ACTION DESCRIPTION:*

- Make sure storm drains + culverts are clear + free running.
- Have sufficient equip + personnel to respond to snow or other emergencies that prevent travel
- Enforce building codes on fire prevention + elevator maintenance.
- Have accessible shelters for cooling + heating + emergencies

*PRIORITY OF THIS ACTION:*

- [x] Very high
- [ ] High
- [ ] Moderate
- [ ] Low

# Preparing for Extreme Weather Events: A Listening Session

June 21, 2018

Name: Brandon Raymond EMAIL: braymond@geosyntec.com

1. *What hazards are you concerned about in Melrose? (Check all that apply and/or add your own)*

- [x] Flood (including ice jam)
- [ ] Dam failure
- [ ] Hurricane / Tropical storm
- [x] Nor'easter
- [ ] Earthquake
- [ ] Other hazard (please specify):
- [ ] Landslide
- [x] Snow & Blizzard
- [x] Ice Storm
- [ ] Wildfire
- [ ] Major Urban Fire
- [ ] Thunderstorm
- [x] High Wind
- [ ] Tornado
- [x] Drought
- [ ] Extreme Temperature
  - [ ] Hot
  - [ ] Cold

2. *What action can the City take to make Melrose more prepared for the hazards you are concerned about?*

| | |
|---|---|
| *ACTION TITLE:* | Grey water storage & systems |
| *ACTION DESCRIPTION:* | Incorporate / Develop ways to collect & use grey water (stormwater) for watering lawns, fire protection. Incentivize private usage of grey water (Mt Hood Golf Course). |
| *PRIORITY OF THIS ACTION:* | ☐ Very high ☐ High ☐ Moderate ☐ Low |

# Preparing for Extreme Weather Events: A Listening Session

June 21, 2018

Name:

EMAIL:

1. *What hazards are you concerned about in Melrose? (Check all that apply and/or add your own)*

- [x] Flood (including ice jam)
- [x] Dam failure
- [x] Hurricane / Tropical storm
- [x] Nor'easter
- [x] Earthquake
- [x] Other hazard (please specify): Storm water
- [x] Landslide
- [x] Snow & Blizzard
- [x] Ice Storm
- [x] Wildfire
- [ ] Major Urban Fire
- [ ] Thunderstorm
- [x] High Wind
- [x] Tornado
- [x] Drought
- [x] Extreme Temperature
  - [x] Hot
  - [x] Cold

increasing issue, we need better warning systems... midwest it's common, but not here

2. *What action can the City take to make Melrose more prepared for the hazards you are concerned about?*

*ACTION TITLE:* Ordinance review/incorporation

*ACTION DESCRIPTION:* Review current city ordinances to see if they are reflective of the HMP action items and processes.

*PRIORITY OF THIS ACTION:*

- [ ] Very high
- [x] High
- [ ] Moderate
- [ ] Low

# Preparing for Extreme Weather Events: A Listening Session

Municipal Vulnerability Preparedness + Hazard Mitigation Plan

*June 21, 2018*

# Welcome and Introductions

# Purpose of Tonight's Meeting

- Present the results of the Massachusetts Municipal Vulnerability Preparedness (MVP) process
- Review the Natural Hazards Mitigation Plan (HMP) process
- Receive public input to the Melrose Natural Hazards Mitigation Plan

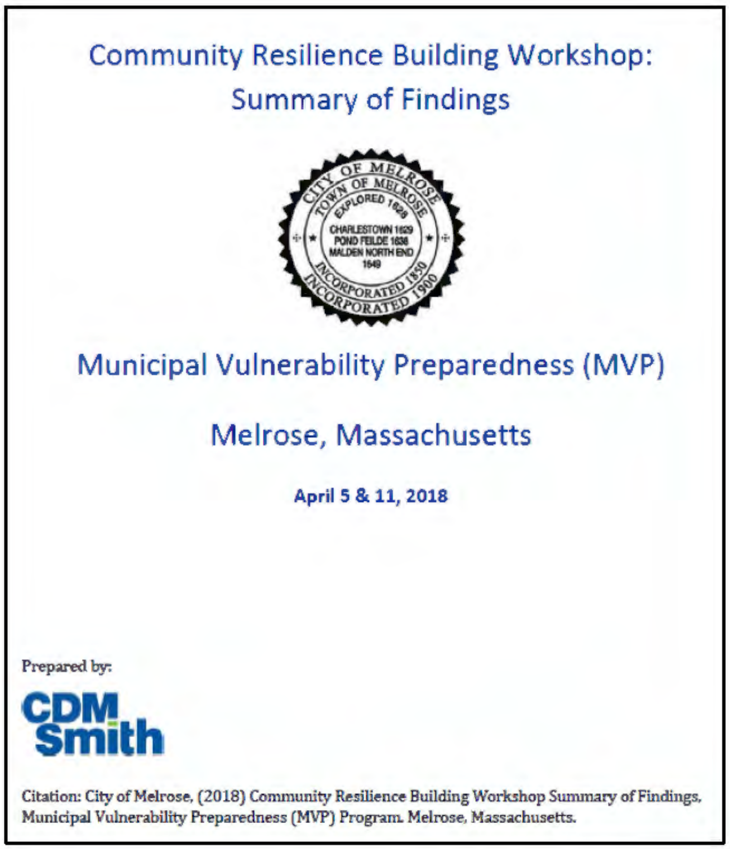
# Agenda

- 7:00 – 7:15 Welcome and review the meeting purpose
- 7:15 – 7:50 Presentation on resilience programs in Melrose
  - *Discuss the Municipal Vulnerability Preparedness program and results*
  - *Review the Hazard Mitigation Plan process*
  - *Discuss actions Melrose has undertaken*
- 7:50 – 8:20 Community feedback:
  - *What additional hazards may be experienced in Melrose?*
  - *What additional actions could Melrose take to reduce hazards?*
- 8:20 – 8:30 Group Exercise: Vote on the hazards and actions in Melrose
- 8:30 – 8:45 Summary discussion on outcome of votes / comments

# Resilience Programs in Melrose

# Resilience Programs in Melrose

- Massachusetts Municipal Vulnerability Preparedness (MVP) Program (complete)



Community Resilience Building Workshop:
Summary of Findings

Municipal Vulnerability Preparedness (MVP)

Melrose, Massachusetts

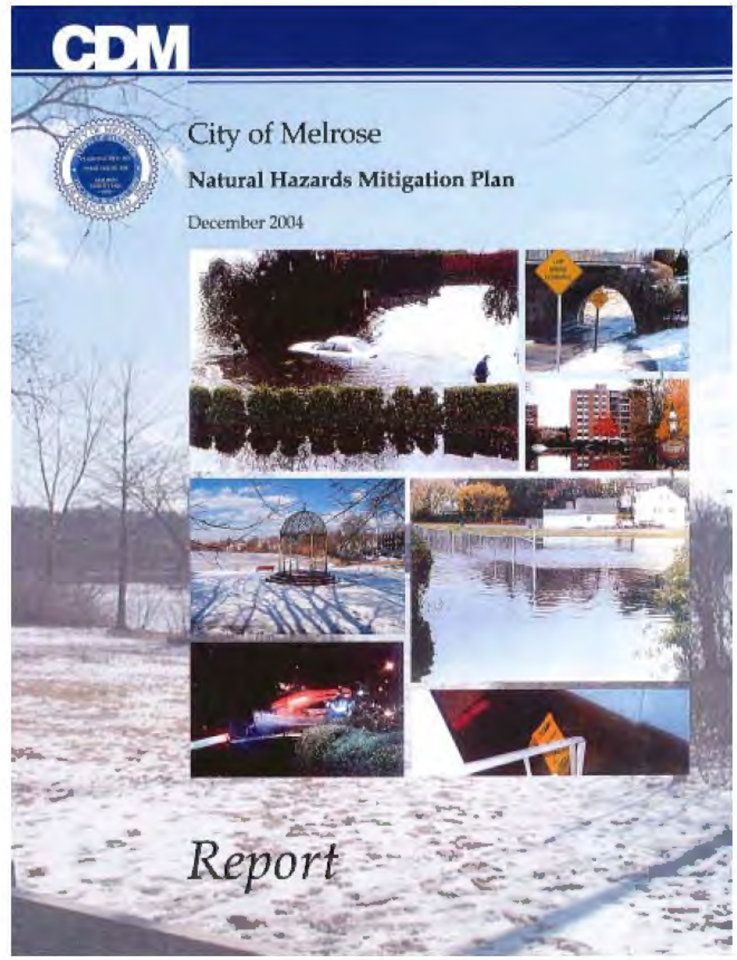
**April 5 & 11, 2018**

Prepared by:

CDM Smith

Citation: City of Melrose, (2018) Community Resilience Building Workshop Summary of Findings, Municipal Vulnerability Preparedness (MVP) Program. Melrose, Massachusetts.

- Natural Hazards Mitigation Plan (updating)



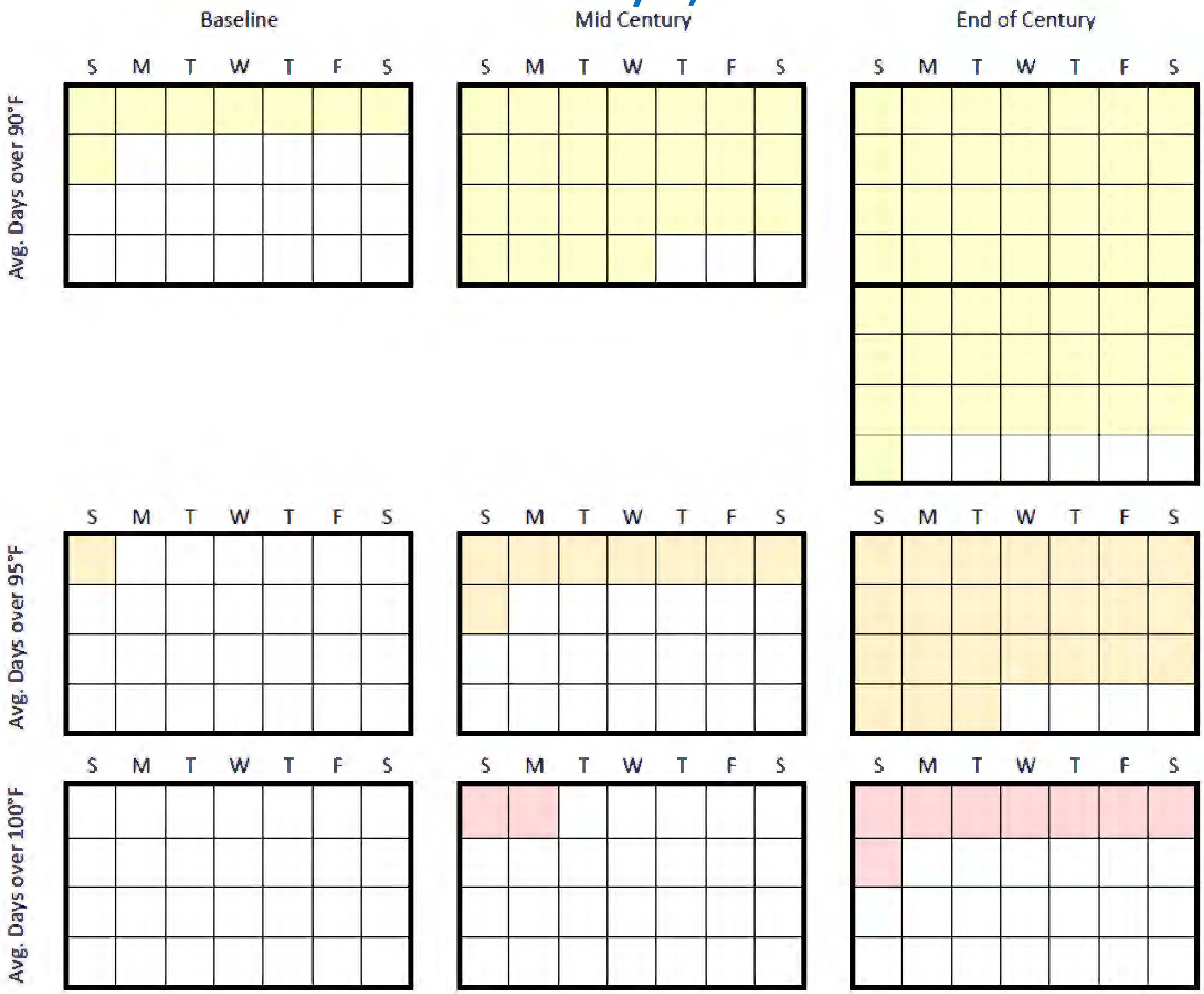
# Massachusetts Municipal Vulnerability Preparedness (MVP) Program

- Massachusetts funded program
- Planning grants to 71 communities (FY18) to conduct the Community Resilience Building process
  - Define climate change hazards in the community
  - Understand how community will be impacted (infrastructure, society, environment)
  - Identify resilient actions
  - Prioritize actions – eligible for additional funding
- Developed the MA Resilience Clearinghouse (data, maps, reports, resources)

resilient MA
Climate Change Clearinghouse for the Commonwealth

Community Resilience Building
Get on the right path to resilience today...

# Temperature Impacts in Melrose (Representation of Hot Days)



# Precipitation Impacts in Melrose

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- Seasonal projections for total precipitation are also variable for the Boston Harbor basin.
  - The winter season is expected to experience the greatest change with an increase of  0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable throughout the 21st century.

**Take away:** *Precipitation will be more variable. "Extreme" precipitation events are likely to occur more often.*

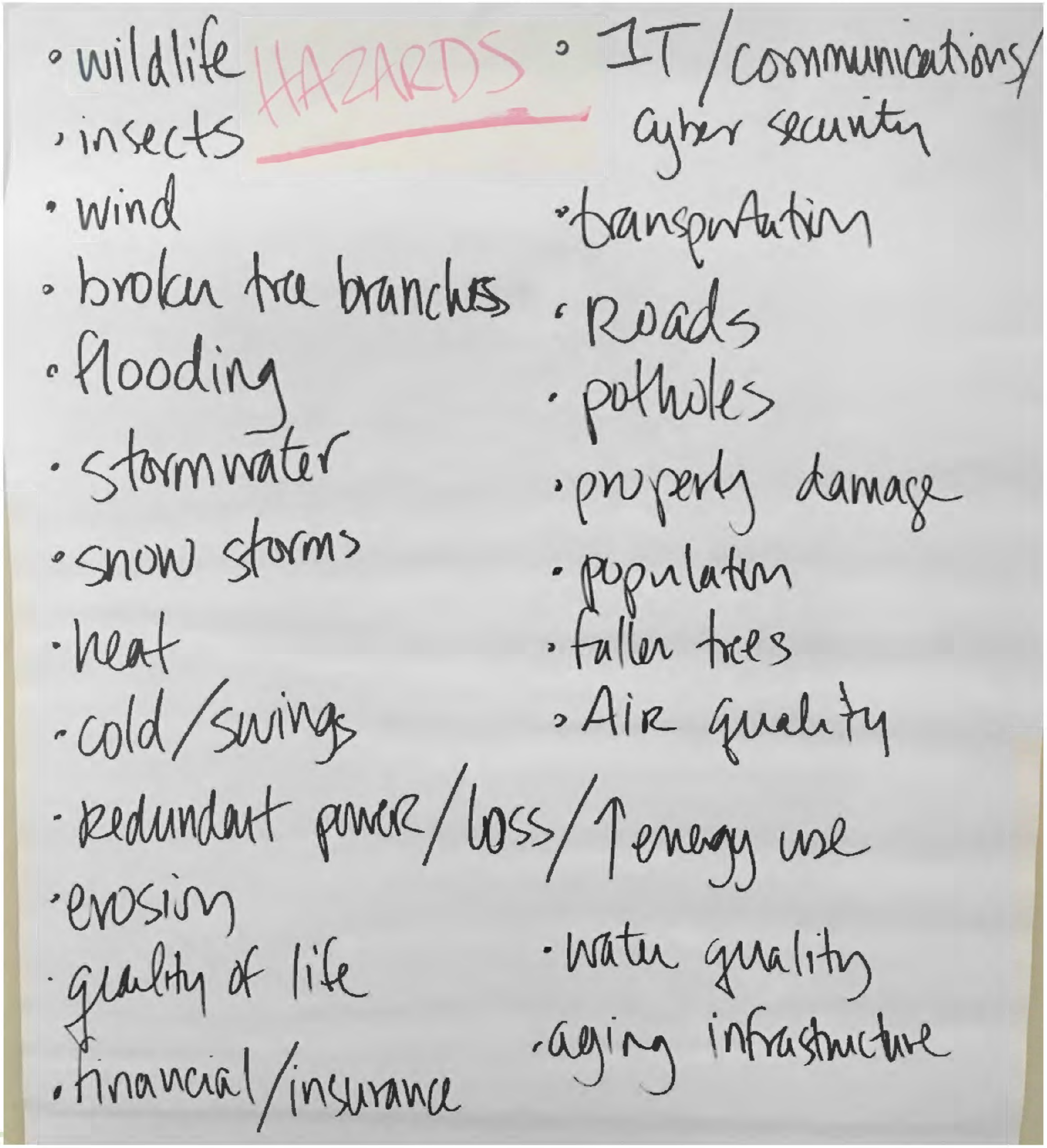
# MVP Workshops in Melrose

- Received a $19,000 grant from the MA. Executive Office of Energy and Environmental Affairs
- Workshops with departments and organizations in Melrose (2 days)
- Achieved an "MVP" designation – funding implications

**Objective:** *"The Workshops are a new initiative to immediately integrate community-derived priorities into a natural hazard mitigation process and identify actions to build resilience in the community."*

# MVP Hazards in Melrose

- Extreme temperatures
- Heat
- Flooding
- Major storms
  (rain and snow)
- Wind
- Power loss
- Disease



# Vulnerabilities Identified Through MVP (examples)

- Need for back-up power at sewer pump stations, cooling stations, and at City Hall
- Maintaining and improving quality of life in Melrose
- Ability to stay in good financial standing / obtain insurance with future hazards
- Ability of aging infrastructure to withstand current and future hazards
- Poor air quality as temperatures rise / during heat waves
- Ability to respond to large snowstorms and clean up after storm events

# Strengths in Melrose (examples)

- Improved and upgraded stormwater systems
- Faith-based organizations and associated places of worship provide community resilience, the potential to use these organizations as a conduit for information to the public, and as a physical location of refuge and aid during or after an event.
- Excellent team of first responders and emergency action plans.
- Shelter Management Plan and identified shelters to provide for citizens during a time of need

# Top Actions Identified through MVP

1. Install an emergency generator at City Hall (17 votes)
2. Advance stormwater management actions (9 votes)
3. Improve emergency management (9 votes)
4. Expand green infrastructure and green buildings (8 votes)

# Natural Hazard Mitigation Plan

- Planning process to reduce the risk of loss of life and property by lessening the impact of disasters
- Developing hazard mitigation plans enables state, tribal, and local governments to:
  - Increase education and awareness around threats, hazards, and vulnerabilities;
  - Build partnerships for risk reduction involving government, organizations, businesses, and the public;
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  - Identify implementation approaches that focus resources on the greatest risks and vulnerabilities; and
  - Communicate priorities to potential sources of funding.

Source: Federal Emergency Management Agency https://www.fema.gov/hazard-mitigation-planning

# HMP Hazards

- Flood (including ice jam)
- Landslide
- Thunderstorm
- Dam failure
- Snow & Blizzard
- High Wind
- Hurricane / Tropical storm
- Ice Storm
- Tornado
- Nor'easter
- Wildfire
- Drought
- Earthquake
- Major Urban Fire
- Extreme Temperature (hot and cold)

# Status of Actions Identified in 2004 HMP

- Reconstruct the Department of Public Works (DPW) Maintenance and Repair Garage
- Reconstruct Middle School/High School Drain
- Reconstruct Roosevelt School Detention Basin
- Study and Implement Mitigation Measures for the Melrose Towers Condominium Complex
- Petition FEMA – Petition FEMA to include the Converse Lane Community Team defined flood hazard area as part of the 100-year floodplain
- Converse Lane Drainage Improvements
- Reconstruct Upstream Portion of Tremont Street Drain
- Study and Implement Mitigation Measures for Several Flood Hazard Areas
- Official City of Melrose Website – Increase public outreach
- Incident Command Course (ICS)
- Portable Generators
- Secure Important Records
- Direct-Connect for City Departments
- Reverse 911
- Enroll in the Community Rating System
- South Washington Street Catch Basin

| Actions Identified in 2004 HMP | Complete | Partial | In Progress | Not Addressed |
|---|---|---|---|---|
| Reconstruct DPW Maintenance and Repair Garage | | X | | |
| Reconstruct Middle School/High School Drain | X | | | |
| Reconstruct Roosevelt School Detention Basin | X | | | |
| Study / Implement Mitigation Measures for the Melrose Towers Condos | X | | | |
| Petition FEMA – include Converse Lane Community in 100-year floodplain | X | | | |
| Converse Lane Drainage Improvements | X | | | |
| Reconstruct Upstream Portion of Tremont Street Drain | | X | | |
| Study and Implement Mitigation Measures for Several Flood Hazard Areas | | | X | |
| Official City of Melrose Website – Increase public outreach | | | X | |
| Incident Command Course (ICS) | | | X | |
| Portable Generators | | X | | |
| Secure Important Records | | | X | |
| Direct-Connect for City Departments | X | | | |
| Reverse 911 | X | | | |
| Enroll in the Community Rating System | | | | X |
| Fellsway East Catch Basin | X | | | |

# Community Feedback

# Community Feedback

- What additional hazards may be experienced in Melrose?
- What additional actions could Melrose take to reduce hazards?

**Preparing for**
**Extreme Weather Events:**
**A Listening Session**

CDM Smith

**June 21, 2018**

**Name:** **EMAIL:**

1. *What hazards are you concerned about in Melrose? (Check all that apply and/or add your own)*

| | | |
|---|---|---|
| ☐ Flood (including ice jam) | ☐ Landslide | ☐ Thunderstorm |
| ☐ Dam failure | ☐ Snow & Blizzard | ☐ High Wind |
| ☐ Hurricane / Tropical storm | ☐ Ice Storm | ☐ Tornado |
| ☐ Nor'easter | ☐ Wildfire | ☐ Drought |
| ☐ Earthquake | ☐ Major Urban Fire | ☐ Extreme Temperature |
| ☐ Other hazard (please specify): | | ☐ Hot ☐ Cold |

2. *What action can the City take to make Melrose more prepared for the hazards you are concerned about?*

***ACTION TITLE:***

***ACTION DESCRIPTION:***

***PRIORITY OF THIS ACTION:***

☐ Very high ☐ High ☐ Moderate ☐ Low

# Group Exercise

Thank you for your input!

# Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan

**Agenda**

**September 25, 2018**

*<u>Meeting Purpose:</u> An opportunity for local and neighboring community partners to provide input to Melrose's Natural Hazard Mitigation Plan process. Your input will assist Melrose by facilitating regionally-focused hazard mitigation strategies and opportunities*

| | |
|---|---|
| 1:00 – 1:15 | Welcome, introductions, review the meeting purpose |
| 1:15 – 1:45 | Review the natural hazards and key vulnerability assessment findings |
| 1:45 – 2:00 | Solicit feedback on the risks and vulnerabilities identified in Melrose |
| 2:00 – 2:45 | Brainstorm actions that reduce regional risks, including how we can work collaboratively to implement them<br>▪ Emergency management<br>▪ Public health<br>▪ Utility networks<br>▪ DPW |
| 2:45 – 3:00 | Summary discussion, next steps |

# Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan

**Sign-In Sheet**

**September 25, 2018**

| Name | Organization/Role |
| --- | --- |
| James Hughes | Saugus EM |
| Stan Usovicz | Verizon |
| LT JAMES MULRENAN | MELROSE POLICE |
| Manisha Bewtra | Board of Aldermen |
| Matt Grafton | Stoneham Fire / EMD |
| JOHN SCENNA | Public Works, Melrose |
| John Ray | MBTA - Commuter Rail |
| Denise Gaffey | DGaffey@cityofmelrose.org |
| Paul Brodeur | State Rep. |
| Ed Collina | FIRE Chief melrose |
| Elena Proakis Ellis | City Engineer, Melrose |
| Lauren Miller | CDM Smith - consultant. |

# Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan

**Meeting Notes**

30 % recyclees

VULNERABILITIES

Fire ⇒ hazard for shelters + E.M. locations

schools ⇒ regional METCO
→ children from Boston to schools.

Pets → shelters for animals → implications on owners (not seeking safety)

## Emer. Mgmt ACTIONS

communication

- MEMA Region → contact info for all E.M. *MEMA will likely step in.
- program ~~EOs~~ others into 911 system

ID:

- "phone tree" process → responsibility?
- access to translators
- Regionalized training + tabletop exercises
- have a CODERED ⇒ need more people to sign-up...
- protocol for communications/plan

communication

*(1) communication btwn EM
(2) com. to public/cohesive

- <u>Officials</u> → use official info. from utilities. Failure may come from <u>NOT</u> using these channels

↓

all city → understand protocol.
- usually same #

crews have been dispatched.

Public health

- pharmacy hrs ~~plan~~ } extend before emergency
- grocery hrs
- Regional coordinated evac. plan → share info among towns
- if <u>local</u> evac → up to community
- current evac. are local incidents } regional resources
  ↳ need Regional

MBTA → commuter rail "goes" to get people... up to com. rail. engineer

· how often are evac. plans updated?
(Boston, etc?)

· Communicate evac. plans.

· Nat'l Grid → list of who needs power...

↳ Better communicate HOW to get on list

↳ communicate this list to Em Mgmt.
<Eversource does this w/ Stoneham>

· ~~need~~ know where/who needs help + for downed wires.

· Can hospital act as 24/hr pharmacy as needed
→ supply

· on/off? access to view N.G. issues/work orders. (
↳ N.G. has triage + phone # for police/fire

· NG cant connect from pole to house (maybe if police request...) → can we have LIST of avail. "emer. electricians"

Utilities

MWRA emer. plan / coordination
↳ annual emer. training (take) *

Boil orders (2010 ~ 5 days; Distribute bottled water)

mutual aid interconnection w/ water (valves) have.
w/ other towns.

Verizon - has emer. power / fewer capacity issues now
* Melrose → have Robust wireless + fiberoptics
Can Melrose have access to resident phones

GAS → regional staging areas
* ↳ where to centrally locate?
Operate at a central location
↳ how to create staging area

people available that can help in CRISIS
- trained in human capacity aspect.

DPW.

Informal "mutual aid" (have) equipment
→ only if we can.

Compatible emer. generators (portable). + other
equipment.

MEMA has mutual aid for public works
Verizon has "cell on wheels" + generators.
MBTA has resources (via MEMA → they
decide who has greatest need)

Quicker DPW, police, + fire can coordinate the better

↳ currently meet before a storm.

DPW - lead snow

- Clarity around who to call + when (Mayor? social media? direct #?)

↳ training for public officials

# Regional Collaboration Meeting

Melrose Natural Hazard Mitigation Plan

CITY OF MELROSE TOWN OF MELROSE EXPLORED 1628 CHARLESTOWN 1629 POND FEILDE 1638 MALDEN NORTH END 1649 INCORPORATED 1850 INCORPORATED 1900

*September 25, 2018*

CDM Smith

# Welcome and Introductions

# Agenda

- 1:00 – 1:15 Welcome, introductions, review meeting purpose
- 1:15 – 1:45 Review the natural hazards and key risk assessment findings
- 1:45 – 2:00 Solicit feedback on the risks identified in Melrose
- 2:00 – 2:45 Brainstorm actions that reduce regional risks, including how we can work collaboratively to implement them
  - Emergency management
  - Public health
  - Utility networks
  - DPW
- 2:45 – 3:00 Summary discussion, next steps

# Purpose of Tonight's Meeting

- Receive input to the Melrose Natural Hazards Mitigation Plan process from local and neighboring community partners to identify regionally-focused hazard mitigation strategies and opportunities

# Introductions

1. Name
2. Department
3. Title/Role
4. *If you're aware of any* - what related plans (formal or informal) does your organization have place?

   Examples:

   - Hazard mitigation plans
   - Emergency management plan
   - Evacuation plans
   - Climate change plans
   - Others?

# Resilience Programs in Melrose

- Massachusetts Municipal Vulnerability Preparedness (MVP) Program (complete)


Community Resilience Building Workshop:
Summary of Findings

Municipal Vulnerability Preparedness (MVP)

Melrose, Massachusetts

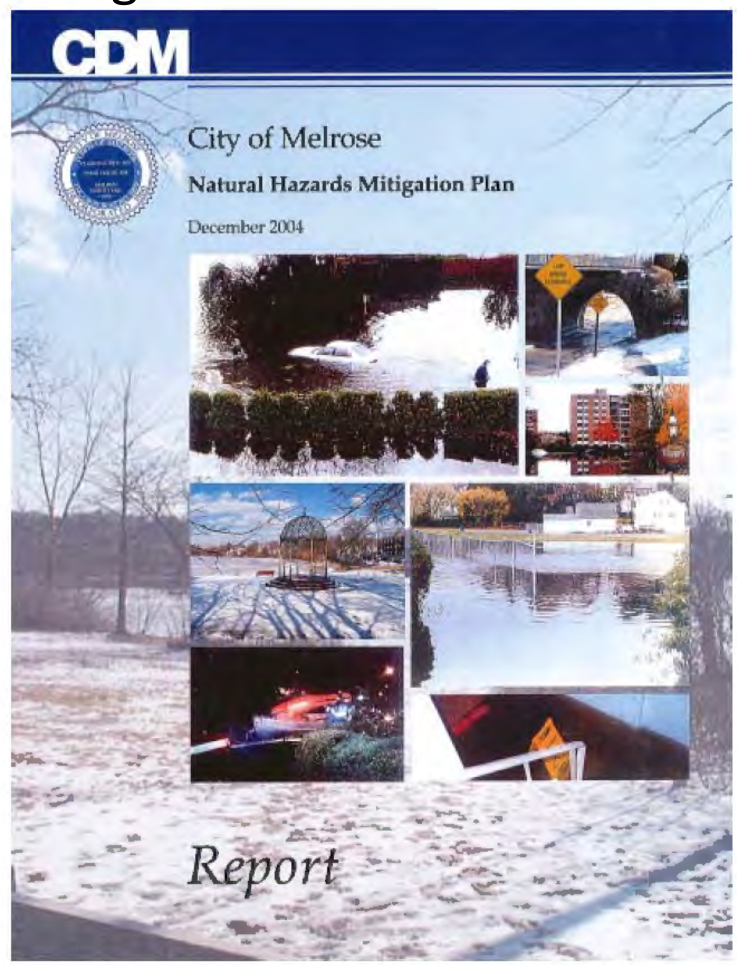
April 5 & 11, 2018

Prepared by:

CDM Smith

Citation: City of Melrose, (2018) Community Resilience Building Workshop Summary of Findings, Municipal Vulnerability Preparedness (MVP) Program. Melrose, Massachusetts.

- Natural Hazards Mitigation Plan (updating) – will include climate change



# Natural Hazard Mitigation Plan

- Planning process to reduce the risk of loss of life and property by lessening the impact of disasters
- Developing hazard mitigation plans enables state, tribal, and local governments to:
  - Increase education and awareness around threats, hazards, and vulnerabilities;
  - Build partnerships for risk reduction involving government, organizations, businesses, and the public;
  - Identify long-term, broadly-supported strategies for risk reduction;
  - Align risk reduction with other state, tribal, or community objectives;
  - Identify implementation approaches that focus resources on the greatest risks and vulnerabilities; and
  - Communicate priorities to potential sources of funding.

Source: Federal Emergency Management Agency https://www.fema.gov/hazard-mitigation-planning

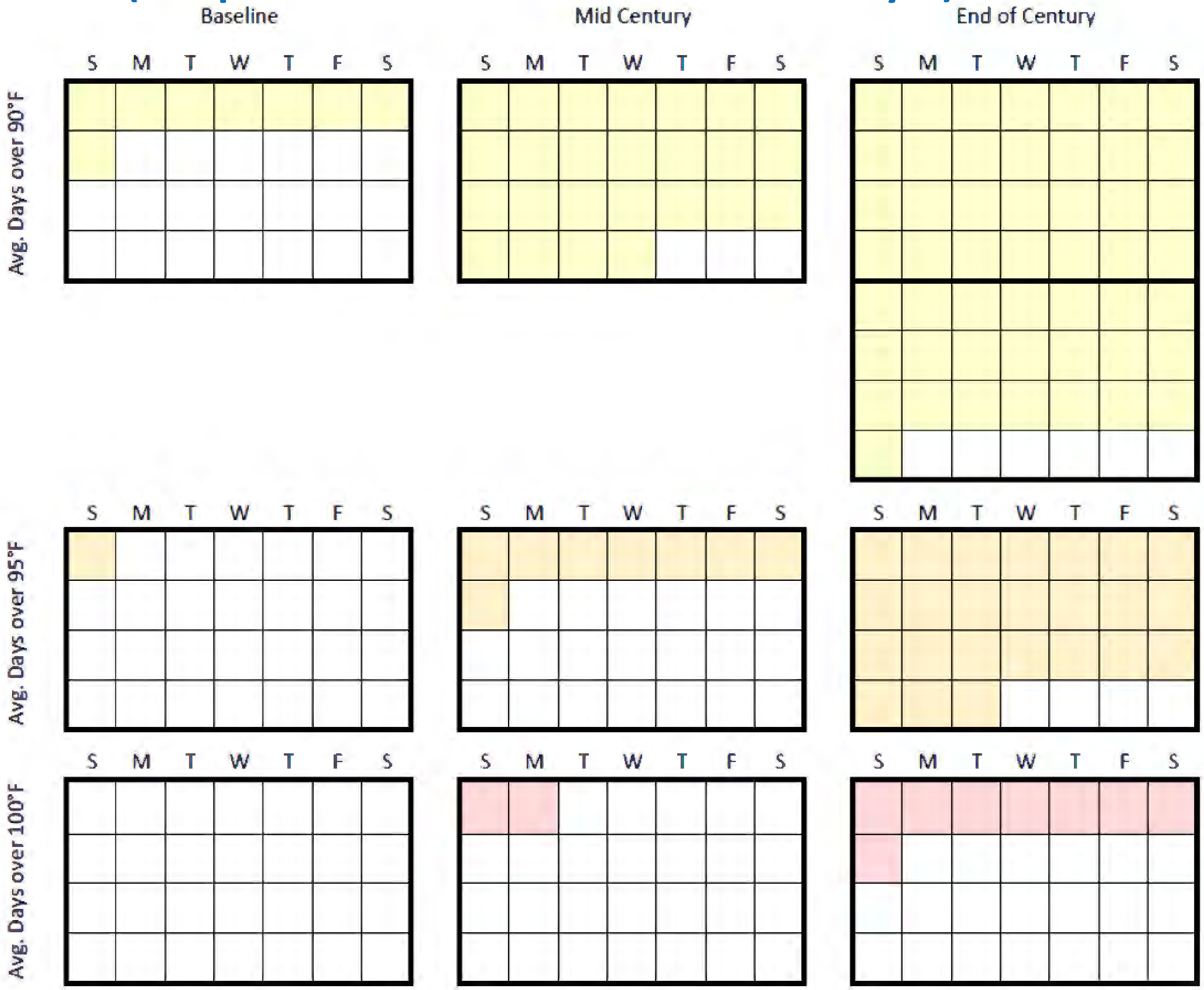
# Natural Hazards in Melrose

# Hazards in Melrose

- Flooding*
  - Dam failure
  - Landslide
- Fire
  - Major Urban Fire
  - Wildfire
- Earthquake
- Invasive Species
- Severe Weather
  - High Wind*
  - Thunderstorm*
  - Tornado
  - Hurricane / Tropical storm*
  - Snow & Blizzard*
  - Nor'easter*
  - Ice Storm*
  - Extreme Temperature (hot and cold)*
  - Drought

*Indicates the hazard was also identified during the MVP process

# Climate Change Temperature Impacts in Melrose (Representation of Hot Days)



# Climate Change Precipitation Impacts in Melrose

- Number of days receiving precipitation over one inch are variable, fluctuating between loss and gain of days.
- Seasonal projections for total precipitation are also variable for the Boston Harbor basin.
  - The winter season is expected to experience the greatest change with an increase of  0-20% by mid-century, and 3-34% by end of century.
- Annual and seasonal projections for consecutive dry days, or for a given period, are variable throughout the 21$^{st}$ century.

**Take away:** *Precipitation will be more variable. "Extreme" precipitation events are likely to occur more often.*

# Review & Feedback: Vulnerability Assessment

# Vulnerabilities (Society)

| Vulnerable Asset | Applicable Hazards | | | | | Regional Impacts |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| **SOCIETY** | | | | | | |
| **Emergency Response / Evacuation Plan** | X | X | X | X | | **X** |
| **Senior / Aging Population** | X | X | X | X | X | **X** |
| **Chronically Ill / Disabled Population** | X | X | X | X | | **X** |
| **Non-English Speaking Population** | X | X | X | X | | **X** |
| **Low-Income Population** | X | X | X | X | | **X** |
| **Faith Based Organizations** | X | X | X | X | | |

# Vulnerabilities (Infrastructure)

| Vulnerable Asset | Applicable Hazards | | | | | Regional Impacts |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| **INFRASTRUCTURE** | | | | | | |
| Transportation Infrastructure | X | X | | X | | X |
| Residential and Commercial Properties | X | X | X | X | | |
| Fire and Police Stations | X | X | | X | | X |
| City Hall | X | X | X | X | | |
| Memorial Hall | X | X | | X | | |
| Emergency Shelters | X | X | | X | | X |
| Schools / Child Care Facilities | X | X | X | X | | |
| Melrose-Wakefield Hospital | X | X | X | X | | X |
| Pharmacies | X | X | X | X | | X |
| Gas Infrastructure | X | X | | X | | X |
| Electrical / Power Infrastructure | X | X | X | X | | X |
| Fuel Sources | X | X | X | X | | X |
| Food Sources | | | | | | X |
| Communications Infrastructure | X | X | X | X | | X |
| Sewer Pump Stations | X | X | | X | | |
| Water and Sewer Pipelines | X | X | | X | | X |
| Stormwater Drainage Infrastructure | | | | | | X |

# Vulnerabilities (Environment)

| Vulnerable Asset | Applicable Hazards | | | | | Regional Impacts |
|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | |
| **ENVIRONMENT** | | | | | | |
| **Water Bodies: Lakes / Rivers / Reservoirs** | X | X | | X | X | **X** |
| **Parks / Natural Areas / Open Space** | X | X | X | | X | |
| **Tree Canopy** | X | X | X | X | X | |
| **Wildlife** | X | X | X | X | X | **X** |
| **Air Quality** | | X | X | | | **X** |

# Group Exercise

# Actions to Reduce Risks from Hazards

- What Regional Action should Melrose take?
  - What Hazard(s) does the action apply to?
  - Who are the Responsible Parties?
  - What is needed for the action to be successful?
  - Is this a Priority?

**Regional Collaboration Meeting: Melrose Natural Hazards Mitigation Plan**

**September 25, 2018**

**Name/City or Town/Department:**

*What Regional Action should be taken to make Melrose and the Region more prepared for hazards?*

***ACTION TITLE:***

***ACTION DESCRIPTION:***

***RESPONSIBLE PARTIES (Check all that apply):***

☐ Melrose DPW ☐ Neighboring City/Town: ☐ Federal Government ☐ Utility (specify):_____
☐ Melrose Police ☐ DPW ☐ State Government ☐ Public Health Organization
☐ Melrose Fire ☐ Police ☐ Regional Government(s)
☐ Fire ☐ Other (specify):_____

***APPLICABLE HAZARD:***

☐ Flood (including ice jam) ☐ Landslide ☐ Thunderstorm
☐ Dam failure ☐ Snow & blizzard ☐ High wind
☐ Hurricane / Tropical storm ☐ Ice storm ☐ Tornado
☐ Nor'easter ☐ Wildfire ☐ Extreme Temperature:
☐ Earthquake ☐ Major Urban Fire ☐ Hot ☐ Cold
☐ Other hazard (please specify): _____

***PRIORITY OF THIS ACTION:***

☐ Very high ☐ High ☐ Moderate ☐ Low

Thank you for your input!

# Definitions

- **Hazard:** A physical process or event (hydro-meteorological or oceanographic variables or phenomena) that can harm human health, livelihoods, or natural resources.
- **Risk:** The potential for consequences where something is at stake and where the outcome is uncertain.
- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected by a hazard.
- **Sensitivity**: The degree to which a system, asset, or species may be affected, either adversely or beneficially, when exposed to climate variability or change or geophysical hazards.
- **Vulnerability or Strength:** The potential effects of hazards on human or natural assets and systems. These potential effects, which are determined by both exposure and sensitivity, may be beneficial or harmful.

Source: World Bank: https://climatescreeningtools.worldbank.org/content/key-terms-0

- **Actions** reduce vulnerability or reinforce strengths.
- **Prioritized actions** take into account the importance of addressing the vulnerability / reinforcing the strength to the community

A *hazard* is like the sun. The *risk* is sunburn. The *vulnerability* includes the length of *exposure* to the sun, how *sensitive* the skin is to it.

**The *actions* to address vulnerability of a sunburn include staying in the shade or wearing sunblock.**

# Background on Climate Data

- Summarized by the MA Executive Office of Energy and Environmental Affairs
- Based on the latest Global Climate Models (GCM) from the International Panel on Climate Change (IPCC)
  - Medium and high greenhouse gas emission scenarios
  - Bracket the "most likely" scenarios
- "Downscaled" to major watershed basin (majority of Melrose is in the Boston Harbor watershed)
  - Temperature (e.g. average/maximum/minimum temperatures annual/seasonal days over 90, 95, 100$^{o}$F)
  - Precipitation (e.g. total annual, seasonal, days over 1, 2, 4 inches)
  - Temperature projections are more certain than precipitation

*Regardless of geographic scale, rising temperatures, changing precipitation, and extreme weather will continue to affect the people and resources of the Commonwealth throughout the 21st century.*

# Temperature Impacts in Melrose

- Average, maximum, and minimum temperatures are expected to increase
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase
- Seasonally, minimum winter and fall temperatures are expected to increase throughout the 21st century.

| Boston Harbor Basin | | Observed Baseline 1971-2000 (°F) | Mid-Century 2050 (°F) | | | End of Century 2090's (°F) | | |
|---|---|---|---|---|---|---|---|---|
| Average | Annual | 50.13 | 52.86 | to | 56.2 | 53.59 | to | 60.97 |
| Maximum Temperature | Summer | 80.04 | 82.27 | to | 86.45 | 83.26 | to | 92.25 |
| | Fall | 61.93 | 65.23 | to | 68.59 | 65.56 | to | 73.71 |
| Minimum Temperature | Annual | 40.7 | 43.61 | to | 46.92 | 44.45 | to | 51.65 |
| | Winter | 21.31 | 24.55 | to | 28.65 | 25.64 | to | 32.22 |
| | Fall | 43.22 | 46.71 | to | 49.67 | 47.14 | to | 54.63 |

# Appendix B

# Vulnerability Assessment and Hazard Mitigation Strategies

CDM Smith

Melrose, MA - Vulnerability Assessment for the Natural Hazards Mitigation Plan
Draft - Updated 2/28/19

| Asset | Applicable Hazards: Flooding | Severe Weather | Fire | Earthquake | Invasive Species | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details: Project Stage | Priority | Timeframe | Responsible Party |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SOCIETY | | | | | | | | | | | |
| Emergency Management Planning | X | X | X | X | | The City of Melrose maintains emergency response and evacuation plans that emergency response personnel follow in the event of a natural disaster such as severe weather, flood, earthquake, or fire. Outdated emergency and evacuation plans that do not take into account increased frequency and intensity of climate change related natural disasters pose a risk to public health and safety as preparedness and mitigation strategies may be overlooked. | • Update Emergency Management Plan for the City of Melrose which may include:<br>--> A memorandum of understanding for emergency response with neighboring communities<br>--> Contact information for all emergency management groups (local and regional)<br>--> Standard communication procedures for emergency management agencies and the public during an emergency event<br>--> Standard procedures for communication between city officials and gas/electric utility representatives during an emergency event<br>--> The programing of critical numbers into the 911 system for easy communication access<br>--> Development of a phone tree process with defined responsibilities<br>--> Direction on access to translation services<br>--> Development of regionalized training, tabletop exercises, and drills<br>--> Methods used to increase the number of people in the community signed up for the City's emergency notification system and Community Emergency Response Team (CERT) trainings / workshops<br>--> Regional evacuation routes and emergency plans<br>--> A defined regional staging area that allows utilities and emergency management to work together on regional events<br>--> Plans with neighboring towns to have compatible, portable emergency generators and other equipment<br>--> Information pertaining to emergency shelter locations and when specific locations should be used | Planning | High | Ongoing / Short | City |
| | | | | | | | • Develop and promote individual and family emergency plans that detail evacuation routes, needed supplies, and shelter locations. | Outreach and Education / Planning | High | Ongoing | City |
| | | | | | | | • Continue to engage the Melrose MVP community to update, track progress, and participate in emergency management planning programs on a regular basis. | Planning | Medium | Ongoing | City |
| Senior / Aging Population | X | X | X | X | X | Senior/aging populations may have impaired mobility, diminished sensory awareness, chronic illness, and/or other social and economic limitations that make them particularly vulnerable to natural hazards. Power outages resulting from flood, severe weather, or earthquake events could cause inadequate indoor heating or air conditioning as well as potential loss of important medical technologies and life-support equipment. Loss of communication with public safety personnel during emergency events also presents immediate danger to the senior/aging population, whether they are in their own homes or in senior housing. Maintaining power and communication with emergency personnel, as well as providing access to emergency relief resources such as food, water, medical supplies, and transportation to nearby shelters or hospitals are important components of keeping senior populations safe during an emergency. The elderly are also particularly susceptible to vector borne diseases making mosquito control an important preparation and mitigation measure. These populations are also particularly vulnerable to acute events such as fire and earthquake as limited mobility, diminished sensory awareness, and/or reliance on medical equipment hinders their ability to evacuate and stay safe during a natural disaster. The Milano Senior Center and non-profit organizations like Mystic Valley Elder Services are the primary entities that house and assist at risk senior populations in Melrose. | • Obtain the utility life support contact list from National Grid to communicate emergency event information to senior / aging populations. This would help plan for adequate availability of power and / or emergency relief resources and expedite power reconnection after an outage. | Planning | High | Short | City / Council on Aging / National Grid |
| | | | | | | | • Develop an education and outreach campaign / program for senior / aging populations, and the labor force that cares for them, that effectively communicates the Emergency Management Plan.<br>--> Education and outreach materials should include detailed information about how individuals can be added to the utility life support contact list that would prioritize seniors/aging populations for power availability, emergency relief and response resources, and power reconnection after an outage. | Outreach and Education / Training | Medium | Ongoing / Short | City / Council on Aging |
| | | | | | | | • Keep current with building codes on fire prevention and elevator maintenance at the Milano Senior Center and Mystic Valley Elder Services to minimize the risk of entrapment for seniors and facilitate successful evacuation in the event of a natural disaster. | Policy | Low | Ongoing | City / Mystic Valley Elder Services |
| | | | | | | | • Install a back-up power generator at the senior center to provide power and air conditioning at a place of refuge for seniors. | Design / Construction | Medium | Short | Council on Aging |
| | | | | | | | • Investigate mosquito management measures that would help to reduce the spread of disease from current and new mosquito populations; implement as appropriate. | Planning | Medium | Short | City |
| | | | | | | | • Ensure appropriate shelter locations are available when needed. | Planning | High | Ongoing / Short | City |

| Asset | Applicable Hazards | | | | | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | | | Project Stage | Priority | Timeframe | Responsible Party |
| Chronically Ill / Disabled Population | X | X | X | X | | Chronically ill and disabled populations are particularly vulnerable to flooding and severe weather events as limited mobility, diminished sensory awareness, and/or reliance on medical equipment hinders their ability to seek shelter and stay safe during a natural disaster. This would include the mentally ill, pregnant women, and the physically disabled. Power outages resulting from natural disasters could cause inadequate indoor heating or air conditioning as well as the potential loss of important medical technologies and life-support equipment. These populations are also particularly vulnerable to acute events such as fire and earthquake as limited mobility, diminished sensory awareness, and/or reliance on medical equipment hinders their ability to evacuate and stay safe during these events as well. | • Develop a utility life support contact list that can be used to communicate with chronically ill / disabled populations during an emergency event to ensure adequate availability of power and / or emergency relief resources. | Planning / Policy | High | Short | City / National Grid |
| | | | | | | | • Develop an education and outreach campaign / program for chronically ill / disabled populations, and the labor force that cares for them, that effectively communicates the Emergency Response and Evacuation Plan<br>--> Education and outreach materials should Include detailed information about how to be added to the utility life support contact list that would prioritize chronically ill / disabled populations for power availability, emergency relief and response resources, and power reconnection after an outage.<br>--> Distribute education and outreach materials to locations such as Melrose-Wakefield Hospital | Outreach and Education / Training | Medium | Ongoing / Short | City / Melrose-Wakefield Hospital |
| | | | | | | | • Install a back-up power generator at City shelters to provide power, air conditioning, and food refrigeration / preparation at a place of refuge for chronically ill / disabled populations. | Design / Construction | Medium | Short | City |
| | | | | | | | • Ensure appropriate shelter locations are available when needed. | Planning | High | Ongoing / Short | City |
| Non-English Speaking Population | X | X | X | X | | The inability to communicate or understand relevant emergency response or health and safety information puts the non-English speaking population at greater risk of life threatening circumstances during a natural hazard event. | • Evaluate demographic information to determine the most prevalent non-English language(s) among Melrose residents. | Planning | Medium | Short | City |
| | | | | | | | • Create multi-lingual signage clearly explaining evacuation routes and emergency response information along roads and emergency shelter locations to improve communication with non-English speaking populations during a natural hazard event. | Planning / Construction | Medium | Short | City / DOT / DCR |
| | | | | | | | • Ensure that important information on the City's website may easily be translated using Google translate or other platforms.<br>--> Consider including a sentence on translation on important public email communications. | Outreach and Education | Medium | Short | City |
| | | | | | | | • Develop an education and outreach campaign / program for the non-English speaking population that effectively communicates the Emergency Management Plan in various languages in collaboration with the Melrose Human Rights Commission. This program should reflect the major languages spoken in Melrose through local newspapers, tv channels, and faith based organizations. | Outreach and Education | Medium | Ongoing / Short | City |
| Low-Income Population | X | X | X | X | | Low-income populations in Melrose face additional challenges in the event of a natural disaster. Low-income housing is generally less able to withstand disaster and may incur more damage than standard, newer build homes, particularly during flood, severe weather, or earthquake events. Lower-income populations may also lack access to personal transportation, communications, and may not have adequate access to healthcare. In addition, low-income populations may be less able to purchase and replace damaged goods and property, and resupply food. During extreme temperature events, low-income populations may be unable to afford the cost of heating or cooling their homes. Low-income housing developments in the City of Melrose are shown in Figure 5-1. | • Develop an education and outreach campaign / program targeting low-income housing developments that effectively communicates the Emergency Management Plan. | Outreach and Education | Medium | Ongoing / Short | City |
| | | | | | | | • Explore the possibility of developing a cooling assistance program to help low-income populations in Melrose pay for air conditioning during heat events. The state's Low Income Home Energy Assistance Program for heating assistance can be used as a model during program development. | Planning / Policy | Low | Ongoing | City / MA Dept. of Housing and Community Development |
| | | | | | | | • Investigate potential methods, partnerships, and programs that would help low-income populations cover replacement costs for essential resources such as food, clothing, transportation, and temporary housing if possessions and food are lost or destroyed during a natural disaster. | Planning / Policy | Low | Ongoing / Short | City / Regional Partners / Non-profit organizations |
| | | | | | | | • Ensure enforcement of building codes on fire prevention and elevator maintenance at low-income housing locations to facilitate successful evacuation in the event of a natural disaster. | Policy | Low | Ongoing | City |
| | | | | | | | • Identify public spaces with air conditioning that residents may go to during heat events to cool down and consider providing transportation to these locations. | Outreach and Education | Low | Short | City |
| Faith Based Organizations | X | X | X | X | | Faith based organizations play an important societal role in Melrose, including in the event of a natural disaster. They have the potential to provide shelter and a safe refuge away from the chaos and destruction of natural hazard events. Due to the important role faith based organizations play in post-disaster relief, ensuring accessibility and maintaining power and communication at such facilities is very important. | • Install a back-up power generator at faith based organizations to supply power and air conditioning at a place that provides refuge for those in need. | Design / Construction | Medium | Short | Faith Based Organizations |
| | | | | | | | • Develop an education and outreach campaign / program for faith based organization leaders that effectively communicates the Emergency Management Plan. | Outreach and Education | Medium | Ongoing / Short | City |
| Pet Owners | X | X | X | X | | During an emergency that requires evacuation from one's home, pet owners may be reluctant to leave if they cannot take their pets with them. Many shelters cannot accommodate pets and kennel capacity may be limited (or impacted by the same event that requires evacuation). People's reluctance to leaving their pets may increase their vulnerability to acute events. | • Define a designated pet-friendly emergency shelter location that would accommodate household pets.<br>--> Develop a pre-registration program for all pets that include proof of residency within the evacuation zone, and current medical and vaccination records for each pet. | Planning | Low | Short | City / Local Animal Shelters |
| | | | | | | | • Develop a list of other possible locations for pets to go during an emergency requiring shelter. | Planning | Low | Short | City |
| | | | | | | | • Include Animal Control Officer in appropriate hazard mitigation training and planning activities. | Planning | Low | Short | City |

| Asset | Applicable Hazards | | | | | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | | | Project Stage | Priority | Timeframe | Responsible Party |
| **INFRASTRUCTURE** | | | | | | | | | | | |
| Transportation Infrastructure | X | X | | X | | Natural disasters such as floods, severe weather events, and earthquakes make transportation services and public transit systems vulnerable to damages and potential service delays or shut downs. Transportation infrastructure, including public transit systems, play an important role in pre and post disaster mitigation by providing evacuation route services to vulnerable populations before a disaster hits, and by distributing emergency relief resources (food, supplies, medical personnel) and safely mobilizing vulnerable populations to local shelters or hospitals post disaster.<br><br>Roadways and parking lots throughout the City of Melrose are primarily vulnerable to flood, snow, or wind related road closures that would present emergency response and accessibility issues. Blocked roadways that prevent access to evacuation routes or that block routes to hospitals, utility infrastructure, and emergency response facilities are of greatest concern. Roadways and parking lots that are particularly vulnerable to flooding include Lebanon St at Sylvan St, Derby Road, the rail bridge at Melrose St., the City Hall parking lot, Grove St, and Geneva Road at Upham (Figure 5-1). | • Identify/confirm evacuation routes and ensure signage exists and routes avoid locations prone to flooding or other potential barriers. | Planning / Construction | High | Ongoing/Short | City / DOT / DCR |
| | | | | | | | • Educate City emergency and DPW personnel on route locations and maintenance. | Training | Low | Ongoing/Short | City |
| | | | | | | | • Create multi-lingual evacuation route signage along roadways that clearly communicates emergency response information to the population of Melrose during a natural hazard event. | Planning / Construction | High | Ongoing/Short | City / DOT / DCR |
| | | | | | | | • Develop and use redundant evacuation routes that allow for faster movement out of flooded areas. | Planning | High | Short | City / DOT / DCR |
| | | | | | | | • Conduct regular maintenance and restore infrastructure previously impacted by flooding or other natural disaster events. | O&M | Medium | Ongoing/Short | City / DOT / DCR |
| | | | | | | | • Upgrade emergency communication and real-time notification of travelers on transportation networks to ensure timely notification of impending weather and climate events and awareness of evacuation routes, delays, and availability of alternate travel routes. Identify communication protocol for notification of evacuation procedures before or during an event. | Planning | High | Short | City / DOT / DCR / Verizon |
| | | | | | | | • Expand green infrastructure, including the use of bioretention ponds, bioswales, rain gardens, and pervious pavements at flood prone areas in Melrose to minimize potential flood impacts and road closures. | Design / Construction | High | Long | City / DOT / DCR |
| | | | | | | | • Upgrade road drainage systems to manage a higher capacity of stormwater in flood prone areas such as Lebanon St at Sylvan St, Derby Rd., rail bridge at Melrose St., Grove St., and Geneva Rd at Upham. | Design / Construction | High | Long | City |
| | | | | | | | • Coordinate emergency and evacuation information with the MBTA commuter rail. | Planning | Medium | Short | City / MBTA |
| | | | | | | | • Develop an ongoing training program to properly educate the labor force on appropriate emergency response actions and evacuation routes.<br>--> Include information about vulnerable populations in Melrose, DOT, DCR, and MBTA evacuation plans | Training | Low | Ongoing/Short | City / DOT / DCR / MBTA |
| | | | | | | | • Clear debris and downed vegetation after an event as soon as practicable that would impact route access to critical locations and road/rail routes. | O&M | Medium | Ongoing | City / DOT / DCR / MBTA |
| City Hall | X | X | X | X | | Melrose City Hall serves as the hub for the City's communications systems and has historically been home to the City's Emergency Management Command Center. The server room in the Information Technology (IT) Department at City Hall contains equipment that runs the City's phone systems for the Police and Fire Departments, along with the phones in City Hall, Memorial Hall, and at the Melrose Public School buildings. Loss of communication with public safety personnel during emergency events presents immediate danger to public safety. Maintaining power at City Hall is of critical importance; it currently is particularly vulnerable due to flooding and severe weather. | • Install a back-up power generator at City Hall to provide power, lighting, and air conditioning for the IT Department that directly controls communication systems with emergency personnel and Melrose Public Schools. | Design / Construction | High | Short | City |
| | | | | | | | • Elevate critical mechanical and electrical equipment, including the future back-up power generator, to protect communication and electrical systems from flood damages. | Design / Construction | Medium | Long | City |
| | | | | | | | • Elevate the current ground surface or install green infrastructure like bioretention ponds, bioswales, rain gardens, and/or pervious pavement, where technically feasible at the City Hall parking lot to minimize flooding. | Design / Construction | High | Long | City |
| | | | | | | | • Continue to secure critical records, by scanning and storing them in multiple locations (including offsite electronic storage). | O&M | Low | Ongoing/Long | City |
| | | | | | | | • Incorporate dry and wet floodproofing techniques at City Hall to minimize potential flood damage. | Design / Construction | Low | Long | City |
| | | | | | | | • Install new emergency lighting in the server room. | Design / Construction | Medium | Short | City |
| | | | | | | | • Install new air conditioning units in the server room. | Design / Construction | High | Short | City |
| Fire and Police Stations | X | X | X | X | | The fire and police stations in Melrose currently have a lack of back-up power. Engines 2 and 3 do not have generators leaving these critical facilities vulnerable to power outages and communication losses during a severe storm, flood, or earthquake event. In addition, communication systems for the central fire station, engines 2 and 3, and the Melrose police station are run through City Hall, which also lacks backup power. Police officers and firefighters offer important first response and rescue operations during an emergency. Power outages and loss of communication with such personnel could inhibit appropriate and timely response to those in need during a natural hazard event. If these facilities are impacted by fire, it impacts the ability for emergency personnel in Melrose to respond to people's needs. | • Install a back-up power generator at the fire stations for Engines 2 and 3 to maintain power and other critical infrastructure at these critical facilities during a power outage; as well as at Melrose City Hall as noted above. | Design / Construction | High | Short | City |
| | | | | | | | • Protect emergency response equipment and materials from flood by storing or relocating back-up power generators and emergency response vehicles outside future flood prone areas, or by elevating storage in areas where relocation is not possible, including at the Police Department and the Fire Department. | Planning | Short | Long | City |

| Asset | Applicable Hazards: Flooding | Severe Weather | Fire | Earthquake | Invasive Species | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details: Project Stage | Priority | Timeframe | Responsible Party |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **INFRASTRUCTURE** | | | | | | | | | | | |
| Residential and Commercial Properties | X | X | X | X | | Residential and commercial properties throughout the City of Melrose are vulnerable to severe weather, floods, fire, and earthquake events. Properties that fall within the 0.2% and 1% flood prone areas are particularly vulnerable (Figure 5-1). | • Expand green infrastructure, xeroscape (or other low water use landscaping) and green buildings to improve building resiliency by:<br>--> Communicating and encouraging the implementation of stormwater BMPs like bioswales, rain gardens, rainwater harvesting, bioretention ponds, pervious pavements, etc. in new and existing developments<br>--> Communicate and encourage energy efficiency and implementation of renewable energy<br>--> Encourage construction of green roofs to cool buildings through evapotranspiration | Design / Construction / Outreach and Education | High | Long | City / Developers / Home owners / Landlords |
| | | | | | | | • Develop and implement stricter ordinances for new and existing developments that would help Melrose protect its residential and commercial buildings from flooding, wind, and prolonged power outage. Targeted strategies may include building code legislation changes, adjustments to zoning codes, development of a stormwater management ordinance, bylaw, or design standards, incentive programs, and best practices guides. The goal is to adopt new ordinances that would help prevent flooding or minimize flood damage. Specific strategies may include:<br>--> Elevating electrical systems in new buildings<br>--> Building higher rather than wider structures<br>--> Installing underground power lines for new development<br>--> Utilizing green infrastructure | Policy | High | Short | City |
| | | | | | | | • Require resilience training and / or certifications for contractors and developers to educate the building community on resilience measures and enable their implementation in the City. | Training | Medium | Short | City / Developers / Contractors |
| | | | | | | | • Ensure enforcement of building codes on fire prevention and elevator maintenance at large commercial buildings to facilitate successful evacuation in the event of a natural disaster. | Policy | Low | Ongoing | City |
| Memorial Hall | X | X | | X | | Memorial Hall is potentially vulnerable to severe weather, floods, and earthquake events. It is also one of the designated locations used as an emergency shelter in Melrose, is located in the downtown area where elevated land surface temperatures are present due to dense urban development. Increased temperatures at this location make access to adequate air conditioning important. | • Install a back-up power generator at Memorial Hall to supply power and HVAC at a shelter that provides refuge to those in need during or after an emergency event. | Design / Construction | High | Short | City |
| | | | | | | | • Protect emergency response equipment and materials from flood by storing things like the back-up power generator and emergency response materials (food, supplies, fuel, etc.) outside future flood prone areas, or by elevating storage in areas where relocation is not possible. | Planning | Medium | Short | City |
| | | | | | | | • Incorporate dry and wet floodproofing techniques at Memorial Hall to minimize potential flood impacts | Design / Construction | Low | Long | City |
| Emergency Shelters | X | X | X | X | | Melrose Middle School and Memorial Hall serve as the City of Melrose's designated emergency shelter locations. Both buildings are particularly vulnerable to severe weather (especially extreme heat) and flood. Melrose Middle School is located in a flood prone area (Figure 5-1) and both emergency shelter locations are in urban areas that experience elevated surface temperatures. Access to adequate emergency relief supplies as well as controlled indoor temperatures and working communication systems at emergency shelters are critically important to public health and safety. | • Install a back-up power generator at emergency shelters to supply power and HVAC at locations that provide refuge to those in need.<br>--> Investigate the technical feasibility of upgrading the Melrose Middle School diesel fuel powered generator system to a renewable energy powered generator system; implement as appropriate. | Design / Construction | High | Short | City |
| | | | | | | | • Develop strategies and plans for emergency shelter management including food supply and storage locations, resources for medications or medical emergencies, water supply, etc. | Planning | Medium | Short | City |
| | | | | | | | • Protect emergency response equipment and materials from flood by storing things like back-up power generators and emergency response materials (food, supplies, fuel, etc.) outside future flood prone areas, or by elevating storage in areas where relocation is not possible. | Planning | Medium | Short | City |
| | | | | | | | • Offer multi-lingual signage and information at shelters that clearly communicate emergency response information to the population of Melrose. | Planning | High | Short | City |
| | | | | | | | • Elevate existing transportation assets, utilize stormwater BMPs, and/or ensure that roadways and sidewalks are clear of debris and downed vegetation that would block access to emergency shelter locations during an emergency event in flood prone areas. | Design / Construction / O&M | High | Long | City |

**Melrose, MA - Vulnerability Assessment for the Natural Hazards Mitigation Plan**
**Draft - Updated 2/28/19**

| Asset | Applicable Hazards | | | | | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | | | Project Stage | Priority | Timeframe | Responsible Party |
| **INFRASTRUCTURE** | | | | | | | | | | | |
| Schools / Child Care Facilities | X | X | X | X | | Schools and child care facilities are vulnerable to impacts associated with flooding, severe weather, earthquakes, or fire. Melrose High School and Melrose Middle School are at greater risk as they are both located within the 0.2% and 1% annual chance flood prone areas (Figure 5-1). Additionally, several schools including Melrose Middle School, Melrose High School, Lincoln Elementary, Beebe School, and the Franklin Early Childhood Center are located in areas where elevated surface temperatures occur due to the heat island effect making access to adequate air conditioning more important. Maintaining communication with emergency personnel during a natural disaster is of critical importance for schools and child care facilities. In addition, Melrose schools are part of METCO, which allows children from Boston to attend Melrose Public Schools. A disruption to the schools impacts children in Melrose and regionally. | • Install green infrastructure such as bioretention ponds, bioswales, rain gardens, and/or pervious pavement at Melrose High School and Middle School to minimize roadway and parking lot flooding. | Design / Construction | High | Long | City |
| | | | | | | | • Incorporate dry and wet floodproofing techniques at local schools in future flood prone areas to minimize potential flood damages. | Design / Construction | Low | Long | City |
| | | | | | | | • Implement strategies that would minimize potential impacts from extreme heat such as upgrading HVAC systems, encouraging green roofs, and/or tree planting efforts to increase shade. | Design / Construction | Medium | Long | City |
| | | | | | | | • Ensure enforcement of building codes on fire prevention and elevator maintenance at local schools and practice regular drills to facilitate successful evacuation and emergency response in the event of a natural disaster. | Policy / Training | Low | Ongoing | City |
| Melrose-Wakefield Hospital | X | X | X | X | | The Melrose-Wakefield Hospital is the only hospital facility in the City of Melrose. Centrally located, the hospital may be vulnerable to impacts from floods, severe weather, fire, and earthquakes. Power loss is the greatest risk associated with these natural hazards. Flooded roadways throughout the City and region have the potential to block transportation routes to the hospital as well. | • Coordinate and cross-train emergency management personnel from the City and MWH so both are aware of emergency plans and protocols. | Training | High | Short | City |
| | | | | | | | • Develop an ongoing training program to properly educate the labor force on appropriate emergency response actions and evacuation plans for patients. | Training | Medium | Ongoing/Short | City / Melrose-Wakefield Hospital |
| | | | | | | | • Elevate existing transportation assets, utilize stormwater BMPs, and/or ensure that roadways and sidewalks are clear of debris and downed vegetation that would block access to emergency shelter locations during an emergency event in flood prone areas. | Design / Construction / O&M | Medium | Long | City / DOT / DCR / Melrose-Wakefield Hospital |
| | | | | | | | • Incorporate dry and wet floodproofing techniques at the hospital to minimize potential flood damages. | O&M / Construction | Low | Long | Melrose-Wakefield Hospital |
| | | | | | | | • Act as a 24 hour pharmacy to the public before, during, and after an emergency situation to serve as a location where the public may acquire needed medications. | Planning | Low | Short | Melrose-Wakefield Hospital |
| | | | | | | | • Develop a protocol that continuously communicates the hospital's capacity and hazard exposure with emergency personnel and the media during an emergency event. | Planning | Medium | Ongoing | City / Melrose-Wakefield Hospital |
| | | | | | | | • Ensure enforcement of building codes on fire prevention and elevator maintenance at the hospital to facilitate successful evacuation and emergency response in the event of a natural disaster. | Policy | Low | Ongoing | City |
| Pharmacies | X | X | X | X | | The availability of life saving medications and prescription drugs for vulnerable populations becomes of critical importance during a natural hazard event. In extreme circumstances, a severe storm, flood, fire, or earthquake could prevent the import of important medications to the local pharmacies in Melrose. | • Partner with pharmacies to extend hours prior to an emergency to ensure the public has an adequate supply of medication. | Planning | Low | Short | City / Pharmacies |
| | | | | | | | • Protect the supply of in demand or difficult to acquire medications from flood by storing reserves outside future flood prone areas, or by elevating reserves in areas where relocation is not possible. | Planning | Medium | Short | Pharmacies |
| | | | | | | | • Elevate existing transportation assets, utilize stormwater BMPs[1], and/or ensure that roadways and sidewalks are clear of debris and downed vegetation that would block access to pharmacy locations during an emergency event in flood prone areas. | Design / Construction / O&M | Medium | Long | City / DOT / DCR / Pharmacies |
| Gas Infrastructure | X | X | | X | | Gas transmission systems are primarily vulnerable to floods, severe weather and earthquake events. Significant flooding in areas with underground gas lines may lead to gas transmission system failures due to increased hydrostatic pressure. Erosion from severe storms or flood events may even expose buried gas lines leaving them vulnerable to damages from flowing debris and disruption of supporting materials. Earthquakes also have the potential to cause wide-scale gas infrastructure failure. | • Conduct regular maintenance and restore gas line infrastructure that was previously impacted from flooding or other natural hazard events. | O&M | Medium | Ongoing/Short | National Grid |
| | | | | | | | • Monitor waterways where buried gas lines are present for scour or erosion that could lead to gas line failure during a flooding event or other natural disaster. | O&M | Medium | Ongoing/Short | City |
| | | | | | | | • Require resilience training and / or certifications for gas infrastructure contractors | Training | Medium | Ongoing/Short | National Grid |
| | | | | | | | • Incorporate resilient design and materials when upgrading National Grid gas pipelines. | Planning / Design / Construction | Low | Long | National Grid |
| | | | | | | | • Continue to aggressively work with National Grid to have leak prone pipe materials replaced | Policy / Design / Construction | High | Ongoing / Long | City / National Grid |

Melrose, MA - Vulnerability Assessment for the Natural Hazards Mitigation Plan
Draft - Updated 2/28/19

| Asset | Applicable Hazards: Flooding | Severe Weather | Fire | Earthquake | Invasive Species | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details: Project Stage | Priority | Timeframe | Responsible Party |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **INFRASTRUCTURE** | | | | | | | | | | | |
| Electrical / Power Infrastructure | X | X | X | X | | Power lines and electrical substations are particularly vulnerable to floods, severe weather, earthquakes, and fire. High wind from severe storms and ground movement from earthquakes could cause downed power lines while extreme heat or drought conditions increase the likelihood of wildfires that may impact power lines or electrical substations. Electrical services for Melrose are provided by National Grid. Earthquakes also have the potential to cause wide-scale power infrastructure failure. | • Develop procedures and plans for when peak power demand exceeds capacity during heat events. | Planning | Medium | Short | National Grid |
| | | | | | | | • Establish and implement design standards for electrical equipment that can withstand higher maximum temperatures. | Design / Construction | Low | Short/Long | National Grid |
| | | | | | | | • Maintain buffer or clear zone between edge of power lines and adjacent tree belts/woodland areas in order to minimize damage caused by falling trees and limbs. | Policy / Design / Construction | Medium | Long | National Grid / City |
| | | | | | | | • Elevate critical electrical equipment in future flood prone areas to protect electrical systems against potential flood damages. | Design / Construction | Medium | Short/Long | National Grid |
| | | | | | | | • Conduct regular maintenance and restore electrical systems / power infrastructure that was previously impacted from flooding or other natural hazard events. | O&M | Medium | Ongoing/Short | National Grid |
| | | | | | | | • Implement "islanding" or microgrids to minimize the occurrence of wide scale power outages and expedite power reconnection, where technically feasible. | Policy / Design / Construction | Medium | Long | National Grid |
| | | | | | | | • Work toward the construction of alternative energy systems and the usage of renewable energy as the primary energy source to improve power infrastructure resiliency. | Policy / Design / Construction | Medium | Long | City / National Grid |
| | | | | | | | • Upgrade electric utility lines and /or install buried lines wherever feasible to minimize risk of downed or damaged power lines during a natural disaster event. | Design / Construction | Medium | Long | National Grid |
| | | | | | | | • Develop a list of available "on call emergency electricians" that are able to connect National Grid power lines from poles to the home for at risk people | Planning / Coordination | Medium | Short | City / National Grid |
| | | | | | | | • Identify and repair locations where buried electrical infrastructure is prone to flooding and associated failure. | Design / Construction | Medium | Short | City / National Grid |
| | | | | | | | • Develop an ongoing training program to properly educate the labor force on appropriate emergency response actions<br>--> Share information about the location vulnerable populations to ensure they are on the list for prioritized electricity reconnection. | Training | Medium | Short | City / National Grid |
| Fuel Sources | X | X | X | X | | Preparation and mitigation of natural disasters are largely dependent on access to sufficient fuel sources, such as gasoline and diesel. Public preparedness for natural hazards such as severe storms and floods include the acquisition and storage of propane or gasoline for transportation vehicles in case there are long-term power outages. | • Designate secure fuel storage locations away from flood prone areas that will house fuel reserves that would be used in the event of a natural disaster. | Planning | Medium | Short | City / Gas Stations |
| | | | | | | | • Protect fuel supplies along evacuation routes, near shelters, and at the DPW yard at 72 Tremont Street. | Planning | Medium | Short | City / Gas Stations |
| | | | | | | | • Partner with gas stations to extend hours prior to an emergency to ensure the public has adequate supplies for a long-term hazard event. | Planning / Coordination | Medium | Short | City / Gas Stations |
| Food Sources | X | X | | | X | Preparation and mitigation of natural disasters are largely dependent on access to sufficient food sources. This would include grocery stores, community gardens, or partnerships with regional farms. Public preparedness for natural hazards such as severe storms and floods include the acquisition and storage of non-perishable food and water in case there are long-term power outages. Some invasive species may impact locally grown produce. | • Partner with grocery stores and food pantry to extend hours prior to an emergency to ensure the public has adequate supplies for a long-term hazard event. | Planning / Coordination | Medium | Short | City / Grocery Stores / Food Pantries |
| | | | | | | | • Ensure adequate food sources have been identified to supply food to emergency shelters when needed and develop protocol to obtain such food; provide information in multiple languages as needed. | Planning / Coordination | Medium | Short | City / Grocery Stores / Food Pantries |
| | | | | | | | • Designate secure food storage locations away from flood prone areas that will house food reserves that would be used in the event of a natural disaster. | Planning | Medium | Short | City / Grocery Stores / Food Pantries |

**Melrose, MA - Vulnerability Assessment for the Natural Hazards Mitigation Plan**
**Draft - Updated 2/28/19**

| Asset | Applicable Hazards: Flooding | Severe Weather | Fire | Earthquake | Invasive Species | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details: Project Stage | Priority | Timeframe | Responsible Party |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **INFRASTRUCTURE** | | | | | | | | | | | |
| Communications Infrastructure | X | X | X | X | | Properly working communication and information technology systems are of fundamental importance during an emergency event. Failure of these systems during a flood, severe weather event, or earthquake presents an immediate threat to public safety. Melrose relies on the City of Melrose IT Department, as well as Verizon and Comcast, to maintain communication pathways and IT systems during a natural hazard event. | • Close the City's fiberoptic loop. In a loop configuration, the backbone of the fiber connects in two or more places to form a redundant pathway for information to get back through the network if there is breach in the loop. | Policy / Design / Construction | Medium | Long | City |
| | | | | | | | • Utilize a voice over internet protocol (VOIP) system which allows telephone networks to quickly be routed to another location because they run on the network. A mirrored phone system may be set up in an emergency location on standby in advance of an emergency or via a cloud platform with no hardware on premises. VoIP phone systems can be tied to phone applications so City officials' phone numbers travel with their cell phones, further eliminating the need for physical phones in an emergency. | Planning | Medium | Short | City |
| | | | | | | | • Bury communication lines wherever possible to minimize potential for damages during a natural disaster. | Policy / Design / Construction | Medium | Long | Verizon |
| | | | | | | | • Conduct regular maintenance and restore communication infrastructure previously impacted by flooding or other natural hazard events. | O&M | Medium | Ongoing/Short | Verizon |
| | | | | | | | • Work with transportation sector to upgrade emergency communication and real-time notification of travelers on transportation networks and evacuation routes. | Planning / Coordination | High | Short | City / DOT / DCR / Verizon |
| | | | | | | | • Upgrade communication systems to provide real-time notifications of emergency events through access of cell phones and other portable devices. | Policy / Planning | High | Short | Verizon |
| | | | | | | | • Elevate critical communication equipment, or relocate equipment away from future flood prone areas, to minimize potential damages during a flood event. | Planning / Construction | Medium | Long | Verizon |
| | | | | | | | • Ensure access to portable cell towers and generator systems that can provide temporary communication and electrical services to areas that need it during an emergency event. | Planning | Medium | Short | City / DOT / DCR / Verizon |
| | | | | | | | • Ensure IT equipment has redundancy, uninterrupted power supply, and other precautions for unforeseen events where deemed beneficial. | Planning / Design / Construction | High | Short | City |
| | | | | | | | • Develop an ongoing training program to properly educate the labor force on appropriate emergency response actions | Training | Medium | Ongoing/Short | Verizon |
| Sewer Pumping Stations | X | X | | X | | Sewer pumping stations are facilities that pump wastewater from low lying areas to higher elevations so it can ultimately reach the Deer Island wastewater treatment plant where the water is treated before being discharged back into the environment. Sewer pumping stations in the City of Melrose are at risk of power loss during flooding, severe weather, or earthquake events. The Union Street pumping station off of Tremont Street by the middle school and high school, as well as the Fellsway station are located in or near a 1% annual chance flood area (Figure 5-1) and are at greater risk of flooding. Power loss and flooding of sewer pumping stations could cause significant sewer system outages and lead to sewer line backups and spills in localized areas that could pose a potential health and safety hazard to the public and the environment. Additionally, when storm flows (inflow) overwhelm all five Melrose sewer pump stations, it could lead to sanitary sewer overflows. The cost of cleanup and repair of sewer system pumping stations could be substantial. | • Install back-up power (either onsite or portable) and bypass capability at the five pumping stations, including exercising generators on a regular basis. Investigate renewable energy options where feasible. | Design / Construction / O&M | High | Short | City / MWRA |
| | | | | | | | • Elevate pumping station equipment located in flood prone areas to minimize risk of flood damage and power failure during a flooding event. | Design / Construction | High | Short | City / MWRA |
| | | | | | | | • Conduct regular maintenance and restore infrastructure previously impacted by natural disaster events. | O&M | Medium | Ongoing/Short | City / MWRA |
| | | | | | | | • Continue infiltration and inflow reduction in sewers to minimize chances of overflows during storm events | Design / Construction | Medium | Ongoing/Short | City / MWRA |
| | | | | | | | • Continue to maintain and possibly modernize remote access and controls. | O&M / Design | Medium | Ongoing/Short | City / MWRA |
| Water Pumping Stations | X | X | | X | | Melrose has two water booster stations to serve the "high service" neighborhoods. Both stations are in the good repair and have emergency back-up pumps in the event of failure of the main pumps or a need for additional pressure during a fire or other high water use event. These stations are critical facilities to fight fires in the high service neighborhoods. | • Elevate pumping station equipment located in flood prone areas to minimize risk of flood damage and power failure during a flooding event. | Design / Construction | High | Short | City / MWRA |
| | | | | | | | • Routinely maintain back-up power equipment to ensure availability during emergency events. | O&M | Medium | Ongoing | City |
| | | | | | | | • Conduct regular maintenance and restore infrastructure previously impacted by natural disaster events. | O&M | Medium | Ongoing/Short | City / MWRA |
| | | | | | | | • Continue to maintain and possibly modernize remote access and controls. | O&M / Design | Medium | Ongoing/Short | City / MWRA |

**Melrose, MA - Vulnerability Assessment for the Natural Hazards Mitigation Plan**
**Draft - Updated 2/28/19**

| Asset | Applicable Hazards: Flooding | Severe Weather | Fire | Earthquake | Invasive Species | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details: Project Stage | Priority | Timeframe | Responsible Party |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **INFRASTRUCTURE** | | | | | | | | | | | |
| Water and Sewer Pipelines | X | X | | X | | MWRA provides drinking water and sanitary sewer services for the City of Melrose; local water and sewer pipelines are owned and maintained by the City, and water transmission mains, sewer interceptors, and treatment facilities are owned and maintained by the MWRA. Loss of clean drinking water and functioning sewer systems presents a significant danger to public health and the environment. Areas at greater risk of failure during a severe storm or flooding event include sanitary sewer overflows off Melrose Street next to Melrose High School, as well as off Grove Street, Tremont Street, Sylvan Street, and Melrose Towers. | • Conduct regular maintenance and restore infrastructure previously impacted by natural disaster events. | O&M | Medium | Ongoing/Short | City / MWRA |
| | | | | | | | • Keep water and wastewater infrastructure condition assessments to identify areas of concern and prioritize repair and replacement efforts. | Planning | Low | Short | City / MWRA |
| | | | | | | | • Coordinate with neighboring towns / cities / state with regard to mutual aid water connections and to potential sewer surcharge conditions when sending wastewater downstream. | Planning | Low | Ongoing/Short | City / MWRA / Neighboring Cities |
| | | | | | | | • Keep water system emergency response plans up to date and provide associated staff training. | Planning / Training | Medium | Ongoing/Short | City / MWRA |
| | | | | | | | • Develop an ongoing training program to properly educate the labor force on appropriate emergency response actions.<br>--> Include information about vulnerable populations to ensure water and sewer connections are prioritized if disrupted during an emergency.<br>--> Encourage staff to complete MWRA emergency training | Training | Medium | Ongoing/Short | City / MWRA |
| Stormwater Drainage Infrastructure | X | X | | | | Stormwater drainage issues have the potential to cause significant flooding and damage to impacted areas. Debris from a storm event could clog storm drains and cause water to back-up with no place to drain. Areas of concern are shown on Figure 5-1. | • Conduct a stormwater drainage study to address flooding that results from insufficient capacity in the drainage system. | Planning | High | Short | City |
| | | | | | | | • Construct stormwater retention basins where applicable to increase water storage capacity during a flood event | Design / Construction | Medium | Long | City |
| | | | | | | | • Implement green infrastructure practices like bioretention ponds, bioswales, rain gardens, and pervious pavements to increase stormwater infiltration rates and minimize potential flood impacts at locations prone to flooding. | Design / Construction | High | Long | City |
| | | | | | | | • Dredge the stormwater outfalls in areas prone to flooding, including outfalls at the Wyoming Cemetery, to reduce potential flood impacts downstream of outfall locations. | Construction | High | Long | City |
| | | | | | | | • Develop a stormwater maintenance plan that requires routine maintenance of culverts, storm drains, and storm sewers to remove sediment / debris and improve stormwater conveyance. | O&M | High | Short | City |
| | | | | | | | • Increase capacity of stormwater infrastructure and drainage system. | Design / Construction | Medium | Long | City |
| | | | | | | | • Keep stormwater maps up to date and ensure operations personnel are aware of outfall locations. | Planning | High | Ongoing / Short | City |
| | | | | | | | • Conduct site specific studies and designs in areas prone to flooding to allow for bidding and construction of associated improvements . | Planning / Design | High | Short | City |
| | | | | | | | • Coordinate with neighboring towns / cities / state when sending drainage downstream (outfalls) and monitor infrastructure issues | Planning / Design / Construction | Low | Ongoing/Short | City / Neighboring Cities |

| Asset | Applicable Hazards: Flooding | Severe Weather | Fire | Earthquake | Invasive Species | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details: Project Stage | Priority | Timeframe | Responsible Party |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ENVIRONMENT** | | | | | | | | | | | |
| Water Bodies: Lakes / Rivers / Reservoirs | X | X | | X | X | Water-bodies such as lakes, rivers, and reservoirs act as mechanisms of storm flow transmission and storage during flood or severe weather events. Drainage systems and flood management measures are designed to direct stormwater flows to area waterways or floodplains. These measures help to minimize the potential for flooding in more populated areas that could cause significant structural damage or pose a risk to public safety. However, due to the stress imposed on water bodies from rapid flow increases or physical forces in the event of a severe storm, flood, or earthquake, erosion, landslides, and dam failures could be potential consequences. Drainage issues may result in the blockage and back-up of stormwater flows that may ultimately impact nearby communities or structures. Additionally, the occurrence of invasive species and extreme temperatures may adversely impact the natural habitat of native aquatic organisms. Invasive plants, aquatic species, and animals could outcompete native organisms for food and/or shelter resulting in potential shifts in ecosystem structure and diminished biodiversity. Invasive insects such as some mosquito species may potentially spread disease. Specific areas of concern in Melrose include areas around Ell Pond, outlet structures at Swains Pond, as well as the connection between Towners Pond and Swains Pond (Figure 5-1). Additionally, If either the High Service Reservoir Earthen Dam or the Spot Pond Dam in the Town of Stoneham were to fail, a substantial volume of water would rush into the City of Melrose. | • Investigate opportunities to install flood control gates to better manage flows during a flooding event | Planning | Medium | Long | City |
| | | | | | | | • Remove obstacles within streams and rivers to allow a higher capacity of flow in high precipitation events | O&M | Medium | Ongoing / Short | City |
| | | | | | | | • Consider dredging water features in flood prone areas like Ell Pond, Swains Pond, and Towners Pond to aid in storage of stormwater runoff. | Construction | High | Long | City |
| | | | | | | | • Investigate mosquito management measures that would help to reduce the spread of disease from current and new mosquito populations; implement as appropriate. | Planning | High | Short | City |
| | | | | | | | • Use vegetation or earthwork to stabilize river and stream embankments and provide riverine buffers. | Design / Construction | Low | Long | City |
| | | | | | | | • Plant more trees along water features to mitigate high water temperatures during extreme heat events and reduce erosion and scouring during a flood event. | Construction | Medium | Long | City |
| | | | | | | | • Expand green infrastructure strategies that retain and infiltrate precipitation near water features to better manage stormwater runoff. Encourage natural solutions through City policies, ordinances, and design standards. | Design / Construction | High | Long | City |
| | | | | | | | • Understand MWRA dam facilities and the actions and consequences for Melrose in the event of failure. | Training / Planning | Medium | Short | City / MWRA |
| Parks/Natural Areas/Open Space | X | X | X | | X | Potential damages to parks and natural areas incurred from floods and severe storms could include downed trees, destroyed natural habitat, and diminished aesthetics. Extreme heat and periods of extended drought may also leave parks and natural areas more susceptible to fire. Invasive species also present a threat to native vegetation and wildlife. Invasive plants and animals could outcompete native organisms for food and/or shelter resulting in potential shifts in ecosystem structure and diminished biodiversity. Invasive insects such as some mosquito species may potentially spread disease. Primary parks in the City of Melrose include the Middlesex Fells Reservation, the Mount Hood Golf Course, Pine Banks Park, the Melrose Common, Conant Park, and many others. | • Investigate mosquito management measures, including ditch maintenance, that would help to reduce the spread of disease from current and new mosquito populations; implement as appropriate. | Planning | High | Short | City |
| | | | | | | | • Protect, expand, and restore wetland areas, natural systems, and vegetative buffers to improve flood management and conserve natural areas. | Design / Construction | Low | Long | City / Conservation Commission |
| | | | | | | | • Conduct routine maintenance of parks and natural areas and remove or relocate dead vegetation that may cause a fire hazard. | O&M | Medium | Ongoing / Short | City / Conservation Commission |
| Tree Canopy | X | X | X | X | X | Tree canopy is a measure of how much of the land surface is covered by tree leaves. Tree canopy is an important component of both urban and natural areas that provide shade, habitat, and aesthetic quality. Increased tree canopy also provides proven human health benefits such as improved cardiovascular, respiratory, and mental health. Tree canopy cover is vulnerable to all types of natural hazards; severe storms, floods, fires, and earthquakes may result in damaged and downed trees while invasive species could potentially impact the health and density of native tree species. Increased tree canopy would also help mitigate extreme heat impacts on natural habitats and reduce the heat island effect in urban areas. | • Create a funded tree warden (certified arborist) position to advise on resilient tree species and consider public-private partnerships for funding of planting and maintenance, or train existing personnel to obtain certification. | Planning / Policy | High | Short | City |
| | | | | | | | • Conduct routine monitoring of trees in parks and natural areas, as well as street trees, and remove or relocate dead trees that may cause a fire hazard. | O&M | Medium | Ongoing / Short | City / Conservation Commission |
| | | | | | | | • Preserve and enhance the tree canopy to reduce urban heat island effects and reduce emissions from cooling loads.<br>--> Continue and enhance annual planting program | O&M / Construction | Low | Long | City / Conservation Commission |
| | | | | | | | • Conduct routine maintenance of trees near critical assets to minimize the potential for downed trees or limbs damaging communication, electrical, gas, transportation, or other infrastructure. | O&M | Medium | Ongoing / Short | City / National Grid |
| | | | | | | | • Perform tree canopy assessments by a certified arborist to identify trees that may be less resilient to new flooding and heat conditions.<br>--> Offer incentive programs or education and outreach for property owners to plant trees with higher survivability and resiliency against extreme conditions. | Planning / Policy Outreach and Education | Medium | Ongoing / Short | City |

**Melrose, MA - Vulnerability Assessment for the Natural Hazards Mitigation Plan**
**Draft - Updated 2/28/19**

| Asset | Applicable Hazards | | | | | Asset Vulnerability | Mitigation Strategy | Mitigation Strategy Planning and Implementation Details | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flooding | Severe Weather | Fire | Earthquake | Invasive Species | | | Project Stage | Priority | Timeframe | Responsible Party |
| Wildlife | X | X | X | X | X | Damage to parks and natural areas from floods, severe weather, earthquakes, fires, or invasive species could harm or displace native wildlife populations. Changes in wildlife populations could cause shifts in ecosystem structure and diminish biodiversity. | • Investigate mosquito management measures that would help to reduce the spread of disease from current and new mosquito populations; implement as appropriate. | Planning | High | Short | City |
| | | | | | | | • Protect, expand, and restore wetland areas, natural systems, and vegetative buffers to conserve wildlife populations. | Design / Construction | Low | Long | City / Conservation Commission |
| | | | | | | | • Identify potential threats to vegetation and monitor to ensure that invasive species are not present. | Planning | Low | Short | City / Conservation Commission |
| | | | | | | | • Promote green infrastructure that provides habitat value along with stormwater volume and quality mitigation. | Planning / Design / Construction | Medium | Ongoing / Short | City |
| Air Quality | | X | X | | | Temperature increases result in poor air quality which can impact public health and safety. On hot days, the level of air pollutants increases making it difficult for vulnerable populations such as children, the elderly, and those with respiratory illness to spend time outdoors. Extreme heat and drought conditions also increase the likelihood of wildfire, which also adversely impacts air quality. | • Increase tree plantings to shade assets and improve air quality. | Construction | Medium | Ongoing / Short | City / Conservation Commission |
| | | | | | | | • Develop an air quality monitoring and alert system to notify the population of Melrose of poor air quality events and provide recommendations for safe levels of outdoor activity, and provide a link on the City's website. | Policy | Medium | Ongoing / Short | City |
| | | | | | | | • Continue to implement Complete Streets principles to encourage behaviors that decrease energy use and reduce emissions. | Planning / Design / Construction | Low | Ongoing | City |
| | | | | | | | • Enforce anti-idling laws for vehicles and implement a related educational campaign to reduce emissions and raise awareness on how idling affects air quality. | Education and Outreach / Policy | Medium | Short | City |