City of Salem
HAZARD MITIGATION PLAN
2020 UPDATE

Draft Plan
February 14, 2020

MAPC
METROPOLITAN AREA PLANNING COUNCIL

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ACKNOWLEDGEMENTS AND CREDITS

This plan was prepared for the City of Salem by the Metropolitan Area Planning Council (MAPC) under the direction of the Massachusetts Emergency Management Agency (MEMA) and the Massachusetts Department of Conservation and Recreation (DCR). The plan was funded by the Federal Emergency Management Agency's (FEMA) Pre-Disaster Mitigation (PDM) Grant Program.

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David Greenbaum	Health Department
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SECTION 1: EXECUTIVE SUMMARY

Hazard Mitigation planning is a proactive effort to identify actions that can be taken to reduce the dangers to life and property from natural hazard events. In the communities of the Boston region of Massachusetts, hazard mitigation planning tends to focus most on flooding, the most likely natural hazard to impact these communities. The Federal Disaster Mitigation Act of 2000 requires all municipalities that wish to be eligible to receive FEMA funding for hazard mitigation grants, to adopt a local multi-hazard mitigation plan and update this plan in five-year intervals.

Planning Process

This is an update of the original Salem Hazard Mitigation Plan, which was adopted by Salem on September 13, 2012. Planning for the Hazard Mitigation Plan update was led by the Salem Local Hazard Mitigation Planning Team, composed of staff from a number of different City Departments. This team met on July 8, 2019 and discussed where the impacts of natural hazards most affect the City, goals for addressing these impacts, updates to the City's existing mitigation measures and new or revised hazard mitigation measures that would benefit the City.

Public participation in this planning process is important for improving awareness of the potential impacts of natural hazards and to build support for the actions the City takes to mitigate them. The City's Conservation Commission hosted two public meetings, the first on August 8, 2019 and the second on February 18, 2020 and the draft plan update was posted on the City's website for public review. Key City stakeholders and neighboring communities were notified and invited to review the draft plan and submit comments.
See meeting documentation in Appendix C.

Risk Assessment

The Salem Hazard Mitigation Plan assesses the potential impacts to the City from flooding, high winds, winter storms, brush fire, geologic hazards, extreme temperatures, and drought. Flooding, driven by hurricanes, northeasters and other storms, clearly presents the greatest hazard to the City. These are shown on the map series (Appendix A).

The Salem Local Hazard Mitigation Planning Team identified 180 Critical Facilities. These are also shown on the map series and listed in Table 23, identifying which facilities are located within the mapped hazard zones.

A HAZUS-MH analysis provided estimates of damages from Hurricanes of category 2 and 4 ($39,011.47 thousand to $188,446.08 thousand) as well as earthquakes of magnitudes 5 and 7 ($913.75 million to $6,142 million). Flood damage estimates range from $50.24 million to $58.74 million.

Hazard Mitigation Goals

The Salem Local Hazard Mitigation Planning Team identified the following hazard mitigation goals for the City:

1. Prevent and reduce the loss of life, injury, public health impacts and property damages resulting from all identified natural hazards.

2. Build and enhance local mitigation capabilities to ensure individual safety, reduce damage to public and private property and ensure continuity of emergency services.

3. Increase cooperation and coordination among private entities, City officials and Boards, State agencies and Federal agencies.

4. Increase awareness of the benefits of hazard mitigation through outreach and education.

Hazard Mitigation Strategy

The Salem Local Hazard Mitigation Planning Team identified a number of mitigation measures that would serve to reduce the City's vulnerability to natural hazard events. Salem would like to complete work on seawall infrastructure, complete work begun to mitigate coastal flooding in the Canal Street, Brooks Road/ Jefferson Avenue/Rosie's Pond neighborhoods, install new tide gates at the North River and mitigate flooding along Bridge Street, continue to acquire priority vacant flood prone land and complete its upgrading of backup generating capacity at all its fire stations.

Informed by its 2014 Coastal Climate Change Vulnerability Assessment, the City's 2018 Municipal Vulnerability Preparedness (MVP), risk assessment and management strategy addressing both coastal and inland hazards mitigation are key for building climate resilience and adaptation.

Based on these, Salem wants to survey all coastal infrastructure, buildings and land impacted by Massachusetts General Law Chapter 91, mitigate flooding on Highland Ave near Walmart, participate in the National Flood Insurance Program's Community Rating System, assess which sewer pump stations can handle flooding, determine how to reduce flooding at Forest River at border with Marblehead and look at ways to update building, planning and zoning regulations to improve climate resilience and adaptation.

Overall, the hazard mitigation strategy recognizes that mitigating hazards for Salem will be an ongoing process as our understanding of natural hazards and the steps that can be taken to mitigate their damages changes over time. Global climate change and a variety of other factors impact the City's vulnerability and in the future. Local officials will need to work together across municipal lines and with state and federal agencies in order to understand and address these changes. The Hazard Mitigation Strategy will be incorporated into the City's other related plans and policies.

Plan Review and Update Process

Table 1 Plan Review and Update Process

Chapter	Reviews and Updates
III – Public Participation	The Local Hazard Mitigation Planning Team placed an emphasis on public participation for the update of the Hazard Mitigation Plan, discussing strategies to enhance participation opportunities at the first local committee meeting. During plan development, the plan was discussed at two public meetings hosted by the Conservation Commission. The plan was also available on the City's website for public comment.
IV – Risk Assessment	MAPC gathered the most recently available hazard and land use data and met with City staff to identify changes in local hazard areas and development trends. City staff reviewed critical infrastructure with MAPC staff in order to create an up-to-date list. MAPC also used the most recently available version of HAZUS and assessed the potential impacts of flooding using the latest data.
V - Goals	The Hazard Mitigation Goals were reviewed and endorsed by the Salem Local Hazard Mitigation Planning Team.
VI – Existing Mitigation Measures	The list of existing mitigation measures was updated to reflect current mitigation activities in the City.
VII & VIII – Hazard Mitigation Strategy	Mitigation measures from the 2012 plan were reviewed and assessed as to whether they were completed, in-progress, or deferred. The Local Hazard Mitigation Planning Team determined whether to carry forward measures into the 2020 Plan Update or modify or delete them. The Plan Update's hazard mitigation strategy reflects both new measures and measures carried forward from the 2012 plan. The Local Hazard Mitigation Team prioritized all of these measures based on current conditions.
IX – Plan Adoption & Maintenance	This section of the plan was updated with a new on-going plan implementation review and five year update process that will assist the City in incorporating hazard mitigation issues into other City planning and regulatory review processes and better prepare the City

	for the next comprehensive plan update.

As indicated on Table 28, Salem made progress on implementing mitigation measures identified in the 2012 Hazard Mitigation Plan. Several projects have been completed, including flood mitigation and drainage upgrades in the South River basin at Canal Street and Rosie's Pond; the installation of a new living shoreline project in Collins Cove, the acquisition of key land parcels in the border area between Marblehead and Salem prone to flooding, and the partial completion of upgrades of seawalls at Daniels Street, Ocean Avenue and Willows Park.

Moving forward into the next five-year plan implementation period there will be many more opportunities to incorporate hazard mitigation into the City's decision-making processes.

Though not formally done in the 2012 Plan, the City will document any actions taken within this iteration of the Hazard Mitigation Plan on challenges met and actions successfully adopted as part of the ongoing plan maintenance to be conducted by the Salem Hazard Mitigation Implementation Team, as described in Section IX, Plan Adoption and Maintenance.

SECTION 2: INTRODUCTION

Planning Requirements under the Federal Disaster Mitigation Act

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

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

The Metropolitan Area Planning Council (MAPC) subcontracted with the City of Salem to update its local Hazard Mitigation Plans, which was first adopted in 2012. The local Hazard Mitigation Plan update produced under this grant is designed to individually meet the requirements of the Disaster Mitigation Act for each community while listing regional concerns and hazards that impact the Town or City creating the plan.

What is a Hazard Mitigation Plan?

Natural hazard mitigation planning is the process of determining how to systematically reduce or eliminate the loss of life and property damage resulting from natural hazards such as floods, earthquakes, and hurricanes. Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries, and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, programs, projects, and other activities.

Previous Federal/State Disasters

The City of Salem, a part of Essex County, has experienced 22 natural hazards that triggered federal or state disaster declarations since 1991. These are listed in Table 2 below. The majority of these events involved flooding, while five were due to hurricanes or nor'easters, and four were due to severe winter weather.

Table 2 Previous Federal/State Disaster Declarations

DISASTER NAME (DATE OF EVENT)	TYPE OF ASSISTANCE	DECLARED AREAS
Hurricane Bob (August 1991)	FEMA Public Assistance Project Grants	Counties of Barnstable, Bristol, Dukes, Salem, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk
	Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Salem, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk (16 projects)
No-Name Storm (October 1991)	FEMA Public Assistance Project Grants	Counties of Barnstable, Bristol, Dukes, Salem, Middlesex, Plymouth, Nantucket, Norfolk
	FEMA Individual Household Program	Counties of Barnstable, Bristol, Dukes, Salem, Middlesex, Plymouth, Nantucket, Norfolk
	Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Salem, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk (10 projects)
March Blizzard (March 1993)	FEMA Public Assistance Project Grants	All 14 Counties
January Blizzard (January 1996)	FEMA Public Assistance Project Grants	All 14 Counties
May Windstorm (May 1996)	State Public Assistance Project Grants	Counties of Plymouth, Norfolk, Bristol
October Flood (October 1996)	FEMA Public Assistance Project Grants	Counties of Salem, Middlesex, Norfolk, Plymouth, Suffolk
	FEMA Individual Household Program	Counties of Salem, Middlesex, Norfolk, Plymouth, Suffolk

DISASTER NAME (DATE OF EVENT)	TYPE OF ASSISTANCE	DECLARED AREAS
	Hazard Mitigation Grant Program	Counties of Salem, Middlesex, Norfolk, Plymouth, Suffolk (36 projects)
1997	Community Development Block Grant-HUD	Counties of Salem, Middlesex, Norfolk, Plymouth, Suffolk
June Flood (June 1998)	FEMA Individual Household Program	Counties of Bristol, Salem, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Counties of Bristol, Salem, Middlesex, Norfolk, Suffolk, Plymouth, Worcester (19 projects)
(1998)`	Community Development Block Grant-HUD	Counties of Bristol, Salem, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
March Flood (March 2001)	FEMA Individual Household Program	Counties of Bristol, Salem, Middlesex, Norfolk, Suffolk, Plymouth, Worcester
	Hazard Mitigation Grant Program	Counties of Bristol, Salem, Middlesex, Norfolk, Suffolk, Plymouth, Worcester (16 projects)
February Snowstorm (Feb 17-18, 2003)	FEMA Public Assistance Project Grants	All 14 Counties
January Blizzard (January 22-23, 2005)	FEMA Public Assistance Project Grants	All 14 Counties
Hurricane Katrina (August 29, 2005)	FEMA Public Assistance Project Grants	All 14 Counties
May Rainstorm/Flood (May 12-23, 2006)	Hazard Mitigation Grant Program	Statewide
April Nor'easter (April 15-27, 2007)	Hard Mitigation Grant Program	Statewide
Flooding (March 2010)	FEMA Public Assistance FEMA Individuals and Households Program SBA Loan	Bristol, Salem, Middlesex, Suffolk, Norfolk, Plymouth, Worcester

DISASTER NAME (DATE OF EVENT)	TYPE OF ASSISTANCE	DECLARED AREAS
	Hazard Mitigation Grant Program	Statewide
Tropical Storm Irene (August 27-28, 2011)	FEMA Public Assistance	Statewide
Hurricane Sandy (October 27-30, 2012)	FEMA Public Assistance	Statewide
Severe snowstorm and Flooding (February 8-09, 2013	FEMA Public Assistance; Hazard Mitigation Grant Program	Statewide
Blizzard of 2015 (January 26-28, 2015)	FEMA Public Assistance; Hazard Mitigation Grant Program	Statewide
Severe Winter Storm (March 2-3, 2018)	FEMA Public Assistance; Hazard Mitigation Grant Program	Salem, Suffolk, Norfolk, Bristol, Plymouth, Barnstable Counties
Severe Winter Storm (March 13-14, 2018)	FEMA Public Assistance; Hazard Mitigation Grant Program	Salem, Suffolk, Norfolk, Worcester Counties

Source: database provided by MEMA

FEMA Funded Mitigation Projects

The City of Salem has received funding from FEMA for one mitigation project under the Hazard Mitigation Grant Program (HMGP).

Project Description/Title	Scope of Work	Total Project Cost (100%)	Federal Funding	Local Funding	Project Status
Sediment Forebay Project	Install sediment forebay in South River	$14,000	$0.00	$3500	Complete

Community Profile

Salem, a city of 8.1 square miles in area, is located in Essex County, approximately 16 miles northeast of Boston. It is one of the oldest urban centers on the North Shore, a subregion of the greater Boston area, which stretches along the coast from the Mystic to the Merrimack Rivers. Salem is bordered on the north by the Danvers River, Beverly

Harbor and the City of Beverly beyond. The eastern shore of Salem faces the Beverly and Salem Harbors and the Town of Marblehead. The southern land boundary of Salem abuts the towns of Marblehead and Swampscott and the City of Lynn. To the west is the City of Peabody.

The city is divided by its natural features into several small neighborhoods. The Salem Neck neighborhood lies northeast of downtown, and North Salem lies to the west of it, on the other side of the North River. South Salem is south of the South River, lying mostly along the banks of Salem Harbor southward. Downtown Salem lies 15 miles (24 km) northeast of Boston, 16 miles (26 km) southwest of Gloucester and Cape Ann, and 19 miles (31 km) southeast of Lawrence, the other county seat of Essex County. The City's water rights extend along a channel into Massachusetts Bay between the water rights of Marblehead and Beverly. (2015 - 2022 Open Space and Recreation Plan and Wikipedia)

The City is governed by a Mayor/City Council form of government. The 2010 population was 41,340 people and there were 19,130 housing units.

There were 17,492 households out of which 24.2% had children under the age of 18 living with them, 38.8% were married couples living together, 13.3% had a female householder with no husband present, and 44.5% were non-families.

34.9% of all households were made up of individuals and 11.5% had someone living alone who was 65 years of age or older. The average household size was 2.24 and the average family size was 2.95. (2010 US Census)

The City maintains a website at http://www.salem.com

Table 3: Salem Characteristics

Population = 43,559 people

- 5.4% are under age 5
- 17.4% are under age 18
- 14.5% are over age 65
- 4.3% live in group quarters
- 8.7% have a disability
- 7.9% of households are limited English-speaking

Number of Housing Units = 19,399

- 50.9% are renter-occupied housing units
- 56.2% of housing units were built before 1940

Sources: US Census, 2017 American Community Survey

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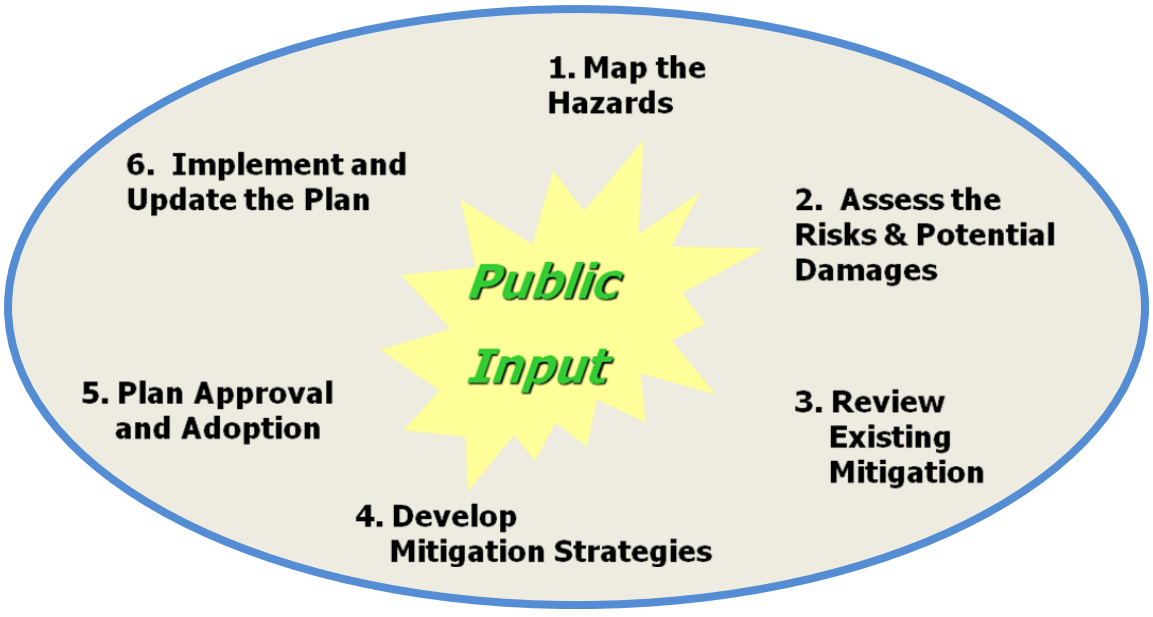
SECTION 3: PLANNING PROCESS & PUBLIC PARTICIPATION

MAPC employs a six-step planning process based on FEMA's hazard mitigation planning guidance focusing on local needs and priorities but maintaining a regional perspective matched to the scale and nature of natural hazard events. Public participation is a central component of this process, providing critical information about the local occurrence of hazards while also serving as a means to build a base of support for hazard mitigation activities. MAPC supports participation by the general public and other plan stakeholders through Regional and Local Hazard Mitigation Planning Teams, two public meetings hosted by the local Hazard Mitigation Team, posting of the plan to the City's website, and invitations sent to neighboring communities, City boards and commissions, the local chamber of commerce, and other local or regional entities to review the plan and provide comment.

Planning Process Summary

The six-step planning process outlined below is based on the guidance provided by FEMA in the Local Multi-Hazard Mitigation Planning Guidance. Public participation is a central element of this process, which attempts to focus on local problem areas and identify needed mitigation measures based on where gaps occur in the existing mitigation efforts of the municipality. MAPC is also able to identify regional opportunities for collaboration and facilitate communication between communities. In plan updates, the process described below allows staff to bring the most recent hazard information into the plan, including new hazard occurrence data, changes to a municipality's existing mitigation measures, and progress made on actions identified in previous plans.



- Map the Hazards – MAPC relies on data from a number of different federal, state, and local sources in order to map the areas with the potential to experience natural hazards. This mapping represents a multi-hazard assessment of the municipality and is used as a set of base maps for the remainder of the planning process. A particularly important source of information is the knowledge drawn from local municipal staff on where natural hazard impacts have occurred, which is collected. These maps can be found in Appendix A.

- Assess the Risks & Potential Damages – Working with local staff, critical facilities, infrastructure, vulnerable populations, and other features are mapped and contrasted with the hazard data from the first step to identify those that might represent particular vulnerabilities to these hazards. Land use data and development trends are also incorporated into this analysis. In addition, MAPC develops estimates of the potential impacts of certain hazard events on the community. MAPC drew on the following resources to complete the plan:

    - City of Salem, City Ordinances
    - City of Salem, Zoning Ordinance
    - Ready for Tomorrow: City of Salem Climate Change Vulnerability Assessment and Adaptation Plan, 2014
    - Salem Community Resilience Building Workshop, 2018 Municipal Vulnerability Preparedness Program
    - City of Salem Open Space and Recreation Plan, 2015 -2022
    - Massachusetts State Hazard Mitigation and Climate Adaptation Plan, 2018
    - FEMA, Local Mitigation Plan Review Guide; October 1, 2011
    - FEMA, Flood Insurance Rate Maps for Essex County, MA, 2014
    - Metropolitan Area Planning Council, GIS Lab, Regional Plans and Data.
    - New England Seismic Network, Boston College Weston Observatory, http://aki.bc.edu/index.htm
    - Northeast Wildfire Risk Assessment Geospatial Work Group
    - NOAA National Centers for Environmental Information, http://www.ncdc.noaa.gov/
    - Northeast States Emergency Consortium, http://www.nesec.org/
    - USGS, National Water Information System, http://nwis.waterdata.usgs.gov/usa/nwis
    - US Census, 2010 and 2015

- Review Existing Mitigation – Municipalities in the Boston Metropolitan Region have an active history in hazard mitigation as most have adopted flood plain zoning districts, wetlands protection programs, and other measures as well as enforcing the State building code, which has strong provisions related to hazard resistant building requirements. All current municipal mitigation measures must be documented.

- Develop Mitigation Strategies – MAPC works with the local municipal staff to identify new mitigation measures, utilizing information gathered from the hazard identification, vulnerability assessments, and the community's existing mitigation efforts to determine where additional work is necessary to reduce the potential damages from hazard events. Additional information on the development of hazard mitigation strategies can be found in Chapter VII.
- Plan Approval & Adoption – Once a final draft of the plan is complete it is sent to MEMA for the state level review and, following that, to FEMA for approval. Typically, once FEMA has approved the plan the agency issues a conditional approval (Approval Pending Adoption), with the condition being adoption of the plan by the municipality. More information on plan adoption can be found in Chapter IX and documentation of plan adoption can be found in Appendix D.
- Implement & Update the Plan – Implementation is the final and most important part of any planning process. Hazard Mitigation Plans must also be updated on a five-year basis making preparation for the next plan update an important on-going activity. Chapter IX includes more detailed information on plan implementation.

The Local Multiple Hazard Community Planning Team

MAPC worked with the local community representatives to organize a local Multiple Hazard Community Planning Team for Salem (Local Committee). MAPC briefed the local representatives as to the desired composition of that team as well as the need for representation from the business community, civic organizations and citizens at large.

The Local Hazard Mitigation Planning Team is central to the planning process as it is the primary body tasked with developing a mitigation strategy for the community. The local team was tasked with working with MAPC to set plan goals, provide information on the hazards that impact the City, existing mitigation measures, and helping to develop new mitigation measures for this plan update. The Local Hazard Mitigation Planning Team membership can be found in Table 4 below.

The Salem Conservation Commission, Zoning Board of Appeals and City Council, as well as the Salem Conservation Commission, are the primary entities responsible for regulating development in City. Feedback from these groups was assured through the participation of the Core Team and the Planning Department staff, both of whom communicate regularly with the Mayor and City boards and commissions. The Conservation Commission hosted two public meetings on the plan, 0n August 8, 2019 and February 18, 2020. In addition, MAPC, the State designated regional planning authority for Salem, works with all agencies that that regulate development in the region, including the listed municipal entities and state agencies, such as the MassDOT.

On July 8, 2019 MAPC conducted a meeting of the Salem Local Hazard Mitigation Team. The meeting was organized by Conservation Agent Darya Mattes. The purpose of the meeting was to review and develop hazard mitigation goals, review the status of mitigation measures identified in the 2012 hazard mitigation plan, identify new potential

mitigation measures and to gather information on local hazard mitigation issues and sites or areas related to these. The meeting also covered measures to be carried forward from the previous plan and to prioritize new measures.

The following Table lists the members of the team. The meeting agenda is included in Appendix B.

Table 4
Membership of the Salem Hazard Mitigation Planning Team

Name	Representing
Gerry Giunta	Fire Department
Darya Mattes	Planning Department
Seth Lattrell	Planning Department
Mason Wells	Planning Department
David Knowlton	Engineering Department
Deborah Duhamel	Engineering Department
Jack Nessen	Engineering Department
Dennis Levasseur	Fire/Emergency Management
David Greenbaum	Health Department
Mary Butler	Police Department

Public Meetings

Public participation in the hazard mitigation planning process is important, both for plan development and for later implementation of the plan. Residents, business owners, and other community members are an excellent source for information on the historic and potential impacts of natural hazard events and particular vulnerabilities the community may face from these hazards. Their participation in this planning process also builds understanding of the concept of hazard mitigation, potentially creating support for mitigation actions taken in the future to implement the plan. To gather this information and educate residents on hazard mitigation, the City hosted two public meetings, one during the planning process and one after a complete draft plan is available for review.

Natural hazard mitigation plans unfortunately rarely attract much public involvement in the Boston region, unless there has been a recent hazard event. One of the best strategies for overcoming this challenge is to include discussion of the hazard mitigation plan on the agenda of an existing board or commission. With this strategy, the meeting receives widespread advertising and a guaranteed audience of the board or commission members plus those members of the public who attend the meeting. These board and commission members represent an engaged audience that is informed and up to date on many of the issues that relate to hazard mitigation planning in the locality and will likely be involved in plan implementation, making them an important audience with which to build support for hazard mitigation measures. In addition, these meetings frequently receive press

coverage, expanding the audience that has the opportunity to hear the presentation and provide comment.

The public had an opportunity to provide input to the Salem hazard mitigation planning process during a Conservation Commission meeting on August 8, 2019 held in the City Hall Annex. The draft plan update was presented at a Conservation Commission meeting held on February 18, 2020 in Salem City Hall Annex. All meetings were publicized as regular meetings of Conservation Commission according to the Massachusetts Public Meeting Law. The attendance list for each meeting can be found in Table 5. See public meeting documentation in Appendix C.

Table 5
Salem Public Meetings

Name	**Representing**
Meeting #1 August 8, 2019	
Gregory St. Louis, Chair	Salem Conservation Commission
Tyler R. Glode	Salem Conservation Commission
Gail Kubik	Salem Conservation Commission
Scott Sheehan	Salem Conservation Commission
Melissa Vieira	Salem Conservation Commission
Darya Mattes	Conservation Agent
Arthur C. Sargent III	City Council Liaison
Approximately 11 members of the public	
Meeting #2 February 18, 2020	
Brittany Dolan	Conservation Agent
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	
Approximately [TBD] members of the public	

Local Stakeholder Involvement

The local Hazard Mitigation Planning Team was encouraged to reach out to local stakeholders that might have an interest in the Hazard Mitigation Plan including neighboring communities, agencies, businesses, nonprofits, and other interested parties. Notice was sent to the following organizations and neighboring municipalities inviting them to review the Hazard Mitigation Plan and submit comments to the City: See meeting notifications and press releases in Appendix C.

Town of Marblehead
Town of Swampscott
Town of Danvers
City of Beverly
City of Peabody
City of Lynn
Salem Chamber of Commerce
Salem Sound Coastwatch
Council on Aging
Salem Housing Authority
North Shore Community Development Coalition
Salem State University
Salem Harbor Port Authority
Salem Maritime National Historic Site
North Shore Medical Center
Historic Salem, Inc.
Salem Historical Commission
Salem Sustainability, Energy, and Resiliency Committee
North Shore Chamber of Commerce
Salem City Council
Salem Zoning Board of Appeals
Salem News
Salem Department Heads

City Web Site

The draft Salem Hazard Mitigation Plan 2020 Update was posted on the City's website following the second public meeting. Members of the public could access the draft document and submit comments or questions to the City. [TBD] public comments were received by the City.

Continuing Public Participation

Following the adoption of the plan update, the planning team will continue to provide residents, businesses, and other stakeholders the opportunity to learn about the hazard mitigation planning process and to contribute information that will update the City's understanding of local hazard. As updates and a review of the plan are conducted by the Hazard Mitigation Implementation Team, these will be placed on the City's web site, and any meetings of the Hazard Mitigation Implementation Team will be publicly noticed in accordance with City and state open meeting laws.

Planning Timeline

July 8, 2019	Meeting of the Salem Local Hazard Mitigation Planning Team
August 8, 2019	First Public Meeting with Salem Conservation Commission
February 18, 2020	Second Public Meeting with Salem Conservation Commission
TBD	Draft Plan Update submitted to MEMA following posting and review
TBD	Draft Plan submitted to FEMA
TBD	Approval Pending Adoption issued by FEMA
TBD	Final Plan adopted by the City
TBD	Final Plan Approval issued by FEMA

Post-Plan Approval Implementation Timeline

After the plan has been approved by FEMA, the City will observe the following timeline to implement the plan over the five-year approval period and prepare for the next plan update.

If the City wishes to apply for a FEMA grant to prepare the next plan update, due in 2025, a grant application should be submitted approximately two years before this plan expires, in order to allow time for the grant to be approved, and the next plan update to be completed before this plan expires. See Section 9 for more details on plan adoption and maintenance.

2022	Conduct Mid-Term Plan Survey on Progress
2023	Seek FEMA grant to prepare next plan update
2024	Begin process to update the plan
2025	Submit Draft 2025 Plan Update to MEMA and FEMA
2025	FEMA approval of 2025 Plan Update

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SECTION 4: RISK ASSESSMENT

The risk assessment analyzes the potential natural hazards that could occur within the City of Salem as well as the relationship between those hazards and current land uses, potential future development, and critical infrastructure. Climate change is projected to have significant impacts on many natural hazards. The City completed climate vulnerability assessments and planning under both the 2014 Ready for Tomorrow: City of Salem Climate Change Vulnerability Assessment and Adaptation Plan and through the Salem Municipal Vulnerability Preparedness Workshop held by the City in 2018. Information from the 2012 Hazard Mitigation Plan was incorporated into both the 2014 assessment and adaptation plan and the MVP Workshop. Both risk assessment and potential mitigation identified in both of those plans are incorporated in this updated Hazard Mitigation Plan. This section also includes a vulnerability assessment that estimates the potential damages that could result from certain large-scale natural hazard events.

Update Process

In order to update Salem's risk assessment, MAPC gathered the most recently available hazard and land use data and met with City staff to identify changes in local hazard areas and development trends. MAPC also used FEMA's damage estimation software, HAZUS (described below).

Overview of Hazards and Impacts

The Massachusetts Hazard Mitigation Plan provides an in-depth overview of natural hazards in Massachusetts. Previous state and federal disaster declarations since 1991 are summarized in Table 2. Table 6 below summarizes the hazard risks for Salem. This evaluation takes into account the frequency of the hazard, historical records, and variations in land use. This analysis is based on the vulnerability assessment in the Massachusetts State Hazard Mitigation Plan. The statewide assessment was modified to reflect local conditions in Salem using the definitions for hazard frequency and severity listed below.

Table 6 - Hazard Risks Summary

Hazard	Frequency		Severity	
	Massachusetts	Salem	Massachusetts	Salem
Flooding	High	High	Serious	Serious
Dam failures	Very Low	NA	Extensive	NA
Hurricane/Tropical Storm	Medium	Medium	Serious	Serious
Tornadoes	Medium	Very Low	Serious	Serious
Thunderstorms	High	High	Minor	Minor
Nor'easter	High	High	Minor	Minor
Winter-Blizzard/Snow	High	High	Minor	Minor

Winter-Ice Storms	Medium	Medium	Minor	Minor
Earthquakes	Very Low	Very Low	Serious	Serious
Landslides	Low	Very Low	Minor	Minor
Brush fires	Medium	High	Minor	Minor
Extreme Temperatures	Medium	Medium	Minor	Minor
Drought	Low	Low	Minor	Minor
Coastal Hazards	High	High	Serious	Serious
Tsunami	Very Low	Very Low	Extensive	Extensive
Major Urban Fires	Low	N/A	Serious	N/A
Ice Jams	Low	N/A	Minor	N/A

Source, Massachusetts State Hazard Mitigation Plan, modified for Salem

Note: Of the hazards listed in the Massachusetts State Hazard Mitigation Plan, several categories are not applicable to Salem:

- Major Urban Fires, due to the lack of significant wildfire areas in close proximity to urban development that could pose a significant threat of urban fire.
- Also, due to the very low probability of Tsunamis, the City chose to include this hazard as a secondary hazard, profiled under earthquake hazards.
- Dam Failures- there are no publicly or privately owned dams in Salem.
- Ice jams are not a hazard in Salem. The US Army Corps Ice Jam Database shows no record of ice jams in Salem.

All other natural hazards listed above will be addressed in this plan.

Definitions used in the Commonwealth of Massachusetts State Hazard Mitigation Plan

Frequency

Very low frequency: events that occur less frequently than once in 100 years (less than 1% per year)
Low frequency: events that occur from once in 50 years to once in 100 years (1% to 2% per year);
Medium frequency: events that occur from once in 5 years to once in 50 years (2% to 20% per year);
High frequency: events that occur more frequently than once in 5 years (Greater than 20% per year).

Severity

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.

Flood Related Hazards

Flooding was the most prevalent serious natural hazard identified by local officials in Salem. Flooding is generally caused by hurricanes, nor'easters, severe rainstorms, and thunderstorms. Global climate change has the potential to exacerbate these issues over time with the potential for changing rainfall patterns leading to heavier storms.

Regionally Significant Floods

There have been a number of major floods that have affected the Metro Boston region over the last fifty years. Significant historic flood events in Salem have included:

- The Blizzard of 1978
- January 1979
- April 1987
- October 1991
- October 1996
- June 1998
- March 2001
- April 2004
- May 2006
- April 2007
- March 2010
- December 2010
- March 2013
- January 2018
- March 2018

The best available local data on previous occurrences of flooding are provided by NOAA's National Centers for Environmental Information for Essex County, which includes Salem. Essex County experienced 50 flood events from 1996 to 2018 (see Table 7). There were 2 deaths and 3 injuries reported and the total property damage in the county was $20.69 million dollars. Locally, the hazard mitigation team identified

Table 7 Essex County Flood Events, 1996- 2019

Date	Deaths	Injuries	Property Damage $
10/22/1996	0	0	0.00K
06/17/1998	0	0	0.00K
06/18/1998	0	0	0.00K
03/05/2001	0	0	0.00K
04/03/2004	0	0	0.00K
10/15/2005	0	0	50.00K
10/25/2005	0	0	45.00K
05/13/2006	2	0	7.000M
07/11/2006	0	0	10.00K
07/28/2006	0	0	20.00K
03/02/2007	0	0	20.00K
04/16/2007	0	0	45.00K
02/13/2008	0	0	30.00K

Date	Deaths	Injuries	Property Damage $
03/08/2008	0	0	0.00K
08/08/2008	0	0	25.00K
09/06/2008	0	0	5.00K
03/14/2010	0	1	9.800M
03/30/2010	0	2	3.270M
04/01/2010	0	0	0.00K
08/05/2010	0	0	7.00K
08/25/2010	0	0	0.00K
10/04/2011	0	0	305.00K
06/23/2012	0	0	0.00K
08/10/2012	0	0	0.00K
06/24/2013	0	0	5.00K
07/01/2013	0	0	0.00K
07/27/2014	0	0	0.00K
10/23/2014	0	0	30.00K
12/09/2014	0	0	0.00K
08/18/2015	0	0	0.00K
09/30/2015	0	0	0.00K
06/29/2016	0	0	0.00K
04/06/2017	0	0	0.00K
06/27/2017	0	0	2.00K
07/08/2017	0	0	0.00K
07/18/2017	0	0	0.00K
09/06/2017	0	0	0.00K
09/15/2017	0	0	10.00K
09/30/2017	0	0	4.00K
10/25/2017	0	0	0.00K
01/13/2018	0	0	5.00K
08/11/2018	0	0	10.00K
08/12/2018	0	0	0.00K
11/03/2018	0	0	0.00K
11/03/2018	0	0	0.00K
04/15/2019	0	0	0.00K
07/31/2019	0	0	3.00K
07/31/2019	0	0	0.00K
09/02/2019	0	0	10.00K
09/02/2019	0	0	0.50K
TOTAL	2	3	**20.72 M**

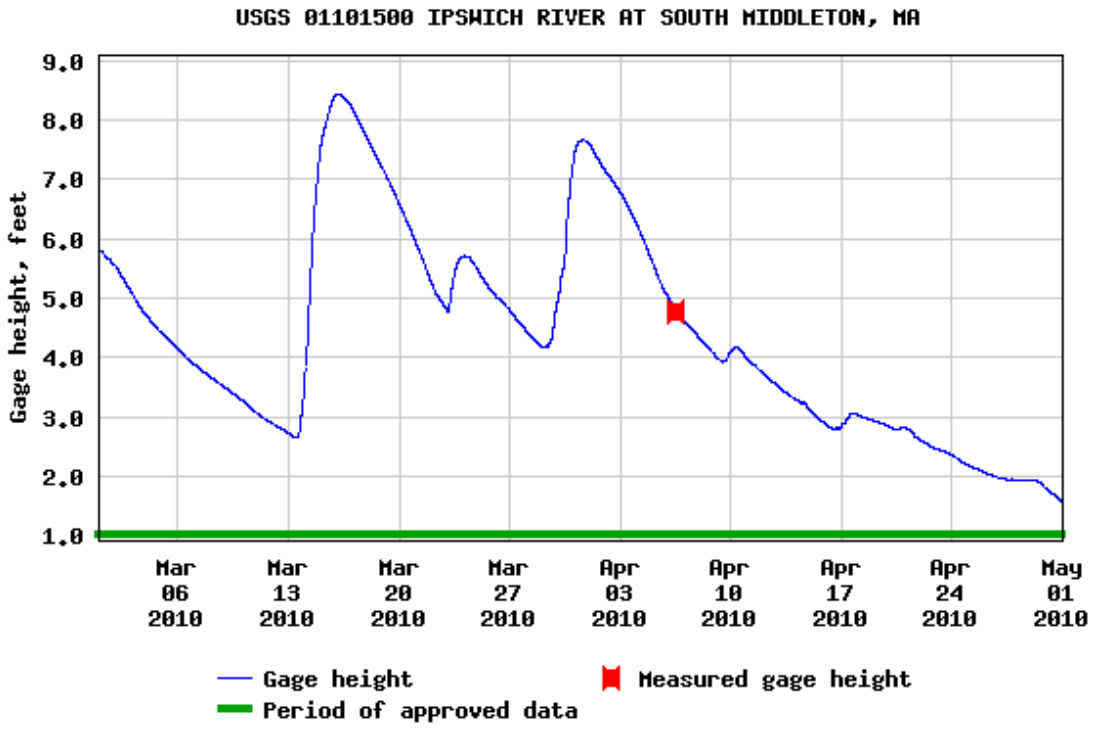
Source: NOAA, National Centers for Environmental Information

Most severe flooding event within last 10 years

The most severe flooding event in Essex County in the last 10 years occurred during March 2010, when a total of 14.83 inches of rainfall accumulation was recorded by the National Weather Service (NWS). The weather pattern that consisted of early springtime prevailing westerly winds that moved three successive storms, combined with tropical moisture from the Gulf of Mexico, across New England. Torrential rainfall caused March 2010 to be the wettest month on record.

One indication of the extent of flooding is the gage height at the nearest USGS streamflow gauging station, which is on the Ipswich River in South Middleton. The USGS gage height, shown in Figure 1, exceeded 8 feet on March 16, 2010 and exceeded 7 feet on March 31, 2010. Normal gage height in March is about 4 feet.

Figure 1- Ipswich River Gage Heights, March-April 2010



Source, US Geological Service, National Water Information System

Coastal Hazards and Flooding

Coastal flooding is associated with severe coastal storms that, through the combination of winds and tides, drive tidal waters to higher levels than normally experienced. This can lead to the inundation of low-lying land areas and the overtopping of seawalls. Coastal flooding issues in Salem include tidal surge and sea level rise; as well as coastal erosion (beaches, dunes, banks). Impacts to infrastructure, such as flooded roads, culverts blown

out or clogging with debris, and power lines knocked down from high winds are also a significant concern in Salem.

The City of Salem is particularly vulnerable to sea level rise and associated coastal hazards being a coastal community located in Essex County, Massachusetts. The Salem city boundary stretches out approximately seven miles into the Salem Sound and contains approximately 10 square miles of aquatic environment in both Salem Harbor and Salem Sound. Salem has 11.2 miles of coastal frontage and has three tidal rivers — the North River, Forest River, and the South River — that flow into Salem Harbor. Much of the natural coastline and inland water bodies have been filled to accommodate centuries of development, and very few of the original plant and animal communities have been left untouched by the same forces. However, within its small area, Salem retains a variety of natural landscapes: wetlands, rivers and streams, ponds, tidal flats, coves and harbors, rocky shores, upland ledges, and scrub forest. (*City of Salem Open Space and Recreation Plan Update, 2015-2022)*

Salem completed its Climate Change Vulnerability Assessment and Adaptation Plan (CCVAAP) in 2014. The City focused on key climate change impacts, many of them related directly to coastal flooding and climate change, that are considered most likely to have significant consequences for Salem. Today, many areas in Salem are prone to serious flooding and the City invests heavily in the management of flood risks. There have been six major flooding events since 1996. However, only one of the City's flood hazard management initiatives to date has considered the impacts of climate change. When climate change is taken into account, flooding in the City is expected to get worse. For this reason, extreme precipitation events, sea level rise, and storm surge were chosen as key climate change impacts to incorporate into the CCVAAP. In addition, extreme heat events were included as a key climate change impact because many areas in the Northeast are not currently equipped to handle frequent temperatures of this degree and scientists are confident that these events will occur more often. (*Salem Climate Change Vulnerability Assessment and Adaptation Plan, 2014)*

The City's 2014 vulnerability assessment and adaptation plan had six main steps:

1. Determine Future Climate Change Impacts.

2. Identify Affected Sectors.

3. Conduct Vulnerability Assessment.

4. Prioritize Vulnerabilities.

5. Develop Adaptation Strategies.

6. Publish Plan and Incorporate into Other Plans and Projects.

Following these steps, the City developed adaptation strategies designed to address the prioritized vulnerabilities identified during the vulnerability assessment and the identification of impacted sectors, with the adaptation strategies and prioritized vulnerabilities shown below in Table 8.

Table 8. Adaptation Strategies and the Prioritized Vulnerabilities they Address

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
		Ineffective seawalls	Ineffective tide gates, Inadequate tide gates at Lafayette	Insufficient capacity and drainage in the stormwater	Flooding and disrupted operation of pump stations	Flooding of the transportation network infrastructure from	Flooding of evacuation routes	Loss of power at critical city buildings	Backup power failure at critical city facilities	Downed power lines	Critical emergency preparedness communication	Poor air quality	Property damage or loss of emergency and critical city facilities	Property damage or loss at Salem State University	Flooding of emergency response facilities	Property damage or loss of historic properties	Flooding of residential areas	Overtopping of Rosie's Pond*
1	Seawall Repair: Installation of Drainage Features	✓																
2	Seawall Repair: Increase Crest/Top of Structure Height	✓																
3	Seawall Repair: Installation of Structural Toe Protection	✓																
4	Seawall Repair: Installation of Recurved Cap Systems	✓																
5	Seawall Repair: Bulkhead Materials	✓																
6	Seawall Repair: Living Shorelines	✓																
7	Seawall Repair: Beach Nourishment	✓																
8	Installation/Upgrades of Tide Gates		✓	✓	✓													
9	Tide Gate Alternative: Duckbill/Tide Flex		✓	✓	✓													
10	Tide Gate Alternative: Buoyant or Self-Regulating Structures		✓	✓	✓													
11	Water Level Monitoring and Alert System		✓															
12	Conduct a Drainage Study			✓	✓	✓												
13	Enlarging and Supplementing the Drainage System			✓		✓												
14	Installation of Above Ground or Subsurface Stormwater Storage Systems			✓	✓	✓												
15	Installation/Upgrade of Pump Stations			✓	✓	✓												
16	Installation of Deployable Floodwalls			✓	✓	✓												
17	Green Infrastructure - Bioretention/Street Planters			✓		✓												

18	Green Infrastructure - Green Roofs			✓		✓												
19	Green Infrastructure - Permeable Pavements			✓		✓												
20	Infrastructure Design and Materials in the Transportation Network			✓		✓	✓											
21	Elevate or Relocate Transportation Infrastructure			✓		✓	✓											

Table 7. Adaptation Strategies and the Prioritized Vulnerabilities they Address (continued)

		Ineffective seawalls	Ineffective tide gates, Inadequate tide gates at Lafayette	Insufficient capacity and drainage in the stormwater	Flooding and disrupted operation of pump stations	Flooding of the transportation network infrastructure from	Flooding of evacuation routes	Loss of power at critical city buildings	Backup power failure at critical city facilities	Downed power lines	Critical emergency preparedness communication	Poor air quality	Property damage or loss of emergency and critical city facilities	Property damage or loss at Salem State University	Flooding of emergency response facilities	Property damage or loss of historic properties	Flooding of residential areas	Overtopping of Rosie's Pond*
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**
22	Increase Energy Efficiency in Critical City Buildings							✓										
23	Install and Elevate Backup Power Sources							✓	✓									
24	Install Renewable Energy Backup Power Sources								✓									
25	Bury the Electrical Distribution System									✓								
26	Maintain Overhead Distribution System									✓								
27	Improve Utility and City Communication							✓		✓								
28	Increase Awareness of Climate Change Risks and Safety										✓							
29	Assist Vulnerable Populations										✓							
30	Community Health Impact Assessment and Public Outreach during Poor Air Quality Events											✓						
31	Redundancy of Evacuation Routes						✓											
32	Review Local Public Health Care Sectors Readiness											✓						
33	Promote and Expand Urban Forestry											✓						
34	Evaluation of Buildings for Flood Proofing Opportunities												✓	✓	✓	✓	✓	
35	Development of New Critical Use Facilities Outside Future Flooding Levels												✓	✓	✓	✓		
36	Re-Development Existing Facilities Outside Future Flooding Levels												✓	✓	✓	✓	✓	

37	Elevate the Building												✓	✓	✓	✓		
38	Elevate a Building's Critical Uses												✓	✓	✓	✓	✓	
39	Adopt and Enforce Updated Building Codes												✓	✓	✓	✓		
40	Limit or Restrict Development in Future Flooding Areas												✓	✓	✓	✓		
41	Improve Land Use Planning and Regulations												✓	✓	✓	✓		
42	Flood Proof Buildings												✓	✓	✓	✓	✓	
43	Perform Wharf Area Water Study												✓					

Source: Salem Climate Change Vulnerability Assessment and Adaptation Plan, 2014

This 2020 hazard mitigation plan update includes some mitigation actions drawn from the adaptation strategies in the CCVAAP addressing coastal flooding issues through drainage studies and updates, seawall repairs and Living Shorelines. Some of this work has already been completed, such as the Collins Cove/Forrester Street Living Shorelines project constructed in 2018 and work begun under the South River Drainage and Flood Mitigation Study.

Sites carried over from the Salem 2013 natural hazard mitigation plan now reclassified for coastal flooding areas the following Areas of Concern, shown on Map 8:

- Canal Street- The City has begun construction work to upgrade resiliency and drainage along Canal Street and projects to complete this work by 2022. Part of the South River watershed, the Canal Street neighborhood is impacted by coastal surge, impaired infrastructure and stormwater storage issues.

- Brooks Road/Jefferson Avenue/Rosie's Pond neighborhood- City plans to have under construction by winter of 2020 and finish by end of 2020. These areas are impacted by coastal surge and stormwater conveyance capacity issues.

- Daniels Street, Ocean Avenue and Willows Park neighborhood- The City anticipates beginning seawall repair work in an area that suffers from coastal storm surge. There are issues with repairs to privately owned seawalls.

- Tide gates and culvert at mouth of the North River and Bridge St. flooding- MA DOT issue- Some green infrastructure work has been done in an area susceptible to coastal storm surge and flooding.

New coastal flooding sites added by the local team for the 2020 plan update included:

- Derby Wharf-floods during storms and King Tides.
- Walmart parking lot off Highland Avenue floods during high precipitation events.

In 2018, the City conducted a community resiliency building workshop through the Massachusetts Municipal Vulnerability Program (MVP). With the completion of the

program and submittal of findings of the workshop to the MVP program, Salem became an MVP Certified Community and eligible to apply for MVP Action Grants. Recommendations from the workshop to address climate resiliency as they relate to coastal hazards often mirrored work already begun through natural hazard mitigation planning and the 2014 CCVAAP, including for the City included the following actions:

- Reduce flooding on Highland Ave near Walmart.
- Reduce flooding at 114/Bridge St./North River.
- Participate in the National Flood Insurance Program's Community Rating System so property owners may receive flood insurance discounts.
- Strengthen zoning and building ordinances and regulations to increase resilience, adaptations and sustainability.
- Assess which pump stations can handle flooding - examine backup power and need for flood barriers.
- Update codes for seawalls being rebuilt to take future flooding into account (Palmer/Point, Juniper Cove, Collins and others).
- Hold a forum with coastal resilience and protection experts to talk to staff and residents about seawalls, coastal resilience and coordinated efforts.
- When repairing or replacing existing parking lots and bus shelters, use green infrastructure and canopy solar (in large parking lots) to reduce heat islands and create clean, renewable energy.

The top four actions from the 2018 Salem MVP workshop, prioritized for high priority, high level of risk and high severity included:

- Assess and identify critical roads for emergency vehicles (Jefferson, Canal, Highland, Bridge, Derby, Lafayette, Washington, Szetela, Webb, Kernwood, and bridges to Beverly).
- Identify key road networks and develop safe evacuation routes; Install evacuation route signage; Develop alternative methods of evacuation (including water).
- Reduce flooding on Highland Ave near Walmart.
- Reduce flooding at Forest River at border with Marblehead.

In 2019, the City of Salem was awarded a Municipal Vulnerability Preparedness (MVP) Grant in the amount of $320,861 in order to complete resiliency projects at Gallows Hill Park, Bertram Field, and to plant additional new street trees downtown. The grant will allow the City to plant street trees downtown using permeable tree pits allowing for

stormwater infiltration, reduce flooding and the heat island effect. At Gallows Hill Park the City has begun to add pervious paving and additional trees, a raingarden to reduce down-watershed flooding and will be adding educational signage. At Bertram Field, the City is incorporating green infrastructure to increase infiltration and reduce flooding along the North and South Rivers further down the watershed as well as adding trees, a new stormwater treatment system and making building facilities more energy efficient.

The best available local data coastal flooding occurrences is for Essex County through the National Centers for Environmental Information (see Table 9). Essex County, which includes the City of Salem, experienced 33 coastal flood events from 2006 to 2019. No deaths or injuries were reported and the total reported property damage in the county was $7.10 million dollars. Damages from the February and March 2013 coastal floods in Essex County accounted for $6.8 million of that total.

Photo of Coastal Flooding in Salem

Coastal Flooding- The Willows-Salem, MA- January 4, 2018 [1]

[1] Photo courtesy of Salem Patch and Sarah Phipps Gordon 2018

Table 9- Essex County Coastal Flood Events, 2006-2019

Date	Deaths	Injuries	Property Damage $
1/31/2006	0	0	60.00K
4/15/2007	0	0	5.00K
4/16/2007	0	0	5.00K
4/17/2007	0	0	20.00K
11/3/2007	0	0	10.00K
11/25/2008	0	0	0.00K
6/21/2009	0	0	0.00K
1/2/2010	0	0	0.00K
2/25/2010	0	0	0.00K
3/1/2010	0	0	0.00K
3/4/2010b	0	0	0.00K
3/15/2010	0	0	0.00K
12/27/2010	0	0	75.00K
10/30/2011	0	0	10.00K
6/2/2012	0	0	0.00K
6/3/2012	0	0	30.00K
6/4/2012	0	0	0.00K
6/4/2012	0	0	0.00K
12/27/2012	0	0	0.00K
2/9/2013	0	0	5.800M
3/7/2013	0	0	1.000M
1/2/2014	0	0	0.00K
1/3/2014	0	0	0.00K
1/27/2015	0	0	50.00K
1/24/2016	0	0	0.00K
2/8/2016	0	0	0.00K
5/25/2017	0	0	40.00K
1/4/2019	0	0	0.00K
1/30/2018	0	0	0.00K
3/2/2018	0	0	0.00K
10/27/18	0	0	0.00K
11/25/18	0	0	0.00K
1028/19	0	0	0.00K
TOTAL	**0**	**0**	**7.105M**

Source: NOAA, National Centers for Environmental Information

The NOAA records for Essex County show a total of $7.1 million in damages from coastal flooding from 2006 to 2019. Based on the record of previous occurrences coastal flooding in Salem is a high frequency event as defined by the Massachusetts State Hazard

Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% chance per year).

Areas of Flooding and Coastal Flooding

Information on potential flood hazard areas was taken from two sources. The first was the National Flood Insurance Rate Maps. The FIRM flood zones are shown on Map 3 in Appendix A and their definitions are listed below.

Flood Insurance Rate Map Zone Definitions

Zone A (1% annual chance): Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs (base flood elevations) or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone AE and A1-A30 (1% annual chance): Zones AE and A1-A30 are the flood insurance rate zones that correspond to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone X500 (0.2% annual chance)**:** Zone X500 is the flood insurance rate zone that corresponds to the 500-year floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs (base flood elevations) or depths are shown within this zone.

Zone VE (1% annual chance): Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

The second source of information was the local Hazard Mitigation Team. The locally identified areas of flooding listed below were identified by City staff as areas where flooding occurs. These areas do not necessarily coincide with the flood zones from the FIRM maps. They may be areas that flood due to inadequate drainage systems or other local conditions rather than location within a flood zone. The numbers correspond to the numbers on Map 8, “Hazard Areas”. The numbers do not reflect priority order.

Locally Identified Areas of Flooding

1) South River Watershed: Canal Street neighborhood impacted by coastal surge impaired infrastructure and stormwater storage issues

2) South River Watershed: Rosie's Pond, Jefferson Avenue, and Brooks Road impacted by coastal surge and stormwater conveyance capacity issues.

3) Forrester Street neighborhood: coastal surge and impaired infrastructure causes water backup and flooding

4) North River/Bridge Street neighborhoods: coastal storm surge flooding

5) Columbus Avenue at Willows Park: flooding due to storm surge

8) Walmart parking lot

9) Derby Wharf area

Repetitive Loss Structures

As defined by the National Flood Insurance Program (NFIP), a repetitive loss property is any property which the NFIP has paid two or more flood claims of $1,000 or more in any given 10-year period since 1978. For more information on repetitive losses see http://www.fema.gov/business/nfip/replps.shtm.

There are 17 repetitive loss structures in Salem, four more than were listed in the 2012 plan. Ten of the properties are single family residences.

Table 10 summarizes the number and type of repetitive loss structures located within Salem and the number of losses and total claims associated with them.

Table 10- Summary of Repetitive Losses and Claims in Salem

	Single Family Residential	Other Residential	Non-Residential	Total Claims Paid
Number of Properties	10	3	4	17
Number of Losses	25	9	12	46
Claims Paid	$252,047.39	$82,867.39	$367,293.38	$ 702,208.16

Source: Department of Conservation and Recreation, FEMA Repetitive Loss data

Based on the record of previous occurrences flooding events in Salem are a High frequency event as defined by the Massachusetts State Hazard Mitigation Plan. This

hazard may occur more frequently than once in five years, or a greater than 20% chance per year.

Dams and Dam Failure

Dam failure can occur as a result of structural failure, independent of a hazard event, or as the result of the impacts of a hazard event such as flooding associated with storms or an earthquake. In the event of a dam failure, the energy of the water stored behind even a small dam can cause loss of life and property damage if there are people or buildings downstream. The number of fatalities from a dam failure depends on the amount of warning provided to the population and the number of people in the area in the path of the dam's floodwaters.

DCR defines dam hazard classifications as follows:

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

Dam failure is a highly infrequent occurrence but a severe incident could result in loss of lives and significant property damage. Since 1984, three dams have failed in or very near to Massachusetts, one of which resulted in a death**.** There are no dams, either municipal or privately owned, listed for Salem by the Massachusetts Office of Dam Safety, Inventory of Dams as of August 2018.

Wind Related Hazards

Wind-related hazards include hurricanes, tropical storms, and tornadoes as well as high winds during Nor'easters and thunderstorms. As with many communities, falling trees that result in downed power lines and power outages are an issue in Salem. Information on wind related hazards can be found on Map 5 in Appendix A.

Hurricanes and Tropical Storms

A hurricane is a violent wind and rainstorm with wind speeds of 74-200 miles per hour. A hurricane is strongest as it travels over the ocean and is particularly destructive to

coastal property as the storm hits the land. The City's entire area is vulnerable to hurricanes. Hurricanes occur between June and November. A tropical storm has similar characteristics, but wind speeds are below 74 miles per hour.

Since 1900, 39 tropical storms have impacted New England (NESEC). Massachusetts has experienced approximately 32 tropical storms, nine Category 1 hurricanes, five Category 2 hurricanes and one Category 3 hurricane. A hurricane or storm track is the line that delineates the path of the eye of a hurricane or tropical storm. There has been one recorded storm tracks through Salem, a tropical storm in 1923. However, Salem experiences the impacts of hurricanes and tropical storms regardless of whether the storm track passes directly through the City, and numerous hurricanes have affected the communities of eastern Massachusetts (see Table 10) The hazard mapping indicates that the 100 year wind speed in Salem is 110 miles per hour (see Appendix A).

Table 10- Hurricane Records for Massachusetts, 1938 – 2019

Hurricane Event	Date
Great New England Hurricane*	September 21, 1938
Great Atlantic Hurricane*	September 14-15, 1944
Hurricane Doug	September 11-12, 1950
Hurricane Carol*	August 31, 1954
Hurricane Edna*	September 11, 1954
Hurricane Diane	August 17-19, 1955
Hurricane Donna	September 12, 1960
Hurricane Gloria	September 27, 1985
Hurricane Bob	August 19, 1991
Hurricane Earl	September 4, 2010
Tropical Storm Irene	August 28, 2011
Hurricane Sandy	October 29-30, 2012

*Category 3. Source: National Oceanic and Atmospheric Administration

Hurricane intensity is measured according to the Saffir/Simpson scale, which categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential. These are combined to estimate potential damage. The following gives an overview of the wind speeds, surges, and range of damage caused by different hurricane categories:

Scale No. (Category)	Winds(mph) Storm	Surge (ft.)	Potential Damage
1	74 – 95	4 - 5	Minimal
2	96 – 110	6 - 8	Moderate
3	111 – 130	9 - 12	Extensive
4	131 – 155	13 - 18	Extreme
5	> 155	>18	Catastrophic

Source: NOAA

Hurricanes typically have regional impacts beyond their immediate tracks. Falling trees and branches are a significant problem because they can result in power outages when they fall on power lines or block traffic and emergency routes. Hurricanes are a City-wide hazard in Salem. Potential hurricane damages to Salem have been estimated using HAZUS-MH. Total damages are estimated at $39,011.47 for a Category 2 hurricane and $188,446.08 (thousands) for a Category 4 hurricane. Other potential impacts such as debris disposal and sheltering needs are detailed in Table 21.

Based on records of previous occurrences, hurricanes in Salem are a Medium frequency event as defined by the Massachusetts State Hazard Mitigation Plan. This hazard occurs from once in 5 years to once in 50 years, or a 2% to 20% chance per year.

Tornadoes

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. These events are spawned by thunderstorms and occasionally by hurricanes and may occur singularly or in multiples. They develop when cool air overrides a layer of warm air, causing the warm air to rise rapidly. Most vortices remain suspended in the atmosphere. Should they touch down, they become a force of destruction. Some ingredients for tornado formation include:

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

Tornado damage severity is measured by the Fujita Tornado Scale, in which wind speed is not measured directly but rather estimated from the amount of damage. As of February 01, 2007, the National Weather Service began rating tornados using the Enhanced Fujita-scale (EF-scale), which allows surveyors to create more precise assessments of tornado severity. The EF-scale is summarized below:

Fujita Scale			Derived		Operational EF Scale	
F Number	Fastest ¼ mile (mph)	3-second gust (mph)	EF Number	3-second gust (mph)	EF Number	3-second gusts (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over -200

Source: Massachusetts State Hazard Mitigation Plan

The frequency of tornadoes in eastern Massachusetts is low; on average, there are six tornadoes that touchdown somewhere in the Northeast region every year. The strongest tornado in Massachusetts history was the Worcester Tornado in 1953 (NESEC).
The most recent tornado events in Massachusetts were in Springfield in 2011, Revere in 2014 and most recently in Concord (Middlesex County) on August 23, 2016. The Concord EF-1 tornado damaged 39 homes but no injuries or deaths were reported. (Source: *Concord Patch*). Most recently, on July 23, 2019 there was a n EF1 tornado on Cape Cod that affected Hyannis Port, West Yarmouth, and Harwich. This tornado caused $4.9 million in damages, bur resulted in no injuries or deaths.

The Springfield tornado caused significant damage and resulted in 4 deaths in June of 2011. The Revere tornado touched down in Chelsea just south of Route 16 and moved north into Revere's business district along Broadway and ended near the intersection of Routes 1 and 60. The path was approximately two miles long and 3/8 mile wide, with wind speeds up to 120 miles per hour. Approximately 65 homes had substantial damages and 13 homes and businesses were uninhabitable.

Although there have been no recorded tornadoes within the limits of the City of Salem, team members recall a tornado warning issued for the City in 2018. Children at the Carleton School took shelter there during the warning. Since 1956 there have been 11 tornadoes in surrounding Essex County recorded by the National Centers for Environmental Information (Table 12), No tornados were F3, one was F2, eight were F1 and two were F 0. These 11 tornadoes resulted in no fatalities and four injuries and up to $560,280 in damages.

Table 12 - Tornado Records for Essex County

Date	Type	Fujita Scale	Deaths	Injuries	Property Damage $	Length	Width
6/13/1956	Tornado	F1	0	0	2500	1	10
11/21/1956	Tornado	F2	0	0	25000	0.8	17
12/18/1956	Tornado	F1	0	0	250	0.5	23
7/13/1960	Tornado	F0	0	0	30	0.1	33
7/21/1962	Tornado	F1	0	3	25000	2.7	33
5/19/1964	Tornado	F0	0	0	2500	0.1	300
5/19/1964	Tornado	F1	0	0	2500	2	300
8/10/1965	Tornado	F1	0	0	0	3.6	33
7/1/1968	Tornado	F1	0	1	250000	0.3	100
7/21/1972	Tornado	F1	0	0	2500	0.3	20
8/15/1991	Tornado	F1	0	0	250000	0.8	300
			0	**4**	**$560,280**		

Source: National Centers for Environmental Information

Buildings constructed prior to current building codes may be more vulnerable to damages caused by tornadoes. Evacuation of impacted areas may be required on short notice. Sheltering and mass feeding efforts may be required along with debris clearance, search and rescue, and emergency fire and medical services. Key routes may be blocked by downed trees and other debris, and widespread power outages are also typically associated with tornadoes.

Although tornadoes are a potential City-wide hazard in Salem, tornado impacts are relatively localized compared to severe storms and hurricanes. Damages from any tornado in Salem would greatly depend on the track of the tornado. Generally the downtown, Bridge Street Neck, Point and South Salem neighborhoods are more densely developed and would likely be subject to more damage in the event of a tornado.

Based on the record of previous occurrences since 1950, Tornado events in Salem are a Medium frequency event as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur from once in 5 years to once in 50 years, or a 2% to 20% chance per year.

Nor'easters

A northeast coastal storm, known as a nor'easter, is typically a large counter-clockwise wind circulation around a low-pressure center. Featuring strong northeasterly winds blowing in from the ocean over coastal areas, nor'easters are relatively common in the winter months in New England occurring one to two times a year. The storm radius of a nor'easter can be as much as 1,000 miles and these storms feature sustained winds of 10

to 40 mph with gusts of up to 70 mph. These storms are accompanied by heavy rains or snows, depending on temperatures.

Previous occurrences of Nor'easters include the following:

February 1978	Blizzard of 1978
October 1991	Severe Coastal Storm ("Perfect Storm")
December 1992	Great Nor'easter of 1992
January 2005	Blizzard/N or'easter
October 2005	Coastal Storm/Nor'easter
April 2007	Severe Storms, Inland & Coastal Flooding/Nor'easter
January 2011	Winter Storm/Nor'easter
October 2011	Severe Storm/Nor'easter
Blizzard of 2013	February 2013
Blizzard of 2015	January 2015
January 2018	Severe Storm, Coastal Flooding/Nor'easter

Many of the historic flood events identified in the previous section were precipitated by nor'easters, including the "Perfect Storm" event in 1991. More recently, blizzards in December 2010, October 2011, February 2013, January 2015 and January 2018 were all large nor'easters that caused significant snowfall amounts.

Salem is vulnerable to both the wind and precipitation that accompanies nor'easters. High winds can cause damage to structures, fallen trees, and downed power lines leading to power outages. Intense rainfall can overwhelm drainage systems causing localized flooding of rivers and streams as well as urban stormwater ponding and localized flooding. Fallen tree limbs as well as heavy snow accumulation and intense rainfall can impede local transportation corridors, and block access for emergency vehicles.

The entire City of Salem could be at risk from the wind, rain or snow impacts from a nor'easter, depending on the track and radius of the storm, with low lying coastal areas at greatest risk. Examples of some areas that suffered damage, power loss and flooding associated with Nor'easters occurred with storms in 2015 and 2018 included the Columbus Avenue, Forrester Street, Collins Cove, Juniper Cove, areas near the Saltonstall School, Bridge Street, Canal Street, Willows Park, Derby Wharf, Forest River Park, and Ocean Avenue.

Based on the record of previous occurrences, nor'easters in Salem are high frequency events as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

Severe Thunderstorms

While less severe than the other types of storms discussed, thunderstorms can lead to localized damage and represent a hazard risk for communities. Generally defined as a storm that includes thunder, which always accompanies lightning, a thunderstorm is a storm event featuring lightning, strong winds, and rain and/or hail. Thunderstorms sometime give rise to tornados. On average, these storms are only around 15 miles in diameter and last for about 30 minutes.

A severe thunderstorm can include winds of close to 60 mph and rain sufficient to produce flooding. The City's entire area is potentially subject to severe thunderstorms.

The City does not keep records of thunderstorms but estimates that at least eight to ten occur each year. Team members remembered several microbursts with sudden high winds and severe thunderstorms occurring in the Forest River neighborhood in 2017 with the loss of five or six utility poles, trees downed and a loss of power for 2 to 3 days. The Saltonstall neighborhood had a severe storm with trees knocked down and a 24 hour loss of power occur in 2018.Most recently there was a microburst in October 2019 in Salem.

The best available data on previous occurrences of thunderstorms in Salem is for Essex County through the National Centers for Environmental Information (NCEC). Between 2000 and 2019 NCEC records show 87 thunderstorm events in Essex County communities (Table 13). These storms resulted in a total of $2.573 million in property damages. There were two injuries and no deaths reported.

Table 13 Essex County Thunderstorm Wind Events, 2000-2019

Date	Magnitude-(knots)	Deaths	Injuries	Damage-$
6/27/2000	50	0	0	0
7/18/2000	50	0	0	0
5/12/2001	50	0	0	0
6/30/2001	50	0	0	0
7/1/2001	50	0	0	0
8/10/2001	50	0	0	0
5/31/2002	50	0	0	4000
6/2/2002	50	0	0	5000
7/23/2002	50	0	0	15000
6/27/2003	50	0	0	15000
7/2/2004	50	0	0	15000
8/20/2004	50	0	0	10000
6/26/2005	50	0	0	10000
6/29/2005	50	0	0	10000

Date	Magnitude-(knots)	Deaths	Injuries	Damage-$
7/27/2005	50	0	0	15000
8/5/2005	50	0	0	60000
5/21/2006	50	0	0	30000
5/21/2006	50	0	0	10000
7/11/2006	78	0	0	515000
7/28/2006	50	0	0	10000
6/1/2007	50	0	0	0
6/2/2007	50	0	0	0
7/5/2007	50	0	0	0
7/6/2007	50	0	0	0
7/28/2007	50	0	0	0
9/8/2007	50	0	0	28000
5/27/2008	50	0	0	3000
6/10/2008	50	0	0	34000
6/27/2008	50	0	0	12500
7/1/2008	50	0	0	27000
7/2/2008	50	0	1	10000
7/3/2008	50	0	1	13000
7/18/2008	50	0	0	3000
7/19/2008	50	0	0	15000
9/9/2008	50	0	0	20000
7/26/2009	50	0	0	25000
7/31/2009	50	0	0	50500
6/3/2010	50	0	0	71000
6/5/2010	50	0	0	60000
6/6/2010	52	0	0	79500
6/24/2010	50	0	0	50000
6/24/2010	50	0	0	15750
7/12/2010	50	0	0	30000
7/19/2010	50	0	0	25000
6/9/2011	50	0	0	111000
6/9/2011	50	0	0	15000
6/9/2011	50	0	0	5000
6/9/2011	50	0	0	15000
6/9/2011	50	0	0	10000
6/9/2011	50	0	0	25000
6/9/2011	50	0	0	20000
6/9/2011	50	0	0	3000
6/9/2011	50	0	0	3000
7/4/2011	50	0	0	31000

Date	Magnitude-(knots)	Deaths	Injuries	Damage-$
7/18/2011	39	0	0	20000
8/19/2011	50	0	0	60000
10/4/2011	50	0	0	10000
6/23/2012	50	0	0	75500
6/25/2012	40	0	0	5000
7/4/2012	50	0	0	5000
6/24/2013	50	0	0	25000
7/1/2013	50	0	0	18000
7/3/2014	50	0	0	100000
7/15/2014	50	0	0	15000
7/28/2014	50	0	0	15000
9/2/2014	45	0	0	5000
9/6/2014	50	0	0	2385000
5/28/2015	61	0	0	50000
5/28/2015	50	0	0	81000
6/23/2015	60	0	0	5000
7/27/2015	45	0	0	1000
8/4/2015	50	0	0	65000
2/25/2016	50	0	0	21000
6/29/2016	50	0	0	25000
7/1/2016	50	0	0	15000
7/18/2016	70	0	0	105000
7/23/2016	50	0	0	155000
9/11/2016	50	0	0	10000
05/18/2017	50	0	0	29.00K
06/23/2017	50	0	0	26.5.00K
06/27/2017	50	0	0	10.00K
06/18/2018	50	0	0	46.50K
09/18/2018	61	0	0	16.00K
06/30/2019	40	0	0	6.00K
07/17/2019	50	0	0	1.75K
07/31/2019	50	0	0	40.00K
08/21/2019	50	0	0	3.00K
TOTAL		**0**	**2**	**2.75 M**

Source: NOAA, National Centers for Environmental Information
Magnitude refers to maximum wind speed in knots.

Severe thunderstorms are a City-wide hazard for Salem. The City's vulnerability to severe thunderstorms is similar to that of Nor'easters. High winds can cause falling trees and power outages, as well as obstruction of key routes and emergency access. Heavy precipitation may also cause localized flooding, both riverine and urban drainage related.

Based on the record of previous occurrences, severe thunderstorms in Salem are high frequency events as defined by the Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year).

Winter Storms

Winter storms, including heavy snow, blizzards, and ice storms, are the most common and most familiar of the region's hazards that affect large geographic areas. The majority of blizzards and ice storms in the region cause more inconvenience than they do serious property damage, injuries, or deaths. However, periodically, a storm will occur which is a true disaster, and necessitates intense large-scale emergency response.

Heavy Snow and Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below ¼ mile.

These conditions must be the predominant condition over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of the definition. The hazard created by the combination of snow, wind and low visibility increases with temperatures below 20 degrees.

Winter storms are a combination hazard because they often involve wind, ice and heavy snow fall. The National Weather Service defines "heavy snow fall" as an event generating at least 4 inches of snowfall within a 12 hour period. Winter Storms are often associated with a Nor'easter event, a large counter-clockwise wind circulation around a low-pressure center often resulting in heavy snow, high winds, and rain.

The Northeast Snowfall Impact Scale (NESIS) developed by Paul Kocin of The Weather Channel and Louis Uccellini of the National Weather Service (Kocin and Uccellini, 2004) characterizes and ranks high impact northeast snowstorms. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five categories: Extreme, Crippling, Major, Significant, and Notable. NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. The largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers. The NESIS categories are summarized below:

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

Source: Massachusetts State Hazard Mitigation Plan

The most significant winter storm in recent history was the "Blizzard of 1978," which resulted in over 3 feet of snowfall and multiple day closures of roadways, businesses, and schools. In Salem blizzards and severe winter storms have occurred in the following years:

Table 14- Severe Winter Storm Records for Massachusetts

Blizzard of 1978	February 1978
Blizzard	March 1993
Blizzard	January 1996
Severe Snow Storm	March 2001
Severe Snow Storm	December 2003
Severe Snow Storm	January 2004
Severe Snow Storm	January 2005
Severe Snow Storm	April, 2007
Severe Snow Storm	December 2010
Severe Snow Storm	January 2011
Blizzard of 2013	February 2013
Blizzard of 2015	January 2015
Blizzard of 2018	January, 2018

Source: National Oceanic and Atmospheric Administration

The average annual snowfall north Salem is 48 - 72 inches and 36 – 48 inches in south Salem (See Map 6 in Appendix A).

The City of Salem does not keep local records of winter storms. Examples of some areas that suffered damage, power loss and flooding associated with severe storms and blizzards occurred with storms most recently in 2015 and 2018 included the Columbus Avenue, Forrester Street, Collins Cove, Juniper Cove, areas near the Saltonstall School, Bridge Street, Canal Street, Willows Park, Derby Wharf, Forest River Park, and Ocean Avenue.

The team indicated that Data for Essex County, which includes Salem, is the best available data to help understand previous occurrences and impacts of heavy snow events. According to the National Climate Data Center (NCDC) records, from 1995 to

January, 2017, Essex County experienced 113 heavy snowfall events, resulting in no deaths, no injuries, and $7.353 million dollars in property damage. See Table 15 for heavy snow events and impacts in Essex County.

Table 15 - Heavy Snow events and Impacts in Essex County 1996 – 2019

Date	Deaths	Injuries	Damage-$
1/2/1996	0	0	0
1/7/1996	0	0	2000000
1/10/1996	0	0	0
1/12/1996	0	0	0
2/2/1996	0	0	0
2/16/1996	0	0	0
3/2/1996	0	0	0
3/7/1996	0	0	0
4/9/1996	0	0	0
4/9/1996	0	0	0
12/6/1996	0	0	0
12/7/1996	0	0	1360000
2/16/1997	0	0	0
3/31/1997	0	0	0
4/1/1997	0	0	0
11/14/1997	0	0	0
12/23/1997	0	0	0
1/15/1998	0	0	0
1/14/1999	0	0	0
3/6/1999	0	0	0
3/15/1999	0	0	0
1/13/2000	0	0	0
2/18/2000	0	0	0
12/30/2000	0	0	0
1/20/2001	0	0	0
2/5/2001	0	0	0
3/5/2001	0	0	0
3/9/2001	0	0	0
3/30/2001	0	0	0
12/8/2001	0	0	0
2/1/2003	0	0	0
3/16/2004	0	0	0
2/21/2005	0	0	0
1/23/2006	0	0	20000
12/13/2007	0	0	0

Date	Deaths	Injuries	Damage-$
12/16/2007	0	0	0
12/19/2007	0	0	0
1/14/2008	0	0	20000
2/22/2008	0	0	0
12/19/2008	0	0	0
12/21/2008	0	0	0
12/31/2008	0	0	0
1/11/2009	0	0	0
1/18/2009	0	0	0
3/1/2009	0	0	0
3/9/2009	0	0	0
12/20/2009	0	0	0
1/18/2010	0	0	0
2/16/2010	0	0	15000
1/12/2011	0	0	0
1/26/2011	0	0	0
2/8/2013	0	0	0
3/7/2013	0	0	0
3/18/2013	0	0	0
12/14/2013	0	0	0
12/17/2013	0	0	0
1/2/2014	0	0	0
1/18/2014	0	0	10000
2/5/2014	0	0	0
2/13/2014	0	0	0
2/18/2014	0	0	0
1/24/2015	0	0	0
1/26/2015	0	0	0
2/2/2015	0	0	0
2/8/2015	0	0	0
2/14/2015	0	0	0
2/5/2016	0	0	40000
3/14/17	0	0	0
11/15/18	0	0	0
TOTAL	**0**	**0**	**$7,353,000**

Source: NOAA, National Centers for Environmental Information

The City's overall vulnerability to heavy snow and blizzards is primarily related to restrictions on travel on roadways, temporary road closures, school closures, and potential

restrictions on emergency vehicle access. Other vulnerabilities include power outages due to fallen trees and utility lines, and damage to structures due to heavy snow loads.

Blizzards are considered to be high frequency events based on past occurrences, as defined by the Massachusetts State Hazard Mitigation Plan. This hazard occurs more than once in five years, with a greater than 20 percent chance of occurring each year.

Ice Storms

The ice storm category covers a range of different weather phenomena that collectively involve rain or snow being converted to ice in the lower atmosphere leading to potentially hazardous conditions on the ground. Hail size typically refers to the diameter of the hailstones. Warnings and reports may report hail size through comparisons with real-world objects that correspond to certain diameters:

Description	Diameter (inches)
Pea	0.25
Marble or Mothball	0.50
Penny or Dime	0.75
Nickel	0.88
Quarter	1.00
Half Dollar	1.25
Walnut or Ping Pong Ball	1.50
Golf ball	1.75
Hen's Egg	2.00
Tennis Ball	2.50
Baseball	2.75
Tea Cup	3.00
Grapefruit	4.00
Softball	4.50

While ice pellets and sleet are examples of these, the greatest hazard is created by freezing rain conditions, which is rain that freezes on contact with hard surfaces leading to a layer of ice on roads, walkways, trees, and other surfaces. The conditions created by freezing rain can make driving particularly dangerous and emergency response more difficult. The weight of ice on tree branches can also lead to falling branches damaging electric lines.

City-specific data for previous ice storm occurrences are not collected by the City of Salem. The best available local data is for Essex County through the National Centers for Environmental Information (see Table 15). Essex County, which includes the City of Salem, experienced one ice storm event from 1995 – 2019. No deaths or injuries were reported and the total reported property damage in the county was $2.0 million dollars.

Table 16- Essex County Ice Storm Events, 1995- 2019

Date	Date	Type	Deaths	Injuries	Damage-$
WESTERN SALEM (ZONE)	12/11/2008	Ice Storm	0	0	$2,000,000

Source: NOAA, National Centers for Environmental Information

Ice storms are considered to be medium frequency events based on past occurrences, as defined by the Massachusetts State Hazard Mitigation Plan, 2013. This hazard occurs once in 5 years to once in 50 years, with 2% to 20% chance of occurring each year. The impacts of winter storms are often related to the weight of snow and ice, which can cause roof collapses and also causes tree limbs to fall which can in turn cause property damage and potential injuries.

Winter storms are a potential City-wide hazard in Salem. The City's vulnerability is primarily related to restrictions to travel on roadways, temporary road closures, school closures, and potential restrictions on emergency vehicle access. The City works to clear roads and carries out general snow removal operations, and bans on-street parking during snow removal to ensure that streets can be plowed and public safety vehicle access is maximized. Transit operations may also be impacted, as they were in the 2015 and 2018 blizzards which caused the closure of the MBTA system for one day and limited services on several transit lines for several weeks. Another winter storm vulnerability is power outages due to fallen trees and utility lines.

Winter storms are considered to be high frequency events based on past occurrences, as defined by the Massachusetts State Hazard Mitigation Plan. This hazard occurs more than once in five years, with a greater than twenty percent chance of occurring each year.

Geologic Hazards

Geologic hazards include earthquakes and landslides. Although new construction under the most recent building codes generally will be built to seismic standards, there are still many structures which pre-date the most recent building code. Information on geologic hazards in Salem can be found on Map 4 in Appendix A.

Earthquakes

Damage in an earthquake stems from ground motion, surface faulting, and ground failure in which weak or unstable soils, such as those composed primarily of saturated sand or silts, liquefy. The effects of an earthquake are mitigated by distance and ground materials between the epicenter and a given location. An earthquake in New England affects a much wider area than a similar earthquake in California due to New England's solid bedrock geology (NESEC).

Seismologists use a Magnitude scale (Richter scale) to express the seismic energy released by each earthquake. The typical effects of earthquakes in various ranges are summarized below.

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

Source: Nevada Seismological Library (NSL), 2005

According to the State Hazard Mitigation Plan, New England experiences an average of five earthquakes per year. From 1668 to 2010, 544 earthquakes were recorded in Massachusetts (NESEC). Most have originated from the La Malbaie fault in Quebec or from the Cape Anne fault located off the coast of Rockport. The region has experienced larger earthquakes, including a magnitude 5.0 earthquake in 1727 and a 6.0 earthquake that struck in 1755 off the coast of Cape Ann. More recently, a pair of damaging earthquakes occurred near Ossipee, NH in 1940, and a 4.0 earthquake centered in Hollis, Maine in October 2012 was felt in the Boston area. Historical records of some of the more significant earthquakes in the region are shown in Table 17.

Table 17- Historical Earthquakes in Massachusetts or Surrounding Area

Location	Date	Magnitude
MA - Cape Ann	11/10/1727	5
MA - Cape Ann	12/29/1727	NA
MA – Cape Ann	2/10/1728	NA
MA – Cape Ann	3/30/1729	NA
MA – Cape Ann	12/9/1729	NA
MA – Cape Ann	2/20/1730	NA
MA – Cape Ann	3/9/1730	NA
MA - Boston	6/24/1741	NA
MA - Cape Ann	6/14/1744	4.7
MA - Salem	7/1/1744	NA
MA - Off Cape Ann	11/18/1755	6
MA – Off Cape Cod	11/23/1755	NA
MA - Boston	3/12/1761	4.6
MA - Off Cape Cod	2/2/1766	NA
MA - Offshore	1/2/1785	5.4
MA – Wareham/Taunton	12/25/1800	NA

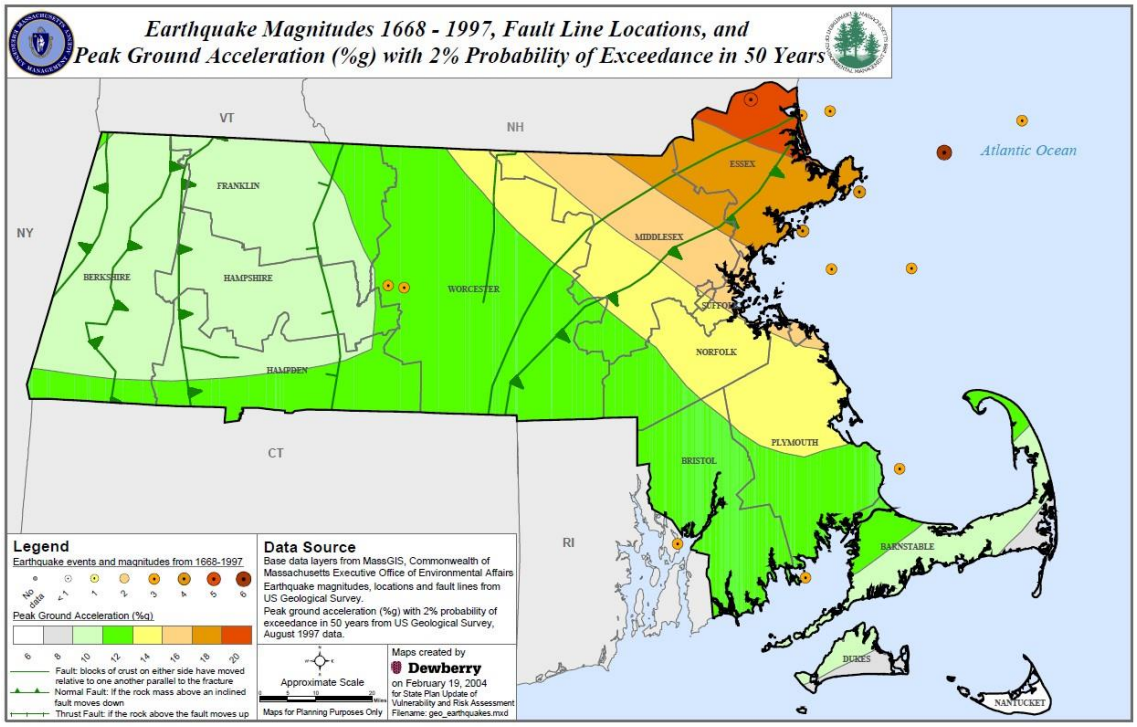
Table 17- Historical Earthquakes in Massachusetts or Surrounding Area

Location	Date	Magnitude
MA - Woburn	10/5/1817	4.3
MA - Marblehead	8/25/1846	4.3
MA - Brewster	8/8/1847	4.2
MA - Boxford	5/12/1880	NA
MA - Newbury	11/7/1907	NA
MA - Wareham	4/25/1924	NA
MA – Cape Ann	1/7/1925	4
MA – Nantucket	10/25/1965	NA
MA – Boston	12/27/74	2.3
VA –Mineral	8/23/11	5.8
MA - Nantucket	4/12/12	4.5
ME - Hollis	10/17/12	4.0

Source: (NESEC).

One measure of earthquake risk is ground motion, which is measured as maximum peak horizontal acceleration, expressed as a percentage of gravity (1 g). The range of peak ground acceleration in Massachusetts is from 10g to 20g, with a 2% probability of exceedance in 50 years. Salem is in the middle part of the range for Massachusetts, at 14g to 16g, making it a relatively moderate area of earthquake risk within the state, although the state as a whole is considered to have a low risk of earthquakes compared to the rest of the country (Figure 2). There have been no recorded earthquake epicenters within Salem (see Map 4 in Appendix A).

Figure 2: Massachusetts Earthquake Probability Map



Source: Massachusetts State Hazard Mitigation Plan

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

Earthquakes are a hazard with multiple impacts beyond the obvious building collapse. Buildings may suffer structural damage which may or may not be readily apparent. Earthquakes can cause major damage to roadways, making emergency response difficult. Water lines and gas lines can break, causing flooding and fires. Another potential vulnerability is equipment within structures. For example, a hospital may be structurally engineered to withstand an earthquake, but if the equipment inside the building is not properly secured, the operations at the hospital could be severely impacted during an earthquake. Earthquakes can also trigger landslides.

Earthquakes are a potential City-wide hazard in Salem. The City has many older buildings that pre-date current building code which could be vulnerable in the event of a severe earthquake. Potential earthquake damages to Salem have been estimated using HAZUS-MH. Total building damages, including business interruption losses are estimated at $81.81 million for a 5.0 magnitude earthquake and $474.52 million for a 7.0 magnitude earthquake. Other potential impacts are detailed in Table 22.

According to the Boston College Weston Observatory, in most parts of New England, there is a one in ten chance that a potentially damaging earthquake will occur in a 50 year time period. The Massachusetts State Hazard Mitigation Plan classifies earthquakes as "very low" frequency events that occur less frequently than once in 100 years, or a less than 1% per year.

Landslides

According to the USGS, “The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors.” Among the contributing factors are: erosion by rivers or ocean waves over steepened slopes; rock and soil slopes weakened through saturation by snowmelt or heavy rains; earthquakes create stresses that make weak slopes fail; and excess weight from accumulation of rain or snow, and stockpiling of rock or ore, from waste piles, or from man-made structures.

Landslides can result from human activities that destabilize an area or can occur as a secondary impact from another natural hazard such as flooding. In addition to structural damage to buildings and the blockage of transportation corridors, landslides can lead to

sedimentation of water bodies. Typically, a landslide occurs when the condition of a slope changes from stable to unstable. Natural precipitation such as heavy snow accumulation, torrential rain and run-off may saturate soil creating instability enough to contribute to a landslide. The lack of vegetation and root structure that stabilizes soil can destabilize hilly terrain.

There is no universally accepted measure of landslide extent but it has been represented as a measure of the destructiveness. The table below summarizes the estimated intensity for a range of landslides. For a given landslide volume, fast moving rock falls have the highest intensity while slow moving landslides have the lowest intensity.

Estimated Volume	**Expected Landslide Velocity**		
($m^{3)}$	Fast moving landslide (Rock fall)	Rapid moving landslide (Debris flow)	Slow moving landslide (Slide)
<0.001	Slight intensity		
<0.5	Medium intensity		
>0.5	High intensity		
<500	High intensity	Slight intensity	
500-10,000	High intensity	Medium intensity	Slight intensity
10,000 – 50,000	Very high intensity	High intensity	Medium intensity
>500,000		Very high intensity	High intensity
>>500,000			Very high intensity

Source: *A Geomorphological Approach to the Estimation of Landslide Hazards and Risks in Umbria, Central Italy*, M. Cardinali et al, 2002

The entire City has been classified as having a low incidence risk for landslides, less than 1.5 % of the area is involved in land sliding. (Map 4, Appendix A) The City does not have records of any damages caused by landslides in Salem. Because of this, no specific mitigation measures for landslides have been included in the plan update.

Potential damages would depend on how many properties were affected. Given the relatively high assessed value of property in Salem, damages affecting a single residence could exceed $500,000, and damages affecting several homes or business properties could theoretically extend from $1 million to several million. However, there are no data available on landslide damages in Salem, as there are no records of any damages caused by landslides in the City.

Should a landslide occur in the future, the type and degree of impacts would be highly localized, and the City's vulnerabilities could include damage to structures, damage to transportation and other infrastructure, and localized road closures. Injuries and casualties, while possible, would be unlikely given the low extent and impact of landslides in Salem.
Based on past occurrences and the Massachusetts Hazard Mitigation Plan, landslides are of Low frequency, events that can occur once in 50 to 100 years (a 1% to 2% chance of occurring each year).

Tsunami

An additional natural hazard associated with earthquakes are tsunamis. Tsunamis are created when the epicenter of an earthquake, the area of the fault where a sudden rupture occurs, is beneath the ocean floor. This can sometimes create immense sea waves if the earthquake causes upward or downward movement of the sea floor. According to the National Centers for Environmental Information, there have been no Tsunami's reported in the Northeast area of the United States. The Massachusetts Natural Hazard Mitigation Plan reports tsunamis have a very low frequency with extensive severity across the coast of Massachusetts. Salem has a very low risk frequency of tsunami but if it were to occur, the damage would likely be extensive.

Fire Related Hazards

A brush fire is an uncontrolled fire occurring in a forested or grassland area. In the Boston Metro region these fires rarely grow to the size of a wildfire as seen more typically in the western U.S. As their name implies, these fires typically burn no more than the underbrush of a forested area. Wildfire season can begin in March and usually ends in late November. The majority of wildfires typically occur in April and May, when most vegetation is void of any appreciable moisture, making them highly flammable. Once "green-up" takes place in late May to early June, the fire danger usually is reduced somewhat.

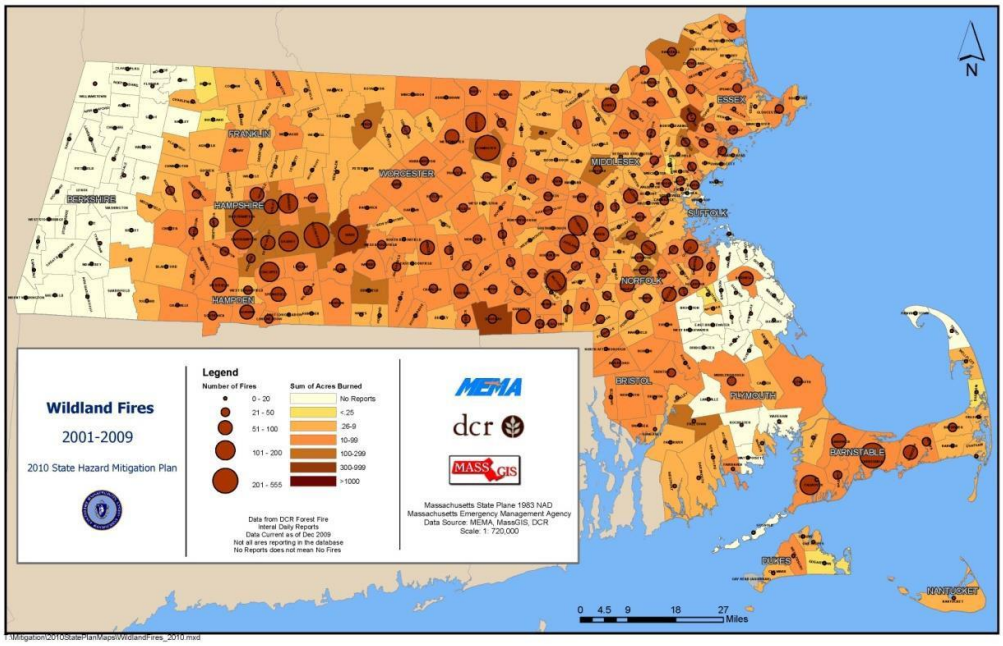
These fires can present a hazard where there is the potential for them to spread into developed or inhabited areas, particularly residential areas where sufficient fuel materials might exist to allow the fire the spread into homes.

The Salem Fire Department responds to approximately 12 woods, brush, and grass fires of varying sizes annually. In 2016, there was an extensive brush fire caused by lightening within the Highland Woods area that lasted approximately three to four days and was probably precipitated by the drought occurring at that time, according to the hazard mitigation team. Within the past year there were no wildfires that resulted in significant property damage. Salem's wildfires tend to be in the more remote wooded areas. The most common cause of these fires has been unattended youth playing with matches and campfires. The following areas of City were identified as having the highest potential for brush fires. The numbers correspond to the numbers on Map 8, "Hazard Areas":

6) Brush Fires: Willows Park area
7) Brush Fires: Salem Woods area
10) Spring Pond area

Wildfires in Massachusetts are measured by the number of fires and the sum of acres burned. The most recent data available for wildfires in Massachusetts, shown in Figure 2 below, indicates that the wildfire extent in Salem consists of .26 - 9 acres burned, with 0-20 fires from 2001 to 2009.

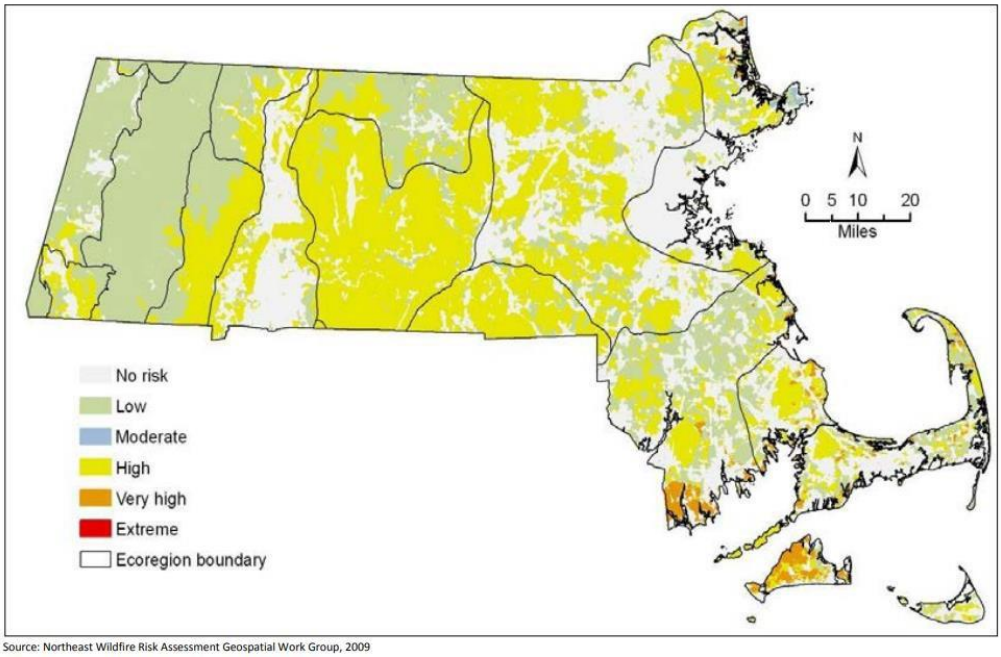
Figure 3 Massachusetts Wildfires 2001-2009



Source: Massachusetts State Hazard Mitigation Plan

According the National Wildfire Risk Assessment, Salem is located in an area that does not have a significant risk of wildfires (Figure 4)

Figure 4: Massachusetts Wildfires Risk Areas



Source: Northeast Wildfire Risk Assessment Geospatial Work Group, 2009

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

Potential damages from wildfires in Salem would depend on the extent and type of land affected. There could be the need for post-fire revegetation to restore burned properties, which could cost from a few thousand dollars to tens of thousands for an extensive area. However, there are no data on actual wildfire damages.

Based on past occurrences and the Massachusetts Hazard Mitigation Plan 2013, brushfires are of High frequency, events that occur more frequently than once in 5 years (Greater than 20% per year)

Extreme Temperatures

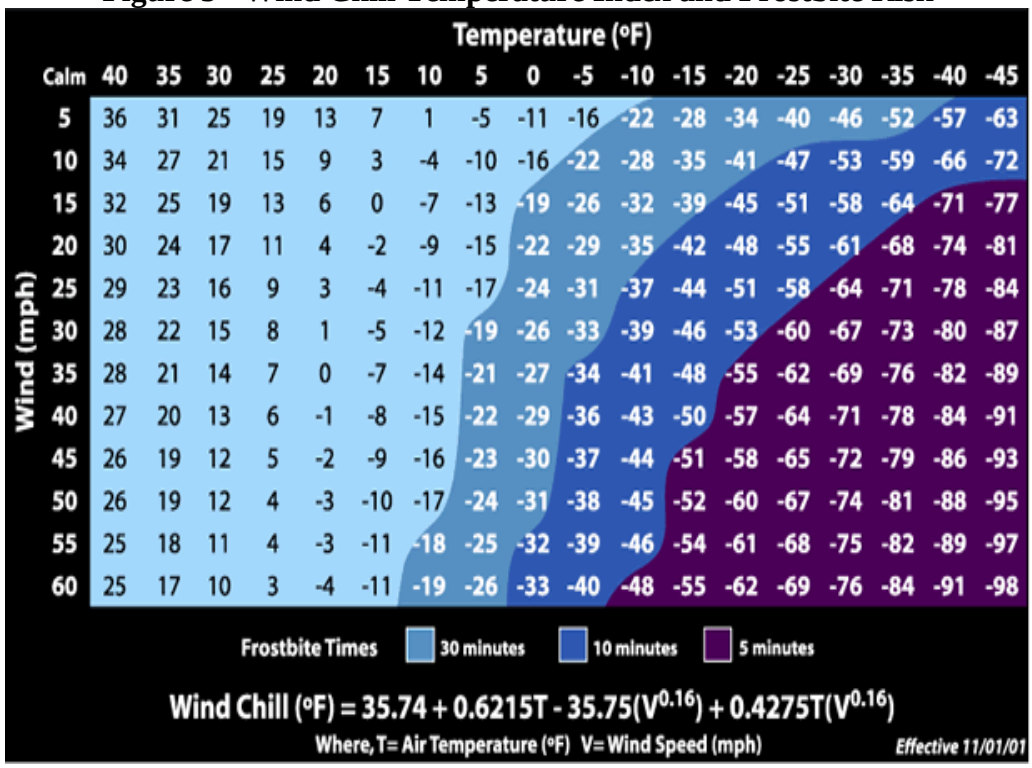
Extreme temperatures occur when either high temperature or low temperatures relative to average local temperatures occur. These can occur for brief periods of time and be acute, or they can occur over long periods of time when there is a prolonged period of excessively hot or cold weather. Salem has four well-defined seasons. The seasons have several defining factors, with temperature the most significant. Extreme temperatures can be defined as those which are far outside of the normal seasonal range for Massachusetts. The average temperatures for Massachusetts are: winter (Dec-Feb) Average = 31.8°F and summer (Jun-Aug) Average = 71°F. Extreme temperatures are a City-wide hazard.

Extreme Cold
For extreme cold, temperature is typically measured using Wind Chill Temperature Index, which is provided by the National Weather Service (NWS). The latest version of the index was implemented in 2001 and it meant to show how cold conditions feel on unexposed skin. The index is provided in Figure 5 below.

Extreme cold is also relative to the normal climatic lows in a region. Temperatures that drop decidedly below normal and wind speeds that increase can cause harmful wind-chill factors. The wind chill is the apparent temperature felt on exposed skin due to the combination of air temperature and wind speed.

Extreme cold is a dangerous situation that can result in health emergencies for susceptible people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. The elderly and people with disabilities are often most vulnerable. In Salem, 14.5 percent of the population are over 65 and 8.7% of the population under age 65 has a disability. (US Census Quick Facts)

Figure 5 - Wind Chill Temperature Index and Frostbite Risk



Source: National Weather Service

The City of Salem does not collect data for previous occurrences of extreme cold. The City's emergency heating and cooling center is located in the Community Life Center on Bridge Street. The best available local data are for Essex County, 1995- 2019, through the National Centers for Environmental Information (NCDC). There are four extreme cold events on record which caused no deaths and no injuries, and no property damage (see Table 18).

Table 18 – Essex County Extreme Cold and Wind Chill Occurrences

Date	Type	Deaths	Injuries	Damage-$
2/15/2015	Extreme Cold/Wind Chill	0	0	0
2/16/2015	Extreme Cold/Wind Chill	0	0	0
2/13/2016	Extreme Cold/Wind Chill	0	0	0
2/13/2016	Extreme Cold/Wind Chill	0	0	0

Source: NOAA, National Centers for Environmental Information

Extreme Heat

While a heat wave for Massachusetts is defined as three or more consecutive days above 90°F, another measure used for identifying extreme heat events is through a Heat Advisory from the NWS. These advisories are issued when the heat index (Figure 6) is forecast to exceed 100 degree Fahrenheit (F) for 2 or more hours; an excessive heat advisory is issued if forecast predicts the temperature to rise above 105 degree F.

Figure 6- Heat Index Chart

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

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke or Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

Source: National Weather Service

Extreme heat poses a potentially greater risk to the elderly, children, and people with certain medical conditions, such as heart disease. However, even young and healthy individuals can succumb to heat if they participate in strenuous physical activities during hot weather. Hot summer days can also worsen air pollution. With increased extreme heat, urban areas of the Northeast are likely to experience more days that fail to meet air quality standards.

The City of Salem does not collect data on excessive heat occurrences. The best available local data are for Essex County, through the National Centers for Environmental Information. From 1995 – 2019, there has been a total of one excessive heat event, with no reported deaths, no injuries, and no property damage resulting from excessive heat (see Table 19).

Table 19 – Essex County Extreme Heat Occurrences 1995 to November, 2018

Date	Type	Deaths	Injuries	Damage
7/22/2011	Excessive Heat	0	0	0

Source: NOAA, National Centers for Environmental Information

Extreme temperature events are projected to be medium frequency events based on past occurrences, as defined by the Massachusetts State Hazard Mitigation Plan. Both extreme cold and hot weather events occur between once in five years to once in 50 years, or a 2 percent to 20 percent chance of occurring each year.

Heat Islands

MAPC performed a heat island analysis to ascertain the areas of Salem that are most at risk to extreme heat. A heat island is defined as an area whose temperature ranges more than 1.8-.5.4˚ F greater during the daytime or up to 22˚ F greater in the evening than the surrounding areas. MAPC used LANDSAT satellite imagery at 30 m resolution to ascertain land surface temperatures during the daytime in the warmest months of 2016. This analysis is shown in Map 10 in Appendix A. The hottest 5% areas, or "hot spots," generally follow the Washington Street and Canal Street corridors in downtown Salem, as well as the commercial area along parts of Highland Avenue (Rt. 107). Map 10 also shows the range of tree cover across the City. Areas with higher tree coverage are the coolest areas on the heat island map, showing the clear benefits of trees to mitigate extreme heat. The greatest amount of tree cover is in the area of Highland Park and in the southern part of Salem along the borders with Lynn and Swampscott.

Extreme Temperatures and Climate Change

Global temperatures increased by nearly 2 degrees in the last century and even small changes in temperature have widespread and significant changes to our climatic system. For example, the northeast has experienced a 10-day increase in the growing season in since 1980.

Extreme cold events are predicted to decrease in the future, while extreme heat is projected to increase. Future temperature projections for the Boston Harbor watershed are shown below (Table 19). The projections show an increase in average temperatures and an increasing likelihood of heat waves, as indicated by the increased number of days over 90 and 100 degrees each year.

Table 20. Projected Temperature Change for the Boston Harbor Watershed

Temperature (F°)	Observed Baseline 1971-2000	Projected 2020-2049	Projected 2040-2069	Projected 2060-2089	Projected 2080-2099
Annual temperature	50°	52-54°	53-56°	53-59°	54-61°
Days over 90 ° (days/year)	8	13-23	16-37	17-57	19-75
Days over 100 °(days/year)	0.05	.29-2	.37-4	.52-9	.60-16

The projected increase in extreme heat and heat waves is the source of one of the key health concerns related to climate change. Prolonged exposure to high temperatures can cause heat- related illnesses, such as heat cramps, heat exhaustion, heat stroke, and death. Heat exhaustion is the most common heat-related illness and if untreated, it may progress to heat stroke. People who perform manual labor, particularly those who work outdoors, are at increased risk for heat- related illnesses. Prolonged heat exposure and the poor air quality and high humidity that often accompany heat waves can also exacerbate pre-existing conditions, including respiratory illnesses, cardiovascular disease, and mental illnesses.

The senior population is often at elevated risk due to a high prevalence of pre-existing and chronic conditions. People who live in older housing stock (as is often the case with public housing), and in housing without air conditioning have increased vulnerability to heat-related illnesses.

Power failures are more likely to occur during heat waves, affecting the ability of residents to remain cool during extreme heat. Individuals with pre-existing conditions and those who require electric medical equipment may be at increased risk during a power outage.

Drought

Drought is a temporary irregularity in precipitation and differs from aridity since the latter is restricted to low rainfall regions and is a permanent feature of climate. Drought is a period characterized by long durations of below normal precipitation. Drought conditions occur in virtually all climatic zones yet its characteristics vary significantly from one region to another, since it is relative to the normal precipitation in that region. Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life.

In Massachusetts, droughts are caused by the prevalence of dry northern continental air and a decrease in coastal- and tropical-cyclone activity. During the 1960's, a cool drought occurred because dry air from the north caused lower temperatures in the spring and summer of 1962-65. The northerly winds drove frontal systems to sea along the Southeast Coast and prevented the Northeastern States from receiving moisture (U.S. Geological Survey). This is considered the drought of record in Massachusetts.

Average annual precipitation in Massachusetts is 44 inches per year, with approximately 3 to 4 inch average amounts for each month of the year. Regional monthly precipitation ranges from zero to 17 inches. Statewide annual precipitation ranges from 30 to 61 inches. Thus, in the driest calendar year (1965), the statewide precipitation total of 30 inches was 68 percent of average.

Although Massachusetts is relatively small, it has a number of distinct regions that experience significantly different weather patterns and react differently to the amounts of

precipitation they receive. The DCR precipitation index divides the state into six regions: Western, Central, Connecticut River Valley, Northeast, Southeast, and Cape and Islands. Salem is located in the Northeast Region. In Salem drought is a potential City-wide hazard.

Five levels of drought have been developed to characterize drought severity: Normal, Advisory, Watch, Warning, and Emergency. These drought levels are based on the conditions of natural resources and are intended to provide information on the current status of water resources. The levels provide a basic framework from which to take actions to assess, communicate, and respond to drought conditions. They begin with a normal situation where data are routinely collected and distributed, move to heightened vigilance with increased data collection during an advisory, to increased assessment and proactive education during a watch. Water restrictions might be appropriate at the watch or warning stage, depending on the capacity of each individual water supply system. A warning level indicates a severe situation and the possibility that a drought emergency may be necessary. A drought emergency is one in which mandatory water restrictions or use of emergency supplies is necessary. Drought levels are used to coordinate both state agency and local response to drought situations.

As dry conditions can have a range of different impacts, a number of drought indices are available to assess these various impacts. Massachusetts uses a multi-index system that takes advantage of several of these indices to determine the severity of a given drought or extended period of dry conditions. Drought level is determined monthly based on the number of indices which have reached a given drought level. Drought levels are declared on a regional basis for each of six regions in Massachusetts. County by county or watershed-specific determinations may also be made.

A determination of drought level is based on seven indices:

1. Standardized Precipitation Index (SPI) reflects soil moisture and precipitation.
2. Crop Moisture Index: (CMI) reflects soil moisture conditions for agriculture.
3. Keetch Byram Drought Index (KBDI) is designed for fire potential assessment.
4. Precipitation Index is a comparison of measured precipitation amounts to historic normal precipitation.
5. The Groundwater Level Index is based on the number of consecutive month's groundwater levels are below normal (lowest 25% of period of record).
6. The Stream flow Index is based on the number of consecutive months that stream flow levels are below normal (lowest 25% of period of record).
7. The Reservoir Index is based on the water levels of small, medium and large index reservoirs across the state, relative to normal conditions for each month.

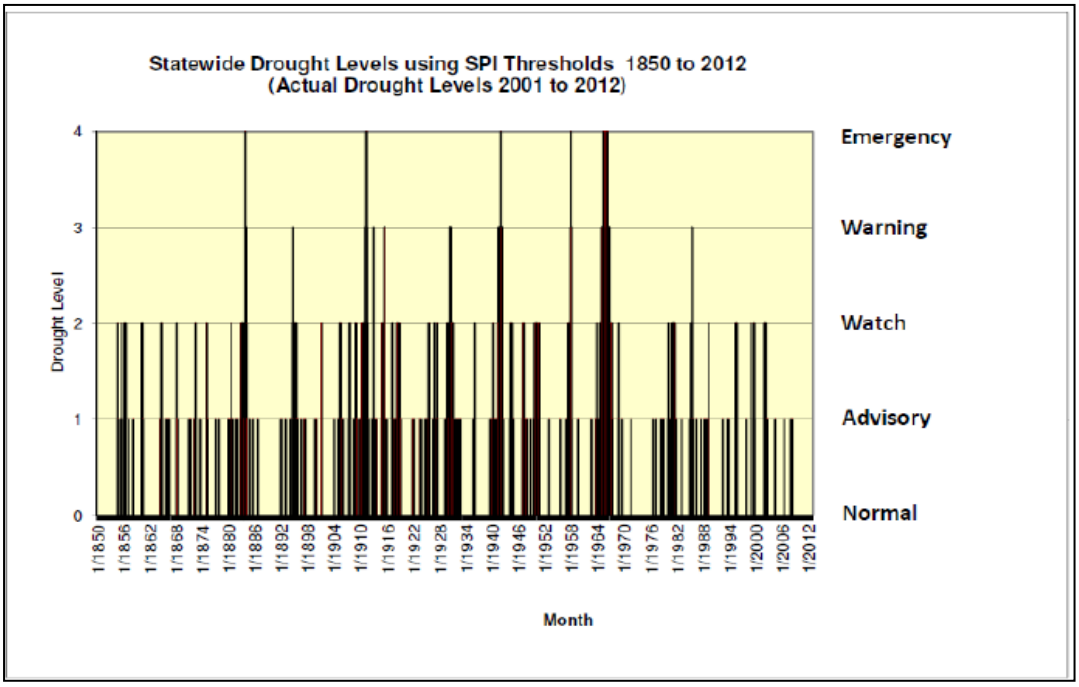
Determinations regarding the end of a drought or reduction of the drought level focus on two key drought indicators: precipitation and groundwater levels. These two factors have the greatest long-term impact on stream flow, water supply, reservoir levels, soil moisture and potential for forest fires.

Previous Occurrences

Salem does not collect data relative to drought events. Because drought tends to be a regional natural hazard, this plan references state and county data as the best available data for drought. The statewide scale is a composite of six regions of the state. Regional composite precipitation values are based on monthly values from six stations, and three stations in the smaller regions (Cape Cod/Islands and West).

Figure 7 depicts the incidents of drought levels' occurrence in Massachusetts from 1850 to 2012 using the Standardized Precipitation Index (SPI) parameter alone. On a monthly basis, the state would have been in a Drought Watch to Emergency condition 11 percent of the time between 1850 and 2012. Table 21 summarizes the chronology of major droughts from 1929 to 2018.

Figure 7 - Statewide Drought Levels using SPI Thresholds



(Source: Mass. State Drought Management Plan

Drought Emergency

Drought emergencies have been reached infrequently, with 5 events occurring in the period between 1850 and 2012: in 1883, 1911, 1941, 1957, and 1965-1966. The 1965-1966 drought period is viewed as the most severe drought to have occurred in modern times in Massachusetts because of its long duration. On a monthly basis over the 162-year period of record, there is a one percent chance of being in a drought Emergency.

Table 21 - Chronology of Major Droughts in Massachusetts

Date	Area affected	Recurrence interval (years)	Remarks
1929-32	Statewide	10 to >50	Water-supply sources altered in 13 communities. Multistate.
	Statewide	15 to >50	More severe in eastern and extreme western Massachusetts. Multistate.
1957-59	Statewide	5 to 25	Record low water levels in observation wells, northeastern Massachusetts.
1961-69	Statewide	35 to >50	Water-supply shortages common. Record drought. Multistate.
1980-83	Statewide	10 to 30	Most severe in Ipswich and Taunton River basins; minimal effect in Nashua River basin. Multistate.
1985-88	Housatonic River basin	25	Duration and severity unknown. Streamflow showed mixed trends elsewhere.
2016	Statewide	N/A	Drought declaration began in July 2016 with a Drought Watch, which was upgraded to a Drought Warning in August 2016. The Central and Northeast regions were the most severely affected.

Source: Mass. Drought Management Plan

Drought Warning

Drought Warning levels not associated with drought Emergencies have occurred five times, in 1894, 1915, 1930, and 1985, and 2016. On a monthly basis over the 162-year period of record, there is a two percent chance of being in a drought Warning level.

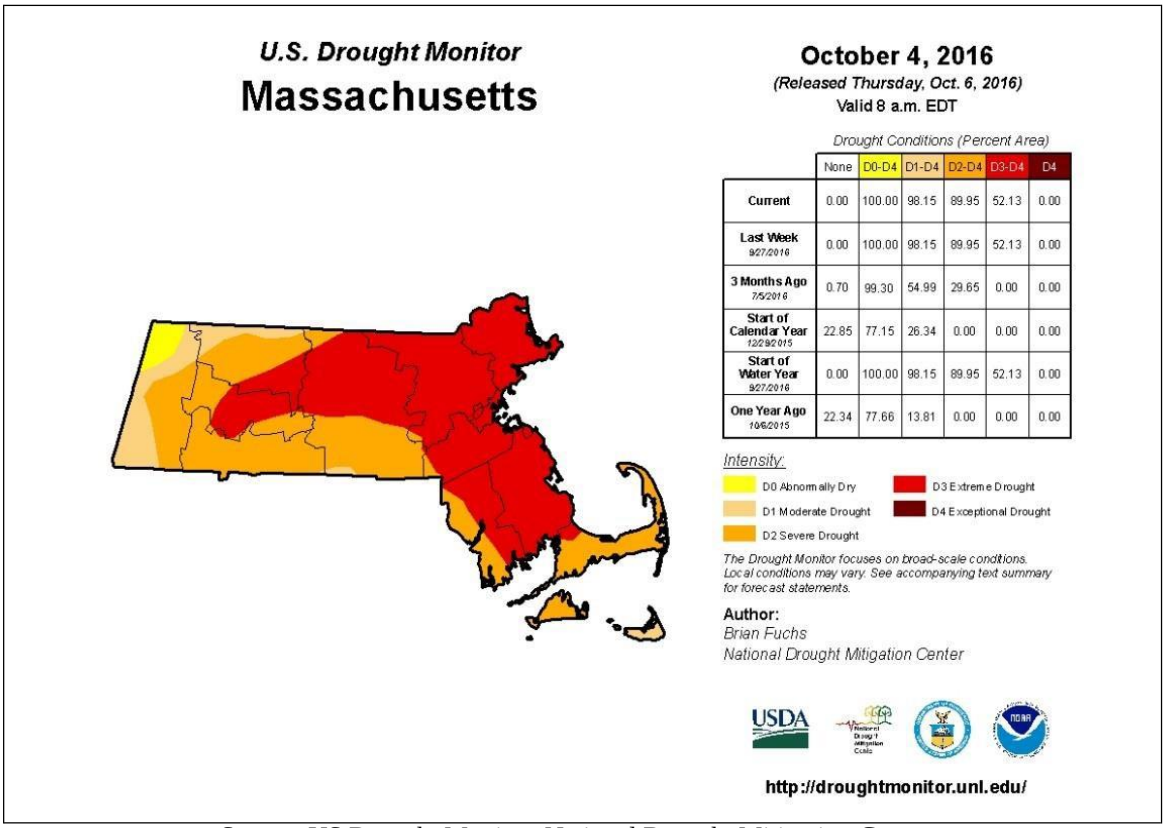
Drought Watch

Drought Watches not associated with higher levels of drought generally have occurred in three to four years per decade between 1850 and 1950. In the 1980s, there was a lengthy drought Watch level of precipitation between 1980 and 1981, followed by a drought Warning in 1985. A frequency of drought Watches at a rate of three years per decade resumed in the 1990s (1995, 1998, 1999). In the 2000s, Drought Watches occurred in 2001 and 2002. The overall frequency of being in a Drought Watch is 8 percent on a monthly basis over the 162-year period of record.

Drought of 2016

The most significant recent drought in Massachusetts occurred in 2016 (Figure 8). On July 8, 2016, following four continuous months of unusually dry weather, Massachusetts Energy and Environmental Affairs (EEA) Secretary Matthew Beaton declared a Drought Watch for Central and Northeast Massachusetts, which includes the City of Salem, and a Drought Advisory for Southeast Massachusetts and the Connecticut River Valley. In August 2016 the Northeast Region was upgraded to a Drought Warning. As of January 1, 2017, four of the six statewide regions in Massachusetts were listed in Drought Warning, the second highest drought stage, and the Northeast Region was listed in the third-ranked Drought Watch stage. By June 1, 2017 all areas of the state were listed as being in a normal condition.

Figure 8: Drought Conditions in Massachusetts, October 2016



Source: US Drought Monitor, National Drought Mitigation Center

Data on drought occurrences for Essex County, is available through the National Centers for Environmental Information. From 1995 – 2019, there have been a total of 8 months of drought events, with no reported deaths, no injuries, and no property damage resulting from drought (see Table 22).

Table 22 – Essex County Drought Occurrences 1995- December, 2019

Date	Type	Deaths	Injuries	Damage-$
4/12/2012	Drought	0	0	0
7/5/2016	Drought	0	0	0
8/1/2016	Drought	0	0	0
9/1/2016	Drought	0	0	0
10/1/2016	Drought	0	0	0
11/1/2016	Drought	0	0	0
12/1/2016	Drought	0	0	0
1/1/2017	Drought	0	0	0

Source: NOAA, National Centers for Environmental Information

Under a severe long term drought the Salem drinking water supply, through the Beverly and Salem Water District, could be vulnerable to restrictions on water supply. Potential damages of a severe drought could include losses of landscaped areas if outdoor watering is restricted and potential loss of business revenues if water supplies were severely restricted for a prolonged period. As this hazard has never occurred in Salem, there are no data or estimates of potential damages, but under a severe drought scenario it would be reasonable to expect a range of potential damages from several million to tens of millions of dollars. However, given the resilience of the MWRA water system due to its large amount of storage in the Quabbin and Wachusett Reservoirs, (equivalent to five years of water demand), severe impacts on the City is unlikely. For example, even during the multi-year drought of record in the 1960s, there were no severe limitations of supply from the regional water system, which at the time was operated by the Metropolitan District Commission.

Probability of Future Occurrences

The state has experienced Emergency Droughts five times between 1850 and 2012. Even given that regional drought conditions may occur at a different interval than state data indicates, droughts remain primarily regional and state phenomena in Massachusetts. Emergency Drought conditions over the 162 period of record in Massachusetts are a Low Frequency natural hazard event that can occur from once in 50 years to once in 100 years (1% to 2% chance per year), as defined by the Massachusetts State Hazard Mitigation Plan.

Impacts of Climate Change

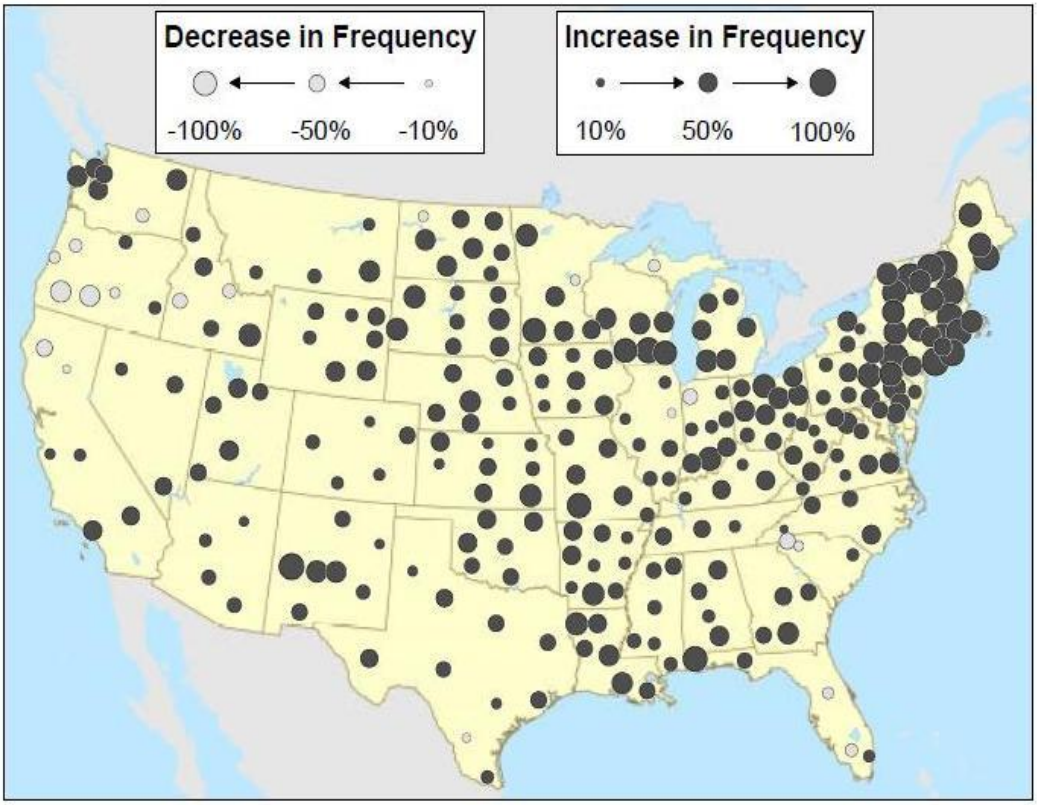
Many of the natural hazards that Salem has historically experienced are likely to be exacerbated by climate change in future years. This is particularly true for flooding caused by extreme precipitation and extreme heat. These are described in more detail below.

Climate Change Impacts: Extreme Precipitation

Salem's average annual precipitation is 47 inches. While total annual precipitation has not changed significantly, according to the 2012 report *When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation from 1948 to 2011* intense rainstorms and snowstorms have become more frequent and more severe over the last half century in the northeastern United States**.** Extreme downpours are now happening 30 percent more often nationwide than in 1948 (see Figure 9). In other words, large rain or snow storms that happened once every 12 months, on average, in the middle of the 20th century, now happen every nine months.

Not only are these intense storm events more frequent, they are also more severe: the largest annual storms now produce 10 percent more precipitation, on average, than in 1948. In particular, the report finds that New England has experienced the greatest change with intense rain and snowstorms occurring 85 percent more often than in 1948.

Figure 9- Changes in Frequency of Extreme Downpours, 1948 – 2011



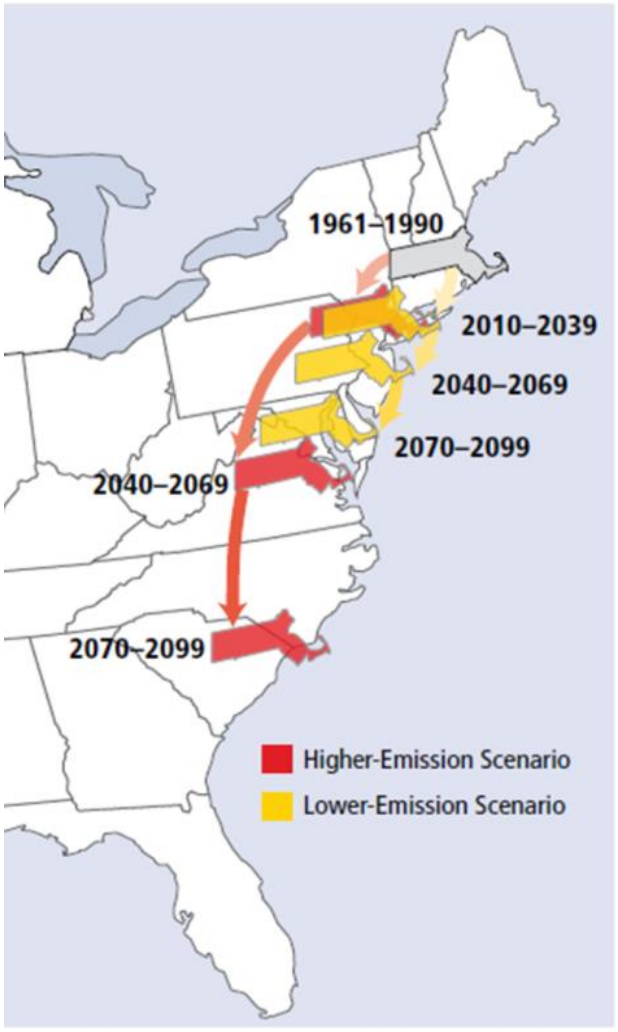
Source: *When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation,* Environment America Research and Policy Center, July 2012

At the other extreme, changes in precipitation patterns and the projected future rising temperatures due to climate change (discussed below) will likely increase the frequency of short-term (one- to three-month) droughts and decrease stream flow during the summer.

Climate Change Impacts: Extreme Heat

Recent temperature trends suggest greater potential impacts to come due to climate change. In the report "Confronting Climate Change in the U.S. Northeast," (2007), the Union of Concerned Scientists presented temperature projections to 2099 based on two scenarios, one with lower carbon dioxide emissions, and the other with high emissions.

Figure 10 – Mass. Extreme Heat Scenarios



Source: Union of Concerned Scientists

Between 1961 and 1990, Boston experienced an average of 11 days per year over 90°F. That could triple to 30 days per year by 2095 under the low emissions scenario, and increase to 60 days per year under the high emissions scenario. Days over 100°F could increase from the current average of one day per year to 6 days with low emissions or 24 days with high emissions By 2099, Massachusetts could have a climate similar to Maryland's under the low emissions scenario, and similar to the Carolinas' with high emissions (Figure 10). Furthermore, the number of days with poor air quality could quadruple in Boston by the end of the 21st century under higher emissions scenario, or increase by half under the lower emissions scenario. These extreme temperature trends could have significant impacts on public health, particularly for those individuals with asthma and other respiratory system conditions, which typically affect the young and the old more severely.

Land Use and Development Trends

Existing Land Use

The most recent land use statistics available from the state are from aerial photography done in 2005. Table 23 shows the acreage and percentage of land in 30 categories. If the five residential categories are aggregated, residential uses make up 33.19 % of the area of the City (5,374.35) acres). The highest percentage single use is forested lands which comprise 23.79 %, 1278.86 acres.

Table 23- Salem Land Use, 2005

Land Use Type	Acres	Percent
Pasture	8.85	0.16
Forest	1278.86	23.79
Wetland	157.11	2.92
Mining	50.80	0.94
Open Land	146.63	2.73
Participation Recreation	119.64	2.22
Spectator Recreation	1.06	0.02
Water-based Recreation	2.52	0.05
Multifamily Residential	757.03	14.08
High Density Residential	786.80	14.64
Medium Density Residential	192.77	3.59
Low Density Residential	47.12	0.88
Very Low Density Residential	30.29	0.56
Saltwater Wetland	48.37	0.90
Commercial	403.34	7.50
Industrial	219.65	4.09
Urban Open	2.93	0.05
Transportation	47.0	0.87
Waste Disposal	16.75	0.31
Water	76.20	1.42
Power line	49.24	0.92
Saltwater Beach	50.98	0.95
Golf Course	189.50	3.53
Marina	5.93	1.10
Urban Public	252.09	4.69
Cemetery	165.70	3.08
Nursery	1.02	0.02
Forested Wetland	127.78	2.38
Junkyards	15.68	0.29
Brush land/Succession	74.34	1.38
Total	**5,374.35**	**100**

Source: Mass. GIS

For more information on how the land use statistics were developed and the definitions of the categories, please go to http://www.mass.gov/mgis/lus.htm.

Description and Economic Elements

While Salem does not have a quantitative measure of the impact of specific businesses, industries, or areas on its local economic conditions, there are several economic drivers within the City that face potential damage during a coastal natural hazard flooding event. These are the businesses located along the waterfront, most especially in the Derby Street, Bridge Street, Fort Avenue and Shetland Industrial Park areas.

Historic, Cultural, and Natural Resource Areas

Salem, the "City of Peace", is a small city with a big history. Founded in 1626 by Roger Conant, Salem has a rich history that includes a key role in the spice trade with the East Indies and is the home of the infamous Salem Witchcraft Trials of 1692. Salem Common is the site of the country's first muster (1637), the birthplace of the National Guard. Salem is the second incorporated city in Massachusetts (April, 1836) and the second oldest settlement in New England (settled four years before the settlement of Boston). In Salem, the birthplace of celebrated author Nathaniel Hawthorne, you will find mansions of some of the country's first millionaires. Notable historic resources include Fort Lee, Fort Pickering, Baker's Island Light Station, Judge Jonathan Corwin House (the Witch House), Pioneer Village, Salem Maritime National Historic Site (where you can visit the *Friendship,* a reconstructed merchant ship) and the House of the Seven Gables. The Peabody Essex Museum also boasts several historic homes in their museum neighborhood.

Located in the Essex National Heritage Area, Salem has a long tradition of community-wide preservation efforts. It was one of the first Massachusetts' communities to establish a local historic district, creating its first district in 1971. There are currently 4 local historic districts, comprising over 600 properties. There are 45 properties and districts listed on the National Register of historic places, (including 8 National Historic Landmarks) and over 4000 inventoried properties (the third highest in the Commonwealth).

Salem Woods, Forest River Conservation Area and Park, Winter Island Park, and Salem Willows Park stand out as breathtaking natural resources and good examples of the City's shoreline resources, but other parks include Mack Park and the Salem Common.

Development Trends

Salem conforms to the historic pattern of settlement on the North Shore: coastal lowlands and lowland valleys first, river basins second and uplands last. After World War II, Salem's population had already passed its peak and residential development pressures were not strong enough to overcome the high cost of development in the ledge- and marsh-filled southern part of the City. In the center-west part of the City, the Witchcraft

Heights subdivision was built in the 1960s and in the southeast the Pickman Park subdivision appeared in the 1970s.

When the first urban renewal plan began in the 1970s with the demolition of several historic buildings, citizen outcry redirected the process towards adaptive reuse and infill projects. The Essex Street pedestrian mall and the Pickering Wharf complex were products of the downtown revitalization movement of the 1970s.

The regional real estate boom of the late 1970s and the 1980s fueled limited residential and commercial growth in Salem. The existing commercial development along Highland Avenue and Loring Avenue expanded, attracting shoppers who formerly patronized downtown stores. New infill condominium developments and condominium conversions of existing buildings proliferated in the already built-up parts of the City. In addition, new condominium complexes in South Salem were built off Highland Avenue and Loring Avenue.

Infill development has continued in recent years as Salem has seen the influx of many new residents from Boston seeking affordable housing and a lower cost of living. These residents tend to be younger, want more value for their dollar, and are willing to commute to Boston via car, train, bus, or ferry. MAPC predicts the population of Salem will grow 20 percent above its 1990 level by the year 2030. The consequences of this may be enormous in scope because Salem has limited land available for development and it needs to balance development pressures and preservation of open space. According to MassGIS, between 1985 and 1999 Salem saw an increase in multi-family residential acres (68%), high density residential areas (.5%), medium density residential acres (13%), and commercial acres (7%). Forested acreage (already limited) decreased 13 percent, and wetland acreage stayed the same. *(Salem Open Space and Recreation Plan, 2007-2012)*

Largely built out and one of the more densely populated communities in Massachusetts, Salem's economy is strongly linked to tourism, a large share of its local employment is in service industries, municipal and State government, health care, and education. The city's largest employers include the City of Salem, North Shore Medical Center, Salem State University, the Peabody Essex Museum, and Salem Five Savings Bank, all of which offer competitive jobs and whose employees and patrons support many of the city's smaller businesses. Salem also maintains an extensive legal community, including both governmental and private institutions. The Essex County Registry of Deeds and the District Attorney's Office are located in Salem, as well as the District, Superior, Juvenile, and Probate Courts. The completion of the J. Michael Ruane Judicial Center in 2011 will result in an expansive courts complex consisting of a new 190,000 square foot facility adjacent to the existing Probate and Family Court/Registry of Deeds building. However, the Registry of Deeds relocated to the Shetland Industrial Park. *(2010 Salem Consolidated Plan)*

Recent and Potential Future Development

MAPC consulted with City staff to determine areas that have been recently developed or may be developed in the future, based on the City's comprehensive planning efforts and current trends and projects. These areas are shown in Table 24 below.

In order to characterize any change in the City's vulnerability associated with new developments, a GIS mapping analysis was conducted which overlaid the development sites with the FEMA Flood Insurance Rate Map. The analysis shows that none of the sites are located in a flood hazard zone (Table 25). All of the developments are in the areas defined as "Low Landslide Incidence." None of the developments are in locally identified areas at high risk for brush fires. Other hazards are categorized at the same level throughout City. With respect to wind, there is no variation across different sites in the City; the hazard map depicts the entire City of Salem within a 100-year wind speed of 110 miles per hour. (See hazard maps in Appendix A).

Table 24- Summary of Built Salem Developments 2013-2019

Developments Completed 2012-2019	**Acres**	**Housing Units**	**Project Type**
Strongwater Crossing	142	131	Residential subdivision being built in 10 phases.
The Woodlands	36	11	Residential subdivision,11 single family homes
Witch Hill Subdivision	43	23	Residential subdivision,23 single family homes
Total	**221**	**165**	

Table 25- Relationship of Recent and Potential Development to Hazard Areas

Parcel	**Landslide risk**	**Flood Zone**	**Brush Fire Area**
Strongwater Crossing	Low incidence	No	No
The Woodlands	Low incidence	No	No
Witch Hill Subdivision	Low incidence	No	No

Critical Infrastructure in Hazard Areas

Critical infrastructure includes facilities that are important for disaster response and evacuation (such as emergency operations centers, fire stations, water pump stations, etc.) and facilities where additional assistance might be needed during an emergency (such as nursing homes, elderly housing, day care centers, etc.). There are 180 facilities identified in Salem. These are listed in Table 26 and are shown on the maps in Appendix A.

Explanation of Columns in Table 26

Column 1: ID #: The first column in Table 10 is an ID number which appears on the maps that are part of this plan. See Appendix B.

Column 2: Name: The second column is the name of the site. If no name appears in this column, this information was not provided to MAPC by the community.

Column 3: Landslide Risk The fourth column indicates the degree of landslide risk for that site. This information came from NESEC. The landslide information shows areas with either a low susceptibility or a moderate susceptibility to landslides based on mapping of geological formations. This mapping is highly general in nature. For more information on how landslide susceptibility was mapped, refer to http://pubs.usgs.gov/pp/p1183/pp1183.html.

***Column 4: FEMA Flood Zone*:** The fourth column addresses the risk of flooding. A "No" entry in this column means that the site is not within any of the mapped risk zones on the Flood Insurance Rate Maps (FIRM maps). If there is an entry in this column, it indicates the type of flood zone. as follows:

Zone AE (1% annual chance) - Zones AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by detailed methods. Mandatory flood insurance purchase requirements apply.

Zone VE (1% annual chance) - Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone X (.2% annual chance) - Zones X is the flood insurance rate zone that corresponds to the 500-year floodplains.

Column 5: ***Locally-Identified Area of Flooding*:** The fifth column indicates the risk of flooding in local hazard areas. A "No" entry in this column means that the site is not within any of the mapped flood hazard zones. If there is an entry in this column, it indicates the local hazard area.

Column 6: Brush Fire Area: The sixth column indicates the risk of brush fire in local hazard areas. A "No" entry in this column means that the site is not within any of the mapped brush fire hazard zones. If there is an entry in this column, it indicates the local hazard area.

Table 26- Critical Infrastructure in Hazard Areas

Map ID	Name	Landslides	Within FEMA Flood Zone	Within Locally Identified Area of Flooding	Within Brush Fire Area	Within Hot Spot	Inundated by 3ft Sea Level Rise
1	Dominion Energy Salem Harbor Station	Low incidence	No	No	No	No	No
2	Keyspan Energy Delivery	Low incidence	X: 0.2% Annual Chance of Flooding	No	No	No	No
3	Veterans Memorial Bridge	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	Yes
4	B&M Tunnel	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
5	South Essex Sewage District	Low incidence	No	No	No	No	No
6	Salem Police Dept	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
7	Salem Fire Dept	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	Yes	No
8	Cingular Wireless Cell Tower	Low incidence	No	Walmart Parking Lot	No	No	No
9	AT&T Broadband Tower	Low incidence	No	Walmart Parking Lot	No	No	No
10	DPW Headquarters	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	Yes	No
11	Salem Municipal Pool	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	Yes

Table 26- Critical Infrastructure in Hazard Areas

Map ID	Name	Landslides	Within FEMA Flood Zone	Within Locally Identified Area of Flooding	Within Brush Fire Area	Within Hot Spot	Inundated by 3ft Sea Level Rise
12	Kernwood Bridge	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	Yes
13	Mass Electric Substation #2	Low incidence	No	No	No	No	No
14	Mass Electric Substation #3	Low incidence	No	No	No	No	No
15	Mass Electric Substation #4	Low incidence	No	No	No	No	No
16	Mass Electric Substation #5	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
17	Mass Electric Substation #6	Low incidence	No	No	No	No	No
18	Mass Electric Substation #7	Low incidence	No	No	No	No	No
19	Mass Electric Substation #8	Low incidence	X: 0.2% Annual Chance of Flooding	No	No	No	No
20	Mass Electric Substation #1	Low incidence	No	No	No	No	No
21	City Hall	Low incidence	No	No	No	Yes	No
22	City Hall Annex	Low incidence	No	No	No	Yes	No
23	Park And Rec Head Quarters	Low incidence	No	No	No	No	No
24	Railroad Tracks	Low incidence	No	No	No	No	No
25	North River	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	Yes
26	Forest River Beach	Low incidence	VE: High Risk Coastal Area	No	No	No	Yes

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
27	Waikiki Beach	Low incidence	VE: High Risk Coastal Area	No	No	No	Yes
28	Willows Pier Beach	Low incidence	VE: High Risk Coastal Area	No	No	No	Yes
29	Dead Horse Beach	Low incidence	VE: High Risk Coastal Area	No	No	No	Yes
30	Collins Cove		VE: High Risk Coastal Area	No	No	No	Yes
31	Steps Beach	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	Columbus Avenue @Willows Park	No	No	Yes
32	Bates Elementary School	Low incidence	No	No	No	No	No
33	St Joseph Elementary School	Low incidence	No	No	No	No	No
34	Pequot Highland Apts.	Low incidence	No	No	No	No	No
35	Salem State College Academic Bldg.	Low incidence	No	No	No	No	No
36	Colonial Terrace	Low incidence	No	No	No	No	No
37	Phillips House	Low incidence	No	No	No	No	No
38	Salem YMCA Afterschool Day Care Location	Low incidence	No	No	No	Yes	No
39	Fairweather Apartments	Low incidence	No	No	No	No	No
40	Little Darlings Preschool	Low incidence	No	No	No	No	No
41	Kiddie Koop Day Care	Low incidence	No	No	No	No	No
42	John Berthram House	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
43	Witchcraft Elementary School	Low incidence	No	No	No	No	No
44	Salem State College Alumni House	Low incidence	No	No	No	No	No
45	Run-a-muck Child Care Center	Low incidence	No	No	No	No	No
46	Norton Terrace	Low incidence	No	No	No	No	No
47	Salem State College O'keefe Ctr.	Low incidence	No	Canal Street	No	Yes	No
48	Horace Mann Laboratory School	Low incidence	No	No	No	No	No
49	Salem State College Preschool Program.	Low incidence	No	No	No	No	No
50	Grosvenor Park Nursing Center	Low incidence	No	No	No	No	No
51	Plumber Home For Boys	Low incidence	No	No	No	No	No
52	Brookhouse Home	Low incidence	No	No	No	No	No
53	Leefort Terrace	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
54	Salem Housing Authority	Low incidence	No	No	No	Yes	No
55	Morency Manor	Low incidence	No	No	No	Yes	No
56	Salem State College, Peabody Hall	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
57	Salem State College, Meier Hall	Low incidence	No	No	No	No	No
58	Boys & Girls Fun Club	Low incidence	No	No	No	No	No
59	Bates Terrace	Low incidence	No	No	No	No	No
60	House Of Seven Gables Preschool	Low incidence	No	No	No	No	No
61	Salem State College - Sullivan Bldg.	Low incidence	No	No	No	No	No
62	Linden St. Apt.	Low incidence	No	No	No	No	No
63	Dalton Housing	Low incidence	No	No	No	Yes	No
64	Salem State College Admin Office	Low incidence	No	No	No	No	No
65	Pioneer Terrace	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
66	Salem State College Bates Town House	Low incidence	No	No	No	No	No
67	Salem Heights Apts.	Low incidence	No	No	No	No	No
68	J. Michael Ruane	Low incidence	No	No	No	No	No
69	Kinder Care Learning Center #668	Low incidence	No	No	No	No	No
70	Green House School	Low incidence	No	No	No	No	No
71	The Essex Condominium	Low incidence	No	No	No	Yes	No
72	Bertram Terrace	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
73	Salem Housing Authority Office & Res.	Low incidence	No	No	No	No	No
74	Carlton Innovation School	Low incidence	No	No	No	No	No
75	Nathaniel Bowditch School	Low incidence	No	No	No	No	No
76	Henny Penny Nursery School	Low incidence	No	No	No	No	No
77	Salem Community Child Care	Low incidence	No	No	No	No	No
78	Northshore Head Start	Low incidence	No	No	No	No	No
79	Salem State College Harrington Bldg.	Low incidence	No	No	No	No	No
80	Crombie St. Church/Salem Mission	Low incidence	No	No	No	Yes	No
81	Salem State College, Food Court	Low incidence	No	No	No	No	No
82	Salem State College, Ellison Ctr.	Low incidence	No	No	No	No	No
83	Salem YMCA Children's Corner Location 2	Low incidence	No	No	No	Yes	No
84	Salem Hospital	Low incidence	No	No	No	Yes	No
85	Loring Towers	Low incidence	No	No	No	No	No
86	Salem State College, Bowditch Hall	Low incidence	No	Canal Street	No	No	No
87	Puddle Jumpers	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
88	Bentley Elementary School	Low incidence	No	No	No	No	No
89	The Phoenix School	Low incidence	No	No	No	Yes	No
90	Salem State College Library	Low incidence	No	No	No	No	No
91	Stephen Zisson	Low incidence	No	No	No	Yes	No
92	North Shore Head Start	Low incidence	No	No	No	No	No
93	North Shore Infant Toddler Developmental	Low incidence	No	No	No	No	No
94	Young World Nursery School	Low incidence	No	No	No	Yes	No
95	Salem Council Aging	Low incidence	No	No	No	No	No
96	Salem Traffic Control Point	Low incidence	No	No	No	No	No
97	Salem Traffic Control Point	Low incidence	No	No	No	No	No
98	Salem Traffic Control Point	Low incidence	No	No	No	No	No
99	Salem Traffic Control Point	Low incidence	No	No	No	No	No
100	Salem Traffic Control Point	Low incidence	No	No	No	No	No
101	Salem Traffic Control Point	Low incidence	No	No	No	No	No
102	Salem Traffic Control Point	Low incidence	No	No	No	Yes	No
103	Salem Traffic Control Point	Low incidence	No	No	No	No	No
104	Salem High	Low incidence	No	No	No	Yes	No
105	Collins Middle	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
106	Saltonstall School	Low incidence	No	No	No	No	No
107	Fire Station # 4	Low incidence	No	No	No	No	No
108	Northshore Community Health Inc.	Low incidence	No	No	No	No	No
109	Fire Station # 5	Low incidence	No	Canal Street	No	No	No
110	Shaughnessy-Kaplan Rehab Hospital	Low incidence	No	No	No	No	No
111	Fire Station # 2	Low incidence	No	No	No	No	No
112	Pioneer Beach		VE: High Risk Coastal Area	No	No	No	Yes
113	Blaney St. Ferry Dock		VE: High Risk Coastal Area	No	No	No	Yes
114	Broad St. Cemetery	Low incidence	No	No	No	No	No
115	CVS Pharmacy	Low incidence	No	No	No	No	No
116	CVS Pharmacy	Low incidence	No	No	No	Yes	No
117	CVS Pharmacy	Low incidence	No	No	No	Yes	No
118	Charter St. Cemetery	Low incidence	No	No	No	No	No
119	Elementary School, Horace Mann Laboratory	Low incidence	No	No	No	No	No
120	Essex Institute Museum	Low incidence	No	No	No	Yes	No
121	Full-Spychalski Funeral Home	Low incidence	No	No	No	No	No
122	Gonet Funeral Home	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
123	Greenlawn Cemetery	Low incidence	No	No	No	No	No
124	Hamilton Hall	Low incidence	No	No	No	No	No
125	Harmony Grove Cemetery	Low incidence	No	No	No	No	No
126	Hawthorne Commons	Low incidence	No	No	No	No	No
127	Crosby's Market	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	Canal Street	No	No	No
128	District Court	Low incidence	No	No	No	Yes	No
129	Salem State College International House (SC)	Low incidence	No	No	No	No	No
130	Salem State College Police Station (CC)	Low incidence	No	No	No	No	No
131	Salem State College Preschool Program (SC)	Low incidence	No	No	No	No	No
132	Salem Waterfront Hotel	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
133	Salem Witch Museum	Low incidence	No	No	No	No	No
134	Salem-Beverly Railroad Bridge		AE: 1% Annual Chance of Flooding; with BFE	No	No	No	Yes
135	Shaw’s Supermarket	Low incidence	No	No	No	Yes	No
136	Small Fry Nursery School	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
137	Southern Essex County Registry of Deeds	Low incidence	No	No	No	No	No
138	Stanetsky Funeral Home	Low incidence	No	No	No	No	No
139	Superior Court	Low incidence	No	No	No	Yes	No
140	TCP - Washington St. & Bridge St.	Low incidence	No	No	No	No	No
141	The Phoenix School	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	Yes	No
142	Thermal Circuits	Low incidence	No	No	No	No	No
143	US Custom House	Low incidence	No	No	No	No	No
144	Univar USA Inc.	Low incidence	No	No	No	No	No
145	US Post Office	Low incidence	No	No	No	No	No
146	Verizon Telephone Exchange	Low incidence	No	No	No	Yes	No
147	Market Basket	Low incidence	No	No	No	Yes	No
148	Murphy Funeral Home	Low incidence	No	No	No	No	No
149	Hawthorne Cove Marina	Low incidence	VE: High Risk Coastal Area	No	No	No	No
150	Hawthorne Hotel	Low incidence	No	No	No	No	No
151	Home Depot	Low incidence	No	No	No	Yes	No
152	Juvenile Court	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas							
Map ID	**Name**	**Landslides**	**Within FEMA Flood Zone**	**Within Locally Identified Area of Flooding**	**Within Brush Fire Area**	**Within Hot Spot**	**Inundated by 3ft Sea Level Rise**
153	Levesque Funeral Home	Low incidence	No	No	No	No	No
154	Lincoln Hotel	Low incidence	No	No	No	Yes	No
155	O'Donnell Funeral Home	Low incidence	No	No	No	No	No
156	Peabody Essex Museum	Low incidence	No	No	No	Yes	No
157	Perkin Elmer	Low incidence	No	No	No	No	No
158	Pickering Wharf Marina	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
159	Probate Court	Low incidence	No	No	No	Yes	No
160	Puddle Jumpers	Low incidence	No	No	No	No	No
161	Saint Mary's Cemetery	Low incidence	No	No	No	No	No
162	Salem Access Television	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
163	Salem Athenaeum	Low incidence	No	No	No	No	No
164	Salem Fire Department	Low incidence	No	No	No	No	No
165	Salem Mission	Low incidence	No	No	No	Yes	No
166	Salem Public Library	Low incidence	No	No	No	No	No
167	Salem State College Admissions (NC)	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	Yes	No
168	Salem State College Affirmative	Low incidence	No	No	No	No	No

Table 26- Critical Infrastructure in Hazard Areas

Map ID	Name	Landslides	Within FEMA Flood Zone	Within Locally Identified Area of Flooding	Within Brush Fire Area	Within Hot Spot	Inundated by 3ft Sea Level Rise
	Action Bldg. (NC)						
169	Salem State College Auditorium (NC)	Low incidence	No	No	No	No	No
170	Salem State College Bertoloni School of Business	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
171	Salem State College Bookstore (Central Campus)	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	Yes	No
172	Salem State College Cat Cove Marine Lab	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
173	Salem State College Central Campus Dorms (CC)	Low incidence	No	No	No	No	No
174	Salem State College Enterprise Center (CC)	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	Yes	No
175	Wal-Mart	Low incidence	No	Walmart Parking Lot	No	No	No
176	Winter Island Yacht Yard	Low incidence	AE: 1% Annual Chance of Flooding; with BFE	No	No	No	No
177	AT&T Broadband Tower	Low incidence	No	No	No	No	No
178	MBTA Train Tunnel	Low incidence	No	No	No	Yes	No
179	Berube & Sons Funeral Home	Low incidence	No	No	No	No	No
180	Cingular Wireless Cell Tower	Low incidence	No	No	No	No	No

Vulnerability Assessment

The purpose of the vulnerability assessment is to estimate the extent of potential damages from natural hazards of varying types and intensities. A vulnerability assessment and estimation of damages was performed for hurricanes, earthquakes, and flooding. The methodology used for hurricanes and earthquakes was the HAZUS-MH software. The methodology for flooding was developed specifically to address the issue in many of the communities where flooding was not solely related to location within a floodplain.

Introduction to HAZUS-MH

HAZUS- MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. The following overview of HAZUS-MH is taken from the FEMA website. For more information on the HAZUS-MH software, go to http://www.fema.gov/plan/prevent/hazus/index.shtm

> "HAZUS-MH is a nationally applicable standardized methodology and software program that contains models for estimating potential losses from earthquakes, floods, and hurricane winds. HAZUS-MH was developed by the Federal Emergency Management Agency (FEMA) under contract with the National Institute of Building Sciences (NIBS). Loss estimates produced by HAZUS-MH are based on current scientific and engineering knowledge of the effects of hurricane winds, floods and earthquakes. Estimating losses is essential to decision-making at all levels of government, providing a basis for developing and evaluating mitigation plans and policies as well as emergency preparedness, response and recovery planning.
>
> HAZUS-MH uses state-of-the-art geographic information system (GIS) software to map and display hazard data and the results of damage and economic loss estimates for buildings and infrastructure. It also allows users to estimate the impacts of hurricane winds, floods and earthquakes on populations."

There are three modules included with the HAZUS-MH software: hurricane wind, flooding, and earthquakes. There are also three levels at which HAZUS-MH can be run. Level 1 uses national baseline data and is the quickest way to begin the risk assessment process. The analysis that follows was completed using Level 1 data. Level 1 relies upon default data on building types, utilities, transportation, etc. from national databases as well as census data. While the databases include a wealth of information on the City of Salem, it does not capture all relevant information. In fact, the HAZUS training manual notes that the default data is "subject to a great deal of uncertainty."

However, for the purposes of this plan, the analysis is useful. This plan is attempting to generally indicate the possible extent of damages due to certain types of natural disasters and to allow for a comparison between different types of disasters.

Estimated Damages from Hurricanes

The HAZUS software was used to model potential damages to the community from a 100 year and 500 year hurricane event; storms that are 1% and .0.2% likely to happen in a given year, and roughly equivalent to a Category 2 and Category 4 hurricane. The damages caused by these hypothetical storms were modeled as if the storm track passed directly through the City, bringing the strongest winds and greatest damage potential.

Though there are no recorded instances of a hurricane equivalent to a 500 year storm passing through Massachusetts, this model was included in order to present a reasonable "worst case scenario" that would help planners and emergency personnel evaluate the impacts of storms that might be more likely in the future, as we enter into a period of more intense and frequent storms.

Table 27 - Estimated Damages from Hurricanes

	100 Year	500 Year
Building Characteristics		
Estimated total number of buildings	11,078	
Estimated total building replacement value (2019 $)	$5,723	
Millions of dollars		
Building Damages		
# of buildings sustaining minor damage	378	1,892
# of buildings sustaining moderate damage	25	303
# of buildings sustaining severe damage	2	28
# of buildings destroyed	1	17
Population Needs		
# of households displaced	5	151
# of people seeking public shelter	2	72
Debris		
Building debris generated (tons)	6,670	24,798
Tree debris generated (tons)	2,264	6,486
# of truckloads to clear building debris	176	732
Value of Damages (Thousands of dollars)		
Total property damage (buildings and content)	$39,011.47	$188,446.08
Total losses due to business interruption	$2,938.63	$19,863.41

Estimated Damages from Earthquakes

The HAZUS earthquake module allows users to define an earthquake magnitude and model the potential damages caused by that earthquake as if its epicenter had been at the geographic center of the study area. For the purposes of this plan, two earthquakes were selected: magnitude 5.0 and a magnitude 7.0. Historically, major earthquakes are rare in New England, though a magnitude 5 event occurred in 1963.

Table-28
Estimated Damages from Earthquakes

	Magnitude 5.0	**Magnitude 7.0**
Building Characteristics		
Estimated total number of buildings	11,078	
Estimated total building replacement value (2019 $) Millions of dollars	$5,723	
Building Damages		
# of buildings sustaining slight damage	3,120	360
# of buildings sustaining moderate damage	1,923	2,062
# of buildings sustaining extensive damage	653	2,786
# of buildings completely damaged	183	5,837
Population Needs		
# of households displaced	1,332	12,563
# of people seeking public shelter	730	6,886
Debris		
Building debris generated (million tons)	0.2	1.38
# of truckloads to clear debris (@ 25 tons/truck)	730	55,120
Value of Damages (Millions of dollars)		
Total property damage	$913.75	6,142$
Total losses due to business interruption	$165.79	865.28$

Estimated Damages from Flooding

The HAZUS-MH flood risk module was used to estimate damages to the municipality at the 100 and 500 return periods. These return periods correspond to flooding events that have a 1% and a 0.2% likelihood of occurring in any given year.

Table-29
Estimated Damages from Flooding

	100 Year Flood	**500 Year Flood**
Building Characteristics		
Estimated total number of buildings	11,078	
Estimated total building replacement value (2019 $) Millions of dollars	$5,723	
Building Damages		
# of buildings sustaining slight damage (1-10%)	65	59
# of buildings sustaining moderate damage (11-50%)	6	41
# of buildings sustaining substantial damage (>50%)	0	0
Value of Damages (millions of dollars)		
Total property damage	$50.24	$58.74
Total losses due to business interruption	$22.53	$34.52

SECTION 5: HAZARD MITIGATION GOALS

The Salem Local Hazard Mitigation Planning Team reviewed and discussed the goals from the 2012 Hazard Mitigation Plan for the City of Salem. The Team modified their 2012 goals to reflect a more inclusive and streamlined approach for this plan update. All of the goals are considered critical for the City and they are not listed in order of importance.

1. Prevent and reduce the loss of life, injury, public health impacts and property damages resulting from all identified natural hazards.

2. Build and enhance local mitigation capabilities to ensure individual safety, reduce damage to public and private property and ensure continuity of emergency services.

3. Increase cooperation and coordination among private entities, City officials and Boards, State agencies and Federal agencies.

4. Increase awareness of the benefits of hazard mitigation through outreach and education.

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SECTION 6: EXISTING MITIGATION MEASURES

The existing protections in the City of Salem are a combination of zoning, land use, and environmental regulations, infrastructure maintenance and drainage infrastructure improvement projects. Infrastructure maintenance generally addresses localized drainage clogging problems, while large scale capacity problems may require pipe replacement or invert elevation modifications. These more expensive projects are subject to the capital budget process and lack of funding is one of the biggest obstacles to completion of some of these.

The City's existing mitigation measures are listed by hazard type here and are summarized in Table 30 below.

Flooding – Existing City-wide mitigation

Salem employs a number of practices to help minimize potential flooding and impacts from flooding, and to maintain existing drainage infrastructure. Existing City-wide mitigation measures include the following:

National Flood Insurance Program (NFIP) – Salem participates in the NFIP with 655 policies in force as of the February 28, 2019. FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website at https://bsa.nfipstat.fema.gov/reports/1011.htm

The City complies with the NFIP by enforcing floodplain regulations, maintaining up-to-date floodplain maps, and providing information to property owners and builders regarding floodplains and building requirements.

The following information is provided for the City of Salem:

Flood insurance policies in force (as of February 28, 2019)	655
Coverage amount of flood insurance policies	$186,375,200
Premiums paid	$782,951
Total Number of Closed Paid Losses	117
Number of Substantial Damage Closed Paid Losses	4
Closed Paid Losses	$1,363,802

Massachusetts State Building Code – The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads. The City has adopted the state building code.

Existing Multi-Hazard Mitigation Measures

Comprehensive Emergency Management Plan (CEMP) – Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan. These plans address mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, hurricanes, tornadoes, dam failures, earthquakes, and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to all of the hazards discussed in this plan.

Communications Equipment – The City utilizes the Incident Command Unit, a mobile communications center available to the City through the MA State Police and The MA Department of Fire Services. The City has a Reverse 911 system in place.

Emergency Power Generators –There are up to date generators in the two primary emergency shelters, the High School and the Bowditch School. The DPW Facility and Fire Stations Two and Five need fixed generator capacity.

Massachusetts State Building Code – The Massachusetts State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.

Southern Essex Regional Emergency Management Planning Committee (REPC) – Salem is a member of a regional emergency planning committee together with Danvers, Essex, Gloucester, Lynn, Manchester-by-the-Sea, Marblehead, Nahant, Peabody, Rockport, Salem, Swampscott

Public Information & Outreach – The City provides information to residents and business owners relating to a range of potential natural hazards, most especially with regard to flooding, hurricanes, and northeasters.

Public Works Operations/Maintenance Activities – The Public Works Department actively maintains the City's storm drain system. The following specific activities serve to maintain the capability of the drainage system through the reduction of sediment and litter build up and proper maintenance and repair.

- *Street sweeping* – Street sweeping is conducted twice times annually, with downtown area streets swept weekly. *Public comment: Street sweeping is not effective in the McIntyre District since the City changed sweeping its regime in 2010.*

- *Catch basin cleaning* –2000 catch basins cleaned annually (some biannually as needed).

- *Roadway treatments* – Calcium Chloride is used for snow/ice treatment.

- *Drainage maintenance*- Approximately 80 % of the City's catch basins and drain lines are now digitally mapped.

2007-2012 Open Space and Recreation Plan- In order to provide enhanced flood plain protection, two of the Plan's top priorities are to identify filled wetlands and work with the owners to restore them as well as placing conservation restrictions on any wetlands in flood plain districts.

Wetlands and Flood Overlay District – Zoning is intended to protect the public health and safety through the regulation of land use. The Salem Zoning Ordinance includes a Floodplain District (Section 8-1). The purposes of this district are:

1. To protect the health and safety of the occupants of lands subject to seasonal or periodic flooding.
2. To protect persons and property from hazard and loss through the regulation of future development of lands adjoining water-courses.
3. To preserve the natural flood-control characteristics and the water storage capacity of wetlands and floodplains and to protect against pollution and contamination of such water supplies and to conserve valuable habitats for wildlife, including fisheries and shellfisheries.
4. To ensure the control and containment of sewage, and the safety of gas, electric, fuel and other utilities from breaking, leaking, short-circuiting, igniting or any other damage due to flooding.
5. To comply with applicable federal standards for flood prone areas.

The Wetlands and Floodplain Overlay District is an overlay district, defined by the 100-year floodplain as designated by FEMA. Within the District, the following requirements must be met:

- All existing and anticipated development and uses will not obstruct or divert flood flow; substantially reduce natural floodwater storage capacity in the local drainage area; destroy valuable habitat for wildlife, including fisheries or shellfisheries; adversely affect groundwater resources or increase stormwater runoff velocity so that water levels on other land are substantially raised or the danger from flooding increased.
- The floor of the basement or, if none, the lowest floor of new construction or substantial improvement of structures for residential uses shall be at or above the 100-year flood level.
- The floor of the basement or, if none, the lowest floor of new construction or substantial improvement of structures for nonresidential uses shall be at or above the one-hundred-year flood level or the structures shall be flood-proofed to that level in compliance with the applicable requirements of the Massachusetts State Building Code. Flood-proofing measures shall ensure that the structure is watertight and that structural components have the capability of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy.

- Where the proposed use will be located within a coastal high hazard area (Zone V3 on the FIA Flood Insurance Rate Maps), the following conditions must be fulfilled:
    - New structures or substantial improvements shall be located landward of the reach of mean high tide.
    - New structures or substantial improvements shall be elevated on adequately anchored pilings or columns and securely anchored to such pilings or columns so that the lowest portion of the structural members the lowest floor (excluding the pilings or columns) is elevated to or above the one hundred-year flood level.
    - The support of new structures or substantial improvements shall not be, in whole or in part, by the use of fill.

Subdivision Rules and Regulations - The Salem Subdivision Rules and Regulations contains provisions intended to reduce the impacts of floods and erosion. Through its design and layout standards, the bylaws contribute to the City's overall efforts to mitigate the risks for damage through flooding. Some of the contributing provisions include the following:

- Any proposed subdivision within a flood prone area must meet the requirements of the Salem Wetlands and Flood Hazard Overlay District regulations.
- Cluster Developments are allowed with a 5-acre minimum lot size and must preserve at least 20% of the parcel as common open space.

Wetlands Protection Ordinance – The purpose of the Wetlands Protection Regulations is to further protect the City's shores, ponds, rivers, and wetlands for, among other reasons, flood control, erosion and sedimentation control, and public safety. The ordinance matches the protections found under the State Wetlands Protection Act and regulations. The Wetlands Ordinance also adds a 100-foor buffer to the FEMA 1% flood zones.

Conservation Overlay District- This overlies Highland Park, one of the last remaining undisturbed acreage in Salem and limits development within the District.

Stormwater Management and Construction Site Management Ordinance –Currently being reviewed in final draft form by Salem, the City's stormwater ordinance will apply to:

- any development or redevelopment that alters more than 10,000 square feet of land,
- any disturbance of land less than 10,000 square feet but which is part of a common plan where land disturbance will exceed 10,000 square feet;
- Certain Approval Not Required parcels.

These must comply with the City's stormwater management ordinance, whose standards match the MA Stormwater Management Standards, including no increase in post-development peak runoff rates compared to pre-development rates. The ordinance also

prohibits illegal stormwater connections, and implements development standards for erosion control and land contour changes.

Mosquito Control Ditch Maintenance – City representatives noted that the mosquito control district had a program of ditch cleaning that helped keep drainage ditches clear of debris. With the advent of West Nile virus, the mosquito control district has shifted funding from maintenance to monitoring. The result is that drainage ditches are not as well maintained.

Seawalls, Jetties and Dikes- Salem's coastline have a significant number of seawalls. Many of the seawalls are privately owned. Though repairs to some have been included in past Capital Improvement Programs, the City has not undertaken a comprehensive study of the condition of all its seawalls.

Existing Wind Hazard Mitigation Measures

CEMP – The Salem Comprehensive Emergency Management Plan contains a section on hurricanes. It lists five generic mitigation measures:

- Develop and disseminate emergency public information and instructions concerning hurricane preparedness and safety.
- Community leaders should ensure that Salem is enrolled in the National Flood Insurance Program.
- Develop and enforce local building codes to enhance structural resistance to high winds and flooding. Build new construction in areas that are not vulnerable to direct hurricane effects.
- Make informed decisions concerning protecting natural attributes such as beaches and dunes with breakwaters and sea walls. Review National Flood Insurance Rate Maps and Hurricane Evacuation Maps for possible impact on the community.
- Maintain plans for managing all hurricane emergency response activities.

The Salem CEMP outlines three generic mitigation measures for tornadoes.

- Develop and disseminate emergency public information and instructions concerning tornado safety, especially guidance regarding in-home protection and evacuation procedures, and locations of public shelters.
- Strict adherence should be paid to building code regulations for all new construction.
- Maintain plans for managing tornado response activities. Refer to the non-institutionalized, special needs and transportation resources listed in the Resource Manual.

Massachusetts State Building Code – The City enforces the Massachusetts State Building Code whose provisions are generally adequate to protect against most wind damage. The

code's provisions are the most cost-effective mitigation measure against tornados given the extremely low probability of occurrence. If a tornado were to occur, the potential for severe damages would be extremely high.

Tree-trimming program – The City conducts its own tree maintenance and also uses its own equipment to trim and remove trees as needed and grind stumps. National Grid also maintains its utility line corridors on a rotating, 3-year cycle.

Existing Winter Hazard Mitigation Measures

Snow disposal – Regular plowing and snow/ice removal is performed by the City. Calcium chloride is used primarily for road treatments. Sand is very rarely used as it creates siltation and clean up problems.

Existing Brush Fire Hazard Mitigation Measures

Burn Permits – Outdoor burning is not allowed in the City of Salem.

Subdivision/Development Review – The Fire Department participates in the review of new subdivisions and development projects.

Existing Geologic Hazard Mitigation Measures

Massachusetts State Building Code – The State Building Code contains a section on designing for earthquake loads (780 CMR 1612.0). Section 1612.1 states that the purpose of these provisions is "to minimize the hazard to life to occupants of all buildings and non-building structures, to increase the expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake". This section goes on to state that due to the complexity of seismic design, the criteria presented are the minimum considered to be "prudent and economically justified" for the protection of life safety. The code also states that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, cannot be achieved economically for most buildings.

Section 1612.2.5 sets up seismic hazard exposure groups and assigns all buildings to one of these groups according to a Table 1612.2.5. Group II includes buildings which have a substantial public hazard due to occupancy or use and Group III are those buildings having essential facilities which are required for post-earthquake recovery, including fire, rescue and police stations, emergency rooms, power-generating facilities, and communications facilities.

Table 30- Existing Mitigation Measures

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
MULTIPLE HAZARDS			
Comprehensive Emergency Management Plan (CEMP)	City-wide.	Emphasis is on emergency response.	None.
Communications Equipment	City-wide.	Effective	None.
Massachusetts State Building Code	City-wide.	Effective for new construction.	None.
Emergency Power Generators	City-wide.	Effective.	Complete installing generator backup at all Fire Stations.
Participation in the Southern Essex Regional Emergency Planning Committee (REPC)	City-wide.	A forum for cooperation on natural and manmade disasters.	None.
FLOOD HAZARDS			
Participation in the National Flood Insurance Program (NFIP)	Areas identified on the FIRM maps.	There are 655 policies in force.	Encourage all eligible homeowners to obtain insurance.
Public Works Operations/Maintenance	City-wide.	Somewhat effective.	Provide more resources for more frequent maintenance of city-owned drainage facilities.
Master Plan	City-wide		Include a new section on Climate Change in the next update.
Open Space Plan	City-wide		Target acquisition of open space parcels with flood storage capacity.
Zoning – Floodplain District and Climate Resilience	City-wide.	Effective for new construction.	Working with FEMA to update Floodplain District, including language and Community Rating System updates. Incorporate green

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
			infrastructure, stormwater retention, and revised parking and landscaping regulations to decrease runoff and urban heat island impacts; implement parking maximum and incentivize walking and transit oriented development.
Subdivision Rules and Regulations	City-wide	Effective.	Incorporate stormwater retention updates under MS4 stormwater permit.
Wetlands Protection Ordinance	Resource Areas	Effective.	None.
Open Space Residential Design Subdivisions	New subdivisions	Effective.	Make as first option for all new subdivisions.
Stormwater Management Ordinance	City-wide	Effective.	Enforce ordinance.
DCR Dam Safety Regulations	Dams	Effective.	NA: no dams in Salem
Mosquito Control Ditch Maintenance	City-wide.	Somewhat effective.	Ditches need more maintenance.
Seawalls, Jetties, and Dikes	Coastline	Not as effective.	Continue with repair and maintenance. Update codes for seawalls being rebuilt to take future flooding/SLR into account (Palmer/Point, Juniper Cove, Collins and others) Additional funding required.
WIND HAZARDS			
CEMP	City-wide	Effective.	Update to address emergency flood evacuation procedures and emergency preparedness outreach

Type of Existing Mitigation Measures	Area Covered	Effectiveness/ Enforcement	Improvements/ Changes Needed
			and communication particularly for non-English speaking people.
The Massachusetts State Building Code	City-wide.	Effective for most situations except severe storms.	None.
Tree trimming and management.	City-wide.	Satisfactory.	Create city-owned tree data base and track overall health, maintenance and re-planting schedule. Set goals for establishing a city wide tree program that uses trees to reduces extreme heat impacts, reduces runoff and provides wind impacts.
WINTER HAZARDS			
Snow Removal	City-wide.	Effective.	None.
BRUSH FIRE HAZARDS			
Development Review	City-wide.	Effective.	None.
Public Education	City-wide	Effective.	None.
GEOLOGIC HAZARDS			
The Massachusetts State Building Code	City-wide.	Effective.	None.

Local Capacity for Implementation

Under the Massachusetts system of "Home Rule," the City of Salem is authorized to adopt and from time to time amend a number of local ordinances and regulations that support the City's capabilities to mitigate natural hazards. These include Zoning Bylaws, Subdivision and Site Plan Review Regulations, Wetlands Ordinances, Health Regulations, Public Works regulations, and local enforcement of the State Building Code. Local Ordinances may be amended by the City Council to improve the City's capabilities, and changes to most regulations simply require a public hearing and a vote of the authorized board or commission, such as the Planning Board or Conservation Commission.

The City of Salem has recognized several existing mitigation measures that require implementation or improvements, and has the capacity within its local boards and departments to address these. The Salem Department of Public Works and Engineering Departments will address the needs for catch basin cleaning, repairs and upgrades to drainage infrastructure. The Planning and Community Development Department will address the updates to the Master Plan and implementation of the Zoning Ordinance, Floodplain District, and Subdivision Rules and Regulations. The Conservation Commission will oversee implementation of the Wetlands Bylaw and the Open Space Plan. The Department of Public Works, together with the Conservation Commission will coordinate implementation and enforcement of the Stormwater Bylaw.

SECTION 7: MITIGATION MEASURES FROM 2013 PLAN

Implementation Status of the Previous Plan

At a meeting of the Salem Hazard Mitigation Planning Committee, City staff reviewed the mitigation measures identified in the 2012 Salem Hazard Mitigation Plan and determined whether each measure had been implemented or deferred. Of those measures that had been deferred, the committee evaluated whether the measure should be deleted or carried forward into this Hazard Mitigation Plan Update. The decision on whether to delete or retain a particular measure was based on the committee's assessment of the continued relevance or effectiveness of the measure and whether the deferral of action on the measure was due to the inability of the City to take action on the measure. Table 31 summarizes the status of mitigation measures, and mitigation projects completed are described in more detail below.

Table 31- Mitigation Measures from the 2012 Plan

Mitigation Measure	Priority	Lead Implementation	Current Status	Include in 2020 Plan? Priority
South River Drainage and Flood Mitigation Study: Finish Canal Street drainage project design and construction .	High	Engineering	Not complete- Project has been started and will complete by 2022	Yes- High
South River Drainage and Flood Mitigation Study: Brooks Road/Jefferson Avenue/Rosie's Pond Design and Construction	High	Engineering	Not complete-Plan to have under construction winter of 2020 and finish by end of 2020.	Yes- High
Storm surge/ precipitation flooding mitigation: Forrester Street/Collins Cove neighborhood	High	Engineering	Complete: Living Shoreline project completed in 2018	No

Mitigation Measure	Priority	Lead Implementation	Current Status	Include in 2020 Plan? Priority
Identify resources to maintain City drainage infrastructure on an ongoing basis.	High	Engineering	Not complete.	Yes-carry over as Medium priority for 2020 plan as ongoing climate resilience issue for the City.
Complete repairs to finish Daniels Street, Ocean Avenue and Willows Park sea wall repairs	High	Engineering	Not completed	Yes-Ocean Avenue piece is partially complete
Install new tide gates at mouth of North River.	High	Engineering	Not completed-MA DOT issue	Yes- High
Acquisition of Vacant Flood Prone Lands	High	Planning/ Conservation Commission	Partially completed: Lead Mills property acquired but this is an ongoing management issue.	Yes- Medium
Install Fixed Generators at DPW and Fire Stations	High	DPW/Fire Dept.	Mostly complete: Station 2 Completed and Station 5 in process. DPW complete.	No
Survey all coastal infrastructure, buildings and land impacted by Massachusetts General Law Chapter 91.	Medium	Conservation/ Engineering	Not completed	Yes- Medium
Assess the earthquake vulnerability of all public buildings. Investigate options to make all public buildings earthquake	Medium	Fire Department	Not completed	Yes- Medium

Salem has made progress on implementing mitigation measures identified in the 2012 Hazard Mitigation Plan, including drainage upgrades and flooding protection along Canal Street, the installation of a Living Shoreline project in Collins Cove, substantial upgrades

to Willows Park and several seawalls throughout the City, the acquisition of flood prone lands at the former Lead Mills property, the work to improve drainage and prevent flooding in the Brooks Road/Jefferson Avenue/Rosie's Pond neighborhood and the upgrades to fixed backup generating capacity at the DPW facility and City fire stations.

Critically, the City took part in climate resilience planning actions through the Climate Change Vulnerability Assessment and Adaptation Plan planning process in 2014 and conducted a climate vulnerability preparedness workshop with the MA Municipal Vulnerability Preparedness (MVP) Program in 2018, of which it is now a certified community. Through those plans, it has begun to establish climate resilience priorities. Both risk assessment and mitigation from the Climate Change Vulnerability Assessment and Adaptation Plan and the MVP Workshop are incorporated in this updated Hazard Mitigation Plan.

Overall, eight mitigation measures from the 2012 plan will be carried forward in the plan update.

Moving forward into the next five-year plan implementation period there will be many more opportunities to incorporate hazard mitigation into the City's decision-making processes. Those will include mitigation found in the 2014 Climate Change Vulnerability Assessment and Adaptation Plan and the City's 2018 MVP Workshop.

The challenges the City faces in implementing these measures are primarily due to limited funding and available staff time. This plan should help the City prioritize the best use of its limited resources for enhanced mitigation of natural hazards.

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SECTION 8: HAZARD MITIGATION STRATEGY

What is Hazard Mitigation?

Hazard mitigation means to permanently reduce or alleviate the losses of life, injuries and property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, education programs, infrastructure projects and other activities. FEMA currently has three mitigation grant programs: the Hazards Mitigation Grant Program (HGMP), the Pre-Disaster Mitigation program (PDM), and the Flood Mitigation Assistance (FMA) program. The three links below provide additional information on these programs.

http://www.fema.gov/government/grant/hmgp/index.shtm
http://www.fema.gov/government/grant/pdm/index.shtm
http://www.fema.gov/government/grant/fma/index.shtm

Hazard Mitigation Measures can generally be sorted into the following groups:

- Prevention: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses. Examples include planning and zoning, building codes, capital improvement programs, open space preservation, and stormwater management regulations.
- Property Protection: Actions that involve the modification of existing buildings or infrastructure to protect them from a hazard or removal from the hazard area. Examples include acquisition, elevation, relocation, structural retrofits, flood proofing, storm shutters, and shatter resistant glass.
- Public Education & Awareness: Actions to inform and educate citizens, elected officials, and property owners about the potential risks from hazards and potential ways to mitigate them. Such actions include outreach projects, real estate disclosure, hazard information centers, and school-age and adult education programs.
- Natural Resource Protection: Actions that, in addition to minimizing hazard losses also preserve or restore the functions of natural systems. These actions include sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
- Structural Projects: Actions that involve the construction of structures to reduce the impact of a hazard. Such structures include storm water controls (e.g., culverts), floodwalls, seawalls, retaining walls, and safe rooms.
- Emergency Services Protection: Actions that will protect emergency services before, during, and immediately after an occurrence. Examples of these actions include protection of warning system capability, protection of critical facilities, and protection of emergency response infrastructure.

(Source: *FEMA Local Multi-Hazard Mitigation Planning Guidance*)

Regional and Inter-Community Considerations

Some hazard mitigation issues are strictly local. The problem originates primarily within the municipality and can be solved at the municipal level. Other issues are inter-community issues that involve cooperation between two or more municipalities. There is a third level of mitigation which is regional; involving a state, regional or federal agency or an issue that involves three or more municipalities.

Regional Partners

In the densely developed communities of the study area, mitigating natural hazards, particularly flooding, is more than a local issue. The drainage systems that serve these communities are a complex system of storm drains, roadway drainage structures, pump stations and other facilities owned and operated by a wide array of agencies including but not limited to the MBTA, Northeast Massachusetts Mosquito Control Board, the Department of Conservation and Recreation (DCR), , and the Massachusetts Department of Transportation (MA DOT). The planning, construction, operations and maintenance of these structures are integral to the flood hazard mitigation efforts of communities. These agencies must be considered the communities regional partners in hazard mitigation. These agencies also operate under the same constraints as communities do including budgetary and staffing constraints and numerous competing priorities. In the sections that follow, the plan includes recommendations for activities to be undertaken by these other agencies. Implementation of these recommendations will require that all parties work together to develop solutions.

According to members of the Salem Multiple Hazard Community Planning Team, the primary current regional issue is addressing mitigation for the North River tide gate. There are ownership issues involved with the Massachusetts Department of Transportation (MA DOT) that have delayed this critical infrastructure improvement. Without mitigation, Bridge Street and the surrounding neighborhood remain vulnerable to coastal flooding during winter storm or other climate driven high wind events. The City's MVP workshop prioritized two other regional emergency transportation issues-assessing and identifying critical roads for emergency vehicles, including the bridges to Beverly and the need to identify safe land and alternative water evacuation routes and install evacuation signage. Reducing flooding along the Forest River with neighboring Marblehead is also a regional issue that was noted during the MVP process.

Process for Setting Priorities for Mitigation Measures

The last step in developing Salem's mitigation strategy is to assign a level of priority to each mitigation measure so as to guide the focus of the City's limited resources towards those actions with the greatest potential benefit. At this stage in the process, the Local Hazard Mitigation Planning Team had limited access to detailed analyses of the cost and

benefits of any given mitigation measure, so prioritization is based on the local team members' understanding of existing and potential hazard impacts and an approximate sense of the costs associated with pursuing any given mitigation measure.

Priority setting was based on local knowledge of the hazard areas, including impacts of hazard events, the extent of the area impacted, and the relation of a given mitigation measure to the City's goals. In addition, the local Hazard Mitigation Planning Team also took into consideration factors such as the number of homes and businesses affected, whether or not road closures occurred and what impact closures had on delivery of emergency services and the local economy, anticipated project costs, whether any environmental constraints existed, and whether the City would be able to justify the costs relative to the anticipated benefits.

Table 32 demonstrates the prioritization of the recommended mitigation measures for the City's hazard mitigation strategy. For each mitigation measure, the geographic extent of the potential benefiting area is identified as is an estimate of the overall benefit and cost of the measures. The benefits, costs, and overall priority were evaluated in terms of:

Estimated Benefits	
High	Action will result in a significant reduction of hazard risk to people and/or property from a hazard event
Medium	Action will likely result in a moderate reduction of hazard risk to people and/or property from a hazard event
Low	Action will result in a low reduction of hazard risk to people and/or property from a hazard event
Estimated Costs	
High	Estimated costs greater than $100,000
Medium	Estimated costs between $10,000 to $100,000
Low	Estimated costs less than $10,000 and/or staff time
Priority	
High	Action very likely to have political and public support and necessary maintenance can occur following the project, and the costs seem reasonable considering likely benefits from the measure
Medium	Action may have political and public support and necessary maintenance has potential to occur following the project
Low	Not clear if action has political and public support and not certain that necessary maintenance can occur following the project

Table 32- Mitigation Measure Prioritization

Mitigation Action	Geographic Coverage	Estimated Benefit	Estimated Cost	Priority
Flooding/Coastal Flooding				
Canal Street Design and construction- drainage and flood prevention for Canal Street neighborhood within South River watershed	South River watershed/Canal Street area	High	High	High
Brooks Road/Jefferson Avenue/Rosie's Pond design and construction- complete work begun to prevent flooding and improve drainage.	South River watershed/Canal Street area	High	High	High
Identify resources to maintain City drainage and climate resilience infrastructure on an ongoing basis.	City wide	High	High	Medium
Conduct comprehensive hydraulic study of the South River watershed.	South River watershed area	High	High	Medium
Complete upgrades to finish Daniels Street, Ocean Avenue and Willows Park sea walls.	South Salem	High	Medium	High
Install new tide gates at mouth of North River.	North Salem and Downtown	High	High	Medium
Acquisition of Vacant Flood Prone Lands.	City wide	Medium	High	Low
Survey all coastal infrastructure, buildings and land impacted by Massachusetts General Law Chapter 91.	City wide	Medium	Medium	Medium
Mitigate flooding on Highland Ave near Walmart.	Highland Avenue neighborhood	Medium	Medium	High
Mitigate flooding at Derby Wharf	Derby Wharf and Derby Street neighborhood	Medium	High	High
Participate in the National Flood Insurance Program's Community Rating System so property owners may receive flood insurance discounts. (MVP)	City-wide	Medium	Low	High

Assess which pump stations can handle flooding - examine backup power and need for flood barriers. (MVP)	City-wide	High	Medium	High
Update codes for seawalls being rebuilt to take future flooding into account (Palmer/Point, Juniper Cove, Collins and others). (MVP)	City-wide	High	Medium	High
Reduce flooding at Forest River at border with Marblehead.	Lafayette St., Riverway Rd., Riverbank Rd., Sunset Rd. neighborhood	Medium	High	High
High Wind Mitigation				
Adopt tree ordinance that creates a city-wide data base of all city owned trees and creates schedule for new plantings and removal of diseased and dead trees from high hazard areas.	City-wide	Medium	Low	Medium
Winter Storms Mitigation				
Install new fixed generators at DPW, Community Life Center and Fire Stations.	City wide	High	Medium	Medium
Brushfire Mitigation				
Forest Protection and Management – Fire Dept., City committees and staff should work with local and regional non-profit partners to better understand the fire risks and impacts of climate change on the forested areas of the City.	City-Wide	Medium	High	Medium
Acquire 4x4 brushfire vehicle with tanks and hose.	City-Wide	Medium	High	Medium

Earthquake Mitigation				
Assess the earthquake vulnerability of all public buildings. Investigate options to make buildings earthquake resistant.	City wide	Medium	Low	Low
Extreme Temperature Mitigation				
Green Site Design to increase tree plantings near buildings, increase the percentage of trees used in parking areas, and along public ways. Promote Green Infrastructure, adopt Net Zero Water Use policies and regulations	City-Wide	Medium	Medium	Medium
Promote Green Building and Cool Roof designs.	City-Wide	Medium	Low	Medium
Assess placement of cooling centers at schools, senior center and emergency shelters.	City-wide	Medium	Low	High
Drought Mitigation				
Promote Green Infrastructure, adopt Net Zero Water Use policies and regulations, use drought tolerant landscaping and site design measures.	City-Wide	Medium	Low	Medium
Climate Resilience/Adaptation				
Strengthen zoning and building ordinances and regulations to increase resilience, adaptations and sustainability. (MVP)	City-wide	High	Medium	High
Incorporate climate resilience/adaptation actions and policies into City capital, strategic, open space, and master plans update.	City-Wide	High	Low	High

When repairing or replacing existing parking lots and bus shelters, use green infrastructure and canopy solar (in large parking lots) to reduce heat islands and create clean, renewable energy. (MVP)	City-Wide	High	Medium	Medium
Hold a forum with coastal resilience and protection experts to talk to staff and residents about seawalls, coastal resilience and coordinated efforts. (MVP)	City-wide	Medium	Low	High
Climate Resiliency Municipal Outreach & Education Program – Develop and implement a program using a "top down" approach led by the City's Emergency Management/Public Health and other municipal committees and boards.	City-wide	High	Low	High
Community Database - Create and maintain a database of vulnerable citizens.	City-wide	High	Low	High
Multi-hazard				
Update Comprehensive Emergency Management Plan (CEMP) with the following: (1).Assess and identify critical roads for emergency vehicles (Jefferson, Canal, Highland, Bridge, Derby, Lafayette, Washington, Szetela, Webb, Kernwood, and bridges to Beverly).)2).Identify key road networks and develop safe evacuation routes; Install evacuation route signage; Develop alternative methods of evacuation (including water). (MVP)	City-wide	High	Low	High

Create multi-faceted Emergency Warning Systems and Supplies – development of a comprehensive system of communications and provisions/services for the public in times of emergency	City-wide	High	Low	High

Introduction to Recommended Mitigation Strategy (Table 33)

Description of the Mitigation Measure – The description of each mitigation measure is brief and cost information is given only if cost data were already available from the community. The cost data represent a point in time and would need to be adjusted for inflation and for any changes or refinements in the design of a particular mitigation measure.

Priority – As described above and summarized in Table 29, the designation of high, medium, or low priority was done considering potential benefits and estimated project costs, as well as other factors in the STAPLEE analysis.

Implementation Responsibility – The designation of implementation responsibility was done based on a general knowledge of what each municipal department is responsible for. It is likely that most mitigation measures will require that several departments work together and assigning staff is the sole responsibility of the governing body of each community.
Time Frame – The time frame was based on a combination of the priority for that measure, the complexity of the measure and whether or not the measure is conceptual, in design, or already designed and awaiting funding. Because the time frame for this plan is five years, the timing for all mitigation measures has been kept within this framework. The identification of a likely time frame is not meant to constrain a community from taking advantage of funding opportunities as they arise.

Potential Funding Sources – This column attempts to identify the most likely sources of funding for a specific measure. The information on potential funding sources in this table is preliminary and varies depending on a number of factors. These factors include whether or not a mitigation measure has been studied, evaluated or designed, or if it is still in the conceptual stages. MEMA and DCR assisted MAPC in reviewing the potential eligibility for hazard mitigation funding. Each grant program and agency has specific eligibility requirements that would need to be taken into consideration. In most instances, the measure will require a number of different funding sources. Identification of a potential funding source in this table does not guarantee that a project will be eligible for, or selected for funding. Upon adoption of this plan, the local team responsible for its implementation should begin to explore the funding sources in more detail.

Additional information on funding sources – The best way to determine eligibility for a particular funding source is to review the project with a staff person at the funding agency. The following websites provide an overview of programs and funding sources.

Army Corps of Engineers (ACOE) – The website for the North Atlantic district office is http://www.nae.usace.army.mil/. The ACOE provides assistance for shoreline protection, flood damage reduction, and floodplain planning services.

Massachusetts Emergency Management Agency (MEMA) – The grants page http://www.mass.gov/dem/programs/mitigate/grants.htm has a useful table that compares eligible projects for the Hazard Mitigation Grant Program and the Flood Mitigation Assistance Program.

Abbreviations Used in Table 33

FEMA Mitigation Grants includes:
- FMA = Flood Mitigation Assistance Program.
- HMGP = Hazard Mitigation Grant Program.
- PDM = Pre-Disaster Mitigation Program

DEP (SRF) = Department of Environmental Protection (State Revolving Fund)
MA DOT = Massachusetts Department of Transportation
CIP= Capital Improvement Program
HMPT=Hazard Mitigation Planning Team
CIP= Capital Improvement Plan
MVP= MA Municipal Vulnerability Preparedness Program
NCRF= National Coastal Resilience Fund
MA CRG= MA Coastal Resilience Grants
CRMAG= MA DER Culvert Replacement Municipal Assistance Grant

Table 33 – Recommended Mitigation Strategy					
Mitigation Measure	**Priority**	**Lead Dept./Group**	**Time Frame**	**Estimated Cost**	**Potential Funding Sources**
FLOODING/COASTAL FLOODING					
Canal Street Design and construction-drainage and flood prevention for Canal Street neighborhood within South River watershed	High	Engineering	Medium Term 2022 - 2023	High Estimated at $18 million for design and construction	Salem CIP/FEMA
Brooks Road/Jefferson Avenue/Rosie's Pond design and construction-complete work begun to prevent flooding and improve drainage.	High	Engineering	Short term 2020-2021	High Estimated at $3 million for design and construc-tion	Salem CIP/FEMA
Identify resources to maintain City drainage and climate resilience infrastructure on an ongoing basis.	Medium	MA DOT	Long Term 2020-2025	High $100,000/ year	Salem CIP/ City Bond/FEMA/ MVP/NCRF/ CRMAG
Conduct comprehensive hydraulic study of the South River watershed.	Medium	Engineering	Long Term 2020-2025	High $150,000	Salem CIP /citybound/FEMA /MVP/NCRF
Complete upgrades to finish Daniels Street, Ocean Avenue and Willows Park sea walls.	High	Engineering	Medium Term 2022 - 2023	High $2 million	Salem CIP /city Bond/FEMA/ MVP/NCRF
Install new tide gates at mouth of North River/ mitigate Bridge Street flooding	High	Engineering/ MA DOT	Long Term 2020-2025	High $5 million	MA DOT/FEMA

Table 33 – Recommended Mitigation Strategy					
Mitigation Measure	**Priority**	**Lead Dept./Group**	**Time Frame**	**Estimated Cost**	**Potential Funding Sources**
Acquisition of Vacant Flood Prone Lands.	Medium	Conservation/ Planning	Long Term 2020-2025	High Up to $1 million	Salem CIP /citybound/FEMA /MVP/ NCRF/CPA
Survey all coastal infrastructure, buildings and land impacted by Massachusetts General Law Chapter 91.	Medium	Conservation/ Engineering	Long Term 2020-2025	High $150,000	Salem/FEMA/ MVP/NCRF
Mitigate flooding on Highland Ave near Walmart.	High	Engineering	Medium Term 2022 - 2023	High- Estimated at $.5 million	Salem CIP/ city Bond/FEMA
Mitigate flooding at Derby Wharf	High	Engineering/ Conservation	Short term 2020-2021	High $>1 million	Salem CIP /citybound/FEMA /MVP/ NCRF/CPA
Participate in the National Flood Insurance Program's Community Rating System so property owners may receive flood insurance discounts. (MVP)	High	Conservation Commission/ Planning	Long Term 2020-2025	Low Estimated costs less than $10,000 and/or staff time	Staff time / City general operating budget
Assess which pump stations can handle flooding - examine backup power and need for flood barriers. (MVP)	High	Engineering	Long Term 2020-2025	Medium $50,000	Staff time / City general operating budget

Table 33 – Recommended Mitigation Strategy					
Mitigation Measure	**Priority**	**Lead Dept./Group**	**Time Frame**	**Estimated Cost**	**Potential Funding Sources**
Update codes for seawalls being rebuilt to take future flooding into account (Palmer/Point, Juniper Cove, Collins and others). (MVP)	Medium	Engineering/ Conservation	Long Term 2020-2025	Low $10,000	Staff time / City general operating budget
Determine how to reduce flooding at Forest River at border with Marblehead.	High	Engineering/ Conservation	Long Term 2020-2025	Medium $50,000	Salem CIP /citybound/FEMA MVP/
HIGH WIND					
Adopt tree ordinance that creates a city-wide data base of all city owned trees and creates schedule for new plantings and removal of diseased and dead trees from high hazard areas.	Medium	DPW/ Tree Warden/ Planning	Long Term 2020-2025	Low $10,000	Staff time / City general operating budget
WINTER STORMS					
Finish installing or upgrading fixed generators at DPW, Community Life Center, City Hall and Fire Stations One and Four.	Medium	Fire/DPW	Short term 2020-2021	Medium $75,000	City general operating budget
BRUSHFIRES					
Acquire 4x4 brushfire vehicle with tanks and hose.	Medium	Fire Dept.	Long Term 2020-2025	Medium $75,000	Salem/CIP/ FEMA

Table 33 – Recommended Mitigation Strategy					
Mitigation Measure	**Priority**	**Lead Dept./Group**	**Time Frame**	**Estimated Cost**	**Potential Funding Sources**
Forest Protection and Management – Fire Dept., City staff should work with local and regional non-profit partners to better understand the fire risks and impacts of climate change on the forested areas of the City.	Medium	Fire Dept.	Long Term 2020-2025	Low Estimated costs less than $10,000 and/or staff time	Staff time / City general operating budget
EARTHQUAKES					
Determine which buildings may be most vulnerable to earthquake damage and conduct a structural assessment if needed.	Low	Engineering	Long Term 2020-2025	Low	Staff time / City general operating budget
EXTREME TEMPERATURES					
Green Site Design to increase tree plantings near buildings, increase the percentage of trees used in parking areas, and along public ways. Promote Green Infrastructure, adopt Net Zero Water Use policies and regulations	Medium	Planning/DPW	Long Term 2020-2025	Medium $50,000	Staff time / City general operating budget
Promote Green Building and Cool Roof designs.	Medium	Building/ Conservation Commission	Long Term 2020-2025	Low Estimated costs less than $10,000 and/or staff time	Staff time / City general operating budget

Table 33 – Recommended Mitigation Strategy					
Mitigation Measure	**Priority**	**Lead Dept./Group**	**Time Frame**	**Estimated Cost**	**Potential Funding Sources**
Assess placement of cooling centers at schools, senior center and emergency shelters.	High	Fire/HMPT	Short Term 2020-2021	Low Estimated costs less than $10,000 and/or staff time	Staff time / City general operating budget
DROUGHT					
Promote Green Infrastructure, adopt Net Zero Water Use policies and regulations, use drought tolerant landscaping and site design measures.	Medium	Conservation Commission	Long Term 2020-2025	Low Estimated costs less than $5,000 per year staff time	Staff time / City general operating budget
CLIMATE RESILIENCE/ ADAPTATION					
Strengthen zoning and building ordinances and regulations to increase resilience, adaptations and sustainability. (MVP).	High	City Council	Short Term 2020-2021	Low Estimated costs less than $10,000 and/or staff time	Staff time / City general operating budget
Incorporate climate resilience/adaptation actions and policies into City capital, strategic, open space, and master plans update.	Medium	Planning, Conservation ,Engineering, Mayor	Long Term 2020-2025	Medium $20,000	Staff time / City general operating budget
When repairing or replacing existing parking lots and bus shelters, use green infrastructure and canopy solar (in large parking lots) to reduce heat islands and create clean, renewable energy. (MVP)	Medium	Planning/Conservation/Building	Long Term 2020-2025	Medium $50,000	MVP/MA Coastal Resilience Grants/NCRF/FEMA/City budget

Table 33 – Recommended Mitigation Strategy					
Mitigation Measure	**Priority**	**Lead Dept./Group**	**Time Frame**	**Estimated Cost**	**Potential Funding Sources**
Hold a forum with coastal resilience and protection experts to talk to staff and residents about seawalls, coastal resilience and coordinated efforts. (MVP)	Low	Community Preservation Committee/BOS	Short Term 2020-2021	Low $5,000	Staff time / City general operating budget
Climate Resiliency Municipal Outreach & Education Program – Develop and implement a program using a "top down" approach led by the City's Strategic Planning Committee and other municipal committees and boards.	High	Emergency Management /Public Health /HMPT	Long Term 2020-2025	Low $5,000 per year	City general operating budget
Community Database - Create and maintain a database of vulnerable citizens.	High	Fire Dept./Emergency Management HMPT	Long Term 2020-2025	Low $2,000 per year	City general operating budget
MULTIHAZARD					
Update Comprehensive Emergency Management Plan (CEMP) with the following:	High	Fire/Police/ Emergency Management	Short Term 2020-2021	Low Estimated costs less than $5,000 per year staff time	Staff time / City general operating budget

Table 33 – Recommended Mitigation Strategy					
Mitigation Measure	**Priority**	**Lead Dept./Group**	**Time Frame**	**Estimated Cost**	**Potential Funding Sources**
1.Assess and identify critical roads for emergency vehicles (Jefferson, Canal, Highland, Bridge, Derby, Lafayette, Washington, Szetela, Webb, Kernwood, and bridges to Beverly). 2. Identify key road networks and develop safe evacuation routes; Install evacuation route signage; Develop alternative methods of evacuation (including water). (MVP)					
Create multi-faceted Emergency Warning Systems and Supplies – development of a comprehensive system of communications and provisions/services for the public in times of emergency.	High	Emergency Management/Fire/Police HMPT	Medium Term 2022 - 2023	Medium $25,000	City general operating budget/ FEMA/MVP

SECTION 9: PLAN ADOPTION & MAINTENANCE

Plan Adoption

The *City of Salem Hazard Mitigation Plan 2020 Update* was adopted by the City Counsil on [ADD DATE]. See Appendix D for documentation. The plan was approved by FEMA on [ADD DATE] for a five-year period that will expire on [ADD DATE]. – To be completed following MEMA and FEMA review.

Plan Maintenance

Although several of the mitigation measures from the City's previous Hazard Mitigation Plan have been implemented, since that plan was adopted there has not been an ongoing local process to guide implementation of the plan. Such a process is needed over the next five years for the implementation of this plan update, and will be structured as described below.

MAPC worked with the Salem Hazard Mitigation Planning Team to prepare this plan. After approval of the plan by FEMA, this group will meet on a regular basis, at least annually, to function as the Hazard Mitigation Implementation Team, with the Director of Public Works designated as the coordinator. Additional members could be added to the local implementation team from businesses, non-profits and institutions. The City will encourage public participation during the next 5-year planning cycle. As updates and a review of the plan are conducted by the Hazard Mitigation Implementation Team, these will be placed on the City's web site, and any meetings of the Hazard Mitigation Implementation Team will be publicly noticed in accordance with City and state open meeting laws.

Implementation and Evaluation Schedule

Mid-Term Survey on Progress– The coordinator of the Hazard Mitigation Implementation Team will prepare and distribute a survey in year three of the plan. The survey will be distributed to all of the local implementation group members and other interested local stakeholders. The survey will poll the members on any changes or revisions to the plan that may be needed, progress and accomplishments for implementation, and any new hazards or problem areas that have been identified.

This information will be used to prepare a report or addendum to the local hazard mitigation plan in order to evaluate its effectiveness in meeting the plan's goals and identify areas that need to be updated in the next plan. The Hazard Mitigation Implementation Team, coordinated by the Conservation Agent, will have primary responsibility for tracking progress and updating the plan.

Begin to prepare for the next Plan Update -- Given the lead time needed to secure funding and conduct the planning process, the Hazard Mitigation Implementation Team will begin to prepare for an update of the plan in year three. The team will use the information

from the Mid-Term progress review to identify the needs and priorities for the plan update and seek funding for the plan update process. Potential sources of funding may include FEMA Pre-Disaster Mitigation grants and the Hazard Mitigation Grant Program. Both grant programs can pay for 75% of a planning project, with a 25% local cost share required.

Prepare and Adopt an Updated Local Hazard Mitigation Plan – FEMA's approval of this plan is valid for five years, by which time an updated plan must be approved by FEMA in order to maintain the City's approved plan status and its eligibility for FEMA mitigation grants. Once the resources have been secured to update the plan, the Hazard Mitigation Implementation Team may decide to undertake the update themselves, contract with the Metropolitan Area Planning Council to update the plan or to hire another consultant. However the Hazard Mitigation Implementation Team decides to update the plan, the group will need to review the current FEMA hazard mitigation plan guidelines for any changes. The Salem Hazard Mitigation Plan Update will be forwarded to MEMA and DCR for review and to FEMA for approval.

Integration of the Plans with Other Planning Initiatives

Upon approval of the *City of Salem Hazard Mitigation Plan 2020 Update* by FEMA, the Local Hazard Mitigation Team coordinator will provide all interested parties and implementing departments with a copy of the plan and will initiate a discussion regarding how the plan can be integrated into that department's ongoing work. The plan will be reviewed and discussed with the following departments during the first six (6) months following plan adoption. During updates of any City department's plans or policies, the relevant portions of this mitigation strategy will be incorporated.

- Fire Department
- Emergency Management
- Police Department
- Public Works Department
- Engineering
- Planning Board/Planning and Community Development
- Conservation Commission
- Parks and Recreation
- Public Health
- Building

Other groups that will be coordinated with include large institutions, Chambers of Commerce, land conservation organizations and watershed groups. The plans will also be posted on a community's website with the caveat that local team coordinator will review the plan for sensitive information that would be inappropriate for public posting. The posting of the plan on a web site will include a mechanism for citizen feedback such as an e-mail address to send comments.

The Hazard Mitigation Plan, which incorporates risk assessment and mitigation actions on climate change from 2014 the Climate Change Vulnerability Assessment and Adaptation Plan and the City's 2018 MVP Workshop, will be integrated into other City plans and policies as they are updated and renewed, including the Salem Master Plan, City Zoning and Subdivision Control Regulations, Open Space Plan, Comprehensive Emergency Management Plan, and Capital Investment Program.

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SECTION 10: LIST OF REFERENCES

Salem Comprehensive Emergency Management Plan, 2017

Climate Change Vulnerability Assessment and Adaptation Plan, 2014

City of Salem, MA Community Resilience Building Workshop Municipal Vulnerability Preparedness Program Summary of Findings June 2018

2015 – 2020 Open Space and Recreation Plan for the City of Salem,

Salem City Ordinances

Salem Zoning Ordinance

Salem Subdivision Regulations

Environment America Research and Policy Center, *When It Rains It Pours – Global Warming and the Increase in Extreme Precipitation,* July 2012

FEMA, Flood Insurance Rate Maps for Essex County, MA, 2012

FEMA, Local Mitigation Plan Review Guide; October 1, 2011.

MA Emergency Management Agency, State *Hazard Mitigation Plan*
MA Geographic Information System, *McConnell Land Use Statistics*, 2005

MA Office of Dam Safety, Inventory of Massachusetts Dams

Metropolitan Area Planning Council, Geographic Information Systems Lab

New England Seismic Network, Weston Observatory, http://aki.bc.edu/index.htm

Northeast States Emergency Consortium, website http://www.nesec.org/

NOAA, National Centers for Environmental Information,
https://www.ncdc.noaa.gov/stormevents/

U. S. Census, 2010, and American Community Survey, 2015

USGS, National Water Information Center, https://waterdata.usgs.gov/nwis

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APPENDIX A: HAZARD MAPPING

The MAPC GIS (Geographic Information Systems) Lab produced a series of maps for each community. Some of the data came from the Northeast States Emergency Consortium (NESEC). More information on NESEC can be found at http://www.serve.com/NESEC/. Due to the various sources for the data and varying levels of accuracy, the identification of an area as being in one of the hazard categories must be considered as a general classification that should always be supplemented with more local knowledge.

The map series consists of eight maps as described below. The maps in this appendix are necessarily reduced scale versions for general reference. Full sized higher resolution PDF's of the maps can be downloaded from: https://mapc-org.sharefile.com/d-s67316042bae47d48

Map 1.	Population Density
Map 2.	Land Use
Map 3.	Flood Zones
Map 4.	Earthquakes and Landslides
Map 5.	Hurricanes and Tornadoes
Map 6.	Average Snowfall
Map 7.	Composite Natural Hazards
Map 8.	Hazard Areas
Map 9	Sea Level Rise
Map 10	High Land Surface Temperatures

Map1: Population Density – This map uses the US Census block data for 2010 and shows population density as the number of people per acre in seven categories with 60 or more people per acre representing the highest density areas.

Map 2: Land Use – This map shows land use based on the MassGIS statewide land use database. The map also shows potential future development sites and critical facilities, both of which were identified by the Local Hazard Mitigation.

Map 3: Flood Zones – The map of flood zones used the FEMA NFIP Flood Zones as depicted on the FIRMs (Federal Insurance Rate Maps) for Essex County as its source. This map is not intended for use in determining whether or not a specific property is located within a FEMA NFIP flood zone. The currently adopted FIRMS for Salem are kept by the City. For more information, refer to the FEMA Map Service Center website http://www.msc.fema.gov. The definitions of the flood zones are described in detail on this site as well. The flood zone map for each community also shows critical infrastructure and repetitive loss areas.

Map 4: Earthquakes and Landslides – This information came from NESEC. For most communities, there was no data for earthquakes because only the epicenters of an earthquake are mapped.

The landslide information shows areas with either a low susceptibility or a moderate susceptibility to landslides based on mapping of geological formations. This mapping is highly general in nature. For more information on how landslide susceptibility was mapped, refer to http://pubs.usgs.gov/pp/p1183/pp1183.html.

Map 5: Hurricanes and Tornadoes – This map shows the storm tracks for both hurricanes and tropical storms, if any occurred in or near this community. This information must be viewed in context. A storm track only shows where the eye of the storm passed through. In most cases, the effects of the wind and rain from these storms were felt in other communities even if the track was not within that community. This map also shows the location of tornadoes with a classification as to the level of damages. What appears on the map varies by community since not all communities experience the same wind-related events. These maps also show the 100-year wind speed.

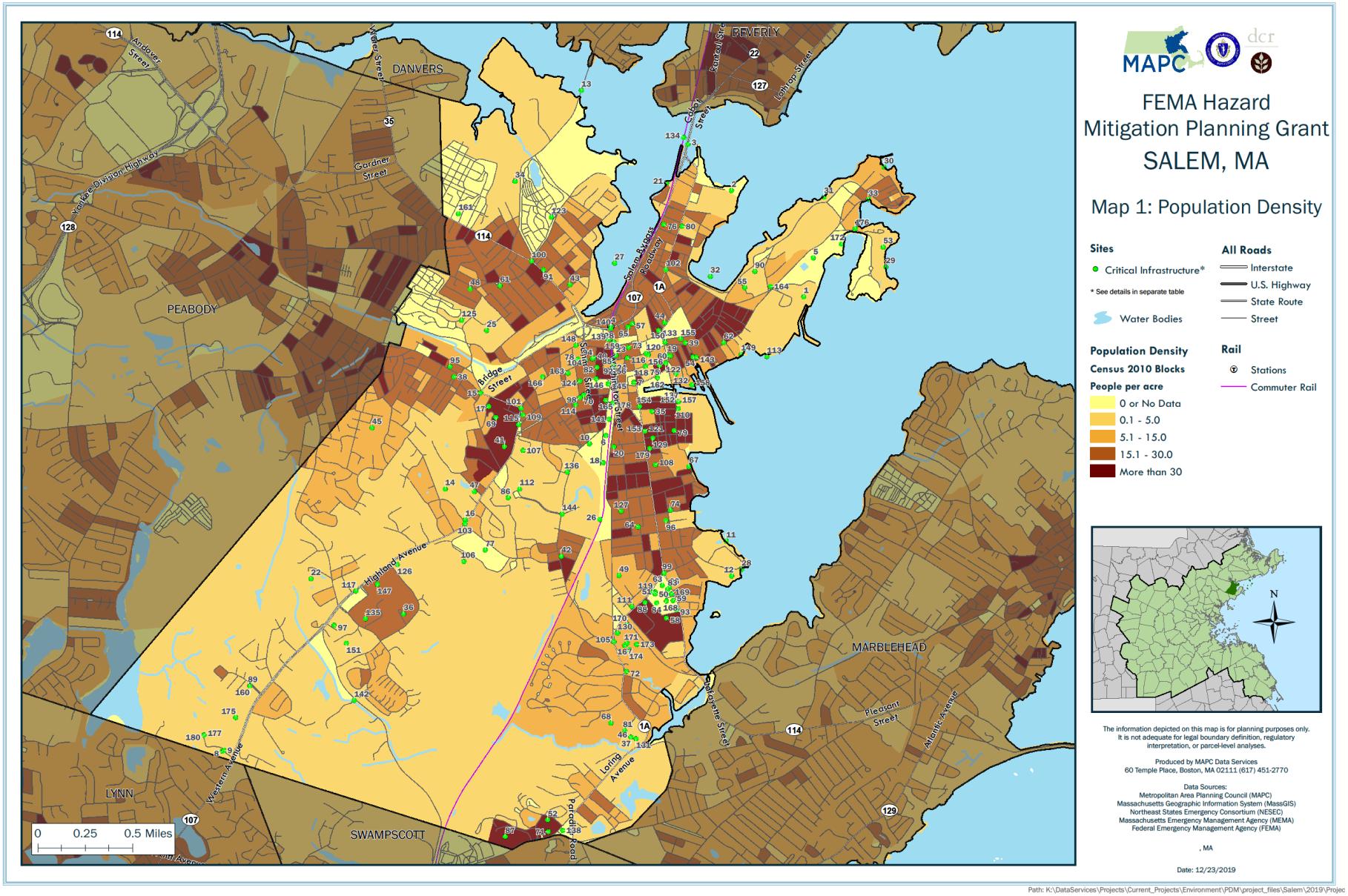
Map 6: Average Snowfall - - This map shows the average snowfall. It also shows storm tracks for nor'easters, if any storms tracked through the community.

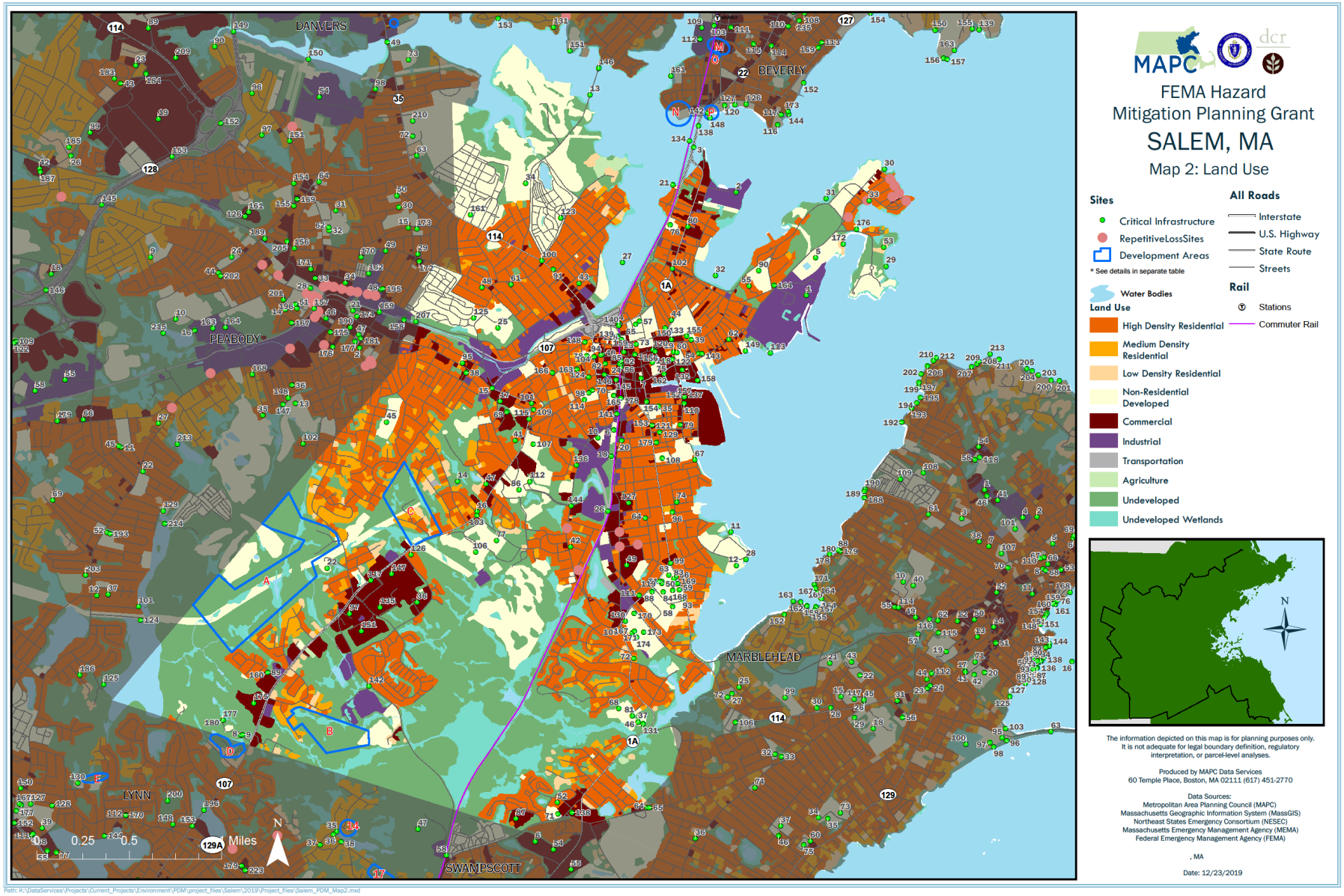
Map 7: Composite Natural Hazards - This map shows four categories of composite natural hazards for areas of existing development. The hazards included in this map are 100-year wind speeds of 110 mph or higher, low and moderate landslide risk, FEMA Q3 flood zones (100 year and 500 year) and hurricane surge inundation areas. Areas with only one hazard were considered to be low hazard areas. Moderate areas have two of the hazards present. High hazard areas have three hazards present and severe hazard areas have four hazards present.

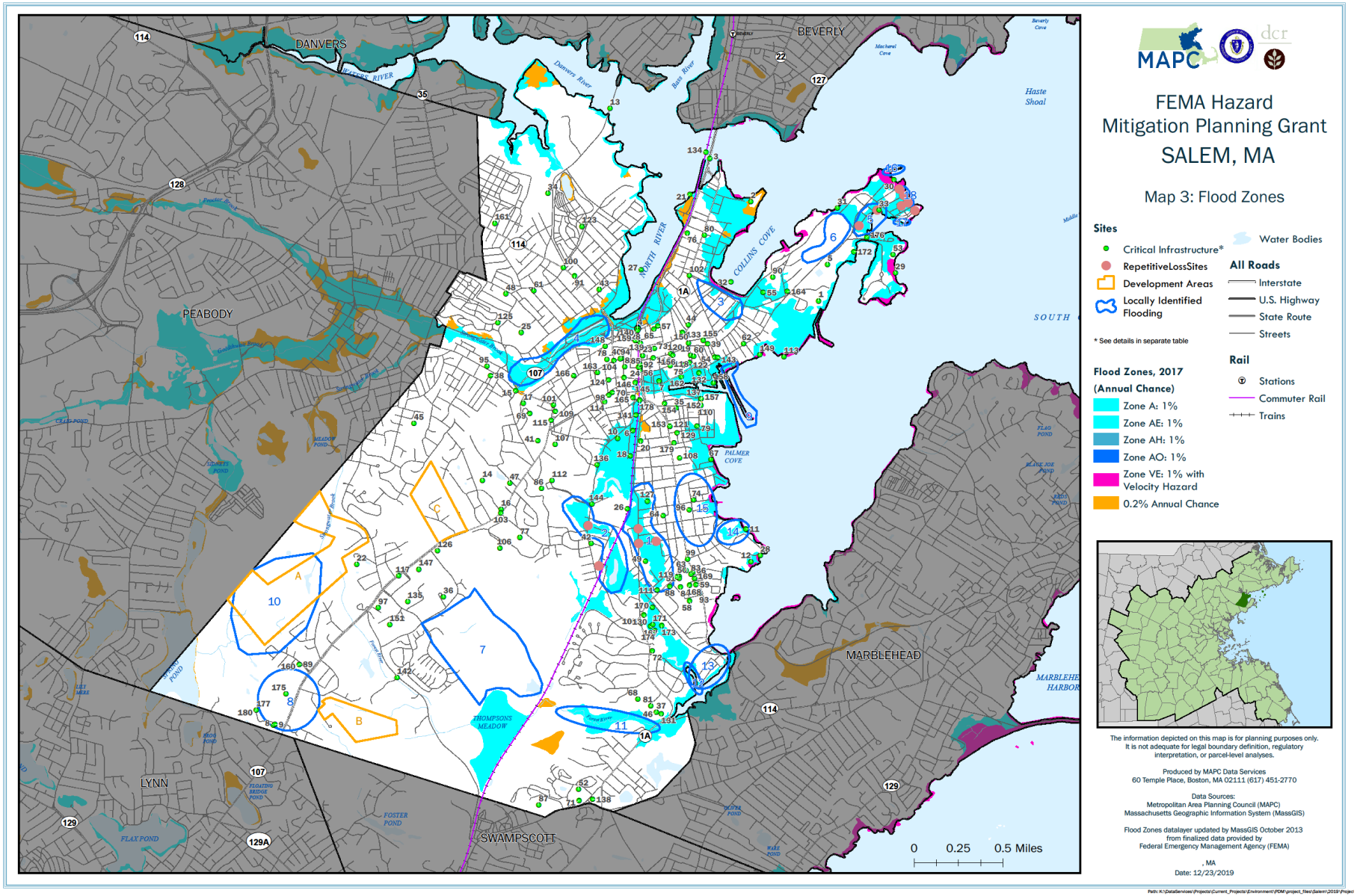
Map 8: Hazard Areas – For each community, locally identified hazard areas are overlaid on an aerial photograph dated April 2010. The critical infrastructure sites are also shown. The source of the aerial photograph is Mass GIS.

Map 9: Sea Level Rise - Based on the National Oceanic and Atmospheric Administration's (NOAA) Sea Level Rise viewer, this map shows the potential shoreline for Sea Level Rise scenarios for 1, 3, 6, and 10 feet of future sea level rise.

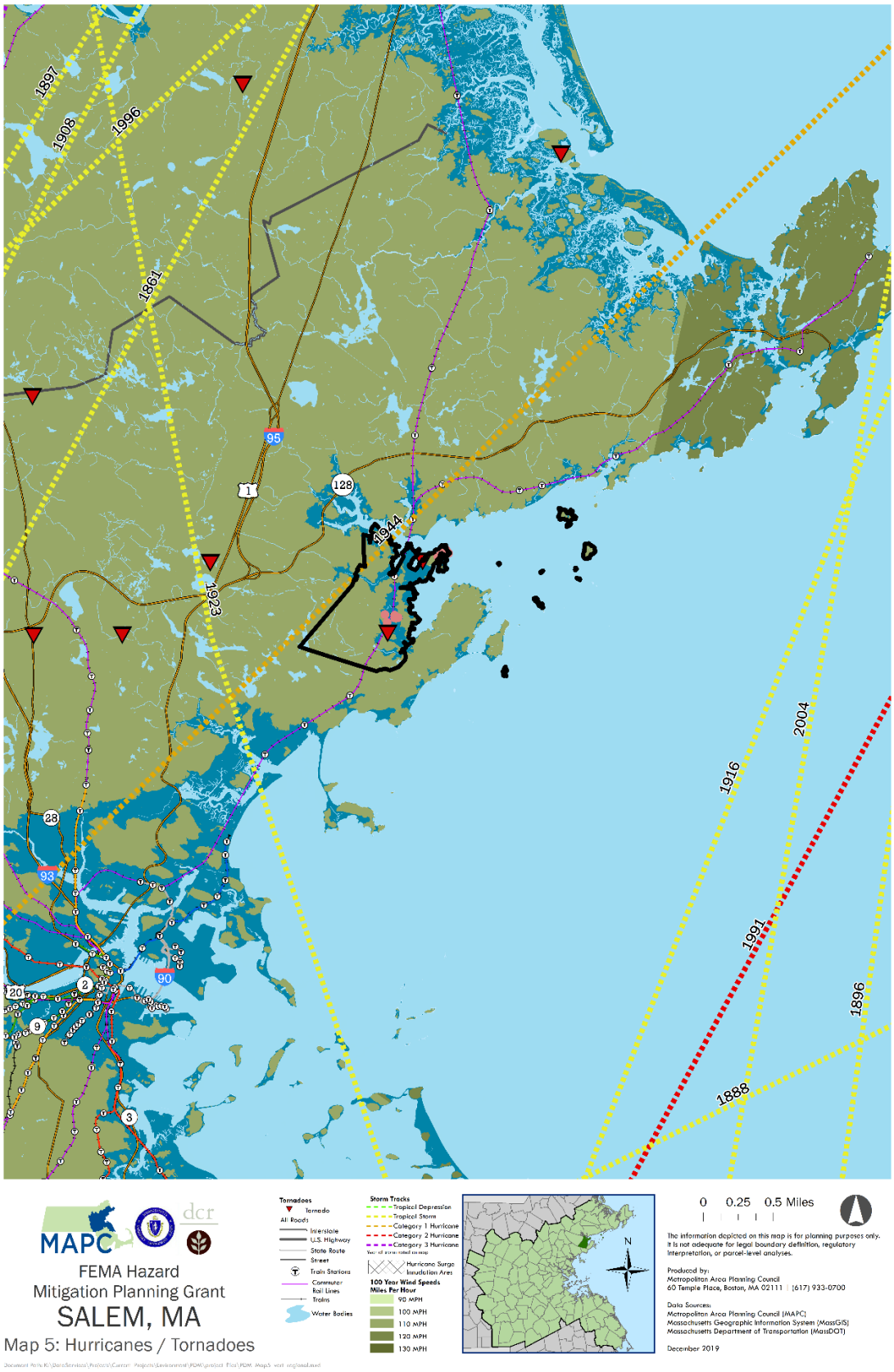
Map 10: High Land Surface Temperature - MAPC uses LANDSAT 30m spatial resolution satellite data to extract land surface temperature to assess a community's exposure to present-day extreme heat and any vulnerabilities to rising temperatures with climate change. The extreme heat analysis uses date from 2016 with satellite images on days of 90˚ or higher at Logan Airport, July 13 and August 30, 2016 and created land surface temperature using a methodology development by Walawender, Hajto, and Iwaniuk (2012) called Landsat TRS Tools. This map illustrates the hottest areas in the top fifth percentile for the 101 towns in Metropolitan Boston.

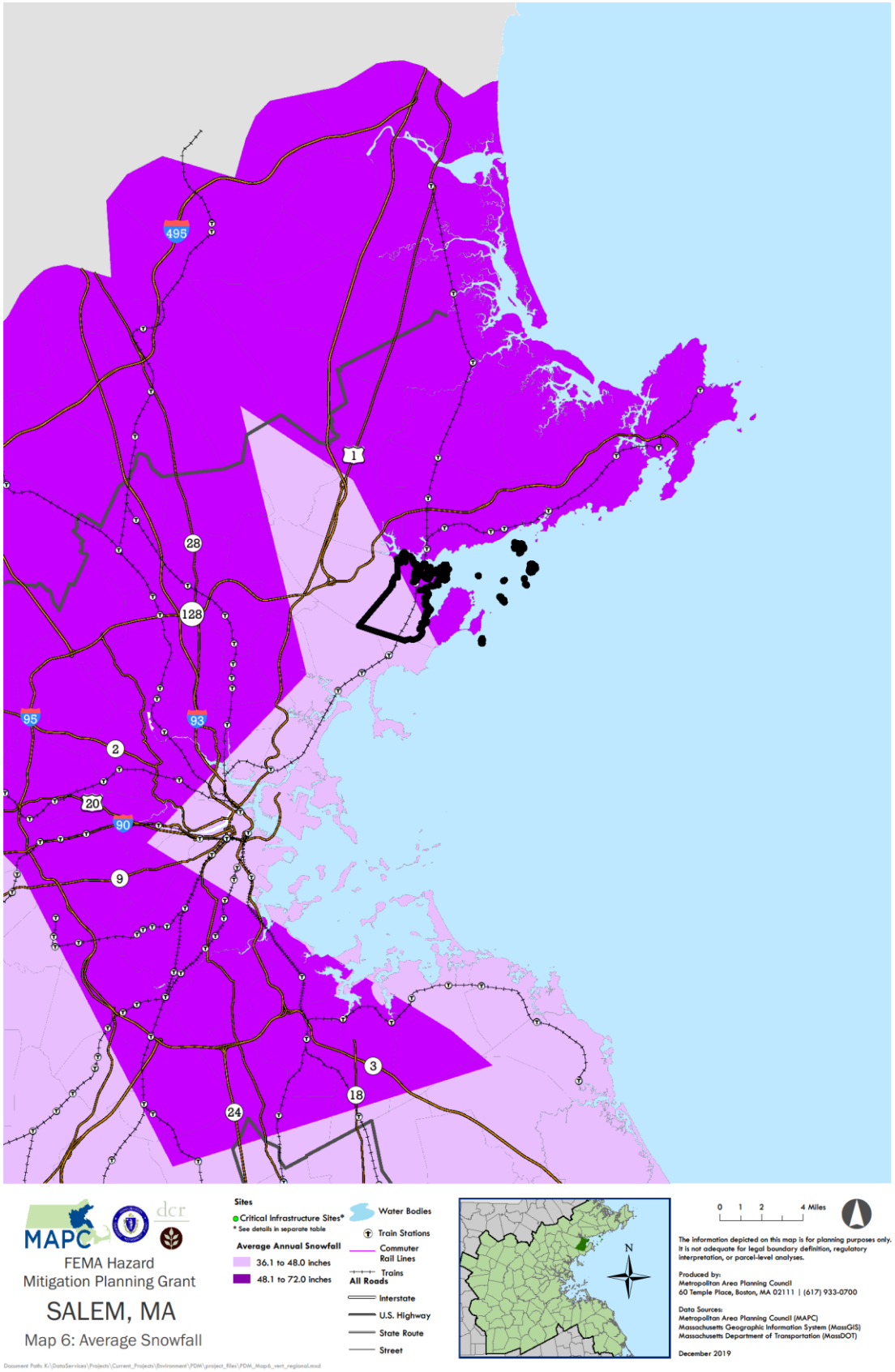

MAPC
dcr
FEMA Hazard Mitigation Planning Grant
SALEM, MA
Map 1: Population Density
Sites
Critical Infrastructure*
* See details in separate table
Water Bodies
All Roads
Interstate
U.S. Highway
State Route
Street
Population Density
Census 2010 Blocks
People per acre
0 or No Data
0.1 - 5.0
5.1 - 15.0
15.1 - 30.0
More than 30
Rail
Stations
Commuter Rail
N
0 0.25 0.5 Miles
PEABODY
DANVERS
BEVERLY
MARBLEHEAD
SWAMPSCOTT
LYNN
Andover Street
Gardner Street
Bridge Street
Highland Avenue
Western Avenue
Loring Avenue
Pleasant Street
Atlantic Avenue
Salem Bypass Roadway
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
, MA
Date: 12/23/2019
Path: K:\DataServices\Projects\Current_Projects\Environment\PDM\project_files\Salem\2019\Projec

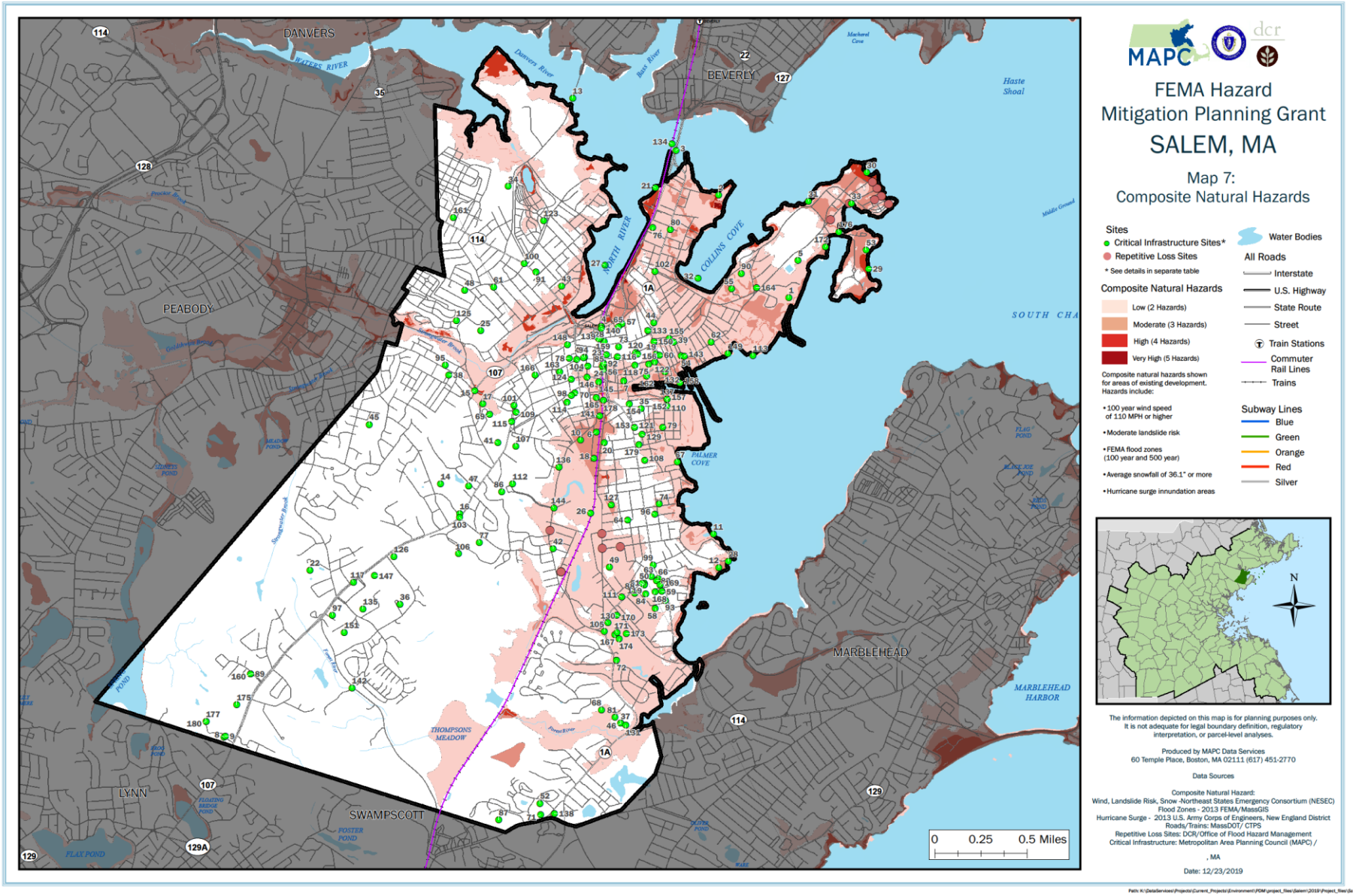

DANVERS
BEVERLY
PEABODY
MARBLEHEAD
LYNN
SWAMPSCOTT
0.25
0.5
Miles
N
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 2: Land Use
Sites
Critical Infrastructure
RepetitiveLossSites
Development Areas
* See details in separate table
Water Bodies
Land Use
High Density Residential
Medium Density Residential
Low Density Residential
Non-Residential Developed
Commercial
Industrial
Transportation
Agriculture
Undeveloped
Undeveloped Wetlands
All Roads
Interstate
U.S. Highway
State Route
Streets
Rail
Stations
Commuter Rail
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
, MA
Date: 12/23/2019

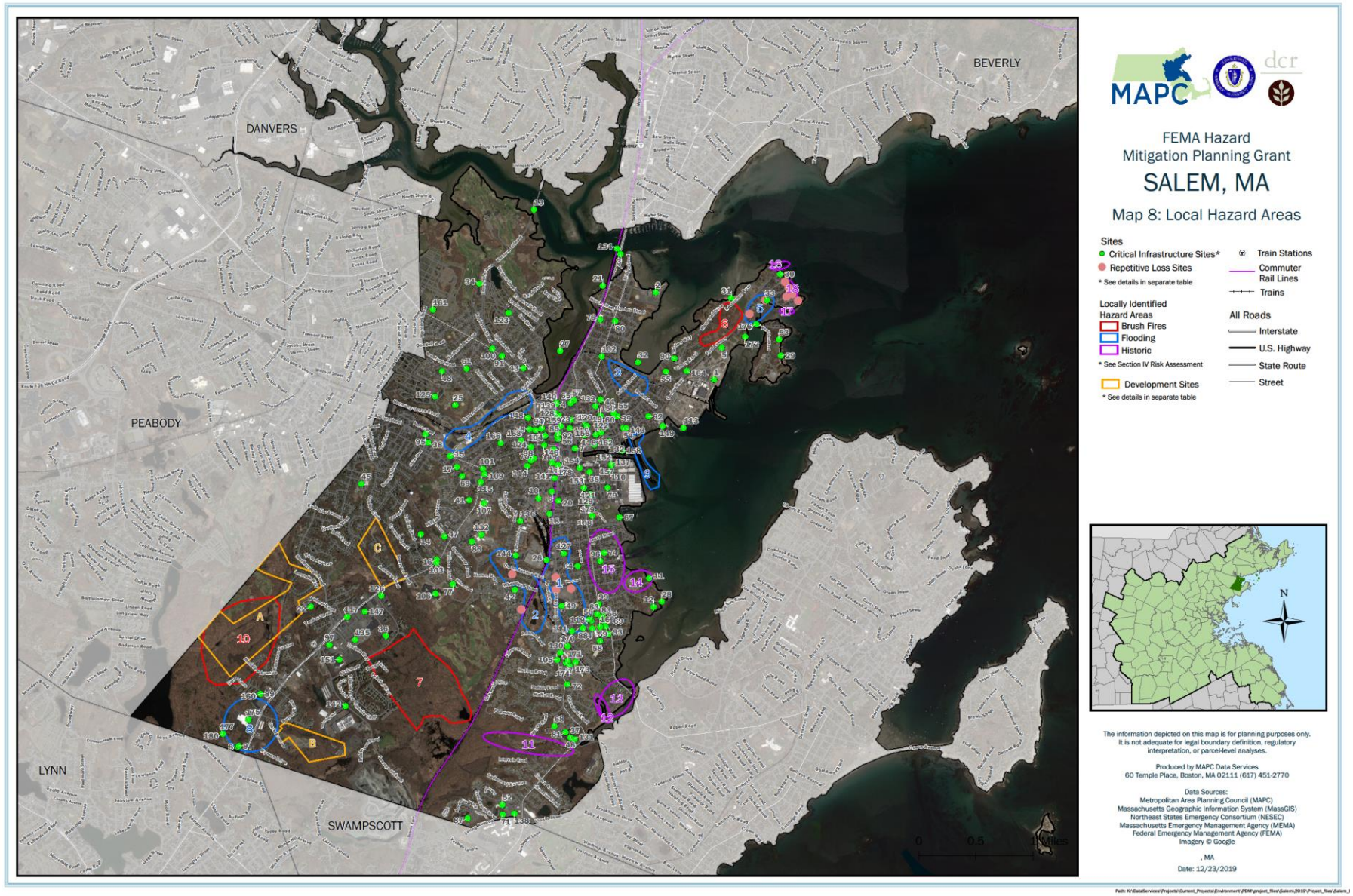

DANVERS
BEVERLY
PEABODY
LYNN
SWAMPSCOTT
MARBLEHEAD
SALEM
Danvers River
North River
Collins Cove
Palmer Cove
Haste Shoal
Marblehead Harbor
Forest River
Thompsons Meadow
0 0.25 0.5 Miles
MAPC
dcr
FEMA Hazard Mitigation Planning Grant
SALEM, MA
Map 3: Flood Zones
Sites
Critical Infrastructure*
RepetitiveLossSites
Development Areas
Locally Identified Flooding
* See details in separate table
Water Bodies
All Roads
Interstate
U.S. Highway
State Route
Streets
Rail
Stations
Commuter Rail
Trains
Flood Zones, 2017 (Annual Chance)
Zone A: 1%
Zone AE: 1%
Zone AH: 1%
Zone AO: 1%
Zone VE: 1% with Velocity Hazard
0.2% Annual Chance
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Flood Zones datalayer updated by MassGIS October 2013 from finalized data provided by Federal Emergency Management Agency (FEMA)
, MA
Date: 12/23/2019

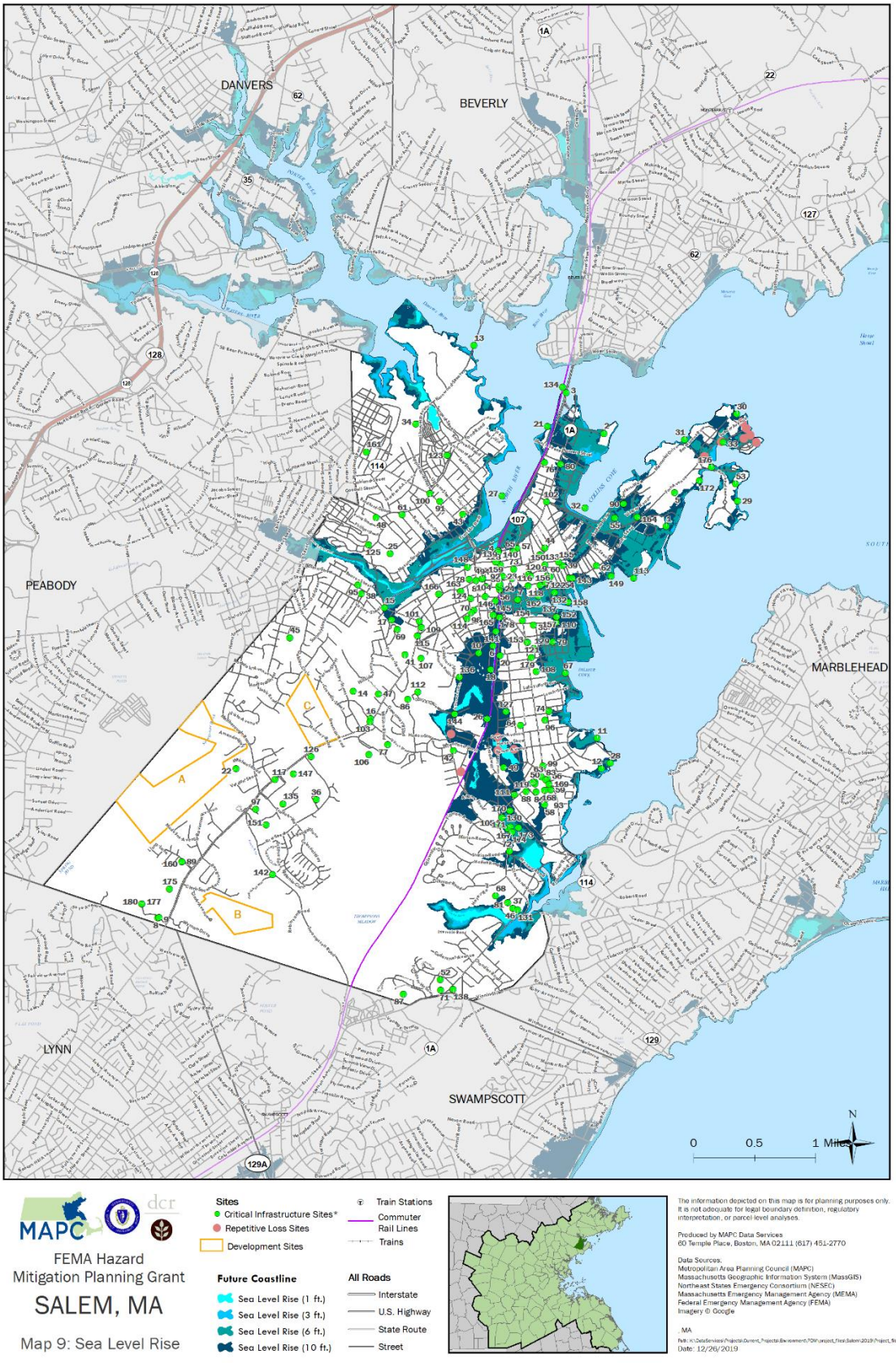

MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 4: Earthquakes / Landslides
Earthquakes
Epicenters
Train Stations
Commuter Rail Lines
Trains
All Roads
Interstate
U.S. Highway
State Route
Street
Water Bodies
Landslides
High landslide incidence (greater than 15% of the area is involved in landsliding)
High susceptibility to landsliding and moderate incidence
High susceptibility to landsliding and low incidence
Moderate susceptibility to landsliding and low incidence
Low landslide incidence (less than 1.5 % of the area is involved in landsliding
0 0.25 0.5 Miles
N
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by:
Metropolitan Area Planning Council
60 Temple Place, Boston, MA 02111 | (617) 933-0700
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Massachusetts Department of Transportation (MassDOT)
December 2019

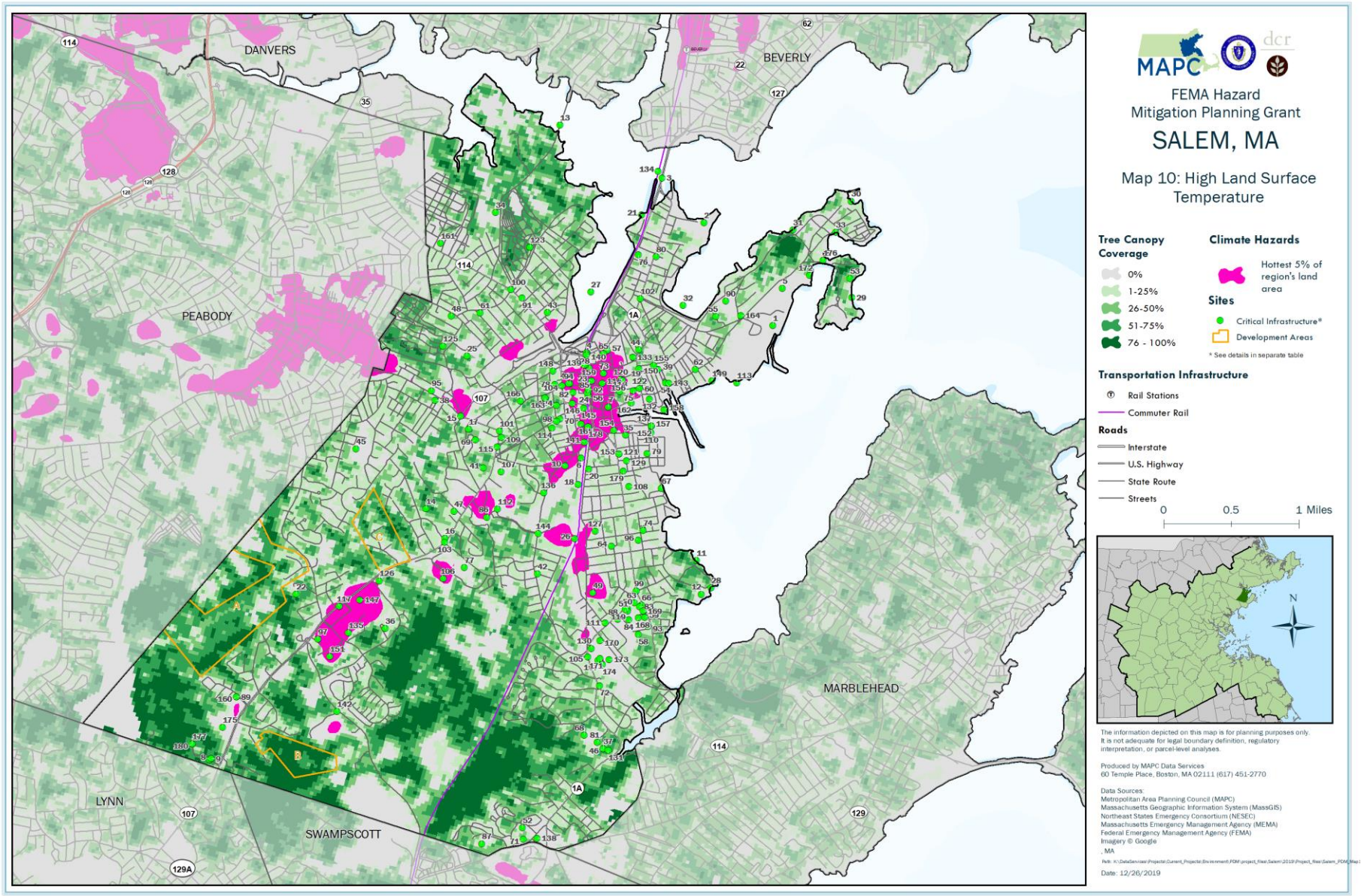

1897
1908
1996
1861
95
1
128
1944
1923
2004
1916
1991
1896
1888
28
93
90
2
20
9
3
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 5: Hurricanes / Tornadoes
Tornadoes
Tornado
All Roads
Interstate
U.S. Highway
State Route
Street
Train Stations
Commuter Rail Lines
Trains
Water Bodies
Storm Tracks
Tropical Depression
Tropical Storm
Category 1 Hurricane
Category 2 Hurricane
Category 3 Hurricane
Hurricane Surge Inundation Area
100 Year Wind Speeds Miles Per Hour
90 MPH
100 MPH
110 MPH
120 MPH
130 MPH
N
0 0.25 0.5 Miles
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by:
Metropolitan Area Planning Council
60 Temple Place, Boston, MA 02111 | (617) 933-0700
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Massachusetts Department of Transportation (MassDOT)
December 2019


495
1
28
128
95
93
2
20
90
9
3
18
24
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 6: Average Snowfall
Sites
Critical Infrastructure Sites*
* See details in separate table
Average Annual Snowfall
36.1 to 48.0 inches
48.1 to 72.0 inches
Water Bodies
Train Stations
Commuter Rail Lines
Trains
All Roads
Interstate
U.S. Highway
State Route
Street
N
0 1 2 4 Miles
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by:
Metropolitan Area Planning Council
60 Temple Place, Boston, MA 02111 | (617) 933-0700
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Massachusetts Department of Transportation (MassDOT)
December 2019


MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 7:
Composite Natural Hazards
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Composite Natural Hazards
Low (2 Hazards)
Moderate (3 Hazards)
High (4 Hazards)
Very High (5 Hazards)
Composite natural hazards shown for areas of existing development. Hazards include:
•100 year wind speed of 110 MPH or higher
•Moderate landslide risk
•FEMA flood zones (100 year and 500 year)
•Average snowfall of 36.1" or more
•Hurricane surge innundation areas
Water Bodies
All Roads
Interstate
U.S. Highway
State Route
Street
Train Stations
Commuter Rail Lines
Trains
Subway Lines
Blue
Green
Orange
Red
Silver
N
0 0.25 0.5 Miles
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources
Composite Natural Hazard:
Wind, Landslide Risk, Snow -Northeast States Emergency Consortium (NESEC)
Flood Zones - 2013 FEMA/MassGIS
Hurricane Surge - 2013 U.S. Army Corps of Engineers, New England District
Roads/Trains: MassDOT/ CTPS
Repetitive Loss Sites: DCR/Office of Flood Hazard Management
Critical Infrastructure: Metropolitan Area Planning Council (MAPC) /
, MA
Date: 12/23/2019
DANVERS
PEABODY
BEVERLY
MARBLEHEAD
SWAMPSCOTT
LYNN
NORTH RIVER
COLLINS COVE
PALMER COVE
MARBLEHEAD HARBOR
THOMPSONS MEADOW
Haste Shoal
SOUTH CHA


BEVERLY
DANVERS
PEABODY
LYNN
SWAMPSCOTT
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 8: Local Hazard Areas
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
* See details in separate table
Locally Identified
Hazard Areas
Brush Fires
Flooding
Historic
* See Section IV Risk Assessment
Development Sites
* See details in separate table
Train Stations
Commuter
Rail Lines
Trains
All Roads
Interstate
U.S. Highway
State Route
Street
N
0
0.5
1 Miles
The information depicted on this map is for planning purposes only.
It is not adequate for legal boundary definition, regulatory
interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © Google
, MA
Date: 12/23/2019


DANVERS
BEVERLY
PEABODY
MARBLEHEAD
LYNN
SWAMPSCOTT
A
B
C
0
0.5
1 Miles
N
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 9: Sea Level Rise
Sites
Critical Infrastructure Sites*
Repetitive Loss Sites
Development Sites
Future Coastline
Sea Level Rise (1 ft.)
Sea Level Rise (3 ft.)
Sea Level Rise (6 ft.)
Sea Level Rise (10 ft.)
Train Stations
Commuter Rail Lines
Trains
All Roads
Interstate
U.S. Highway
State Route
Street
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © Google
, MA
Date: 12/26/2019


DANVERS
BEVERLY
PEABODY
MARBLEHEAD
LYNN
SWAMPSCOTT
MAPC
dcr
FEMA Hazard
Mitigation Planning Grant
SALEM, MA
Map 10: High Land Surface Temperature
Tree Canopy Coverage
0%
1-25%
26-50%
51-75%
76 - 100%
Climate Hazards
Hottest 5% of region's land area
Sites
Critical Infrastructure*
Development Areas
* See details in separate table
Transportation Infrastructure
Rail Stations
Commuter Rail
Roads
Interstate
U.S. Highway
State Route
Streets
0
0.5
1 Miles
N
The information depicted on this map is for planning purposes only. It is not adequate for legal boundary definition, regulatory interpretation, or parcel-level analyses.
Produced by MAPC Data Services
60 Temple Place, Boston, MA 02111 (617) 451-2770
Data Sources:
Metropolitan Area Planning Council (MAPC)
Massachusetts Geographic Information System (MassGIS)
Northeast States Emergency Consortium (NESEC)
Massachusetts Emergency Management Agency (MEMA)
Federal Emergency Management Agency (FEMA)
Imagery © Google
, MA
Date: 12/26/2019

APPENDIX B: LOCAL HAZARD MITIGATION PLANNING TEAM

Meeting Agenda
Natural Hazard Mitigation Plan Update
City of Salem, City Hall Annex
July 8, 2019, 10:00 AM – 11:30 AM

Local Team Meeting #1 (Information Gathering)

1. Review 2012 mitigation actions- check status and what to carry forward in 2020 Plan Update
2. Hazard Mitigation Planning Map Series and Digitized Ortho Photo Map
3. Identify/Update Critical Facilities as needed
4. Identify local hazards:

    a. Coastal and Inland Flood Hazard Areas
    b. Fire Hazard Areas (brushfires/wildfires)
    c. Dams
    d. Ice jams
    e. Thunderstorms
    f. Drought
    g. Extreme Temps
    h. Tornadoes
    i. High winds
    j. Snow and Blizzards
    k. Nor'easters
    l. Ice storms
    m. Earthquakes
    n. Landslides
    o. Invasive species
    p. Future Potential Development Areas

5. Review Plan Goals and Objectives- see over
6. Discuss Public Involvement and Outreach
    a. Identify local stakeholders
    b. Schedule first public meeting

Project Overview MAPC is working with Salem to update its 2012 natural hazards *Pre-Disaster Mitigation Plan* to mitigate potential damages of natural hazards such as floods, winter storms, hurricanes, earthquakes and wild fires, before such hazards occur. The federal *Disaster Mitigation Act of 2000* requires that all municipalities adopt a *Pre-Disaster Mitigation Plan* for natural hazards in order to remain eligible for FEMA Disaster Mitigation Grants.

HAZARD MITIGATION GOALS AND OBJECTIVES

The 2012 plan goals were as follows

1. Ensure that critical infrastructure sites are protected from natural hazards.
2. Protect existing residential and business areas from flooding.
3. Maintain existing mitigation infrastructure in good condition.
4. Continue to enforce existing zoning and building regulations.
5. Educate the public about zoning and building regulations, particularly with regard to changes in regulations that may affect tear-downs and new construction.
6. Work with surrounding communities to ensure regional cooperation and solutions for hazards affecting multiple communities such as coastal erosion.
7. Encourage future development in areas that are not prone to natural hazards.
8. Educate the public about natural hazards and mitigation measures.
9. Make efficient use of public funds for hazard mitigation.
10. Protect the City's ability to respond to various natural hazard events.

Recommended Goals to align with the Massachusetts Hazard Mitigation and Climate Adaptation Plan and FEMA Guidelines:

1. Prevent and reduce the loss of life, injury, public health impacts and property damages resulting from all identified natural hazards.

2. Build and enhance local mitigation capabilities to ensure individual safety, reduce damage to public and private property and ensure continuity of emergency services.

3. Increase cooperation and coordination among private entities, City officials and Boards, State agencies and Federal agencies.

4. Increase awareness of the benefits of hazard mitigation through outreach and education.

APPENDIX C: DOCUMENTATION OF PUBLIC MEETINGS

CALENDAR LISTING / MEDIA ADVISORY

SALEM NATURAL HAZARD PLAN PUBLIC MEETING

Meeting to present an overview of the update of Salem's Natural Hazards Mitigation Plan and solicit public comments

Who: Salem residents, business owners, representatives of non-profit organizations and institutions, and others who are interested in preventing and reducing damage from natural hazards.

What: The Salem Emergency Management Team (EMT) will hold a public meeting to present an overview of the pending update of the City of Salem's Natural Hazards Mitigation Plan. The Metropolitan Area Planning Council (MAPC) is assisting the City on the plan update, and a representative of MAPC will present an overview of the plan update.

The City of Salem adopted its first Hazard Mitigation Plan in 2012, which was approved by the Federal Emergency Management Agency (FEMA). The plan identifies natural hazards affecting Salem such as floods, hurricanes, winter storms, and earthquakes, as well as actions that the City can take to reduce the impacts of these hazards. FEMA requires that plans be updated regularly, so MAPC is assisting the City prepare an updated plan.

When: August 8, 2019, 7:00 PM

Where: Salem City Hall Annex, 98 Washington Street

MAPC is the regional planning agency for 101 communities in the metropolitan Boston area, promoting smart growth and regional collaboration. More information about MAPC is available at www.mapc.org.

Amanda Linehan, Communications Manager, Metropolitan Area Planning Council, 617-933-0705, alinehan@mapc.org

CITY OF SALEM
CONSERVATION COMMISSION

NOTICE OF MEETING

*You are hereby notified that the Salem Conservation Commission will hold its regularly scheduled meeting on **Thursday, August 8, 2019 at 6:30 PM at the City Hall Annex, 1st floor public hearing room, 98 Washington Street, Salem, MA.***

Gregory St. Louis, PE,
Chair

MEETING AGENDA

I. ROLL CALL

II. OLD/NEW BUSINESS

A. City of Salem's Hazard Mitigation Plan Update: presentation by Sam Cleeves, MAPC

III. REGULAR AGENDA

A. 46 Columbus Avenue and the beach at Juniper Avenue and Beach Street – DEP # TBD – Continuation of Public Hearing – Notice of Intent for the City of Salem, 98 Washington Street, Salem, MA. Purpose of hearing is to discuss proposed removal of approximately 15 cubic yards of beach sand from the northeast corner of the beach at 46 Columbus Avenue, and relocation of the sand to the ocean side of the seawall at Juniper Ave and Beach Street, within an area subject to protection under the Wetlands Protection Act MGL c.131§40 and Salem Wetlands Protection & Conservation Ordinance.

B. 79 Columbus Avenue – DEP # TBD – Continuation of Public Hearing – Notice of Intent for Eric Cormier, 20 Cutter Street, Waltham, MA. Purpose of hearing is to discuss proposed reconstruction of a single-family home at 79 Columbus Avenue, within an area subject to protection under the Wetlands Protection Act MGL c.131§40 and Salem Wetlands Protection & Conservation Ordinance.

C. 379 and 383 Highland Avenue, 14 and 16 Barnes Road, and 9, 12, 14, 15, 16, and 18 Cedar Road – DEP #64-679 -- Public Hearing -- Abbreviated Notice of Resource Area Delineation under the Wetlands Protection Act, Mass. General Laws c.131§40 and Salem Wetlands Protection and Conservation Ordinance for Peter Lutts, Overlook Acres LLC, 5 Briscoe Street, Beverly, MA 01915. The purpose of the hearing is to discuss the proposed delineation of wetland resource area boundaries and their associated buffer zones for the properties located at 379 and 383 Highland Avenue, 14 and 16 Barnes Road, and 9, 12, 14, 15, 16, and 18 Cedar Road.

D. Rosie's Pond Flood Mitigation – DEP #64-601 – Public Hearing – Request to Amend Order of Conditions for the City of Salem, 98 Washington St, Salem MA. Purpose of hearing is to discuss

CALENDAR LISTING / MEDIA ADVISORY

SALEM'S DRAFT HAZARD MITIGATION PLAN TO BE PRESENTED AT FEBRUARY 18 PUBLIC MEETING

Meeting to present the update of Salem's Hazard Mitigation Plan and solicit public comments

Who: Salem residents, business owners, representatives of non-profit organizations and institutions, and others who are interested in preventing and reducing damage from natural hazards.

What: The Salem Conservation Commission and Emergency Management Team (EMT) will hold a public meeting to present an overview of the draft Salem Hazard Mitigation Plan Update. The Metropolitan Area Planning Council (MAPC) is assisting the City on the plan update, and a representative of MAPC will present an overview of the plan update.

The City of Salem adopted its first Hazard Mitigation Plan in 2012, which was approved by the Federal Emergency Management Agency (FEMA). The plan identifies natural hazards affecting Salem such as floods, hurricanes, winter storms, and earthquakes, as well as actions that the City can take to reduce the impacts of these hazards. FEMA requires that plans be updated regularly, so MAPC is assisting the City prepare an updated plan.

When: Tuesday, February 18, 2020, 7:00 PM

Where: Salem City Hall Annex, 98 Washington Street

MAPC is the regional planning agency for 101 communities in the metropolitan Boston area, promoting smart growth and regional collaboration. More information about MAPC is available at www.mapc.org.

Amanda Linehan, Communications Manager, Metropolitan Area Planning Council
617-933-0705, alinehan@mapc.org

Hazard Mitigation Plan
Public Meeting

Natural hazards can have serious impacts on the City of Salem and its residents and businesses



The City of Salem has prepared a Hazard Mitigation Plan to help the city reduce its vulnerability to natural hazards such as flooding, hurricanes, and winter storms. Please join the Conservation Commission for a public meeting with a presentation about the Hazard Mitigation Plan. Your input and suggestions for the plan are welcome, please join us!

Date:	Tuesday, February 18, 2020
Time:	6:30 pm
Location:	Conservation Commission City Hall Annex 98 Washington Street Salem, MA

For more information, please contact
Martin Pillsbury at mpillsbury@mapc.org

MAPC
METROPOLITAN AREA PLANNING COUNCIL

MAPC
METROPOLITAN AREA PLANNING COUNCIL

Smart Growth & Regional Collaboration

What is the Hazard Mitigation Plan Update?
Hazard Mitigation planning is a proactive effort to identify actions that can be taken to reduce the dangers to life and property from natural hazard events.

Why is this plan important?
The Federal Disaster Mitigation Act of 2000 requires that a city or town have an approved hazard mitigation plan in order to qualify for federal funding from the following grant programs:

- Pre-Disaster Mitigation Competitive (PDM-C)
- Hazard Mitigation Grant Program (HMGP)
- Flood Mitigation Assistance (FMA)

Additionally, the plan provides a municipality the opportunity to review potential vulnerabilities to natural hazards and develop measures that can reduce or mitigate these vulnerabilities and be included in the local planning process.

What goes into a hazard mitigation plan?
A hazard mitigation plan assesses the municipality's risks and vulnerabilities to natural hazard events such as flooding, hurricanes, winter storms, and earthquakes. MAPC uses statewide data and information directly from the community to make this assessment.

The plan includes a set of goals related to the overall goal of hazard mitigation planning, an assessment of existing mitigation measures, and a set of new mitigation measures that will serve to advance the plan goals. The plan update will also look at implementation progress that has been made on mitigation measures from the previous plan.

What is the Local Hazard Mitigation Committee?
The Local Hazard Mitigation Committee includes and coordinates with representatives from a number of different Town departments including Public Works, Engineering, Health, Community Development, Emergency Management and Fire. This committee provides the local on-the-ground knowledge necessary to write this plan including information on local hazard areas and current mitigation measures. This committee also identifies and prioritizes mitigation measures to be included in the plan.

How can the public become involved in the Hazard Mitigation planning process?
Public participation is very important to the hazard mitigation planning process. FEMA requires a minimum of two public meetings. When the first draft of the plan is developed, the Town will provide an online link where the plan can be viewed and comments may be provided by the public.

60 Temple Place, Boston, MA 02111 • 617 451 2770 • Fax 617 482 7185 • www.mapc.org

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APPENDIX D: DOCUMENTATION OF PLAN APOPTION

[To be completed following MEMA and FEMA review of the plan]
[Print on City letterhead]

CERTIFICATE OF ADOPTION
CITY COUNCIL

CITY OF SALEM, MASSACHUSETTS

A RESOLUTION ADOPTING THE
CITYOF SALEM HAZARD MITIGATION PLAN 2020 UPDATE

WHEREAS, the City of Salem established a Committee to prepare the *City of Salem Hazard Mitigation Plan 2020 Update*; and

WHEREAS, the *City of Salem Hazard Mitigation Plan 2020 Update* contains several potential future projects to mitigate impacts from natural hazards in the City of Salem, and

WHEREAS, duly noticed public meetings were held by the Conservation Commissoin August 8, 2019, and February 18, 2020

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

NOW, THEREFORE BE IT RESOLVED that the City of Salem adopts the *City of Salem Hazard Mitigation Plan 2020 Update*, in accordance with M.G.L. 40 §4 or the charter and ordinances of the City of Salem.

ADOPTED AND SIGNED this Date. _____

Name(s)

Title(s)

Signature(s)

ATTEST

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APPENDIX E: DOCUMENTATION OF PLAN APPROVAL

[To be added after FEMA approval of the plan]