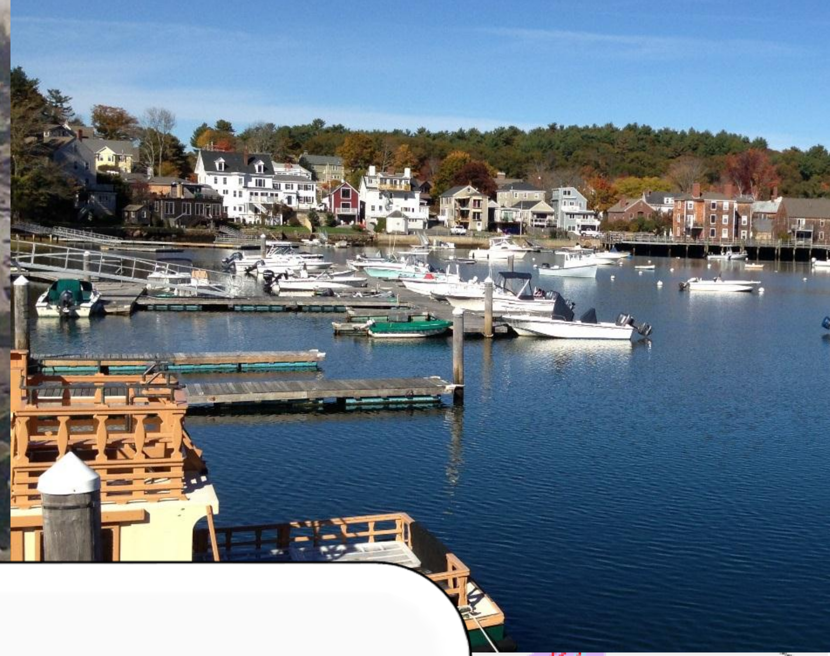
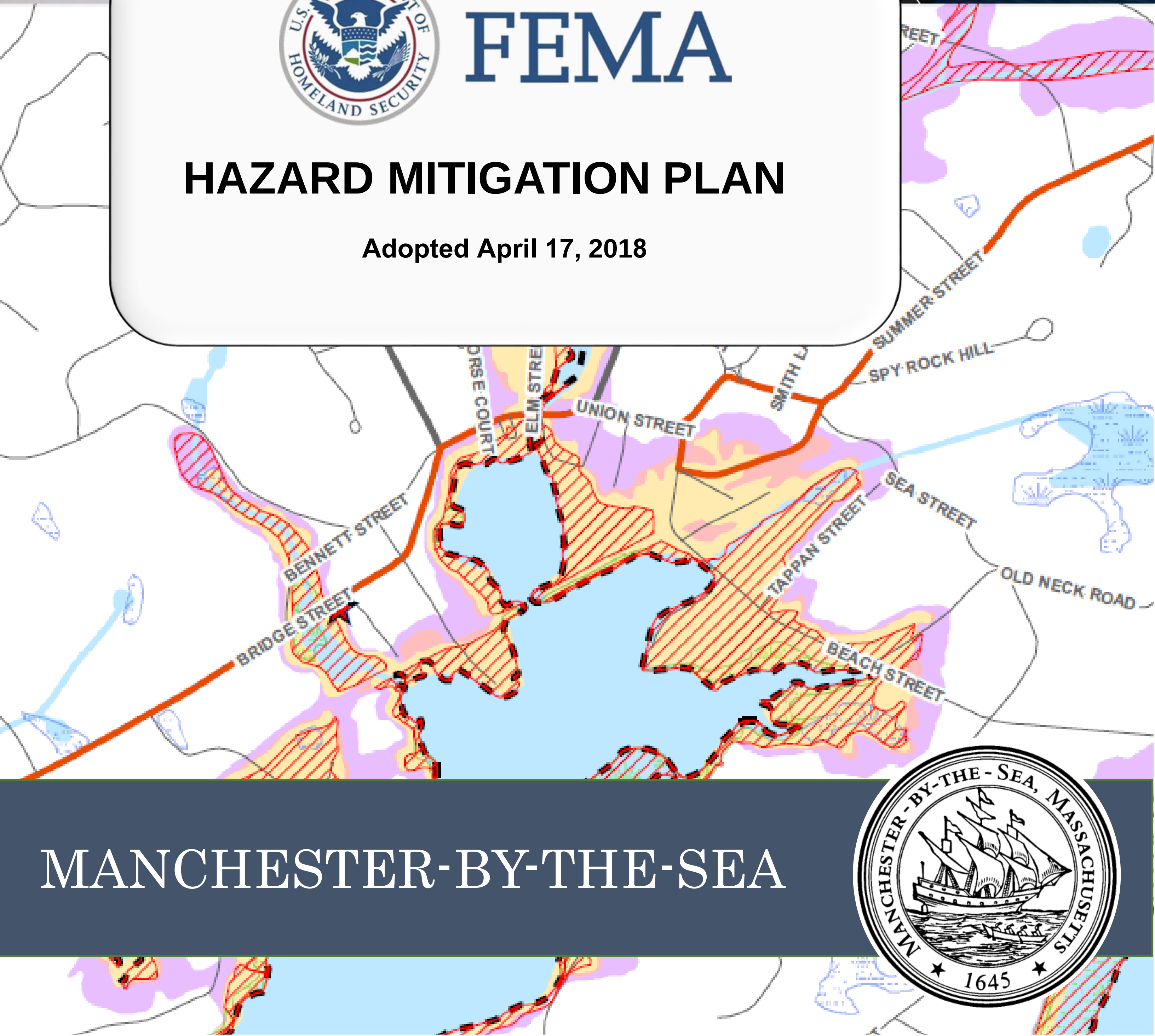


HAZARD MITIGATION PLAN

Adopted April 17, 2018



MANCHESTER-BY-THE-SEA

Acknowledgements

For providing data, other plans and studies, editorial assistance, and guidance to the consulting team, special thanks go to the following Manchester-by-the-Sea town department heads and staff: Greg Federspiel, Town Administrator, Mary Reilly, Grants Administrator, Carol Murray, Interim Director, Department of Public Works; Barbara Warren, Salem Sound Coastwatch, Jessica Lamothe, and members of the Manchester Coastal Stream Team, Sue Brown, Town Planner, Bion Pike, Harbormaster, the Manchester Essex Regional High School Green Team, the Manchester-by-the-Sea Board of Selectmen for their continued support, the Manchester Historical Society, resident volunteers, and the Downtown Business owners who assisted with this plan.

We gratefully acknowledge the hard work and commitment of the Coastal Resource Advisory Group, who reviewed draft report documents and met regularly throughout this planning process to provide invaluable input and guidance.

- Greg Federspiel, Town Manager
- Mary Reilly, Grants Administrator
- Tom Kehoe, Board of Selectmen, Emergency Management Director
- Carol Murray, P.E., Interim Director Department of Public Works
- Todd Fitzgerald, Lieutenant ,Manchester Police
- Tod Biggar, Fire Captain/EMT, Manchester Fire and Rescue
- Geroge Kramlinger, Fire Chief, Emergency Management Assistant Director
- Edward Conley,Police Chief, Manchester Police
- Susan Brown, Town Planner
- Chris Bertoni, Conservation Administrator
- Bion Pike, Harbor Master
- Barbara Warren, Salem Sound Coastwatch
- Jessica Lamothe, Manchester Coastal Stream Team
- Rick Gibson, Downtown Improvement Committee
- Ben Rossi, Downtown Improvement Committee
- Jori Everitt, Citizen Volunteer
- Lise Koufman, Citizen Volunteer
- Sarah White, Hazard Mitigation Grants Coordinator, Massachusetts Emergency Management Agency
- Alan Philips, Program Coordinator, Federal Emergency Management Agency

Cover and Report images: Sources of all report photos are cited unless taken by Tighe & Bond staff.

List of Maps and Figures

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Appendices

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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 Federal Emergency Management Agency (FEMA) funding for hazard mitigation grants must adopt a local Hazard Mitigation Plan. This planning requirement does not affect disaster assistance funding.

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The Town of Manchester-by-the-Sea has received grant funding from FEMA under the Pre-Disaster Mitigation (PDM) Program to enhance and update their local Hazard Mitigation Plan. The federal hazard mitigation planning and grant programs are administered in Massachusetts by the Massachusetts Emergency Management Agency (MEMA) in partnership with the Department of Conservation and Recreation (DCR).

The single jurisdiction local Hazard Mitigation Plan (Plan) produced under this grant is designed to meet the requirements of the Disaster Mitigation Act, following guidance provided in FEMA's Local Mitigation Planning Handbook (March 2013) and FEMA's Local Mitigation Plan Review Guide (October 1, 2011).

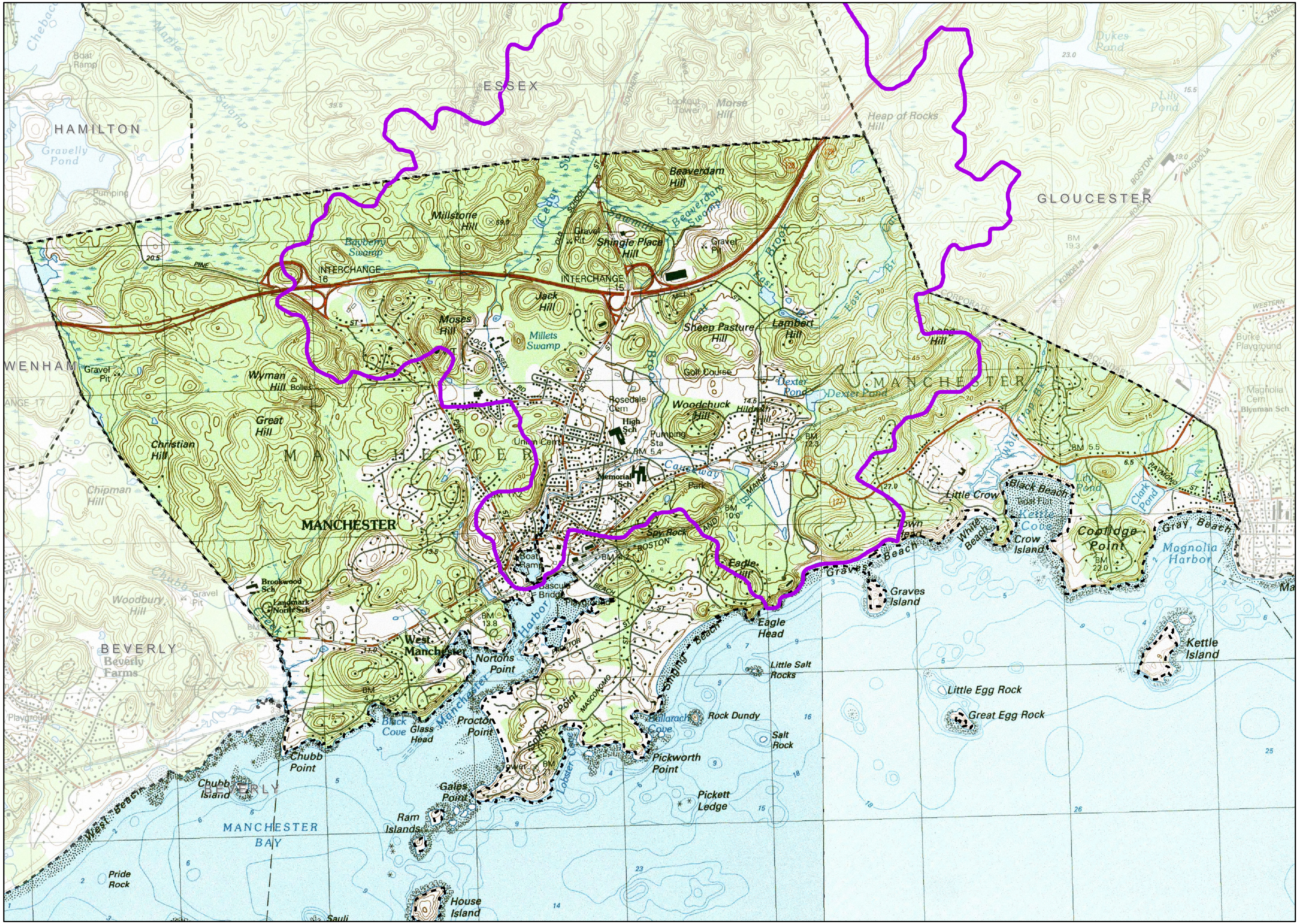
What is Hazard Mitigation?

The purpose of hazard mitigation is to reduce loss from future natural hazards. Storms and other natural disasters such as floods, earthquakes, and hurricanes can cause loss of life, damage to buildings and infrastructure, and negatively affect a community's economic, social, and environmental well-being. Manchester-by-the-Sea has developed a Hazard Mitigation Plan as a means to permanently reduce or alleviate the losses of life, injuries, and damage to property resulting from natural hazards through long-term strategies. These long-term strategies include planning, policy changes, programs, projects, educational outreach, and other activities. The desired outcome of implementing the Plan will be creating a more resilient community that is better prepared prior to a natural disaster and can recover more quickly after an event occurs.

Community Profile

Manchester-by-the-Sea is a small coastal community located in Essex County, approximately 32 miles north of Boston, consisting of approximately 5,000 acres. Manchester is considered part of Cape Ann along the north shore of Massachusetts Bay, which includes the communities of Essex, Gloucester, Rockport, and Manchester-by-the-Sea **(Map 1).** Two state highways, Route 127 and Route 128, traverse the town from Beverly to the west and Gloucester to the east, as does the Rockport branch of the MBTA commuter rail line. Two local roads link the town with neighboring Essex to the north and Hamilton to the northwest. Manchester also shares many natural resources with its regional neighbors. The Town is governed by a Board of Selectmen with a Town Administrator. The Town operates under the open town meeting format. The Town maintains a website at www.manchester.ma.us.

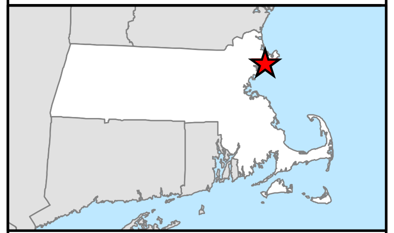
MAP 1
LOCATION OF MANCHESTER-BY-THE-SEA



LEGEND

Sawmill Brook Watershed

LOCUS MAP



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DATA SOURCES

1. Based on USGS Topographic Map for Manchester-by-the-Sea, MA Quadrangle. Revised

Hazard Mitigation Plan

Manchester-by-the-Sea, Massachusetts

2017

Tighe&Bond
Engineers | Environmental Specialists

Manchester-by-the-Sea's coastline extends for several miles and includes many beautiful homes and parks situated along coves and inlets, and a vibrant economic center adjacent to Manchester Harbor. Inland, Sawmill Brook and its tributaries drain rocky uplands, expansive wetlands, forested open space, and developed residential areas before discharging to the Harbor through a narrow tide gate. Many areas of the town are located in FEMA flood zones and are subject to flooding during extreme storm events due to the combination of storm surge, hydraulic restrictions from culverts and the tide gate, stormwater runoff from impervious areas, the channelized stream system, and poor infiltration conditions. Future impacts due to a changing climate, including increased precipitation and sea-level rise, will exacerbate flooding,

Federal/State Disaster Declarations

Manchester-by-the-Sea has experienced 21 natural hazard incidents that triggered federal or state disaster declarations since 1991, listed in **Table A** below. The majority of events involved flooding.

Table A
Federal and State Disaster Declarations 1991-2016[1]

Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in Massachusetts
Hurricane Bob (August 1991)	FEMA Public Assistance Project Grants Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk Statewide Hazard Mitigation
No-Name Storm (October 1991)	FEMA Public Assistance Project Grants FEMA Individual Household Program Hazard Mitigation Grant Program	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, Suffolk Statewide Hazard Mitigation
March Blizzard (March 1993)	FEMA Public Assistance Project Grants	Statewide
January Blizzard (January 1996)	FEMA Public Assistance Project Grants	Statewide
October Flood (October 1996)	FEMA Public Assistance Project Grants FEMA Individual Household Program Hazard Mitigation Grant Program	Counties of Essex, Middlesex, Plymouth, Norfolk, Suffolk Statewide Hazard Mitigation
June Flood (June 1998)	FEMA Individual Household Program Hazard Mitigation Grant Program Community Development Block Grant-HUD	Counties of Bristol, Essex, Middlesex, Plymouth, Norfolk, Suffolk, Worcester Statewide Hazard Mitigation
March Flood (March 2001)	FEMA Individual Household Program Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Plymouth, Norfolk, Suffolk, Worcester Statewide Hazard Mitigation
February Snowstorm (Feb 17-18, 2003)	FEMA Public Assistance Project Grants	Statewide
January Blizzard (January 22-23, 2005)	FEMA Public Assistance Project Grants	Statewide

[1] FEMA Disaster Declarations for Massachusetts https://www.fema.gov/disasters/grid/state-tribal-government/2?field_disaster_type_term_tid_1=All data

Table A

Federal and State Disaster Declarations 1991-2016[1]

Disaster Name (Date of Event)	Type of Federal Assistance Provided	Declared Areas in Massachusetts
May Rainstorm/Flood (May 12-23, 2006)	Hazard Mitigation Grant Program	Statewide Hazard Mitigation
April Nor'easter (April 15-27, 2007)	Hazard Mitigation Grant Program	Statewide Hazard Mitigation
Flooding (March 2010)	FEMA Public Assistance FEMA Individual and Household Programs SBA Loans Project Grants Hazard Mitigation Grant Program	Counties of Bristol, Essex, Middlesex, Plymouth, Norfolk, Suffolk, Worcester Statewide Hazard Mitigation
Nor'easter (January 11-12, 2011)	FEMA Public Assistance Grants Hazard Mitigation Grant Program	Counties of Berkshire, Essex, Hampshire, Middlesex, Norfolk and Suffolk Statewide Hazard Mitigation
Tropical Storm Irene (August 27-28, 2011)	FEMA Public Assistance Grants Hazard Mitigation Grant Program	Counties of Franklin and Berkshire Statewide Hazard Mitigation
"Snowtober" October 29-30, 2011	FEMA Public Assistance Grants Hazard Mitigation Grant Program	Counties of Berkshire, Franklin, Hampshire, Hampden, Worcester and Middlesex Statewide Hazard Mitigation
Hurricane Sandy October 27- Nov 8, 2012	FEMA Public Assistance Grants Hazard Mitigation Grant Program	Counties of Bristol, Plymouth, Barnstable, Dukes and Nantucket Statewide Hazard Mitigation
Winter Storm Nemo February 8-10, 2013	FEMA Public Assistance Grants Hazard Mitigation Grant Program	Statewide
Winter Storm Juno January 26-28, 2015	FEMA Public Assistance Grants Hazard Mitigation Grant Program	Counties of Worcester, Middlesex, Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Dukes and Nantucket Statewide Hazard Mitigation

FEMA Funded Mitigation Projects

Over the last 5 years, Manchester-by-the-Sea has received funding from FEMA for 2 hazard mitigation planning projects. These funds were from the PDM Grant Program and the 2 planning projects totaled $96,230, with $66,960 covered by federal grants and $29,270 by Town funding, including cash and in-kind services.

With funding from a FEMA 2014 PDM grant, the Town completed a Hazard Mitigation Plan Enhancement to incorporate flooding impacts due to climate change, including sea level rise, storm surge, and extreme precipitation and their potential effects on critical sectors of the Town.

As part of the grant, 8 global models for predicting sea level rise, storm surge, extreme precipitation events, and existing localized projections were evaluated. The evaluation was completed by comparing a variety of quantitative and qualitative variables available from online sources and interviews with model developers. The models chosen for Manchester-by-the-Sea included one model for inland extreme precipitation and one model that included future flood risk for storm surge and sea level rise as well as annual coastal flooding and hurricane surge.

Traditionally, Hazard Mitigation Plans focus on critical sectors such as buildings and infrastructure essential to meeting public health and safety needs in the event of a natural disaster. The Enhanced Plan provided a revised evaluation of Town “critical sectors” to be consistent with FEMA guidelines, adding economic and natural resources as additional community asset categories to evaluate in the Plan. The downtown business area is especially vulnerable to coastal storms, located almost exclusively within the 100-year floodplain. Natural resource areas, such as beaches, tidal estuaries, and wetlands provide a first line of defense to coastal storms, reducing the magnitude of hazard impacts and increasing resiliency. These areas also provide a tremendous socio-economic benefit to Manchester-by-the-Sea.

The flooding risk from inland and coastal sources with climate change at 25, 50 and 100-year planning horizons were evaluated for all identified community assets. Assets were then prioritized depending on the risk and degree of flooding from each source (extreme precipitation, storm surge, sea level rise, shallow coastal flooding, and hurricane surge). A Vulnerability and Risk Assessment (VRA), based on EPA methodology, was completed for chosen sites and facilities with the highest risk for flooding. The VRA utilized a weighted comparison of consequence and likelihood of occurrence to define risk, and sensitivity and adaptive capacity to define vulnerability. The VRA resulted in a prioritized list of sites and facilities to initiate planning for adaptation strategies.

Public outreach and education were incorporated into all aspects of the Enhancement project. The multi-media effort included creation of dedicated websites to post project deliverables, public surveys to solicit information about localized flooding and evaluate gaps in knowledge about flood related climate change impacts, an article series on flooding and climate change, regularly scheduled public meetings for the Coastal Resiliency Advisory Group (CRAG), and public forums to inform the public about the grant and provide general education about impacts of climate change and the need for resiliency planning.

A second round of FEMA funding was awarded in 2016 under a 2015 PDM grant to complete the 5-year Hazard Mitigation Plan Update. Information generated for the Enhancement was incorporated into Manchester-by-the-Sea’s 2017 Hazard Mitigation Plan 5-year Update.

Review Tool Description

FEMA developed a “Local Mitigation Review Guide” to help Federal, State and Local official assess Local Hazard Mitigation Plans and make sure they will meet the requirements of the Stafford Act and Title 44 Code of Federal Regulations (CFR) 201.6. This guide was used in updating the Manchester-by-the-Sea Hazard Mitigation Plan. Where text in the Hazard Mitigation Plan meets an element identified in the Review Guide, it is called out in a colored box in the margins.

SECTION 1

THE PLANNING PROCESS

Manchester-by-the-Sea has worked over the past two years with residents, business leaders, Town officials, and representatives from neighboring communities to develop the 2017 Manchester-by-the-Sea Hazard Mitigation Plan. Throughout the planning process the planning team has sought input from the community and provided opportunities to educate residents about the risk and vulnerability related to natural hazards and to build support for policies and mitigation actions that reduce future losses from natural hazards. Section 1 provides documentation on the hazard mitigation planning team and the public outreach process used to develop the 2017 Hazard Mitigation Plan.

Section 1
THE PLANNING PROCESS

A1 a e

The Town of Manchester-by-the-Sea used a planning process framework based on FEMA's hazard mitigation planning guidance focusing on local needs and priorities, but maintaining a regional perspective on natural hazard events. The process included the following steps:

(1) **Identifying and Mapping the Hazards** – The Town used data from federal, state, and locally developed data to identify hazards that impact Manchester-by-the-Sea. A profile of each hazard was developed including previous occurrences, magnitude and severity of the hazard, and probability for future occurrences. Maps were created to show areas affected by the identified natural hazards and were used as the basis for developing the risk assessment. Under the Plan Enhancement, the Town completed analysis and mapping of flooding impacts due to climate change. The **Natural Hazards Risk Assessment** is included in Section 2.

(2) **Assessing the Critical Community Assets and Potential Damages** – Critical community assets including municipal facilities, infrastructure, vulnerable populations, economic, and natural resources were located and compared with hazard data to identify those that may be vulnerable to hazards. Manchester developed estimates of the potential impacts of certain hazard events on the community including flooding, flooding impacts due to future climate change, earthquakes, and hurricane winds. Further discussion is included in the **Asset Inventory** in Section 3 **and the Vulnerability Assessment** in Section 4.

(3) **Reviewing Existing Mitigation** – Manchester-by-the-Sea has implemented many mitigation strategies including floodplain zoning, wetland protection, and other measures as well as enforcing the State Building Code. All current municipal mitigation measures were documented and discussed as part of the **Capabilities Assessment** in Section 5.

(4) **Developing Mitigation Strategies** – The Town worked with a designated planning group, local stakeholders, and their consultants to identify new mitigation measures, utilizing information gathered from the hazard identification, vulnerability assessment, and exiting mitigation measures to determine where additional work is needed to reduce potential future damages from hazard events. The **Mitigation Strategy** discussed in Section 6 includes goals and objectives, mitigation actions, and an implementation strategy.

(5) **Plan Approval and Adoption** – Once a final draft of the Plan is complete it is sent to MEMA for the state level review and pending the completion of any revisions, it is sent to FEMA for approval. Once FEMA approves the Plan, FEMA issues a conditional approval pending adoption of the Plan by the Manchester-by-the-Sea Board of Selectmen. The **Plan Approval Process** is included in Section 7.

(6) **Implementing and Updating the Plan** – Implementation is the final and most important part of any planning process. Hazard Mitigation Plans must also be updated on a 5-year basis making preparation for the next Plan update an important on-going activity. A schedule for implementation, **Plan Evaluation and Maintenance** is included in Section 8.

The steps included public participation as an important component of the process, providing critical information about the local occurrence of hazards, a discussion on regional issues, and to build support for hazard mitigation activities.

Public participation was accomplished with the assistance of the Manchester-by-the-Sea Coastal Resiliency Advisory Group (CRAG) representing local, state and federal stakeholders. In addition, the Town identified other interested stakeholders including neighboring communities and solicited their input for the Plan. Overall, Manchester held 12 public meetings open to the general public to present and discuss aspects of the Hazard Mitigation Plan Enhancement and 5-year Update. Five of the meetings were specifically focused on the 5-year Update.

1.1 Planning Team

A2 a b

The CRAG was designated as the Hazard Mitigation Planning Team (Planning Team) and met regularly throughout the planning process under the leadership of Mary Reilly, Grants Administrator. This core group was responsible for developing and reviewing drafts of the Plan, creating the mitigation strategy and adaptation actions, and submitting the Plan for adoption by FEMA and the Manchester-by-the-Sea Board of Selectmen. The members are listed in **Table 1.1**.

Table 1.1
Hazard Mitigation Planning Team

CRAG Member	Title	Affiliation
Greg Federspiel	Town Manager	Administration
Mary Reilly	Grants Administrator	Administration
Carol Murray, P.E.	Interim Director	Department of Public Works
Edward Conley	Police Chief	Manchester Police
Todd Fitzgerald	Lieutenant	Manchester Police
George Kramlinger	Fire Chief/Emergency Management Director	Manchester Fire and Rescue
Alan Philips	Program Coordinator	FEMA
Tom Kehoe	Selectman/Emergency Management Assistant Director	Manchester Fire and Rescue
Susan Brown	Town Planner	Community Development
Bion Pike	Harbor Master	Harbor Department
Chris Bertoni	Conservation Administrator	Conservation Department
Barbara Warren	Executive Director	Salem Sound Coastwatch
Jessica Lamothe	Committee Chairman	Manchester Coastal Stream Team
Rick Gibson	Member	Downtown Improvement Committee
Ben Rossi	Member	Downtown Improvement Committee
Sarah White	Hazard Mitigation Grants Coordinator	Massachusetts Emergency Management Agency
Jori Everitt	Citizen Volunteer	Manchester-by-the-Sea Resident

1.2 Outreach Strategy

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The Town included a robust public outreach strategy under both phases of the Hazard Mitigation Plan Enhancement and Update including Planning Team meetings, public forums, public surveys, and multi-media outreach including articles and press releases in the local newspaper, website postings and cable TV broadcasts. More detail on the outreach strategy is provided below and in **Table 1.2**.

Local Multiple Hazard Community Planning Team Meetings

The Planning Team met a total of 8 times over the course of a 30-month planning period, beginning in May 2015 and ending in September 2017. **Table 1.2** below includes a listing of meetings held under both the Hazard Mitigation Plan Enhancement grant (Meeting # 1-5) and under the Hazard Mitigation Plan 5-year Update grant (Meetings # 6-8). Meeting # 8 included both a local planning session and public meeting.

Public Meetings

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The public had an opportunity to provide input to the Manchester hazard mitigation planning process at 5 public meetings hosted by the Town. Three public meetings were held during the Hazard Mitigation Plan Enhancement grant. The purpose for these meetings was to introduce the hazard mitigation planning process, solicit input from citizens with knowledge of vulnerable areas of town, gauge citizen awareness of climate change impacts on Manchester, and to present the Vulnerability and Risk Assessment (the final product of the Hazard Mitigation Plan Enhancement).

Two additional public meetings were held during the planning process for the 5-year Update, including a presentation of the draft 2017 Hazard Mitigation Plan 5-year Update and a presentation to the Board of Selectmen of the final draft version prior to MEMA review.

Public meeting notice was sent to local stakeholders that might have an interest in the Hazard Mitigation Plan including the neighboring communities of Rockport, Hamilton, Beverly, and Gloucester, agencies, businesses, academia, nonprofits, and other interested parties, inviting them to review and submit comments on the Manchester 2017 Hazard Mitigation Plan 5-year Update.

These stakeholders had an opportunity to participate in public meetings, which were subject to the requirements of the Open Meeting Law requiring that the meeting be posted in a public location. Manchester Board of Selectmen agendas are also posted on the Town's website and in advance of the public meeting.

The Plan, deliverables from the Hazard Mitigation Plan Enhancement, and presentations from the public meetings were available on the Town's website.

Documentation of all public meetings during the 30-month planning process including agendas and sign-in sheets are included in Appendix B.

Public Surveys

Two public surveys were completed as part of the planning process to solicit information about localized flooding and evaluate gaps in knowledge about flood related climate change impacts. The surveys and summary of results are provided in Appendix C.

Other Outreach Methods

A series of articles about climate change and hazard mitigation planning appeared in the local Manchester-by-the-Sea weekly paper in early 2016. The Town's dedicated webpages for all reports and maps developed as part of the Hazard Mitigation Plan Enhancement and 5-Year Update can be accessed at the following URL: http://www.manchester.ma.us/355/FEMA-PDM-Grant-Projects.

Table 1.2
Schedule of Public Participation Meetings and Educational Events

Meeting Date	Topic	Audience / Purpose
May 12, 2015	MEMA Kickoff	CRAG Meeting #1/ Introduce Approach
April 22, 2015	Public Forum #1- Present MBTS Plan to enhance the HMP to include Climate Change	Public Outreach Event #1/ Present MBTS Plan to enhance the HMP to include Climate Change. Conduct survey to poll citizens on knowledge and characterize local flooding
July 21, 2015	Presentation of Draft Climate Change Model Selection Task 1 Memo/ Community Asset Selection	CRAG Meeting #2/ Present Modeling and Discuss Community Asset Selection
October, 26, 2015	Present Draft Potential Climate Change Impacts to Manchester-by-the-Sea, Task 2 Memo	CRAG Meeting #3/ Approve Task 1 Memo and Presentation of Task 2
January 13, 2015	Final Community Asset Selection and Draft VRA methodology	CRAG Meeting #4/ Approve Task 2 Memo and Presentation of Task 3
February 11, 2016	Public Forum #2	Public Outreach Event #2/ Conduct Survey
June 8, 2016	Final Draft VRA Memo	CRAG Meeting #5/ Present Revised Draft VRA
September 27, 2016	Final VRA, Task 3 and HMP update	CRAG Meeting #6 and Public Meeting #3/ Present Final VRA Memo and solicit input from Neiboring Communities on 5-year HMP update
November 30, 2016	Multi Hazard Vulnerability Assessment	CRAG Meeting #7/ Present and Discuss Sections 2 and 3
May 1, 2017	Mitigation Action and Adaptation Strategy	CRAG Meeting #8/ Present and Discuss Mitigation Action and Adaptation Strategy
August 7, 2017	Hazard Mitigation Plan 5-year update Final Draft	Public Meeting #4 Board of Selectmen/ Presentation of Final Draft

1.3 Available Documents

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See Appendix A for a list of all reports, plans, studies, and technical information that was used in the development of the 5-year Update. Information that was used to develop key findings is cited directly in the Hazard Mitigation Plan.

1.4 Disclaimer

The information in this plan related to potential extent of inundation due to climate change is based on publicly available data and best available science and is subject to change as new data become available. Information is being provided only to help understand extent of possible future risk, and not for the purposes of construction regulations, flood insurance, or other insurance requirements. The information and maps included in this plan are for planning purpose only, they are not adequate for legal boundary definition, regulatory interpretation, actual hazard assessment, or parcel level analysis. The presentation of the material in this Plan does not imply the expression of any opinion whatsoever on the part of the Town of Manchester-by-the-Sea concerning the accuracy of information or extent of the potential inundation areas.

Section 2
NATURAL HAZARDS (RISK ASSESSMENTS)

2.1 Hazards Identification

State Hazards

The 2013 Massachusetts Hazard Mitigation Plan (State Plan) provides an in-depth overview of natural hazards in Massachusetts. The State Plan identifies 11 natural hazards that have an impact or have a history of impacting communities in the Commonwealth of Massachusetts. These hazards are as follows:

- Flood
- Coastal Erosion
- Severe Winter Weather (includes snow, blizzards and ice storms)
- Nor'easters
- Severe Weather (includes high winds, tornadoes, thunderstorms, extreme temperatures and drought)
- Hurricane and Tropical Storms
- Dam Failure
- Fire (urban and wildland)
- Landslides
- Tsunami
- Earthquake

Selection of Hazards that affect Manchester-by-the-Sea

B1

As suggested under FEMA planning guidance, the Planning Team reviewed the full range of natural hazards identified in the 2013 State Plan and identified natural hazards that have impacted the Town in the past or could impact Manchester-by-the-Sea in the future. The hazards selection for Manchester-by-the-Sea was made using local expertise from the Planning Team, data from the 2013 State Plan, and other sources.

Table 2.1 below includes list of all hazards selected by the Town for inclusion in this Plan. The table indicates the history and possibility for future occurrence of each hazard, current frequency and geographical extent, severity of hazard impact, and results of a hazard index rating based on a scale of 1 (highest risk) through 5 (lowest risk). The definition of geographical extent, probability of occurrence, frequency, geographical extent, and impact severity are provided in **Table 2.2**.

Flooding due to climate change is not part of the State Plan, but was added to Manchester-by-the-Sea's Plan based on information compiled under the Plan Enhancement. A separate discussion of flooding due to climate change is included in Section 2.2.12.

B3 a

Table 2.1

Relevant Natural Hazards for Manchester-by-the-Sea

Type of Natural Hazard	History of Occurrence in MBTS	Possible occurrence of hazard in the future	Frequency	Geographic Area	Impact	Hazard Risk Ranking
Dam and Culvert Failure	Yes	Highly Likely	High	Medium	Extensive	1
Severe Winter Weather (Snow & Blizzard)	Yes	Highly Likely	High	Large	Serious	1
Nor'easter	Yes	Highly Likely	High	Large	Serious	1
Flood	Yes	Highly Likely	High	Medium	Serious	1
High Wind (Severe Weather)	Yes	Highly Likely	High	Large	Minor	1
Thunderstorm (Severe Weather)	Yes	Highly Likely	High	Large	Minor	1
Coastal Erosion and Shoreline Change	Yes	Likely	High	Medium	Serious	2
Hurricane/ Tropical Storm (Severe Weather)	Yes	Likely	Medium	Large	Serious	2
Extreme Temperature (Severe Weather)	Yes	Likely	Medium	Large	Minor	2
Tornado (Severe Weather)	Yes	Likely	Medium	Small	Serious	3
Drought (Severe Weather)	Yes	Likely	Low	Large	Minor	3
Earthquake	No	Possible	Very Low	Large	Serious	3
Flooding due to Climate Change	Yes	Likely	Low	Medium	Serious	3
Tsunami	No	Unlikely	Very Low	Large	Extensive	3
Fire (Urban and Wildland)	Yes	Possible	Low	Small	Minor-Urban Medium-Wild	4
Landslide	No	Unlikely	Very Low	Small	Minor	5

The hazard risk rankings were calculated by assigning points to each hazard (see **Table 2.2**) and totaling the scores. A score of 11-12 ranked as #1, 9-10 as #2, 7-8 as #3, 5-6 as #4, and 3-4 as #5, with #1 as the highest hazard risk and # 5 the lowest hazard risk for the Town of Manchester-by-the-Sea.

Table 2.2

Hazard Profile Definitions [2]

Ranking Points	Ranking Description	Geographical Area Impacted by a Given Natural Hazard
1	Small	Less than 10% of the Town affected
2	Medium	10-50% of the Town affected
3	Large	More than 50% of the Town affected

Ranking Points	Ranking Description	Hazard Frequency
0	Very Low	Events that occur less frequently than once in 1,000 years (less than 0.1% per year).
1	Low	Events that occur from once in 100 years to once in 1,000 years (0.1% - 1% per year).
2	Medium	Events that occur from once in 10 years to once in 100 years (1% - 10% per year).
3	High	Events that occur more frequently than once in 10 years (greater than 10% per year).

Ranking Points	Ranking Description	Severity of Impact from Hazard
1	Minor	Limited and scattered property damage; no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e. one or two communities); essential services (utilities, hospitals, schools, etc.) not interrupted; no injuries or fatalities.
2	Serious	Scattered major property damage (more than 10% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services briefly interrupted up to 1 day; some minor injuries.
3	Extensive	Consistent major property damage (more than 25%); major damage public infrastructure damage (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and possible fatalities.
4	Catastrophic	Property and public infrastructure destroyed (more than 50%); essential services stopped for 30 days or more, multiple injuries and fatalities.

Ranking Points	Ranking Description	Hazard Probability
1	Unlikely	Less than a 1% probability over the next 100 years
2	Possible	1-10% probability in the next year or at least one chance in the next 100 years
3	Likely	10-100% probability in the next year or at least one chance in the next 10 years
4	Highly Likely	Near 100% probability in the next year

[2] Commonwealth of Massachusetts 2013 State Hazard Mitigation Plan

2.2 Hazard Profiles

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B2 a b c.

Hazard profiles are provided in **Sections 2.2.1** to **2.2.12** for each of the natural hazards that could impact Manchester-by-the-Sea in the future or have impacted the Town in the past. Each hazard profile includes a definition and description of the hazard, previous occurrence and extent, local areas of impact, and probability for future occurrence. A discussion of previous occurrences includes historic data. Evaluation of the extent or severity of the hazard includes the measuring scale for a specific hazard. Locally identified areas of impact include maps showing the areas identified by the hazard whenever possible. The probability of future occurrences is based on best available science and historic events using the hazard probability scale provided in **Table 2.2.** All resources used are referenced as footnotes in the text of each hazard profile that follows.

2.2.1 Flooding

Storm surge is an abnormally high dome of water that is pushed onshore during a storm. Storm surge can be a significant threat to life and property. Storm surge can occur before, during or after a storm passes through an area and can quickly cut off evacuation routes. It only takes about 6 inches of fast moving water to knock over an adult and 2 feet to carry away a car.

Floods are the most common natural hazard in the United States. There are several types of flood hazards that frequently impact Manchester-by-the-Sea as the direct result of coastal storms, Nor'easters, heavy rains, tropical storms, and hurricanes:

- **Coastal Flooding** includes storm surge, shallow coastal flooding, and sea level rise.
  - **Storm surge** may occur multiple times per year causing severe flooding in coastal areas. Storm surge is an abnormal rise of water caused by low atmospheric pressure and/or water pushed toward the shore by strong winds during a storm, over and above predicted astronomical tides. When a storm surge coincides with a high tide, this is called a storm tide (see **Figure 2.1**)[3]. The height of the storm surge is affected by many variables, including atmospheric pressure, wind direction, storm size and duration, storm intensity, storm track and speed, the presence of waves, offshore depths, and shoreline configuration (Source: FEMA). Nor'easters and hurricanes are the most common types of storms that generate enough energy to create significant storm surge.

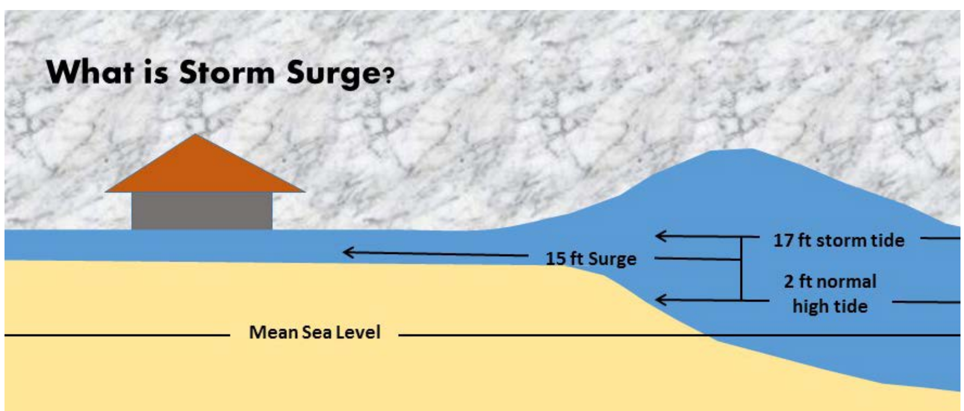

Figure 2.1
Storm Surge Characteristics

[3] NOAA, National Hurricane Center http://www.nhc.noaa.gov/surge/

- **Shallow coastal flooding** occurs several times a year during astronomical high tides (also known as King Tides, or perigean spring tide) and can be several feet higher than normal tides. A coastal storm is not necessary for shallow coastal flooding to occur, but onshore winds and/or low atmospheric pressure coinciding with a King Tide can dramatically increase the level of flooding.
- **Sea Level Rise** flooding impacts will occur several times per day as a result of predicted rise in sea level. The rise is primarily caused by a change in the volume of the Earth's oceans due to temperature increase (thermal expansion), uncovering of glaciated land because of melting of the glacier (deglaciation), and land ice melt. A discussion of climate change risk assessment is provided in **Section 2.2.12**.

- **Inland or Riverine Flooding** occurs where the rate of precipitation from a severe storm like a Nor'easter or tropical storm causes a large amount of rain in a short period of time, overwhelming the capacity of natural or constructed drainage systems causing overflows.

- **Urban drainage** occurs in flat area where runoff or rain collects and cannot drain. Poor drainage after flood events is associated with poorly infiltrating soils and undersized stormwater conveyance, including channelized streambeds and culverts that do not have adequate capacity to handle runoff from larger storm events. Most of the systems in Manchester-by-the-Sea were designed to handle the amount of water expected during a 10-year storm event. Larger storm events and other sources water including snow melt and high groundwater can overload the system and result in backups, flooding streets and properties.[1]

These types of flooding are often combined. Areas located where both coastal and inland flooding occur may be especially hard hit when storm surge, high tides and stream discharge coincide in the same storm and high tides surcharge the inland drainage networks.

Previous Occurrence and Extent

The State Plan indicates that Massachusetts is 1 of the 10 states that account for 76% of all repetitive loss buildings in the United States. Flooding was the most prevalent serious natural hazard identified by local officials in Manchester-by-the-Sea's 2012 Plan, and this continues to be the biggest natural disaster that impacts Manchester-by-the-Sea. There have been 20 flood-related Federal disaster declarations in the Commonwealth from 1954 to 2015. Eighteen of these flooding events directly impacted Essex County and Manchester-by-the-Sea, more than any other county in the Commonwealth.

The most notable coastal events include the Great Hurricane of September 1938 (a Category 3 hurricane), the Blizzard of 1978 (the most devastating Nor'easter in Massachusetts history), and the "No-name" or "Perfect Storm" in October 1991 (a Nor'easter that coincided with an astronomical high tide). Trees were leveled, roads swept away, bath-houses plucked off the shore and smashed, and Singing Beach washed out to sea. **Table 2.3** below summarizes these historic flooding events.

Table 2.3
Historic Flooding Events and Local Impacts for Manchester-by-the-Sea

Date	Type of Event	Local Impacts
September 21, 1938	The Great New England Hurricane - Cat 3	10-17 inches of rainfall and up to 20-foot storm surge was recorded.
September 15, 1944	The Great Atlantic Hurricane - Cat 1	11 inches of rain and up to 70 foot waves reported.

Table 2.3

Historic Flooding Events and Local Impacts for Manchester-by-the-Sea

Date	Type of Event	Local Impacts
August 31, 1954	Hurricane Carol - Cat 2, followed by Edna	2 hurricanes struck within 12 days with 7 inches of rain causes stream flooding and streets washed out.
September 12, 1960	Hurricane Donna - Cat 2	10-20 inches of rain and 5-10-foot storm surge. Wettest tropical cyclone to impact New England.
March 1972	Severe Storms and Flooding	No information available
February 1978	The Blizzard of ‘78	Most devastating Nor’easter in Massachusetts history. Set all-time high water mark of 15.25 feet above Mean Lower Low Water in Boston Harbor- 30 foot waves recorded off shore. 30 inches snowfall, with 20 foot drifts recorded. Singing Beach seawall destroyed. 2 Repetitive Loss Claims in Manchester-by the Sea.
September 27, 1985	Hurricane Gloria - Cat 3	Arrival at low tide resulted in moderate storm surge.
March 31-April 7, 1987	Severe Storms and Flooding	Spring storms added 7 inches to already high river conditions to produce major flooding. 2 Repetitive Loss Claims in Manchester-by the Sea.
August 19-21, 1991	Hurricane Bob - Cat 3	4-7 inches of rain, and storm surge impacts.
October 15-18, 1991	“The No-Name Storm” or “Perfect Storm” Nor’easter	25 foot waves on top of 4-foot high tide. Many coastal roads were washed out. 9 Repetitive Loss Claims in Manchester-by the Sea.
December 11-13, 1992	Nor’easter	Highest water levels 1 foot below record of 1978 (25 ft dunes wiped out in Ipswich) and 6 inches of rain. 5 Repetitive Loss Claims in Manchester-by the Sea.
October 20-21, 1996	Severe storms and flooding	13 inches of rainfall in Essex County (7.89 in Boston). 5 Repetitive Loss Claims in Manchester-by the Sea.
June 13-18, 1998	Heavy rain and flooding	Flash flooding from June 12-14, over 8 inches fell in under 12 hours.
March 21-22, 2001	Nor’easter	High tides ran 2-3 feet above normal along east facing coastline. 8 Repetitive Loss Claims in Manchester-by the Sea.
February 2003	Presidents Day Storm	Astronomical high tide coincided with 15-foot seas to cause flooding along most of eastern Massachusetts coastline. 27.5 inches of snow recorded at Logan Airport.
March 31-April 2, 2004	Flooding	6 inches fell over several days. Flood waters caused many roads to be closed along the river and damaged nearby homes.
May 9-16, 2006	“Mother’s Day Flood”	Extreme rainfall >12 inches. 6 feet of water on roadways alongside Sawmill Brook. School Street Bridge washed out. 150 homes

Table 2.3
Historic Flooding Events and Local Impacts for Manchester-by-the-Sea

Date	Type of Event	Local Impacts
		damaged. Route 127 impassable. 10 Repetitive Loss Claims in Manchester-by the Sea.
April 15-20, 2007	"Patriot's Day Storm" Nor'easter	Worst coastal flooding coincided with evening high tide on April 17 (3.6 inches recorded at Logan Airport). 1 Repetitive Loss Claim in Manchester-by the Sea.
December 11-12, 2008	Severe winter storm	8-12 inches of snow fell in Manchester accompanied by 30-40 mph winds resulting in coastal flooding and structural damage.
March 12-16, 2010	Nor'easter	Record breaking rainfall (7.06 inches at Logan Airport) coastal flooding, and 70 mph winds
January 11-12, 2011	Nor'easter	Snow, high winds, and coastal flooding
October 29-30, 2012	Nor'easter	Rare October snow storm, icing, high winds
February 8-10, 2013	Winter Storm Nemo - Nor'easter	24.9 inches of snow in Boston, hurricane-force winds, and 4.2 feet of storm surge.
January 26-28, 2015	Winter Storm Juno	24 inches of snow fell in Boston with 4 feet of storm surge and high winds.

Locally Identified Areas of Impact

The topography of Manchester-by-the-Sea and convoluted shoreline configuration play a big part in understanding where and when properties and infrastructure are vulnerable to flooding from storm events. Coastal flooding impacts low lying areas adjacent to the coast, embayments, and tidal rivers.

Inland flooding also occurs along the main stem and tributaries of Sawmill Brook and Bennetts Brook as well as numerous wetland areas throughout Town. Inland flooding is worsened by poorly infiltrating soils, channelized stream flow, and undersized culverts that do not have adequate capacity to handle runoff from larger storm events, particularly in the stretch of Sawmill Brook that extends from the Central Street tide gate to the Manchester Essex High School upstream of the Lincoln Street culvert.

Areas located where both coastal and inland flooding occur are especially impacted when storm surge, high tides, and stream discharge coincide in the same storm and high tides result in backups of water into the inland drainage networks.

Lands abutting Manchester Harbor are partly protected from some coastal storm flooding and subsequent damage by the headlands between Tucks Point and Proctor Point. Storm surge and wave heights are lesser here as compared to the open exposed south/southeastern facing shoreline along west and east Manchester-by-the-Sea. Singing Beach and Graves Beach are particularly exposed to storm waves and surge, where there are no coves or headlands to deflect wave energy.

Areas at risk of flooding are mapped by FEMA as part of the National Flood Insurance Program (NFIP). The Flood Insurance Rate Maps (FIRMs) include areas impacted by 100-year, 500-year flood events, and storm surge and wave action. Floodplains and areas subject to coastal storm surge are shown as high-risk areas or Special Flood Hazard Areas. The most recent FIRM was issued in 2015, but several areas of map revision were approved in 2017. . The value of municipal structures within the flood zone including Town Hall, emergency services, and water and wastewater facilities is over $10 million.[4] Section 4.2 provides more information on flood risk to parcels.

To gain a more local perspective on the current flooding areas of concern, residents and Town officials were surveyed in winter 2015. A table of the areas of local flooding concern is provided below in **Table 2.4.** Appendix C presents the survey results.

Repetitive Loss Structures

B4 a

As defined by the Community Rating System (CRS) of the NFIP, a repetitive loss property is any property which the NFIP has paid 2 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 19 repetitive loss structures in Manchester-by-the-Sea, 15 single family homes and 4 non-residential properties. These 19 properties have experienced a total of 44 losses (35 residential and 9 non-residential) between 1978 and 2015. Damage claims over this period totaled $868,792, including $539,796 for residential properties and $337,996 for non-residential properties. The repetitive loss data used was the best available during the Plan's 5-year Update drafting period of 2015-2017.

All but 5 of the Town's repetitive loss properties are located within designated flood zones A and AE. Eleven of the properties are located along the coast in the southern part of Town, 7 are located near the Town center, and 1 is to the north at the junction of Route 128 and School Street. The locations of repetitive loss properties are shown on **Maps 2 East and West**, including the areas of flooding based on combined areas of inundation from the 2015 FIRM and approved revisions from 2016.

Probability of Future Occurrence

The Planning Team has determined that it is **HIGHLY LIKELY** that flooding will impact Manchester-by-the-Sea in the future. The Town has implemented both structural and non-structural measures to withstand coastal storms. The shoreline has been fortified in locations with revetment and seawalls, the Town enforces a stricter building code than the State in flood prone areas (100-year floodplain as shown on the FIRM), and the Town has plans in place to respond to flood related emergencies including the Code Red system to inform residents of an emergency.[5]

In spite of these best efforts, a storm with sufficient magnitude could result in damages far greater than any the Town has known, impacting the economy, natural resources, cultural and historic assets, and buildings and structures. Therefore, it is in the best interest of the Town and residents to understand how climate change may influence flooding for both coastal and inland areas, and begin proactive planning to adapt or mitigate these impacts. A discussion of flooding impacts due to climate change is included in **Section 2.2.12**.

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[4] 2013 assessor's data and FEMA Flood Insurance Study Number 25009CV001B, dated June 3, 2013
[5] To register for Code Red, go to: https://public.coderedweb.com/cne/en-US/C83D2DD3CE2B.

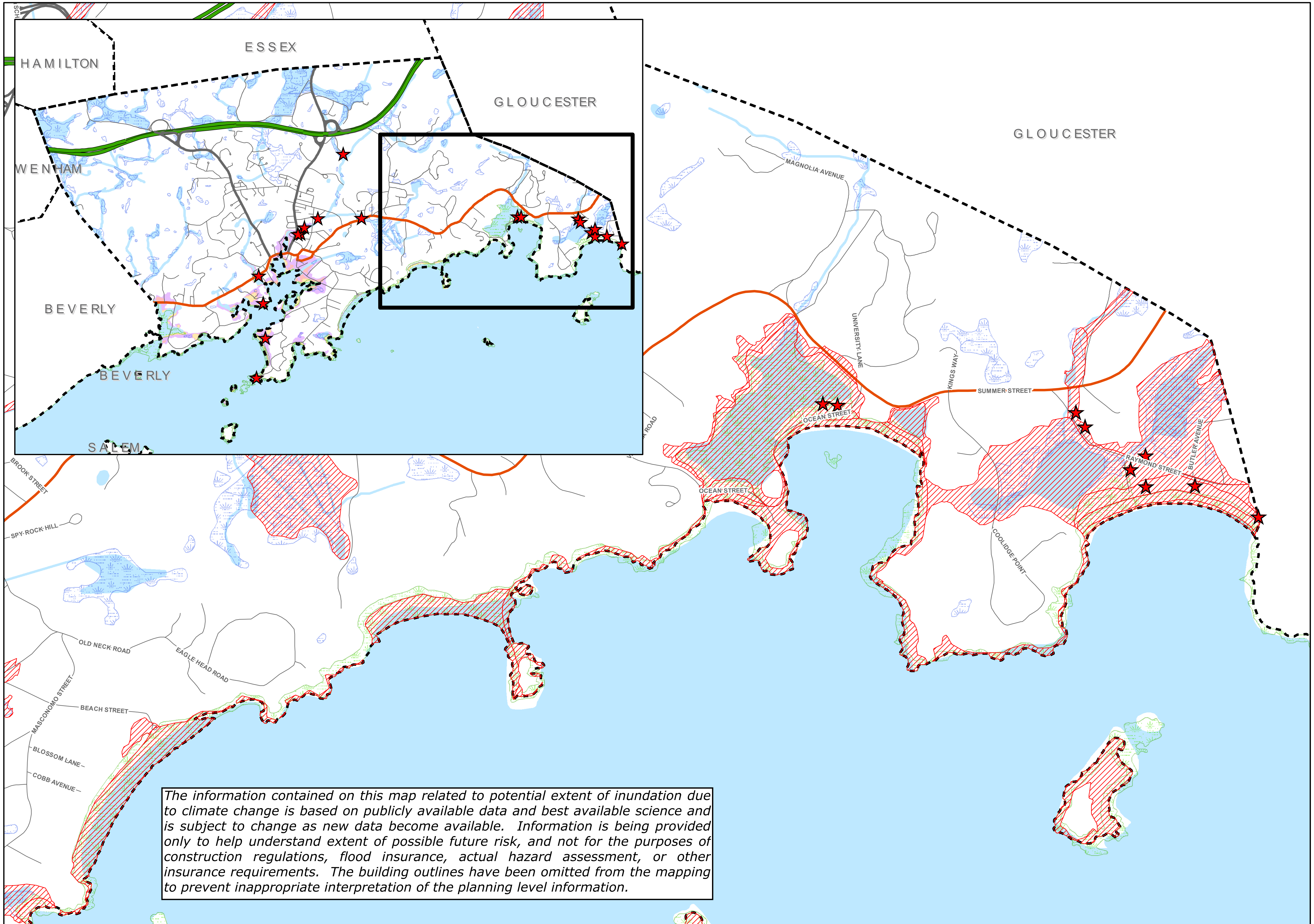
Table 2.4

Summary of Local Observations of Areas Prone to Flooding in the Sawmill Brook Watershed

Location	Cause of Flooding								Notes
	Rising ground-water	Extreme rain events	High Tide	Storm Surge	Stream bank overflow	Catch basin overflow	Culvert backup	Swamp/ wetland overflow	
School Street north of 128	✓	✓					✓		culvert washed out in 2012 and replaced
Atwater Ave, culvert rebuilt in 2005	✓	✓					✓		
Blue Heron Lane	✓	✓			✓		✓	✓	neighborhood flooding
Lincoln Street, junction of Causeway and Sawmill Brooks	✓	✓			✓		✓		flooding and culvert damage
Brook Street	✓	✓			✓				playing fields flood.
School Street, Sawmill Brook north of School St.							✓		culvert, wall, and vegetation reestablished
School Street		✓			✓		✓		roadway and culvert collapsed in 2006 storm
Brook Street, School Street, Norwood Avenue, and Putnam Court		✓			✓				flooding in 2006, 6 feet of water damage to 150 homes
Central Street		✓	✓	✓					parking lot near Town Hall floods
Brook Street	✓	✓	✓						floods during high tide AND heavy rain
School Street		✓			✓		✓		culvert backup
Norwood Ave	✓	✓			✓		✓		basement flooding, stone wall collapse
Knight Circle	✓	✓			✓	✓			yard floods from brook overflow, sump pump drainage to catch basin
Forest Lane, backup of Cat Brook along the Route 128		✓			✓				debris in culvert

Location	Cause of Flooding: Rising ground-water	Extreme rain events	High Tide	Storm Surge	Stream bank overflow	Catch basin overflow	Culvert backup	Swamp/ wetland overflow	Notes
Old Essex Rd/ Pleasant Street/ Pine Street		✓				✓			runoff from DPW yard
Old Essex Rd/ Pleasant St/ Blue Heron Lane south side of Pleasant St (foot of Powder House Hill)		✓			✓				floods during heavy rains Debris in culvert
Knight's Circle & Friend Street		✓			✓				flooding consistent with large rain event
Vine & Lincoln		✓				✓			catch basin doesn't drain after storms
Sawmill Brook									debris
12 School Street, Central Pond		✓	✓		✓				flooding, notably when a lunar high tide and rainfall event coincide
Bennetts Brook	✓						✓	✓	
Raymond Street			✓	✓					septic systems
Ocean Street			✓	✓					roadway could be breached
20 Forest Lane								✓	debris in Culvert.
7 Knight Circle, house at the end of Millet Brook	✓	✓			✓		✓	✓	flooded out 3 times since 1996
14 Ancient County Way	✓	✓							basement floods from snow melt rain even with sump pumping

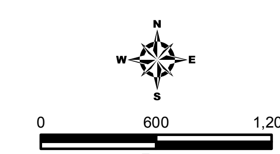
MAP 2 EAST FIRM BOUNDARIES AND REPETITIVE LOSS STRUCTURES



LEGEND

- Repetitive Loss Structures
- SFHA Inundated by 100-year Flood [2]
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP



1:12,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. FEMA Flood Zones with revisions are based on FIRM panels for Manchester-by-the-Sea, effective date July 16, 2014 and approved Letter of Map Revisions for Manchester Bay via Manchester Harbor and Blacks Cove, effective date January 2, 2017. Special Flood Hazard Areas (SFHA) Inundated by 100-Year Flood Sources includes Zones A, AE, AH, AO, V and VE.

Hazard Mitigation Plan

Manchester-by-the-Sea, Massachusetts

2017

Tighe&Bond
Engineers | Environmental Specialists

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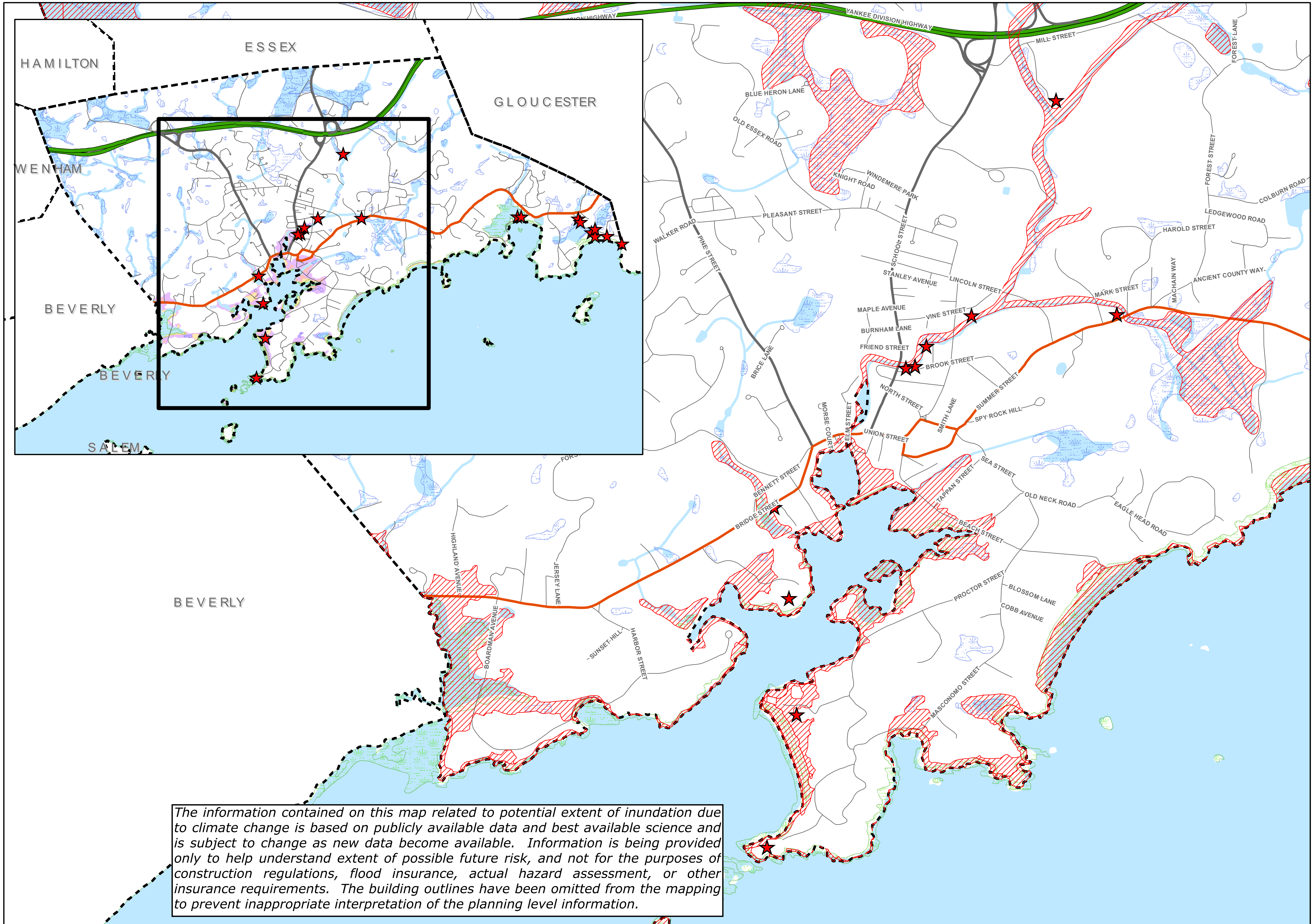

The information contained on this map related to potential extent of inundation due to climate change is based on publicly available data and best available science and is subject to change as new data become available. Information is being provided only to help understand extent of possible future risk, and not for the purposes of construction regulations, flood insurance, actual hazard assessment, or other insurance requirements. The building outlines have been omitted from the mapping to prevent inappropriate interpretation of the planning level information.

MAP 2 WEST FIRM BOUNDARIES AND REPETITIVE LOSS STRUCTURES

LEGEND

- Repetitive Loss Structures
- SFHA Inundated by 100-year Flood [2]
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP

N W E S

0 625 1,250
Feet

1:15,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. FEMA Flood Zones with revisions are based on FIRM panels for Manchester-by-the-Sea, effective date July 16, 2014 and approved Letter of Map Revisions for Manchester Bay via Manchester Harbor and Blacks Cove, effective date January 2, 2017. Special Flood Hazard Areas (SFHA) Inundated by 100-Year Flood Sources includes Zones A, AE, AH, AO, V and VE.

Hazard Mitigation Plan

Manchester-by-the-Sea, Massachusetts

2017

Tighe&Bond
Engineers | Environmental Specialists

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2.2.2 Coastal Erosion

Coastal shorelines, especially beaches, dunes, and banks, change constantly in response to wind, waves, tides, and other factors including seasonal variation, sea level rise, and human alterations to the shoreline system.[6] Every day, wind, waves and currents move sand, pebbles, and other materials along the shore or out to sea. This dynamic and continuous process of erosion, transport, and accretion shape the coastal shoreline, creating and feeding beaches and dunes. Shorelines change seasonally, tending to accrete gradually during the summer months when sediments are deposited by relatively low energy waves and erode dramatically during the winter when sediments are moved offshore by high energy storm waves, such as those generated by Nor'easters. Coastal erosion is a natural process, but it also causes damage to coastal property, infrastructure, and may have an adverse impact on beaches and coastal habitat.

Coastal erosion is measured as the horizontal displacement of a shoreline over a specific period of time, measured in units of feet or meters per year. Shoreline changes can be monitored over short-term and long-term time scales. Monitoring shoreline change on a relatively short period of record does not always reflect actual conditions and can misrepresent long-term erosion rates. Long-term patterns of coastal erosion are difficult to detect because of substantial, rapid changes in coastline over days or weeks from storms and natural tidal processes.

Previous Occurrence and Extent

The Massachusetts Office of Coastal Zone Management's (CZM's) Shoreline Change Project was used to illustrate how the shoreline of Massachusetts, in the area of Manchester-by-the-Sea, has shifted between the mid-1800's and 2009 (**Figure 2.2**). Using data from historical and modern sources, up to 8 shorelines depicting the local high water line (i.e., the landward limit of wave runup at the time of local high tide) were generated with transects at 50-meter (approximately 164-feet) intervals along the ocean-facing shore. The results of the Shoreline Project can be viewed online at the Massachusetts Office of Geographic Information (MassGIS) website "Massachusetts Shoreline Change Browser."[7]

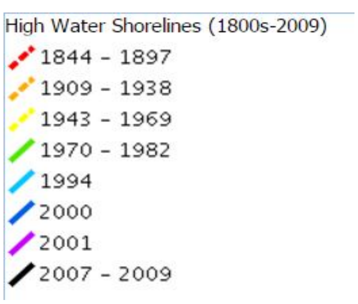

Figure 2.2
Shoreline Change near Grey's Beach (Magnolia Harbor)

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[6] Report of the Massachusetts Coastal Erosion Control Commission, 12/2015 http://www.mass.gov/eea/waste-mgnt-recycling/coasts-and-oceans/erosion-commission-report.html
[7] http://maps.massgis.state.ma.us/map_ol/czm_shorelines.php

The average shoreline change rates for Manchester-by-the-Sea are as follows, where positive values indicate accretion and negative values indicate erosion:[6]

- Short -Term Rate (approximately 30 years): -0.2 ± 0.7 ft/year
- Long-Term Rate (approximately 150 years): 0.1 ± 0.3 ft/year

Additional information provided by the Massachusetts Coastal Erosion Commission shown in **Figure 2.3** shows the coastal landforms, habitats, developed lands, and hardened coastal structures identified along the immediate, exposed shoreline in Manchester. Classes were identified for every 50 meters of shoreline and summarized by percentage of total assessed shoreline for the community. Residential structures were located along approximately 75% of the shoreline. Bulkhead/seawall and revetment were located on approximately 35% of the shoreline. Coastal bank dominated the coastal landforms, found along 65% of the shoreline, with dune and salt marsh making up less than 10%.[6]

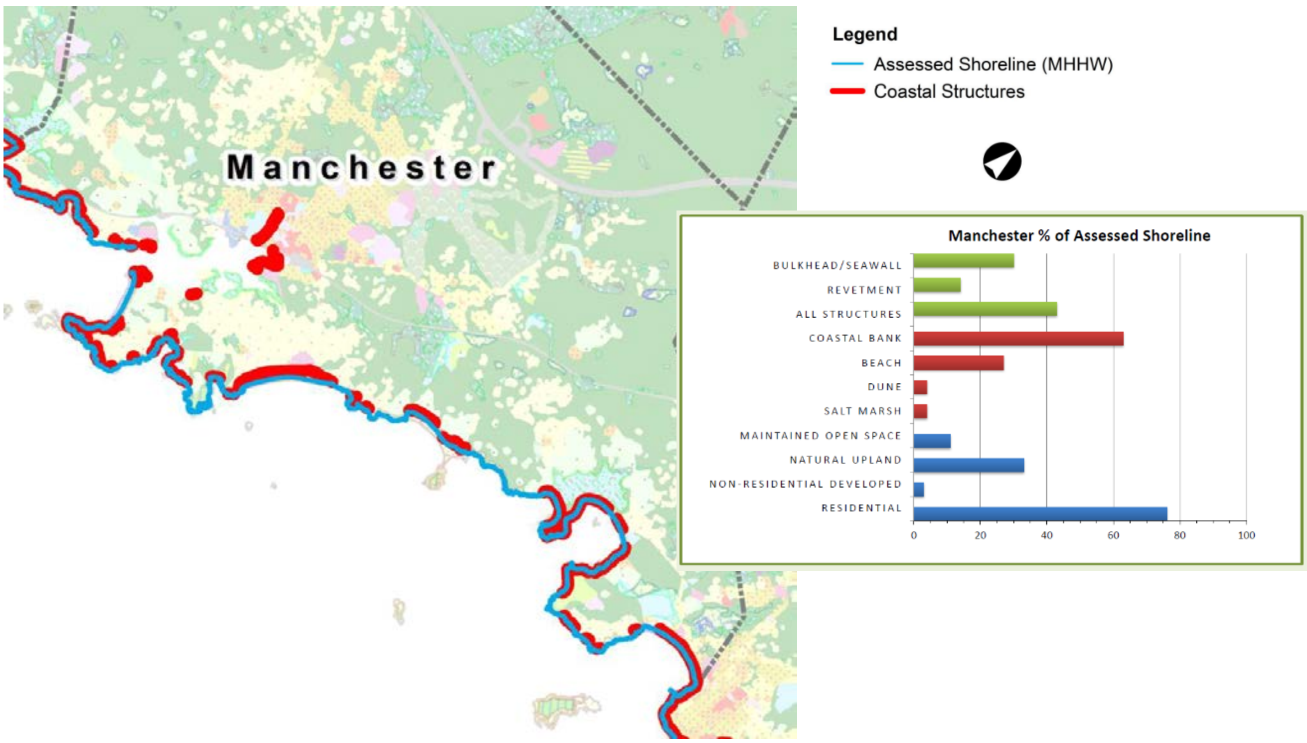


Figure 2.3
Manchester Shoreline Characterization

Information on the location and condition of specific municipal coastal structures was provided by the Massachusetts Coastal Infrastructure Inventory and Assessment Project by the Massachusetts Department of Conservation and Recreation Office of Waterways.[8] Based on the 2009 report, there were a total of 21 structures including bulkhead, seawall and revetment for a total length of 7075 feet. The report summary of condition includes 1 structures were rated at B Rating or "Good conditions," 13 at C Rating or "fair" conditions, 3 at D Rating or "poor condition" and 1 at F Rating "critical

[8] http://www.mass.gov/eea/docs/czm/stormsmart/seawalls/north-shore/manchester-salem.pdf

condition." The report estimates a total of $9.3 million to bring all the coastal structures to "A" Rating. The complete inventory with locations and conditions is included in Appendix D.

According to the Manchester-by-the Sea's Harbormaster, 4 seawalls have been damaged in recent storms with repair costs over $1 million dollars. The location, extent of damages, and cost to repair are summarized below:

Singing Beach - The revetment wall at Singing Beach failed due to erosion from strong storms. The repairs were completed in 2013 at a cost of $153,000.

Tuck's Point - The seawall and footing failed due to erosion from tidal rise and fall as well as wake and wave action from passing vessels. The repairs were completed in 2016 at an approximate cost of $220,000.

Morss Pier/Masconomo Park - The concrete wall that supports the east side of the fishermen's pier and the road access to Masconomo Park is badly degraded. A large section of the wall beneath the shelter is completely gone and several sinkholes have developed in the parking area adjacent to the shelter on the pier. In addition, the wall from the pier to Beach Street and then Reed Park is showing signs of pushing out into the harbor. An estimate for immediate repair to the wall at the pier is $300,000 and a study of the condition of the wall from the pier to Reed Park is $27,000.

31 Proctor Street Private Wall - During summer 2016 a significant portion the wall just beyond the fence at the head of Proctor Cove failed. The wall appeared to fail at the foot and cascaded the entire height of the wall. The wall has been repaired by the homeowner.

Locally Identified Areas of Impact

Based on shoreline assessment data from the CZM Shoreline Change Project and Coastal Erosion Commission and recent seawall damages due to coastal erosion, the Planning Team concluded that the entire coastline of the planning area is vulnerable to coastal erosion. Many of the coastal residential properties abutting the shoreline have the highest real estate values for the Town.

Probability of Future Occurrence

The Massachusetts Coastal Erosion Commission Report noted that changing climate conditions may accelerate coastal erosion due to increase in frequency and severity of coastal storms and sea level rise. For Manchester-by-the-Sea, where the majority of the shoreline is facing southwest, coastal erosion due to hurricanes and sea level rise is the biggest concern. The Planning Team determined that is **LIKELY** that coastal erosion will impact Manchester-by-the-Sea in the future.

2.2.3 Severe Winter Weather

Severe Winter Weather includes snow storms, blizzards, and ice storms. A winter storm occurs when there is significant precipitation during periods of low temperatures. Winter storms are a combination of hazards because they often involve wind, ice, and heavy snow fall. Winter storms can occur from early autumn to late spring and include any of the following events:[9]

- Blizzards
- Ice pellets and sleet

[9] http://www.nws.noaa.gov/om/winter/index.shtml

- Blowing Snow
- Snow Squalls
- Snow Showers
- Snow Flurries
- Icing
- Coastal flooding
- Ice jams and flow
- Snow melt

Impacts from winter weather – in addition to non-passable streets and sidewalks – include downed power lines causing loss of electric power service, catch basins being buried and sometimes clogged, water service pipes bursting and shut-off valves being buried (more common when cold and windy), fire hydrants being buried by snow, older water mains bursting, and dangerous icicles forming on buildings. Snow can also block building ventilation, increasing the risk of indoor carbon monoxide poisoning and place a heavy load on roofs.

Previous Occurrence and Extent

Snow and other forms of winter precipitation occur frequently in Manchester-by-the-Sea, with a normal 30-year average between 40-50 inches per year as shown in **Figure 2.4**. [10]

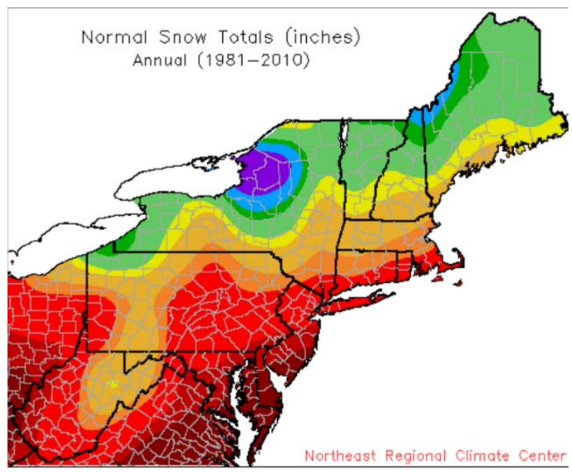


Figure 2.4
Annual Snow Totals in inches from 1981-2010

The most significant winter storm in recent history was the “Blizzard of 1978,” which resulted in over 3 feet of snowfall and high winds that caused multiple day closures of roadways, businesses, and schools. More recently, the Blizzard of 2015, also known as Winter Storm Juno, deposited 31 inches of snow in Manchester-by-the-Sea. According to a National Weather Service summary, the blizzard lasted for almost 3 days, with wind gusts of 50 to 65 mph. Coastal flooding north of Boston was less than expected, due to a shift in the winds concurrent with the high tide. If the timing of the storm had been only 4 to 5 hours faster, the storm surge might have exceeded records set in the Blizzard of 1978.[11]

Federally-declared disasters from winter storm events in Essex County are provided in **Table 2.5**.

Table 2.5
FEMA Winter Storm related disaster declarations (1978-2915)

Number	Disaster Type	Incident Period
DR-546	Coastal storms, flood, ice, snow	February 6-8, 1978
DR-975	Winter coastal storm	December 11-13, 1992
EM-3103	Blizzard, high winds and record snowfall	March 16, 1993
DR-1090	Blizzard	January 7-13, 1996

[10] http://www.nrcc.cornell.edu/regional/climatenorms/climatenorms.html
[11] http://www.mass.gov/governor/docs/news/emergency-declaration-request-enclosures.pdf

EM-3175	Severe Snowstorm	February 17-18, 2003
EM-3191	Severe Snowstorm	December 6-5, 2003
EM-3201	Severe Snowstorm	January 22-23, 2005
DR-4110	Severe winter storm, snowstorm and flooding	February 8-10, 2013
DR-4214	Severe winter storm, snowstorm, flooding	January 26-29, 2015

Locally Identified Areas of Impact

The entire planning area is at risk for severe winter weather. During these events, the areas along the shoreline and downtown Manchester-by-the Sea may experience higher snow accumulations and higher winds than other areas of town due to the additional ocean moisture.

Manchester-by-the-Sea's overall vulnerability to winter weather is primarily related to restrictions to 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.

Probability of Future Occurrence

Based on the record of previous occurrences, winter storm events in Manchester-by-the-Sea are high frequency events as defined by the 2013 Massachusetts State Hazard Mitigation Plan. This hazard may occur more frequently than once in 5 years (greater than 20% per year). Based on the past record, the Planning Team concludes that it is **HIGHLY LIKELY** that severe winter weather will impact Manchester-by-the Sea in the future.

2.2.4 Nor'easters

Nor'easters are a ferocious type of northeastern coastal storm that typically occur in the winter months. The storm's name refers to the continuous strong northeasterly winds blowing in a large counter-clockwise circulation pattern around a low-pressure center, resulting in heavy snow and rain, gale force winds, rough seas, and coastal flooding that often cause shoreline erosion. The radius of these storms can extend up to 1,000 miles.[12] Impacts along the coast are typically worse than inland locations due to the additional moisture picked up from the ocean. Nor'easters may be especially damaging because they can sit stationary for several days, affecting multiple tidal cycles and producing extended periods of heavy precipitation, resulting in increased flooding, shoreline erosion, and damage to coastal infrastructure.

The level of damage in a hurricane is often more severe than a Nor'easter, but historically Massachusetts has suffered more damage from Nor'easters because of the greater frequency of these coastal storms (1 to 2 per year). As another comparison, the duration of high surge and winds in a hurricane is 6 to 12 hours while a Nor'easter can last from 12 hours to 3 days. Nor'easters are not typically named the way that hurricanes are by the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS), though locally coined names have been used. For example, Winter Storm Juno and Winter Storm Nemo were named by the Weather Channel in 2014 and 2015.[13] The unofficial storm naming is controversial with meteorologists because winter storms

[12] 2013 Massachusetts State Hazard Mitigation Plan
[13] https://en.wikipedia.org/wiki/Winter_storm_naming_in_the_United_States

can reform more than once, making naming hard and redundant. Naming a storm may bring more attention to the event and help people with advance emergency preparations.

Previous Occurrence and Extent

Essex County has been impacted by more Nor'easters than any county in Massachusetts. Since 1954, there have been 9 Nor'easters of significant magnitude to trigger disaster funds (**Table 2.6**).

There is no widely used scale to classify Nor'easters, but a combination of scales including the Beaufort Scale for wind speed, Regional Snowfall Index for snowfall, and precipitation associated with a historic recurrence interval (i.e. 100-year rainfall) can be combined to evaluate the magnitude of the storm. For Manchester-by-the-Sea, precipitation amounts of 8.7 inches are associated with a 100-year storm event (1% chance of occurring in any one year). Winter and spring flooding from Nor'easters may be exacerbated due to snow melt and frozen ground conditions.

Table 2.6
FEMA Nor'easter Related Disaster Declarations (1954-2015)

Disaster #	Dates	Unofficial Storm Name	Impact
DR-4214	January 26-29,2015	"Winter Storm Juno"	Severe winter storm, snowstorm, flooding
DR-4110	February 8-10, 2013	"Winter Storm Nemo"	Severe winter storm, snowstorm and flooding
EM-3343	October 29-30, 2011	"Snowtober"	Severe Storm
DR-1959	January 11-12, 2011	Nor'easter	Severe Winter Storm and Snowstorm
DR-1701	April 15-25, 2007	"Patriot's Day Storm"	Severe Storms and Inland and Coastal Flooding
DR-1614	October 7-16, 2005	Nor'easter	Severe Storms and Flooding
DR-975	December 11-13-, 1992	Nor'easter	Winter Coastal Storm
DR-920	December 30-November 2, 1991	"Perfect Storm"	Severe Coastal Storms
DR-546	February 6-8, 1978	"Blizzard of '78"	Coastal Storms, Flood, Ice, Snow

Locally Identified Areas of Impact

The entire planning area is at risk for impacts due to Nor'easters. Manchester's overall vulnerability for Nor'easters is similar to severe winter weather and flooding.

Probability of Future Occurrence

Nor'easters may occur at any time of the year, however, they are most common from September to April. Based on the historical record of the top winter storm events from 1953 to 2011, Nor'easters have an average frequency of 1 or 2 per year. However, as recently as 2010, Essex County experienced 4 Nor'easters in 1 year.

Based on the historic record of Nor'easters impacting Manchester-by-the-Sea, the Planning Team determined that is **HIGHLY LIKELY** that a Nor'easter will impact the planning area in the future.

2.2.5 Severe Weather-Wind Related Hazards

Severe weather wind related hazards include hurricanes, tropical storms, and tornadoes as well as high winds during severe rainstorms and thunderstorms. The typical wind speed in Manchester-by-the-Sea range from 11-14 miles per hours over the course of the year, with peak gusts over 80 mph.[14] The prevailing wind direction is north-northwest, and the highest wind speeds occur January through March. **Figure 2.5** shows the average monthly wind speed for the contiguous US for March based on wind conditions in the lower troposphere.[15] The coastal areas, including Essex County, have the highest average wind speeds in the contiguous US.

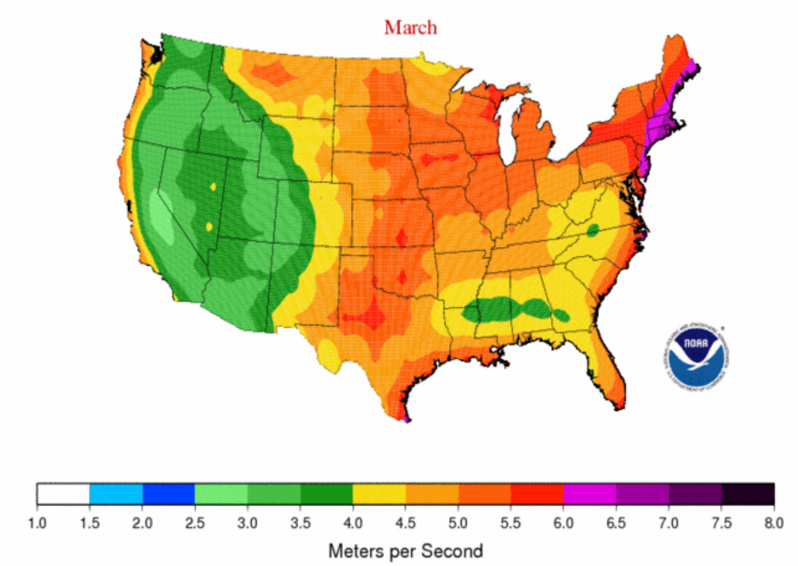


Figure 2.5
March Average Wind Speeds in the Lower Troposphere (1971-2000)

High winds can occur as an isolated event or accompany other weather events such as:

- Before and after frontal systems
- Hurricanes and tropical storms
- Severe thunder and lightning storms
- Tornadoes
- Nor'easters

National wind zone designations were developed by FEMA based on 40 years of tornado history and 100 years of hurricane history. As shown in **Figure 2.6**, Essex County lies within Zone II with maximum winds of 160 mph. Manchester-by-the-Sea is also within the Hurricane-Susceptible region along

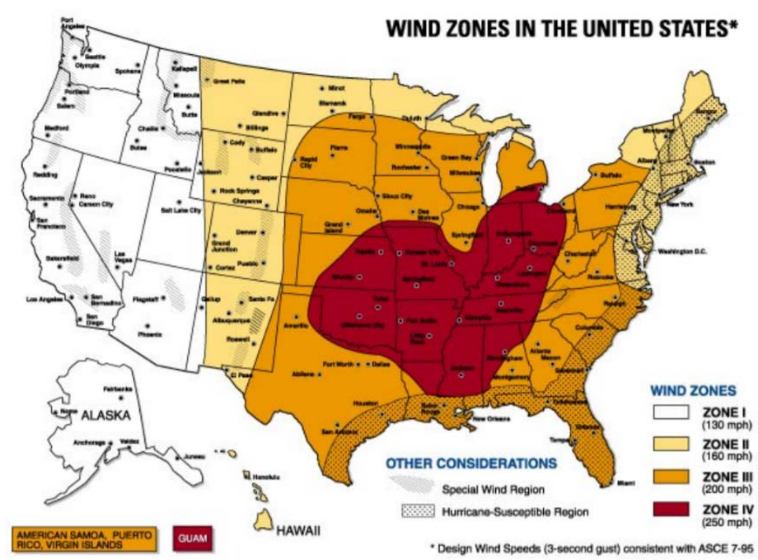


Figure 2.6
Wind Zones in the United States

[14] NOAA Climatic Wind Data for the United States 1930-1996- Data for Boston
[15] https://www.ncdc.noaa.gov/societal-impacts/wind/w-mean/201603

with the entire East Coast and Gulf of Mexico.[16]

Table 2.7 includes the high wind warning categories issued by the NWS for both non-tropical and tropical events. Winds measuring under 30 mph are not considered to be hazardous under most conditions.[17]

Table 2.7
NWS High Wind Warnings

Type of Warning	Wind Speeds
Non-tropical event over land:	
Wind Advisory	Sustained winds of 31-39 mph for at least 1 hour, or any gust 46 to 57 mph
High Wind Warning	Sustained winds 40+ mph or any gust 58+ mph
Non-tropical event over water:	
Small Craft Advisory	Sustained winds 25-33 knots
Gale Warning	Sustained winds 24-47 knots
Storm Warning	Sustained winds 48 to 63 knots
Hurricane Force Winds	Sustained winds 64+ knots
Tropical storm events (inland or coastal):	
Tropical Storm Warning	Sustained winds 39 to 73 mph
Hurricane warning	Sustained winds of 74+ mph

Effects from high winds can include downed trees and/or power lines, damage to structures, etc. This is especially true after periods of heavy snow, rain or prolonged drought due to the weakening of tree branches and roots. High winds can cause scattered power outages and are a hazard for the boating, shipping, and aviation industry sectors. More specific discussion on severe weather high wind events impacting Manchester-by-the-Sea follows in Sections 2.2.5.1 and 2.2.5.2.

2.2.5.1 Hurricanes and Tropical Storms

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originate over tropical or subtropical water. The 4 types of tropical cyclones are classified as follows:

- **Tropical Depression:** A tropical cyclone with maximum sustained winds of 38 mph (33 knots) or less.
- **Tropical Storm:** A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).
- **Hurricane:** A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher.

[16] FEMA Taking Shelter from the Storm: Building a Safe Room Inside Your House. https://www.fema.gov/pdf/library/ism2_s1.pdf
[17] 2013 State Hazard Mitigation Plan

- **Major Hurricane:** A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4 or 5 on the Saffir-Simpson Hurricane Wind Scale.

Hurricanes are characterized by high winds and extratropical moisture resulting in torrential rainfall, especially if the storm is slow moving. The rotational nature of hurricanes often results in winds changing direction as the storm passes, altering wave generation and surge setup. A hurricane is strongest as it travels over the ocean and is particularly destructive to coastal property as storms hit the land. In the Atlantic Basin, the hurricane season runs from June 1 to November 30 with peak activity occurring in early to mid-September.[18]

Hurricanes are classified by the Saffir-Simson Scale, which categorizes intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential. **Table 2.8** shows the wind speeds, surges, and range of damage caused by different hurricane categories:

Table 2.8

Saffir/Sipson Scale to Measure Hurricane Intensity

Scale No. (Category)	Winds (mph)	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

[18] National Hurricane Center Educational Resources http://www.nhc.noaa.gov/climo/

Previous Occurrence and Extent

The National Hurricane Center has created maps showing the tracks of all known North Atlantic hurricanes and major hurricanes including what counties were stuck. **Figure 2.7** shows that 4 hurricanes have struck in Essex County between 1900 and 2010. The return period for a hurricane (greater than 64 knots) passing within 50 nautical miles of Essex County is 30 years.[19] Put another way, a 30-year return period means that on average during the previous 100 years, a Category 3 or greater hurricane passed within 50 nautical miles (58 miles) about 3 times.

Total number of hurricane strikes by counties/parishes/boroughs, 1900-2010

Figure 2.7
Hurricane Strikes by County (1900-2010)

Within the last 25 years, hurricanes and tropical storms that have impacted Massachusetts include Hurricane Irene (Category 2, 2011), Earl (Category 4, 2010), and Bob (Category 2, 1991); and Tropical Storms Sandy (2012), Bill (2009), Hanna (2008), and Beryl (2006).[20]

While historic records include 28 tropical storms and hurricanes for New England, only 3 events have resulted in FEMA hurricane-related disasters for Essex County as listed in **Table 2.9**.

Table 2.9
FEMA Hurricane-Related Declared Disasters Impacting Essex County

FEMA Disaster #	Name	Date	Category
DR-751	Hurricane Gloria	9/27/1985	Cat 3
DR-914	Hurricane Bob	8/19/1991	Cat 2
EM-3315	Hurricanes Earl	9/1/-9/4/2010	Cat 4

Source: FEMA

Hurricane Gloria, a Category 3 hurricane, was the most severe to have impacted Manchester-by-the-Sea, with sustained winds of 115 mph and up to 12 feet of storm surge.

[19] National Hurricane Center http://www.nhc.noaa.gov/climo/
[20] 2013 State Hazard Mitigation Plan

Locally Identified Areas of Impact

Based on past history, the Planning Team determined the entire planning area is at risk for impacts due to hurricanes and tropical storms.

More specific information on hurricane risk was developed as part of the HMP Enhancement using the IRM model, based on SLOSH data for Hurricane Storm Surge. Results from a Category 1 or greater event was shown to affect 59 percent, or 41 out of 70 identified community assets. The Hurricane Storm Surge impacts modeled by the IRM was more extensive than indicated by the 2012 HMP risk analysis.[21]

Probability of Future Occurrence

According to the 2013 State Hazard Mitigation Plan and NOAA Hurricane Research Division, the Commonwealth has a 6 to 30 percent chance of a tropical storm or hurricane affecting the area each year. The probability increases moving from the northwest corner of the state to the southeast, with the highest probability along the coast, specifically Cape Cod and the Islands. New England averages about one hurricane per decade, but there is some evidence that more and stronger hurricanes occur when Atlantic Sea-Surface-Temperatures are warm. While the science of global warming and hurricanes is evolving, present research calls for slightly stronger and wetter storms, but changes in frequency are unknown. Based on the past regional and local history of tropical cyclones, the Planning Team determined that it is **LIKELY** that a hurricane or tropical storm will impact the area in the future**.**

2.2.5.2 Tornadoes, High Winds, and Thunderstorms

Tornadoes

A tornado is a violently rotating column of air extending from a cumuliform cloud, such as a thunderstorm, to the ground. Tornadoes are not always visible as funnel clouds because they may appear nearly transparent until they pick up dust and debris. The average tornado moves from southwest to northeast, but they can move in any direction and can suddenly change direction. The average speed of a tornado is 30 mph, but they can be stationary or move as fast as 70 mph. The strongest tornadoes have rotating winds of more than 200 mph.[22] **Table 2.10** shows the Enhanced Fujita Tornado Damage Scale developed by T. Theodore Fujita.[23]

Table 2.10
Enhanced Fujita Scale Levels and Description of Damage

EF-Scale Number	Intensity Phrase	3-Second Gust (MPH)	Type of Damage Done
EF0	Gale	65-85	Some damage to chimneys; breaks branches off trees; shallow rooted trees pushed over; sign boards damaged
EF1	Moderate	86-110	Peels surfaces off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.

[21] Potential Climate Change Impacts to Manchester-by-the-Sea, October, 29, 2015
[22] Thunderstorms, Tornadoes, Lightning: Nature's Past Violent Storms, A Preparedness Guide, US Department of Commerce, NOAA, and the National Weather Service
[23] http://www.spc.noaa.gov/efscale/

Table 2.10
Enhanced Fujita Scale Levels and Description of Damage

EF2	Significant	111-135	Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	Severe	136-165	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
EF4	Devastating	166-200	Well-constructed houses leveled; structures with weak foundations blown off some distances; cars thrown and large missiles generated.

Thunderstorms

A thunderstorm is a storm with lightning and thunder produced by a cumulonimbus cloud, usually producing gusty winds, heavy rain, and sometimes hail. The NWS classifies a thunderstorm as 'severe' when it produces damaging wind gusts in excess of 58 mph (50 knots), hail that is 1 inch in diameter or larger (quarter size), or a tornado (NWS, 2013).

Three basic ingredients are required for a thunderstorm to form:[16]

- moisture to form clouds and rain
- rising unstable air warm air that can rise rapidly
- lift- caused by cold or warm fronts, sea breezes, mountains, or the sun's heat

While less severe than other types of storms, a thunderstorm can lead to localized damage and represents a hazard risk for all communities in Massachusetts. An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. Southern New England typically experiences 10 to 15 days per year with severe thunderstorms.

Thunderstorms have masses of air, an updraft (rising air), and a downdraft (sinking air). A strong downdraft, also known as a downburst, can cause tremendous wind damage similar to a tornado. Damage from hail and lightning are secondary impacts to thunderstorms. Hail can cause damage to vehicles and crops especially when the hail stones are large in diameter.

Previous Occurrence and Extent

According to the NOAA National Climatic Data Center (NCDC), Essex County experienced the following events between January 1, 1950 and November 1, 2016:

- 12 days with reported Tornado (EF0-EF1 magnitude, 4 injuries, $562.78K property damage)
- 39 days with reported Lightning (3 deaths and 4 injuries, $1.099M property damage)
- 90 days with reported Hail (0-3.5 inch diameter, $155K property damage)
- 162 days of reported High/Strong Wind (up to 59 knots, 4 injuries, $3.77M property damage)
- 251 days of reported Thunderstorm Wind (up to 100 knots, 1 death, 7 injuries $7.5M property damage

Locally Identified Areas of Impact

Based on local experience and NOAA weather records, the entire planning area has experienced severe weather events due to wind, including lightning, hail, strong winds, thunderstorms and tornadoes. There are no reports of tornadoes in Manchester-by-the-Sea, but of the 12 reported events in Essex County, 2 were reported in Salem (1962 and 1964) and 2 reported in Ipswich (1965).

Probability of Future Occurrence

Based on the past regional and local history of severe weather wind events, the Planning Team determined that it is **HIGHLY LIKELY** that a weather event due to wind, including lightning, hail, strong winds, and thunderstorms will impact the area in the future**.** The planning team thinks that it is **LIKELY** that a weather event due to tornadoes will impact the area in the future.

2.2.6 Severe Weather-Extreme Temperatures and Drought

Severe weather is also a category of other climatological extremes such as extreme temperatures and drought. Hazard profiles for these severe weather events are included separately in this section.

2.2.6.1 Extreme Temperature

Extreme temperatures are defined as temperatures that are far outside the normal ranges for the season in a specific area. Extreme cold events are characterized in a temperate zone by the air temperature dropping to approximately 0 ºF or below. Extreme heat is identified as the number of days with a maximum temperature greater than or equal to 90ºF and greater than or equal to 100ºF.

Previous Occurrence and Extent

According to NOAA NCDC data, the entire area is vulnerable to extreme temperature. For the past decade, Massachusetts has been reporting 2 to 4ºF warmer than the 20th Century Average.[24] **Figure**

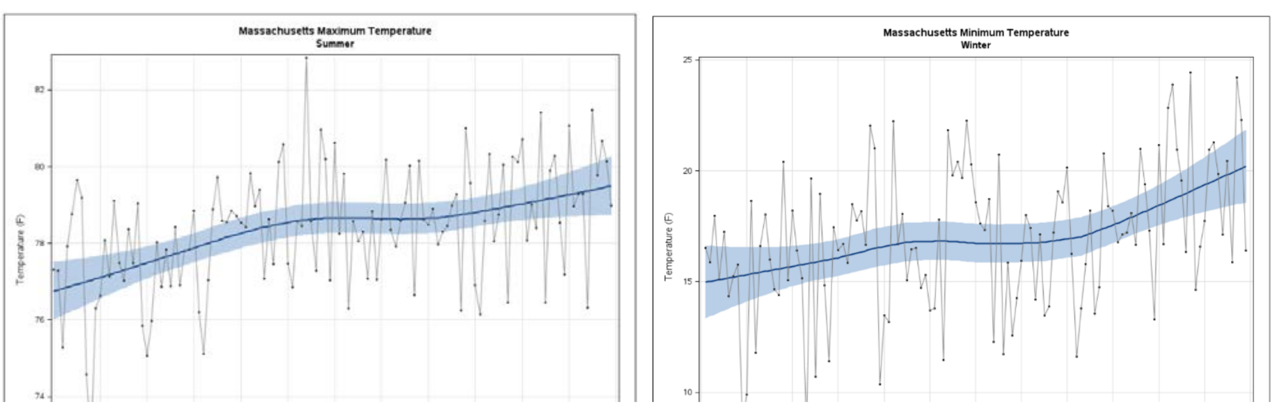


Figure 2.8
Maximum Summer (left) and Minimum Winter (right) Monthly Temperatures in Massachusetts (1895-2016)

[24] https://www.ncdc.noaa.gov/temp-and-precip/state-temps/

2.8 depicts the trend of maximum high summer temperatures and minimum low winter temperatures from 1895 to 2015.

According to the Northeast Regional Climate Center at Cornell University, 2012 was the warmest year in the US to date, and the third hottest summer. Extreme heat for Essex County is most common in July with the record high of 105ºF set in July 2011. Extreme cold temperatures are most common in January with the lowest recorded temperatures being -18ºF in February 1934.

Table 2.11 shows the recent history of extreme temperatures for Manchester-by-the-Sea, using data for Beverly Airport, downloaded from the NOAA National Centers for Environmental Information.[25] A total of 102 days were reported with temperatures above or equal to 90ºF with only 2 days above or equal to 100ºF. A total of 79 days were reported with temperatures less than or equal to 5ºF with 27 days less than or equal to 0ºF.

Table 2.11

Extreme Temperatures for Manchester-by-the-Sea 2006-2016

Year	Number of days≥90	Number of days≥100	Number of days ≤5 degrees	Number of days ≤0 degrees
2006	5		1	
2007	13		9	
2008	2		3	
2009	4		8	5
2010	18	1	2	
2011	6	1	12	4
2012	10		1	
2013	13		4	1
2014	4		15	4
2015	9		20	10
2016	18		4	3
TOTAL	102	2	79	27

According to the NOAA'S National Climatic Data Center, the following extreme heat and extreme cold events were reported for Essex County between January 1, 1950 and November 1, 2016:

- July 6, 2010 Beverly Airport recorded 100 ºF with heat index of 100-106 ºF
- July 22, 2011 Beverly Airport recorded 105 ºF with heat index of 105-017 ºF over 3 hours
- February 13-14 2016 Beverly Airport reported wind chills as low as -35 ºF
- February 15-16, 2016. Beverly Airport reported wind chills as low as -27 ºF

[25] https://www.ncdc.noaa.gov/cdo-web/

Locally Identified Areas of Impact

The entire planning area is at risk for impacts due to extreme temperatures.

Probability of Future Occurrence

The Planning Team determined that it is **POSSIBLE** that extreme temperatures will impact the planning area.

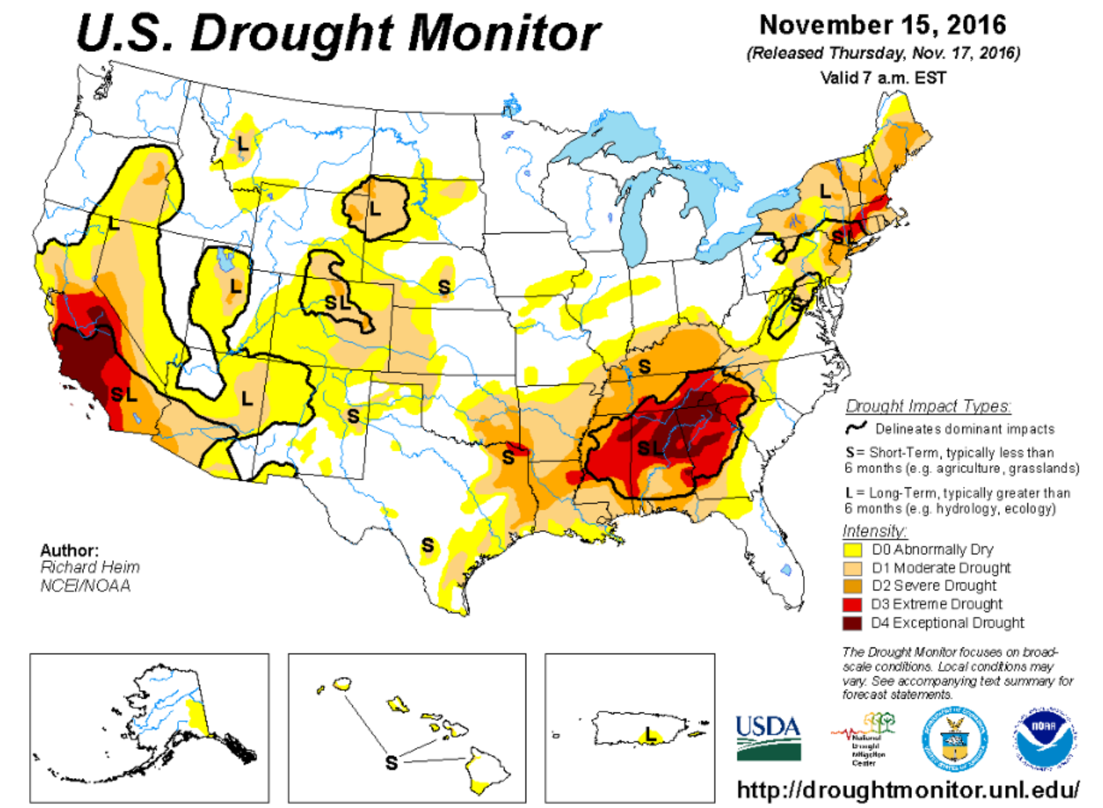
2.2.6.2 Drought

Drought is a period characterized by long durations of below normal precipitation.[26] Drought conditions typically last a season or more and result in water shortages, causing adverse impacts on vegetation, animals, and people. Drought characteristics vary significantly from one region to another, since it is relative to the normal precipitation in that area. Drought is a temporary aberration, and is different from aridity, which is a permanent feature of climate in areas where low precipitation is normal, such as in a desert.[19]

Previous Occurrence and Extent

The entire planning area can be affected by drought, impacting local water resources often requiring voluntary or required use restrictions on water use. The US Drought Monitor was established in 1999 as a partnership between NOAA, US Department of Agriculture, and the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln, and is published weekly to forecast drought conditions across the US. **Figure 2.9** below is an example of conditions occuring in November 2016.

[26] NOAA May 2008, Drought Public Fact Sheet http://www.nws.noaa.gov/om/brochures/climate/DroughtPublic2.pdf



[27]

Figure 2.9
Drought Conditions across the US

The Massachusetts Office of the US Geological Service provides local data to monitor streamflow and drought conditions across Massachusetts. The USGS maintains the statistics and streamflow information on their Water Watch website,[28] and the DCR Water Resource Commission issues monthly reports of Hydrologic conditions that utilizes a drought index shown below in **Table 2.12**, based on monthly precipitation, streamflow and reservoir levels, and crop moisture index to assign levels of drought.[29]

[27] http://droughtmonitor.unl.edu/
[28] http://newengland.water.usgs.gov/drought/index.html
[29] http://www.mass.gov/eea/agencies/dcr/water-res-protection/water-data-tracking/drought-status.html

Table 2.12
Description of Drought Indices

Description of Drought Indices
(from Table 3 of Massachusetts Drought Management Plan).

Drought Level	Standardized Precipitation Index	Crop Moisture Index*	Keetch-Byram Drought Index*	Precipitation	Groundwater	Streamflow	Reservoir***
Normal	3-month > -1.5 **or** 6-month > -1.0 **or** 12-month > -1.0	0.0 to -1.0 slightly dry	< 200	1 month below normal	2 consecutive months below normal**	1 month below normal**	Reservoir levels at or near normal for the time of year
Advisory	3-month = -1.5 to -2.0 **or** 6-month = -1.0 to -1.5 **or** 12-month = -1.0 to –1.5	-1.0 to -1.9 abnormally dry	200-400	2 month cumulative below 65% of normal	3 consecutive months below normal**	At least 2 out of 3 consecutive months below normal**	Small index Reservoirs below normal
Watch	3-month < -2.0 **or** 6-month = -1.5 to -3.0 **or** 12-month = -1.5 to -2.0	-2.0 to –2.9 excessively dry	400-600	1 of the following criteria met: 3 month cum. < 65% **or** 6 month cum. < 70% **or** 12 month cum. < 70%	4-5 consecutive months below normal**	At least 4 out of 5 consecutive months below normal**	Medium index Reservoirs below normal
Warning	6-month < -3.0 **or** 12-month = -2.0 to -2.5	< -2.9 severely dry	600-800	1 of the following criteria met: 3 month cum. < 65% and 6 month cum. <65%, **or** 6 month cum. <65% and 12 month cum. <65%, **or** 3 month cum. <65% and 12 month cum. <65%	6-7 consecutive months below normal**	At least 6 out of 7 consecutive months below normal**	Large index reservoirs below normal
Emergency	12-month < -2.5	<-2.9 severely dry	600-800	Same criteria as Warning and previous month was Warning or Emergency	>8 months below normal**	>7 months below normal**	Continuation of previous month's conditions

* The Crop Moisture Index is subject to frequent change. The drought level for this indicator is determined based on the repeated or extended occurrence at a given level.
** Below normal for groundwater and streamflow are defined as being within the lowest 25th percentile of the period of record.
*** Water suppliers should be consulted to determine if below normal reservoir conditions are due to operational issues.

Source: Massachusetts Drought Management Plan. May 2013 (http://www.mass.gov/eea/docs/eea/wrc/droughtplan.pdf).

While drought does involve multiple indices, historic multi-year droughts were identified by the USGS by analyzing annual and cumulative departures from long-term average streamflow at gauging stations across Massachusetts. Streamflow deficits were analyzed and recurrence intervals computed for selected droughts. The droughts of 1929-32, 1939-44, 1961-69, and 1980-83 stand out as particularly significant because of their severity and areal extent. The severest drought on record in the Northeastern United States was during 1961 through 1969. Water supplies and agriculture were affected because of the severity and long duration of the drought.[30]

Table 2.13 below summarizes other drought periods including 2001, 2007, 2010, 2014, and 2016. The drought experience in 2016 has been the most severe since the 1960's multi-year drought.

[30] U.S. Geological Survey Water-Supply Paper 2375 National Water Summary 1988-89--Floods and Droughts: Massachusetts Floods and Droughts

Table 2.13

Drought Dates and Levels in Massachusetts (2001-2016)

				Drought Levels by Regions					
Year	**Begin Date**	**End Date**	**Comment**	**Western**	**CT River**	**Central**	**Northeast**	**Southeast**	**Cape & Islands**
	12/28/2001	1/31/2003							
2001	12/28/2001			Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			February 2002	Advisory	Watch	Watch	Watch	Advisory	Advisory
2002			March 2002	Watch	Watch	Watch	Watch	Watch	Watch
2002			April 2002	Watch	Watch	Watch	Watch	Watch	Watch
2002			May 2002	Watch	Watch	Watch	Watch	Watch	Watch
2002			June 2002	Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			July 2002	Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			August 2002	Advisory	Advisory	Advisory	Advisory	Watch	Watch
2002			September 2002	Advisory	Advisory	Advisory	Advisory	Watch	Watch
2002			October 2002	Advisory	Advisory	Advisory	Advisory	Advisory	Advisory
2002			December 2002	Normal	Normal	Normal	Normal	Normal	Advisory
2003		1/31/2003	As of January 31, 2003	Normal	Normal	Normal	Normal	Normal	Normal
	10/1/2007	3/18/2008							
2007	10/1/2007			Normal	Advisory	Advisory	Advisory	Advisory	Normal
2008		3/18/2008	As of March 18, 2008	Normal	Normal	Normal	Normal	Normal	Normal
	8/1/2010	11/19/2010							
2010	8/1/2010			Normal	Normal	Advisory	Advisory	Normal	Normal
			October 2010	Normal	Advisory	Advisory	Advisory	Normal	Normal
2010		11/19/2010	As of November 19, 2010	Normal	Normal	Normal	Normal	Normal	Normal
	10/1/2014	11/30/2014							
2014	10/1/2014			Normal	Normal	Normal	Normal	Advisory	Advisory
2014		11/30/2014	As of December 1, 2014	Normal	Normal	Normal	Normal	Normal	Normal
	7/1/2016								
2016	7/1/2016		June 2016	Normal	Advisory	Watch	Watch	Advisory	Normal
			July 2016	Advisory	Watch	Warning	Warning	Watch	Advisory
			August 2016	Advisory	Watch	Warning	Warning	Warning	Watch
			September 2016	Watch	Warning	Warning	Warning	Warning	Watch
			October 2016	Warning	Warning	Warning	Warning	Warning	Advisory
Note: The information in this table dates to 2001, when the Massachusetts Drought Management Plan was developed in response to a period of deficient precipitation, starting in 1999. The most severe drought of modern times was the drought of the 1960's, equivalent to a drought emergency. A less severe drought occurred in the early 1980's. See Appendix F of the plan for more details. http://www.mass.gov/eea/wrc/droughtplan.pdf									

Locally Identified Areas of Impact

The entire planning area can be affected by drought, impacting local water resources often requiring voluntary or required use restrictions on water use. Essex County relies on data from the Beverly Airport and a USGS groundwater well located in Wenham[31] to provide information on local conditions for Manchester-by-the-Sea that are interpreted by the USGS and DCR to establish local water conditions. **Figure 2.10** below shows that overall status of Drought for Massachusetts in November of 2016, indicating Severe to Extreme Drought conditions for Essex County.

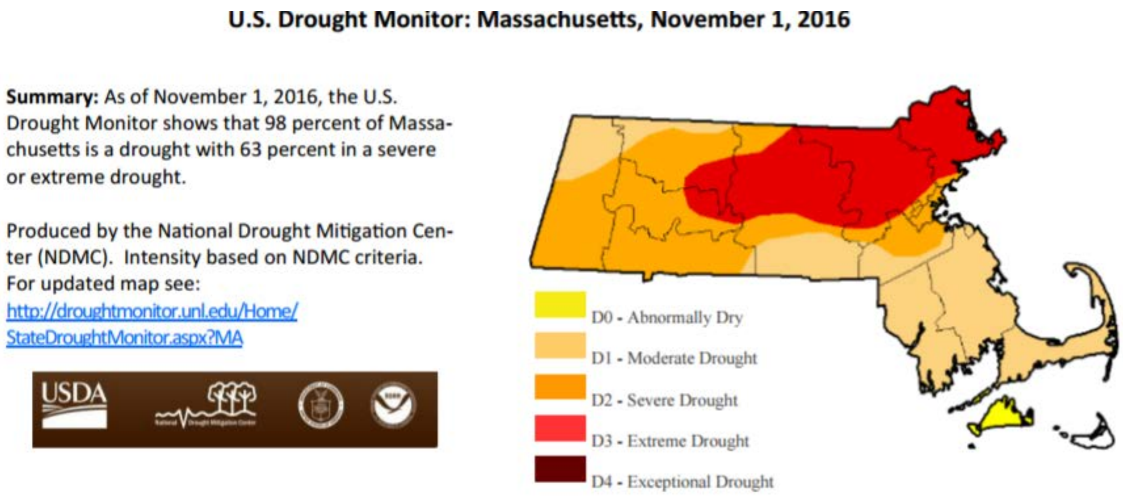


Figure 2.10
Massachusetts Drought Conditions, November 2016

Probability of Future Occurrence

The Planning Team determined that based on past history of drought events it is **LIKELY** that drought will impact the planning area in the future.

2.2.7 Dam and Culvert Failure

A dam is an artificial barrier that has the ability to impound water for the purpose of storage or control of water. Dam failure is a catastrophic type of failure characterized by a sudden, rapid, and uncontrolled release of impounded water. 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.

A culvert is defined as a structural opening under a roadway that allows water to pass from one side of a roadway to the other. A culvert can impound water similar to a dam under certain flood conditions, and if conditions are extreme, culverts can fail, causing road and property damage. A culvert can fail under the following conditions:

- clogged with debris and sediment

[31] http://waterdata.usgs.gov/ma/nwis/uv/?site_no=423505070491702&PARAmeter_cd=72019

- buildup of flood water or on the upstream side of the culvert exceeding the capacity of the culvert
- loss of structural integrity
- culvert and road are washed out during a heavy rain or from snowmelt
- soil around the culvert erodes, and without support, the culvert will buckle or sag and the culvert will collapse

Previous Occurrence and Extent

Manchester relies on a system of culverts along Sawmill Brook and associated tributaries to facilitate drainage for the majority of the Town. Lesser drainage features include Bennetts Brook and Chubb Creek. Stream crossing infrastructure along the Brooks and their tributaries includes culverts, bridges, and a tide gate. These structures, many of which are over 100 years old, include arches, bridges, and pipes constructed from a wide variety of materials including granite block, stone, aluminum, iron, and concrete.

The Town Department of Public Works (DPW) and Highway Department crews report dozens of culverts in Town that appear to be undersized, in poor condition, or impacted by beaver dams. Deterioration, blocked culverts, and undersized structures frequently create flood water that backs up onto roadways and adjacent land, resulting in roadway closure and property damage. Culverts that have collapsed in the recent past due to flooding include 2 locations on School Street (one at Brook Street and one near Route 128) and the culvert at Atwater Ave. The culvert at Central Street is combined with a tide gate and a seawall, and is particularly problematic during large storm events, causing water to back up into Sawmill Brook.

There are 3 small private, unregulated dams in Manchester including Small Brook, Forster Road and Gorman Pond Dams.

<u>Culvert Inspections</u>

Twenty four culverts were inventoried by the Town in June 2015. The majority were open bottom arch construction, and about half of the culverts were observed to have condition issues. The majority of the culvert locations had sediment buildup upstream and about half of the locations also had sediment buildup downstream. Blockages that might impede flow included concrete pipe, detritus, woody vegetation, metal, and beaver dams. **Table 2.14** provides a descriptive summary of the observed culvert construction and observed issues.

Table 2.14
Summary of Culvert Observations

Culvert	Location	Construction and Other Features	Observed Issue
1	Conservation	N/A	Does not exist or was unable to be located
2	School St	Old, dry stone box culvert construction, beaver deceiver	Beavers
3	School St	New, metal open bottom arch construction	None
4	Atwater Ave	Old, metal open bottom arch construction	Upstream erosion and beaver dam
5	Conservation	Metal open bottom arch construction	Rust, upstream scour
6	School St	New concrete round culvert	
7	Forrest Ln	Old, stone open bottom arch construction	Collapsing, upstream backup and sediment buildup, downstream erosion
8	Loading Place Road	New, plastic round culverts (3)	Sediment buildup up and downstream, beaver dam upstream
9	Pine St	Old, metal round culverts (2)	Upstream sediment buildup, downstream clogged with sand
10	Rockwood Hts	Old, concrete and stone embedded round culverts (2)	Up and downstream sediment buildup, downstream clogged with mud
11	Mill St	Concrete open bottom arch construction	Up and downstream sediment buildup
12	Millet Ln	Metal embedded elliptical culvert	Rusty outlet, organic debris, up and downstream sediment buildup, erosion along headwall
13	The Plains	New, metal open bottom arch construction	Up and downstream sediment buildup
14	Old Essex Rd	N/A	Does not exist or was unable to be located
15	Blue Heron Ln	New, concrete open bottom arch construction	Up and downstream sediment buildup, downstream erosion and headwall needs patching
16	Golf Course	Metal bridge with stone abutments	Natural gravel and stone bottom. *
17	Lincoln St	Old, stone open bottom arch construction	Up and downstream bank erosion, downstream sediment buildup
18	Lincoln St	Old, stone open bottom arch construction	Branches blocking outlet
19	School St- Golf	Old, metal open bottom arch construction	Wood debris blocking inlet, sediment buildup and detritus downgradient
20	Summer St	Old, metal open bottom arch construction	Concrete channel
21	Summer St	Old, concrete box culvert construction	Upstream sediment buildup and obstructions

Culvert	Location	Construction and Other Features	Observed Issue
22	Norwood Ave	Old, metal/stone bridge with abutments	Upstream erosion sediment buildup, downstream erosion, metal falling off
23	School St	Old, concrete/stone open bottom arch construction with 2 culverts	Upstream sediment buildup
24	Summer St	Old, concrete/plastic culverts underneath bridge with abutments	Rusted and upstream sediment buildup
25	Central St*	Old, stone/concrete open bottom arch construction	Erosion, collapsing support walls, overlay repair
27	Mill St	Old, stone open bottom arch construction	Branches blocking outlet

Central Street Culvert/Tide Gate Inspection

The mouth of Sawmill Brook drains through a narrow culvert and tide gate under Central Street, shown below in **Figure 2.11**. This location was the site of several sawmills and other historic hydro-powered industries, documented as early as 1790. The seawall actually serves as the road bed for Central Street, along a Town controlled section of Route 127. The tide gate was added around 1900 to dam the Brook for a fire reservoir and to provide a winter skating pond. Installation of the tide gate resulted in the creation of Central Pond. The tide gate and culvert are currently undersized, creating a hydraulic restriction during storm events and impeding the passage of diadromous fish.

Figure 2.11
Tide Gate, Seawall, and Culvert Structures at Central Street

Locally Identified Areas of Impact

The Sawmill Brook Watershed within Manchester-by-the-Sea is particularly vulnerable to failing culverts. **Figure 2.12** shows the location of the municipally-owned dams and culverts in Manchester-by-the Sea**.**

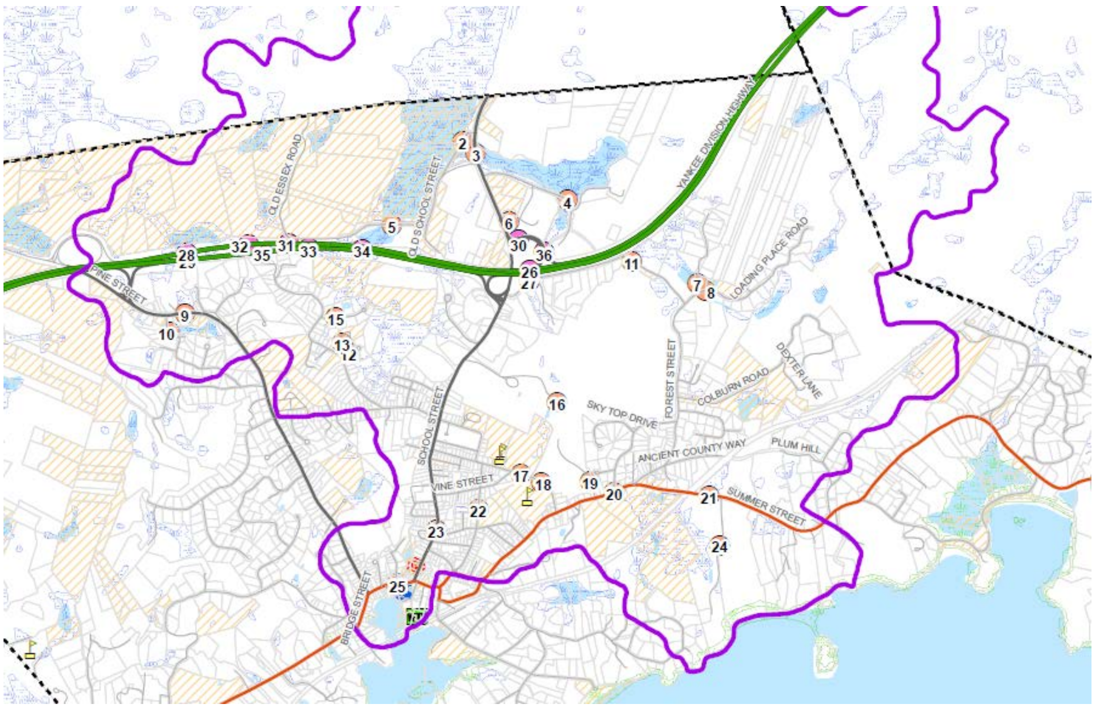


Figure 2.12
Culverts, Bridges, Tide Gates, and Dams located in Manchester-by-the-Sea

The Town completed a detailed hydrogeologic model of the Town's major drainage basin, the Sawmill Brook Watershed, to evaluate the existing capacity of culverts, required future capacity under climate change, and the mitigation value of potential stormwater best management practices, including green stormwater infrastructure, conveyance projects, and flood storage. Using the model, existing conditions were simulated for culverts and bridges for 25-year, 50-year and 100-year storm events. For the 25-year storm in 2015, the existing conditions models indicate that 48% of the culverts overtop the roadway. For the 50-year storm, this number increases to 52%, and with a 100-year storm, 59% of culverts overtop.

Probability of Future Occurrence

Future impact on culverts and bridges in the watershed was assessed based on the 50% probability for both stillwater (annual storm surge) and sea level rise. By 2100, almost all of the culverts in the watershed will be overtopped for storms more frequent than the 100-year event. **Figure 2.13** shows an example of model results for the year 2100. Culverts shown in red will overtop during a 25-year storm, orange will over top during a 50-year storm, yellow will overtop during a 100-year event, and culverts in green will not overtop even with a 100-year storm event. Areas of surficial flooding are shown in pink.

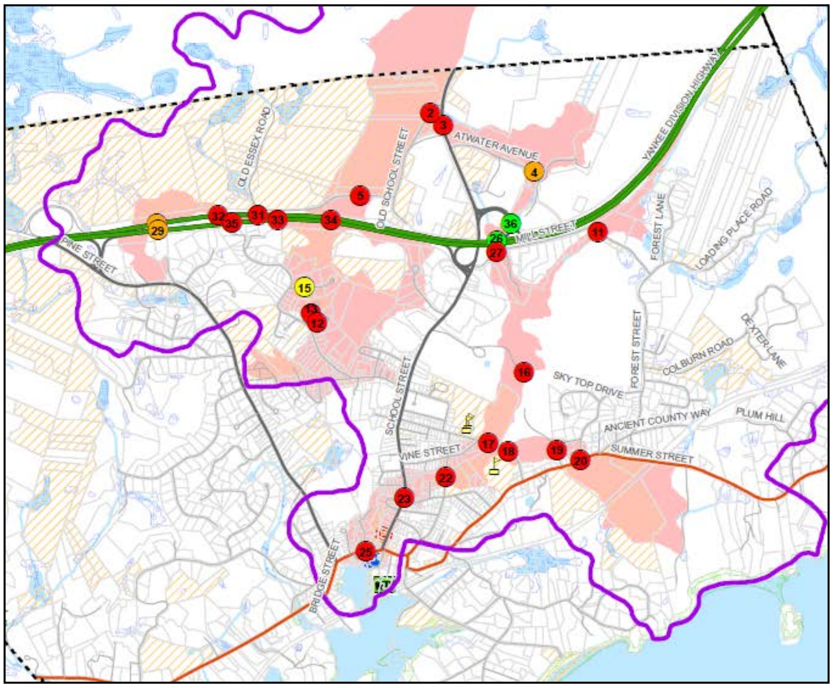


Figure 2.13
Culvert Overtopping for 2100 Due to Storm Surge

The Planning Team determined that based on past history of culvert failure and modeling results of culvert capacity, it is **HIGHLY LIKELY** that dam or culvert failure will impact the planning area in the future. The Town is actively working to make improvements to increase the hydraulic capacity of culverts based on exiting flow conditions and projected future conditions due to climate change.

2.2.8 Urban and Wildfire

Fire needs the right combination of heat source, fuel, and oxygen in order to ignite and thrive. Availability of fuel, weather conditions, and terrain all dictate how a fire will behave. Fires are classified as disasters when they affect people or developed areas. Fires can start from a variety of natural or anthropogenic causes. Urban fires occur in developed landscapes, where a fire has the potential to spread from one structure to another.

A wildfire is any non-structural fire that occurs in the vegetative wildlands. The 3 major classes of wildfires are surface, ground, and crown fires. A surface fire creeps slowly on the forest floor, while killing or damaging trees. Often occurring during droughts, ground fires burn organic ground cover below the forest floor. Rapidly spreading due to wind, crown fires quickly jump along the treetops.

Major urban and wildfires often result from other hazards, such as storms, earthquakes, gas leaks, transportation accidents, hazardous material spills, criminal activity, or terrorism. In contrast, small structural fires occur frequently from mundane events.

Previous Occurrence and Extent

The wildfire season in Massachusetts typically begins in late March and usually culminates in early June, following the driest live fuel moisture periods of the year. Historically, April has the highest wildfire danger.[32]

The Manchester-by-the-Sea Fire Department responds to 5 or fewer wildland-related fires annually. However, because of the extensive wildland-urban-interface (WUI) throughout the Town, the potential for a wildland fire is considered a serious hazard. The 2 most recent significant brush fires include May 1957 when 1,200 acres were burned and more recently in May 1996 when 300 acres were burned. Otherwise, wildfires have not resulted in any significant property damage and there have been no deaths as a result of brush fires. The areas with the highest incidence of brush fires are in the wooded western parts of town, including the Crooked Lane neighborhood, as well as land adjacent to Route 128. There are fire prevention access and brush management issues in some of the areas associated with more frequent brush fires. The Fire Department has a dedicated but poorly designed forestry vehicle. The Department must increase its effectiveness with a multi-role mini pumper.

Manchester-by-the-Sea has its history of urban fires. On August 27, 1836, a fire started in the Sawmill Brook steam veneering mill and rapidly spread to nearby cabinet shops and wooden residences.[33] After another fire in 1871, the Town widened Central Street. When the mill burned in 1872, it marked the end of the furniture business in Manchester-by-the-Sea.[34] In 1873, the Town purchased the Mill Pond to help protect the Town from fire.[35] Between the 5-year period of 2010-2015, the Manchester-by-the-Sea Fire Department responded to 40 calls involving structure fires. Damages total in excess of $6 million.

Locally Identified Areas of Impact

The Northeast Wildfire Risk Assessment Geospatial Work Group determined the wildfire risk based off of fuels, wildland-urban interface and topography, as shown in **Figure 2.14.**[36] Manchester-by-the-Sea is in an area of **high** risk. Based on this mapping, the entire planning area is at risk for wildfires.

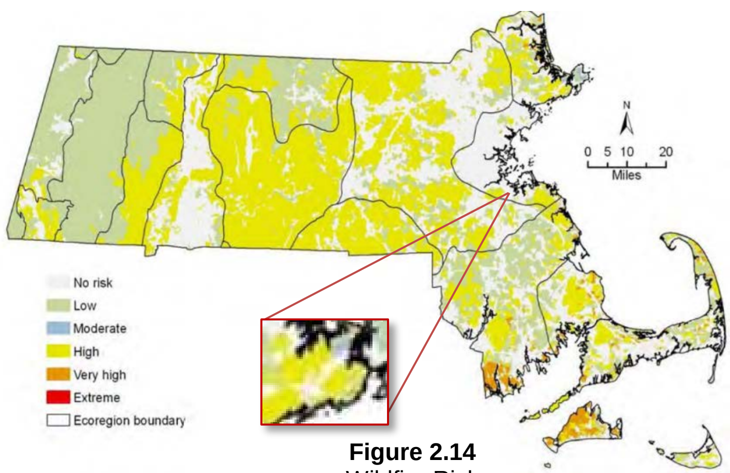


Figure 2.14
Wildfire Risk

Probability of Future Occurrence

It is difficult to predict the likelihood of urban and wildfires given the complexity of predicting the factors leading to fires. Fires will continue to present a risk. The Planning Team determined that it is **POSSIBLE** that an urban fire will impact Manchester-by-the-Sea based on the population and

[32] 2013 Massachusetts State Hazard Mitigation Plan
[33] Manchester Historical Society, Handwritten Notes on Mills at the Mouth of Sawmill Brook
[34] Manchester Cricket December 1904, The Story of Saw Mill Brook
[35] Manchester Historical Society, Handwritten Notes on Mills at the Mouth of Sawmill Brook
[36] 2013 Massachusetts State Hazard Plan

POSSIBLE that a wildfire will impact the planning area based on the open space and past history of fires.

2.2.9 Landslides

Landslides encompass a wide variety of ground movements under the effect of gravity including rock falls, slope failures, and shallow debris flows. In the Commonwealth of Massachusetts, landslides are primarily caused by slope saturation by water, which increases the weight on the slope, as well as the pore pressure.[37] Increasing the pore pressure will decrease the cohesiveness of the material, making the land more vulnerable to outside pressures (i.e. gravity). In Massachusetts, landslides are often caused by construction-related failures, undercut slopes, and water saturation.

- Construction-related failures are caused by construction activities that weaken the slope by increasing the steepness of the bank and decreasing supporting material along the bank.
- Undercut slopes occur when streams, tides, or other water movement cut into the toe of the slope, eventually undermining.
- Slope saturation on a slope occurs after high precipitation events and drastic water level changes that augments the weight on the slope and diminishes the slope's cohesiveness.

Landslide incidence is the number of landslides that have occurred in a given geographic area. High incidence means greater than 15 percent of a given area has been involved in landsliding, medium incidence means 1.5 to 15 percent of an area has been involved, and low-incidence means that less than 1.5 percent of an area has been involved. Manchester-by-the-Sea has a low incidence of landslides.

Previous Occurrence and Extent

Landslides tend to coincide with other natural disasters such as earthquakes and floods that exacerbate relief and reconstruction efforts. As a result, landslide frequency is related to the frequency of other hazards. There have been zero federally declared landslide disasters from 1954 to 2012.[38] According to the 2013 State Hazard Mitigation Plan, there are roughly 1 to 3 landslides events each year. There is no specific data on events in Manchester-by-the-Sea. Town officials and the public did not identify any problems with areas of geologic instability such as sinkholes or subsidence, or any past occurrences with landslides, sinkholes or subsidence.

Locally Identified Areas of Impact

The entire planning area is identified with a low risk for landslides.

[37] 2103 Mass State Hazard Mitigation Plan
[38] 2013 Mass State Hazard Mitigation Plan

Probability of Future Occurrence

Based on the low lying topography and the low incidences of landslides, the Planning Team determined that it is **UNLIKELY** that landslides will impact Manchester-by-the-Sea.

2.2.10 Tsunamis

A tsunami is a series of traveling ocean waves of extremely long wavelength often caused by displacement of the ocean floor by seismic or volcanic activity or underwater landslides. The waves can move hundreds of miles per hour in open ocean and can come ashore as high as 100 feet or more.

Previous Occurrence and Extent

All coastal areas of Massachusetts are exposed to the threat of tsunamis. According to *U.S. States and Territories National Tsunami Hazard Assessment: Historical Record and Sources for Waves*, the U.S Atlantic coast and Gulf Coast have experienced very few tsunamis in the last 200 years. Only 6 tsunamis have been recorded in the other Gulf and East Coast states. There is no data for tsunami events in Manchester-by-the-Sea.

Locally Identified Areas of Impact

Based on the elevations of Manchester-by-the-Sea, most if not all of the planning area is at risk from impacts caused by a tsunami.

Probability of Future Occurrence

At the present time, it is unknown what the probability of a damaging tsunami along the Massachusetts coast would be. Based on the low frequency of tsunami events on the East Coast, the Planning Team determined that it is **UNLIKELY** that tsunamis will impact Manchester-by-the-Sea. The probability that a tsunami will reach the Atlantic is low, but not outside the realm of possibility.

2.2.11 Earthquakes

An earthquake is the movement or trembling of the ground produced by a sudden displacement of rock in the Earth's crust. The theory of plate tectonics is commonly used to explain much of the earthquake activity in the world. The plates over the Earth are in constant slow motion and this movement can cause earthquakes, most frequently at the boundary of the plates.[39]

In general, magnitude measures the size of an earthquake, while intensity measures the effects, which vary according to how far you are from the earthquake and the soils you are on.[4] Two scales are frequently used to measure earthquakes: Richter Scale measures the amount of energy released by an earthquake, or its magnitude. The Richter Scale ranges from 3.5 to 8.0, where 3.4 may be felt but doesn't cause damage, to an 8 which includes Great Earthquakes, and serious damage over extremely large areas. The Modified Mercalli Intensity Scale measures the intensity or impact of an earthquake on people and the built environment, and the Scale ranges from a Level 1, where the earthquake is not felt except by very few under especially favorable circumstances to a X11, with total damage: where

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[39] Earthquake Causes and Characteristics, FEMA Emergency Management Institute Training Guide, https://training.fema.gov/emiweb/is/is8a/is8a-unit3.pdf

all works of construction are damaged or destroyed, lines of sight and level are distorted, and objects are thrown into the air.[4]

Earthquake hazards have multiple impacts beyond the obvious building collapse. Buildings may suffer structural damage that 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.

Previous Occurrence and Extent

According to the State Hazard Mitigation Plan, New England experiences an average of 5 earthquakes per year. Between 1627 and 2008, 366 earthquakes were recorded in Massachusetts. Most earthquakes in the northeast region tend to be small in magnitude and cause little damage; however, between 1924 and 2012 there have been 104 earthquakes measured at a magnitude of 4.5 or greater on the Richter Scale. Due to the geologic composition and rock structure in the Northeast, seismic shaking for many of these larger earthquakes were felt throughout all of New England. Most of the earthquakes originated from the La Malbaie fault in Quebec or from the Cape Ann fault located off the coast of Rockport. The list below includes earthquakes that affected eastern Massachusetts:

- August 8, 1847: No data available on the extent of hazard.
- November 27, 1852: No data available on the extent of hazard.
- December 10, 1854: No data available on the extent of hazard.
- September 21, 1876: No data available on the extent of hazard.
- May 21, 1880: No data available on the extent of hazard.
- January 21, 1903: No data available on the extent of hazard.
- April 24, 1903: No data available on the extent of hazard.
- October 15, 1907: No data available on the extent of hazard.
- January 7, 1952: Earthquake occurred off of Cape Ann and the reported felt area extended from Providence, RI to Kennebunk, ME.
- April 24, 1925: No data available on the extent of hazard.
- January 28, 1940: No data available on the extent of hazard.
- October 16, 1963: Intensity VI, caused plaster to fall in a house, crack walls, dishes and windows.
- October 30, 1963: No data available on the extent of hazard.
- October 24, 1965: Slight damage to homes on Nantucket, house timbers creaked, doors, windows and dishes rattled.
- December 30, 2012: Magnitude 1.2 earthquake about 7 miles south of Gardner, MA. No extent data available.

- April 2012: A swarm of 12 or more earthquakes occurred off of the New England coast about 250 miles east of Boston. The largest of these earthquakes measured a magnitude of 4.4 on the Richter Scale. This swarm of earthquakes was of particular concern because of the major earthquake on the continental shelf further north in 1929 that produced a deadly and damaging tsunami in Nova Scotia.

There have been no earthquake declared disasters for Massachusetts. There have been no recorded earthquake epicenters within Manchester-by-the-Sea and there have been no historical recorded effects on the Town associated with earthquake impacts originating from outside of Manchester-by-the-Sea. FEMA has published maps with seismic design categories (SDCs) for building design and construction professionals. Most of New England is classified as SDC “B,” as areas that could experience shaking of moderate intensity.[40]

Locally Identified Areas of Impact

Based on mapping by FEMA, the entire planning area is at risk from impacts due to earthquakes**.**

Probability of Future Occurrence

Earthquakes cannot be predicted and may occur at any time of the day and any time of the year. However, for the purpose of this Plan, the USGS 2014 Seismic Hazard Map was used to review the probability of future occurrence as shown in **Figure 2.15** below.[41]

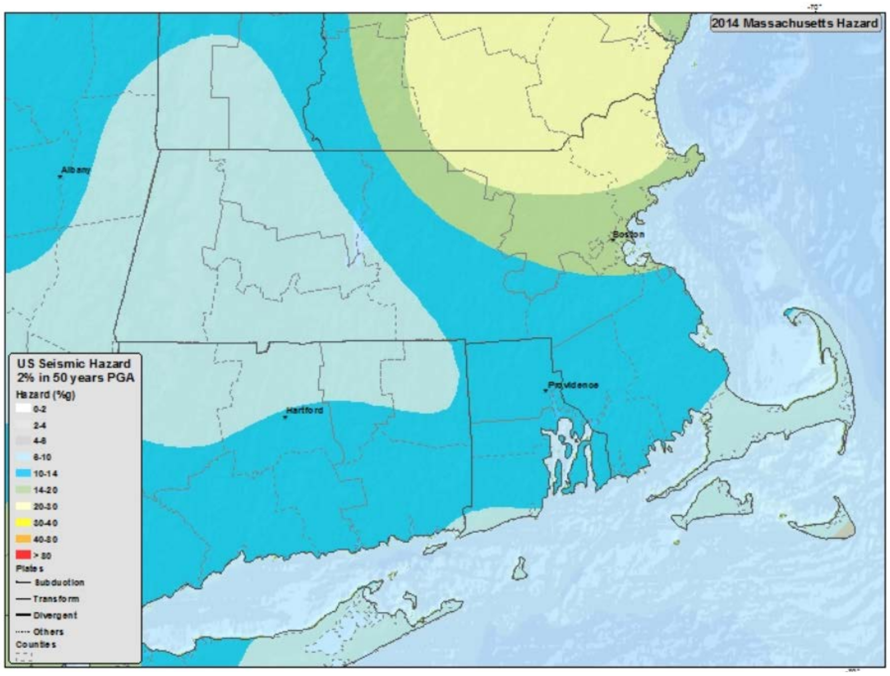


Figure 2.15
2014 Seismic Hazard Map of New England

[40] https://www.fema.gov/earthquake-hazard-maps
[41] https://earthquake.usgs.gov/hazards/hazmaps/conterminous/index.php#2016

The data is derived from seismic hazard curves and depict probabilistic ground motions with a 2 percent probability of exceedance in 50 years. For Manchester-by-the-Sea, moderate peak gravity acceleration from 14 to 20 percent is predicted.

The Town of Manchester-by-the-Sea acknowledged that earthquakes were the hazard for which their community was least prepared. Although new construction under the most recent building codes will be built to seismic standards, much of the development in the Town predates the most recent building code.

The Planning Team determined that it is **POSSIBLE** that an earthquake will impact Manchester-by-the Sea in the future and therefore are including it in the Multi-Hazard Mitigation Plan.

2.2.12 Flooding Due to Climate Change

As discussed earlier in **Section 2.2.1**, for coastal areas like Manchester-by-the-Sea, flooding sources include astronomical tides, storm driven surge, and wave action from high winds. Inland flooding occurs from snow melt, high groundwater, and poor drainage following extreme rainfall events.

For many areas of town the high water levels present during extreme storm events from natural hazards is worsened due to a combination of factors such as hydraulic restrictions from culverts and the tide gate, stormwater runoff from impervious areas, the channelized stream system, and poor infiltration conditions.

Climate change is expected to worsen flooding based on predictions of increased precipitation, more frequent and intense coastal storms, and sea level rise. As the climate warms, the hurricane season may extend longer, and duration and intensity of the storms is predicted to increase by 10 percent.

Global Sea Level Rise is the predicted rise in sea level primarily caused by a change in the volume of the world's oceans due to temperature increase (thermal expansion), uncovering of glaciated land because of melting of the glacier (deglaciation), and land ice melt. NOAA has documented tide gauge data showing the average sea level relative to land has been slowly rising in Boston Harbor and has been rising at a rate of 0.92 feet per 100 years since 1920.[42] This sea level rise is relative to the land surface and does include a significant component that is crustal subsidence in this region and it can be considered a minimum base line sea level rise that has a high probability of continuing in the near future.

Climate change sea level rise acceleration has been predicted, typically with low, medium, and high amounts of rise projection curves. Future sea level rise predictions vary and will be influenced by future fossil fuel usage and rate of acceleration of global warming due to carbon dioxide already in the atmosphere. The Third National Climate Assessment consensus range for sea level rise, applied to this region, is 1 to 4 feet by year 2100 depending on the extent to which the Greenland and West Antarctic Ice Sheet experience significant melting.[43] In Massachusetts, sea level rise relative to the land surface may be greater than average global rates due to the documented subsidence of land along the coast.[44]

[42] https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8443970
[43] http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf
[44] http://www.globalchange.gov/what-we-do/assessment

Previous Occurrence and Extent

NOAA has documented that the average sea level has been slowly increasing in Boston Harbor and has increased by approximately 2 millimeters on average per year since 1920, for a cumulative increase of 0.67 feet to the present (**Figure 2.16**).[45]

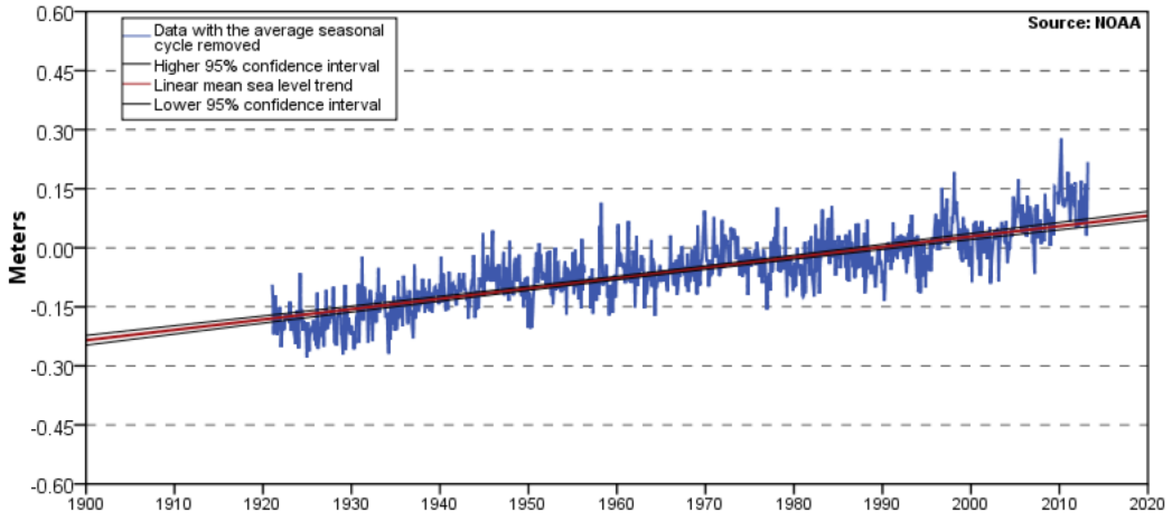


Figure 2.16
Observed Mean Sea Level, Boston, MA

Locally Identified Areas of Impact and Probability of Future Occurrence

Manchester completed several inundation assessments to identify areas that flood beyond historically known locations. The first assessment was completed in 2014 using a basic still-water "bath-tub model" recommended by the CZM StormSmart Coasts program.[46] This approach expands the currently known 100-year floodplain boundaries defined FEMA FIRMs by adding sea level rise for future time periods. The Manchester study assumed that sea level will expand the base 100-year floodplain by 1 foot by the year 2025, 2 feet by 2050 and 4 feet by 2100. Inundation maps were prepared depicting corresponding areas within the defined topographic contours. This type of model is considered "static" in that it does not account for impact of hurricane storm surge, wave dynamics or land form responses, such as erosion, breaching or migration. The flood zone expansion map is shown in Section 4 as Map 5.

In 2015 the Town commenced work under a FEMA PDM14 grant as an Enhancement to Manchester's Hazard Mitigation Plan to include flooding impacts due to climate change from sea level rise, storm surge, and extreme precipitation. The Town undertook modeling and mapping studies to predict where, when, and to what degree future climate impacts on coastal flooding may be experienced and to complete a vulnerability assessment of the Town's most critical assets. The methodology and mapping produced is included in Appendix E,

[45] http://tidesandcurrents.noaa.gov/sltrends/sltrends.html
[46] http://climate.buzzardsbay.org/storm-smart.html

Summary of Work Completed Under the PDM14 Grant

1. Identify Critical Sectors: The 2012 Manchester-by-the-Sea Hazard Mitigation Plan included a listing of 35 identified critical infrastructure facilities and provides a summary of natural hazards impacting these critical facilities. With the assistance of the Planning Team, the list of critical facilities was re-examined and updated to include additional community assets following the guidelines included in the 2012 FEMA Local Mitigation Handbook. The initial effort identified 70 community assets, which were evaluated for flooding impacts under climate change for 3 planning periods, 2025, 2050 and 2100. **The selection process for the 70 community assets is further explained in Section 3.**

2. Climate Change Model Selection: A comparative evaluation of climate change modeling was presented to the Planning Team in August 2015. The climate change models selected by the Town were the Inundation Risk Model (IRM), developed for Salem Sound communities[47] that includes modules for both sea level rise and storm surge and the Oyster River Culvert Evaluation Project (ORCEP), an EPA Climate Ready Estuaries project,[48] for the extreme precipitation model. A separate watershed assessment using the US Army Corps of Engineers HEC-RAS model was developed for the Sawmill Brook Watershed to capture the inland impacts of increased precipitation on riverine flooding.

3. Model Results and Inundation Mapping Due to Climate Change: The watershed modeled future conditions output for 2025, 2050 and 2100 included the extreme precipitation values from the ORCEP, and both sea level rise and storm surge data to modify tail water conditions at the mouth of Sawmill Brook. The combined modeling resulted in 5 different outputs: sea level rise, shallow coastal flooding, storm surge, Category 1 hurricanes, and upland flooding. See **Table 2.15** for a description of the model outputs, risk and data sources.

Table 2.15
IRM Model Outputs, descriptions and data sources

Output	Description of Risk	Data Sources
Sea Level Change	Level is mean higher high water. Risk describes chance of being inundated at least once per day.	Sea Level Change NOAA curves are source for future water levels.
Shallow Coastal Flooding	Risk describes chance of area being flooded several times a year, where inundation becomes a deterrent to development.	
Storm Surge	Risk describes the chance of an area being inundated once a year from coastal storms other than hurricanes (i.e. Nor'easters).	Historic still water surge data (Boston gauge) is used to define surge height.
Hurricane/ Category 1	Risk describes chance of area being inundated if a category 1 hurricane is predicted to strike in the area. Rare occurrence.	Data from SLOSH model defines hurricane surge height for grid cells.

[47] http://www.geosciconsultants.com/projects/2015/5/27/coastal-risk-mapping-in-salem-sound
[48] https://www.epa.gov/sites/production/files/2014-04/documents/2010-cre-progress-report.pdf

4. Analysis of Impacts: The model outputs from the coastal flooding and watershed models were utilized to complete an analysis of the flooding hazards due to climate change for all 70 community assets. The spatial location of each critical sector was evaluated in relation to the 5 different model outputs: sea level rise, shallow coastal flooding, storm surge, Category 1 hurricanes, and upland flooding. The model output contained 4 probabilities of flooding for each of the 5 coastal flooding sources:

    - 1-10% = low risk, highly unlikely to unlikely occurrence
    - 33% = medium risk, as likely to occur as not
    - 66% = medium-high risk, likely to occur
    - 90-99% = high, very likely to certain to occur

Summary of Modeling Results

The model developed for Manchester focused on the Sawmill Brook watershed and included the "dynamic" aspects of coastal flooding for a variety of flooding scenarios (i.e. hurricanes, shallow coastal flooding, storm surge and sea level rise) and considered results for years 2015, 2025, 2050, and 2100. The Sawmill Brook watershed model also accounted for inland flooding due to future precipitation estimates. These estimates predict a 3% increase of the 25-year storm by 2025, and a 22% increase in the 100-year rainfall event by 2100 under a balanced energy emissions scenario.

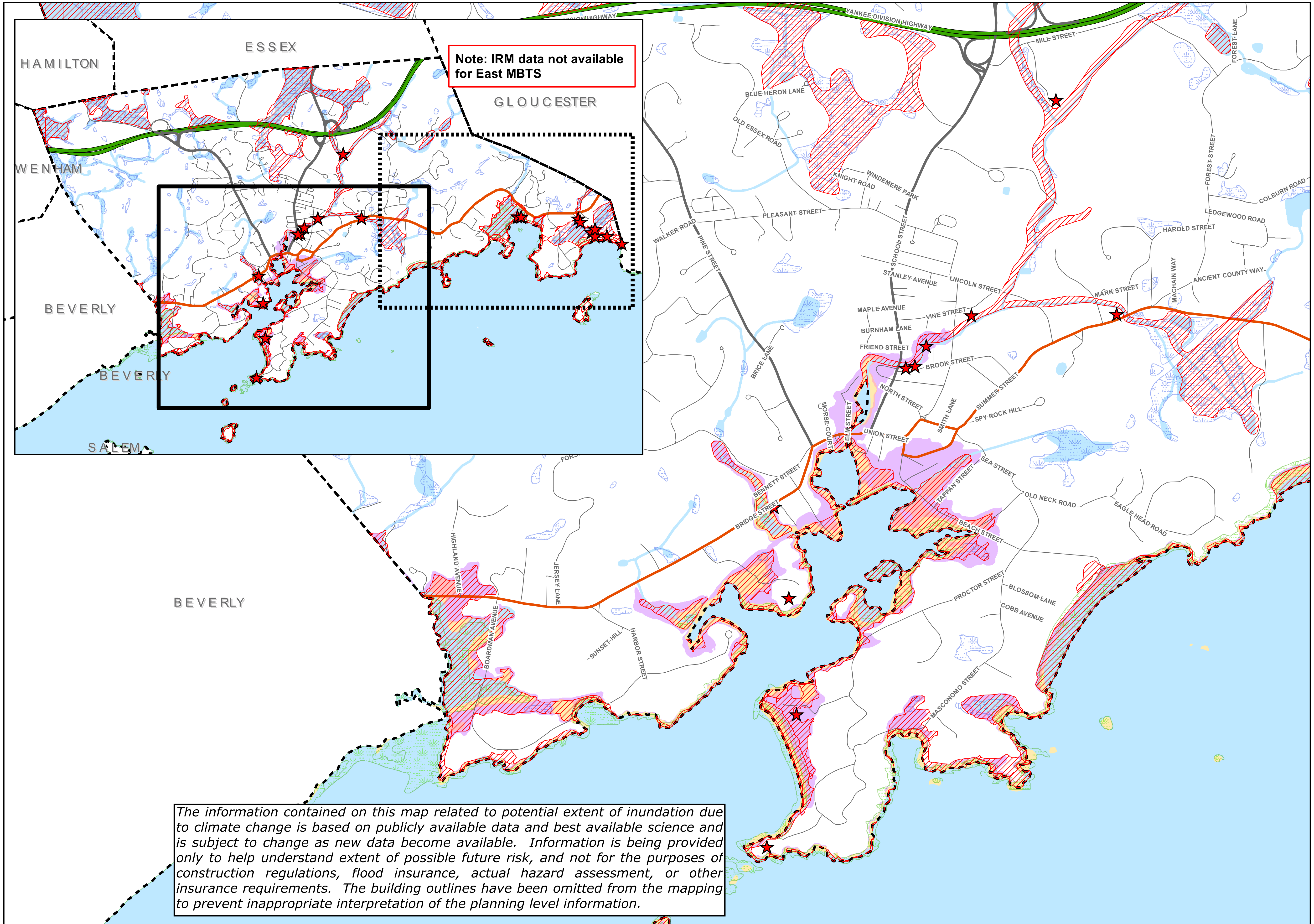
The dynamic coastal model also accounts for other important variables including probability of an area flooding (i.e. 1% is least likely to occur and 99% is most likely to occur) and 2 different emission scenarios that dictate impacts from climate change under a more hopeful scenario and under a worse-case scenario.

Inundation mapping for future years 2025, 2050 and 2100 indicates that out of the 70 sites, the flooding risks are prevalent at almost all of the facilities, either in the present or at some time in the future.

Understanding the probability of a flood occurrence is as important as understanding where it might occur. For example, 59% of all community assets are mapped within hurricane surge areas, but hurricanes are the least likely type of flooding event to occur for Manchester-by-the-Sea. On the other hand, inundation from sea level rise will impact locations multiple times a day, concurrent with the tides, yet sea level rise impacts the fewest community assets, 23% in the near term (2025) and up to 37% by 2100. Storm surge is likely to impact the Town several or more times a year due to Nor'easters; 33% of the community assets may be impacted by storm surge in the near term (2025) and over 50% may be impacted by 2100.

Maps 3A, B and C includes the coastal and inland flooding impacts due to sea level rise, storm surge and extreme precipitation for the 3 planning periods. A more complete explanation and maps are provided in Appendix E Potential Climate Change Impacts to Manchester-by-the-Sea – Technical Memo including description of model evaluations and mapping results.

MAP 3A WEST IRM SEA LEVEL RISE[2]

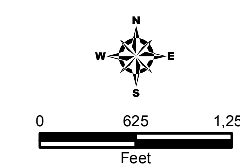


The information contained on this map related to potential extent of inundation due to climate change is based on publicly available data and best available science and is subject to change as new data become available. Information is being provided only to help understand extent of possible future risk, and not for the purposes of construction regulations, flood insurance, actual hazard assessment, or other insurance requirements. The building outlines have been omitted from the mapping to prevent inappropriate interpretation of the planning level information.

LEGEND

- Repetitive Loss Structures
- SFHA Inundated by 100-year Flood[3]
- 2025 IRM Sea Level Rise
- 2050 IRM Sea Level Rise
- 2100 IRM Sea Level Rise
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP



1:15,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. IRM: Schmidt, Keil. Inundation Risk Model, 2015, Geoscience Consultants.
3. FEMA Flood Zones with revisions are based on FIRM panels for Manchester-by-the-Sea, effective date July 16, 2014 and approved Letter of Map Revisions for Manchester Bay via Manchester Harbor and Blacks Cove, effective date January 2, 2017. Special Flood Hazard Areas (SFHA) Inundated by 100-Year Flood Sources includes Zones A, AE, AH, AO, V and VE.

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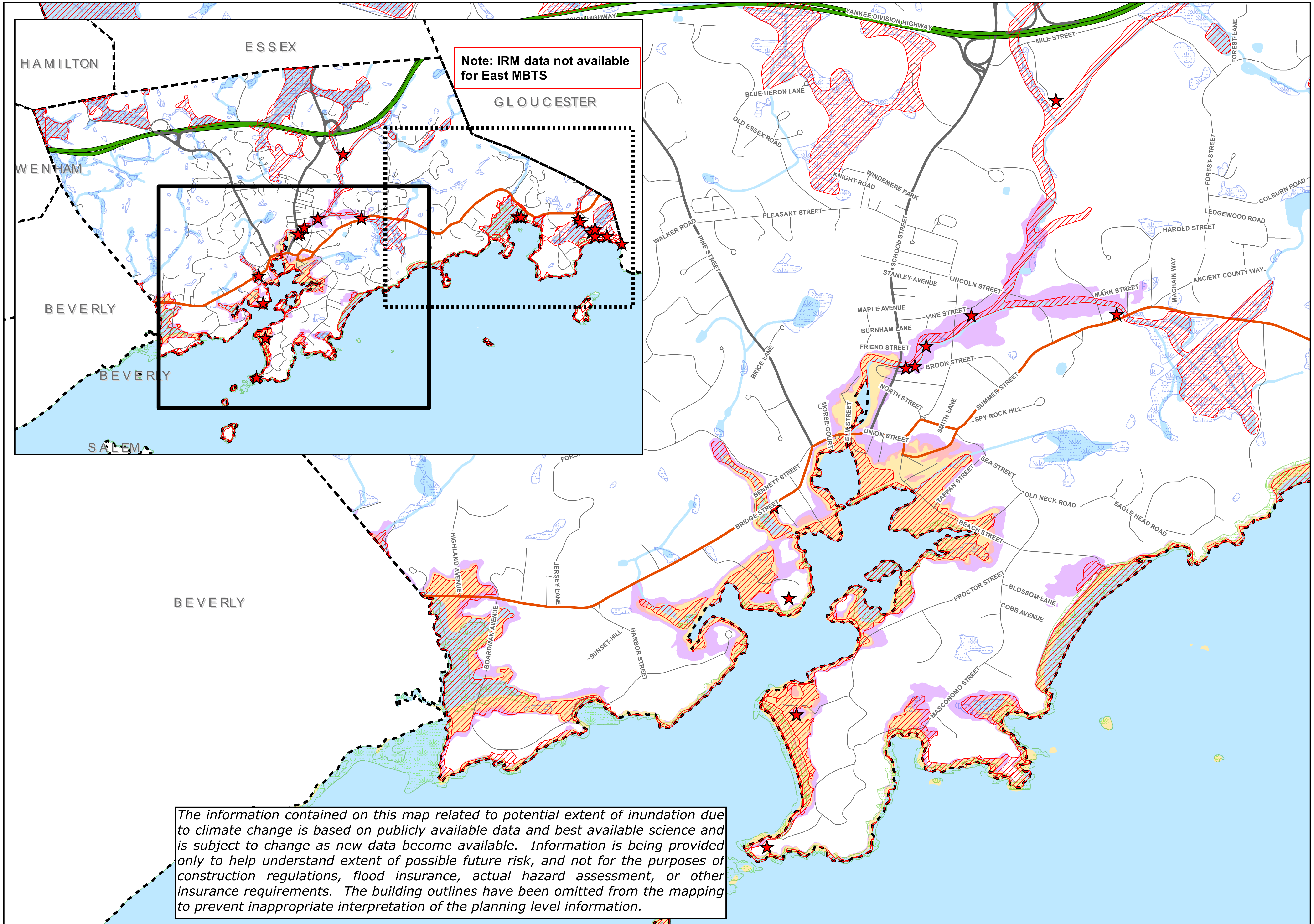
MAP 3B WEST IRM STORM SURGE FLOODING [2]

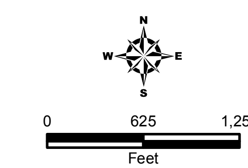


The information contained on this map related to potential extent of inundation due to climate change is based on publicly available data and best available science and is subject to change as new data become available. Information is being provided only to help understand extent of possible future risk, and not for the purposes of construction regulations, flood insurance, actual hazard assessment, or other insurance requirements. The building outlines have been omitted from the mapping to prevent inappropriate interpretation of the planning level information.

LEGEND

- Repetitive Loss Structures
- SFHA Inundated by 100-year Flood [3]
- 2025 IRM Storm Surge
- 2050 IRM Storm Surge
- 2100 IRM Storm Surge
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP



1:15,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. IRM: Schmidt, Keil. Inundation Risk Model, 2015, Geoscience Consultants.
3. FEMA Flood Zones with revisions are based on FIRM panels for Manchester-by-the-Sea, effective date July 16, 2014 and approved Letter of Map Revisions for Manchester Bay via Manchester Harbor and Blacks Cove, effective date January 2, 2017. Special Flood Hazard Areas (SFHA) Inundated by 100-Year Flood Sources includes Zones A, AE, AH, AO, V and VE.

Hazard Mitigation Plan

Manchester-by-the-Sea, Massachusetts

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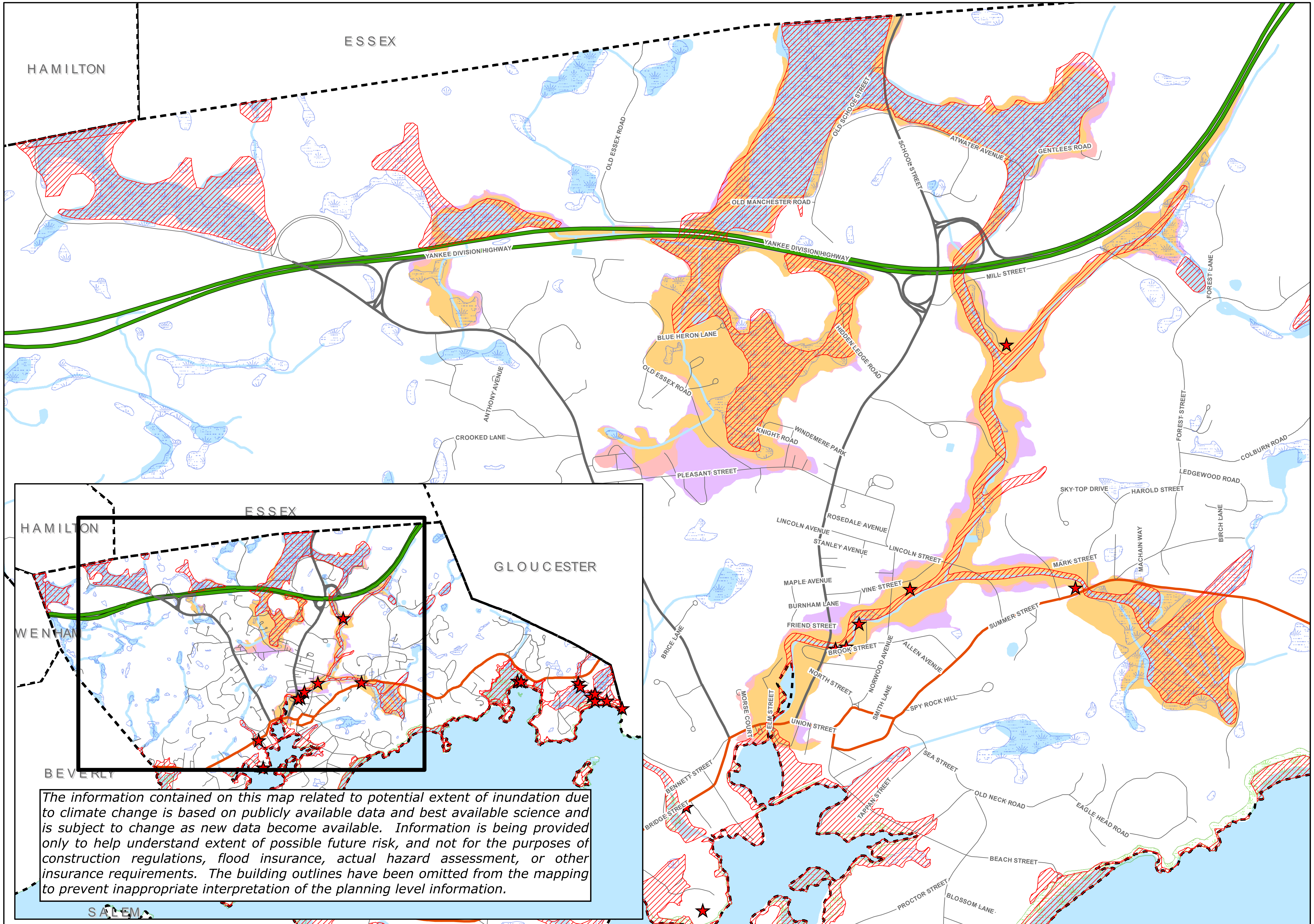
MAP 3C
EXTREME PRECIPITATION BASED ON STORM SURGE & FOSSIL INTENSIVE ENERGY USE [2]



The information contained on this map related to potential extent of inundation due to climate change is based on publicly available data and best available science and is subject to change as new data become available. Information is being provided only to help understand extent of possible future risk, and not for the purposes of construction regulations, flood insurance, actual hazard assessment, or other insurance requirements. The building outlines have been omitted from the mapping to prevent inappropriate interpretation of the planning level information.

LEGEND

- Repetitive Loss Structures
- SFHA Inundated by 100-year Flood [3]
- 2025 Inland Flooding
- 2050 Inland Flooding
- 2100 Inland Flooding
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP

N
W E
S

0 625 1,250
Feet

1:13,200

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. Sawmill Brook and Green Infrastructure Analysis Task 4 Final Report Evaluation of Locations for Flood Mitigation, Feb. 2016.
3. FEMA Flood Zones with revisions are based on FIRM panels for Manchester-by-the-Sea, effective date July 16, 2014 and approved Letter of Map Revisions for Manchester Bay via Manchester Harbor and Blacks Cove, effective date January 2, 2017. Special Flood Hazard Areas (SFHA) Inundated by 100-Year Flood Sources includes Zones A, AE, AH, AO, V and VE.

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Table 2.16 below summarizes the projected change in flooding impact over 75 years.

Table 2.16
Flooding Sources Near to Long Term Impacts on Community Assets 2025-2100

Flooding Source Mapped by IRM	Near Term Impacts - 2025	Long Term Impacts - 2100
Hurricanes (Category 1 or greater)	59% of community assets impacted (41 out of 70). Hurricane Storm Surge impacts modeled by the IRM impact more coastal and inland sites, compared to the current 2012 HMP risk analysis based on SLOSH maps.	No long term impacts can be modeled, IRM data is only for current hurricane.
Inland Flooding (with sea level rise and fossil intensive energy use)	Impacts 40% (28 out of 70) of the locations.	Increases to 43% (30 out of 70).
Coastal Storm Surge	Impacts 33% of community assets (23 out of 70).	Increases to 54% (38 out of 70).
Shallow Coastal Flooding	Impacts 31% of community assets (22 out of 70).	Increases to 47% (33 out of 70).
Inundation from Sea Level Rise	Impacts 23% (16 of 70) of the community assets.	Increases to 37% (25 out of 70).

To provide an additional graphic visualization of the modeling results, **Figure 2.17** is included as a snapshot of flooding in Manchester from 2015 to 2100, using data for storm surge, under a “more hopeful” emissions scenario, using a 50% probability of flooding occurrence (i.e. the area included is just as likely to flood as it is not). This figure also shows the approximate location of 15-foot topographic elevation contour, which was the outermost extent of the area impacted by sea level rise defined by the Town’s first modeling exercise or “bath-tub model.” Assuming sea level rises by 4 feet by 2100, the base 100-year floodplain elevation of 11 feet above mean sea level will expand to this approximate extent in most of the downtown area, which is also consistent with the IRM modeling. Inland, the flooding areas extend further inland than the expanded flood plain elevation.

Based on the modeling results, the Planning Team determined that it was **LIKELY** that flooding due to climate change would impact Manchester-by-the-Sea near-term and **HIGHLY LIKELY** that flooding due to climate change would impact Manchester-by-the-Sea in the long-term. To best capture planning for projects over the next 5-year period, the near-term risk assessment was used in the hazard rating index in **Table 2.1**.

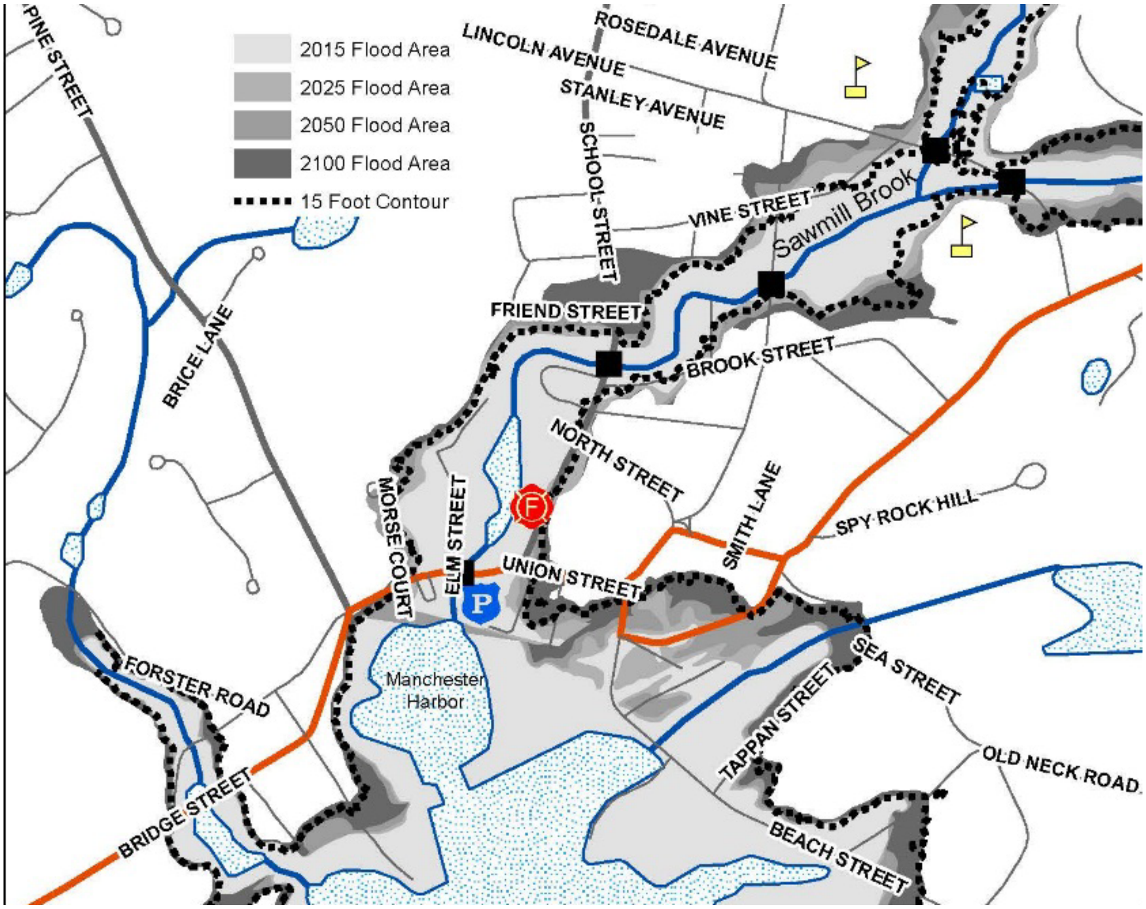


Figure 2.17
Flood Areas with Modeled Future Storm Surge

SECTION 3

ASSET INVENTORY

In this Plan, community assets are locations and resources that are considered to be vital to the function and character of Manchester-by-the-Sea. A description of town-wide community assets characterizes the community, while an inventory of site specific community assets sets the stage for determining which assets are vulnerable to the impacts of natural hazards. Section 3 provides a detailed inventory of site specific community assets related to the built environment, vulnerable populations, cultural resources, natural resources and economic centers.

Section 3
ASSET INVENTORY

Section 3 provides an inventory of the community assets that are important to the Town of Manchester-by-the-Sea. The Section is broken up into 2 parts: town-wide community assets and site-specific community assets. Identifying the community assets allows the Town to investigate how they will be impacted by the different natural hazards.

3.1 Town-Wide Community Assets

Population and Housing Characteristics

Manchester's population is stable, aging, and affluent. According to the US Census Bureau, Manchester's population declined 1.76% between 2000 and 2010 to 5,136 residents and has been essentially stable since 1970 when it reported 5,151 residents. According to the 2014 Town Census, the total population was 5,808 people. The 2010 US Census reported 2,394 housing units and real estate values among the highest in the state. A highly ranked school system, low crime, scenic shoreline and yachting harbor, substantial protected open space, and relatively low population density are some of the attributes that support Manchester's property valuations.[49]

Land Use Trends

Table 3.1 shows the acreage and percentage of total land in Manchester-by-the-Sea as based on 1999 Mass GIS data, and revised in 2013. Due to the differences in how the land use coverages were interpreted by MassGIS from 1999 to 2013, a direct comparison between the 2 data sets may be misleading.

Table 3.1
Land Use

Land Use Type	1999[50]		2013[51]	
	Acres	%	Acres	%
Cropland	5	<1	5	<1
Pasture	20	<1	20	<1
Forest	2,719	54	3,039	61
Non-forested wetlands	57	1	104	2
Mining	15	<1	13	<1
Open land	100	2	128	3
Participatory recreation	128	3	155	3
Spectator recreation	0	0	0	0

[49] Manchester-by-the-Sea Open space and Recreation Plan, August 21, 2014
[50] Source: 2012 Hazard Mitigation Plan
[51] MassGIS Land Use Data

Table 3.1
Land Use

Land Use Type	1999[50]		2013[51]	
	Acres	%	Acres	%
Water recreation	56	1	12	<1
Multi-family residential	8	<1	76	2
High density residential (< ¼ acre lots)	189	4	125	3
Medium density residential (¼ - ½ acre lots)	215	4	100	2
Low density residential (> ½ acre lot)	1,170	23	881	18
Salt water wetlands	45	1	57	1
Commercial	35	1	19	<1
Industrial	26	1	9	<1
Urban open	46	1	57	1
Transportation	125	3	116	2
Waste disposal	1	<1	14	<1
Water	31	1	35	1
Woody perennials	3	<1	17	<1

Potential Future Land Uses

Development trends in Manchester-by-the-Sea are tracked by the Metropolitan Area Planning Council's (MAPC's) Development Database, which provides an inventory of new development over the last decade. The database tracks both completed developments and those currently under construction. The database includes 6 new developments in Manchester since 2010, 2 of which are completed, 1 was under construction as of November 2016, and 3 are planned projects. The projects are summarized in **Table 3.2** below.

Table 3.2
Manchester-by-the-Sea's Recent and Planned Developments

Project Name	Description	Year Completed
Cape Ann Self Storage Iron Rail Gymnastics	<2,000 SF commercial on 7.8 acres	Planned completion date unknown
Knight Circle	Residential unit on 0.3 acres	Planned completion date unknown
Crooked Lane	3 residential units on 14 acres	2018
Elm Street Village	12 units in 6 duplexes on 1.6 acres	2016
601 Summer Street	12 lots with 32 bedrooms on 13.27 acres	2016
Historic Railroad Station	7,000 SF mixed commercial	Completed in 2014

Economy

Manchester's local economy is fueled by 219 businesses, many with one to a few employees, but overall employing nearly 1,700 people, and providing an estimated average annual income of less than $50,000. The majority of Manchester residents are employed in high-skill, high wage professions resulting in a per capita income that nearly doubles the average of the state and county. The majority of residents are employed in and around the North Shore and Boston with nearly 1 in 5 working from home, 60 percent driving alone, and 12 percent taking public transportation.

Natural Resources

Manchester shares large expanses of woodlands and wildlife habitats with neighboring communities. The Chubb Creek and Bennetts Brook watersheds and the Round Pond-Gravelly Pond watershed include extensive wooded areas of Beverly and Wenham as well as western Manchester. The Sawmill Brook watershed includes the major part of the woodlands north of Route 128, including a good part of the Essex woods. The Kettle Cove watershed combines a mix of forested areas adjoining Gloucester reservoirs and Manchester woodlands with 2 large industrial parks – the Gloucester Industrial Park, which drains to Wolf Trap Brook and the Kettle Cove Industrial Park, which drains through Coolidge Point. Both streams ultimately empty into Kettle Cove at Black Beach.

Manchester-by-the-Sea is part of the North Coastal Watershed with an irregular coastline of rocky peninsulas, interspersed with embayments, pockets of salt marsh, and vibrant estuaries. Manchester Harbor forms the Town's geographic center. Two major streams, Sawmill Brook and Bennetts Brook flow into the Harbor. Other coastal features include 3 large public beaches (Singing, White, and Black Beach) and numerous smaller private beaches.

Because Manchester has few ponds and only one source of high-quality groundwater, in 1907 the Town turned to the General Court of the Commonwealth for permission to acquire a new water supply source in the neighboring Town of Hamilton. Both Gravelly Pond and Round Pond were taken, together with "all the waters which flow into and from the same, in the Towns of Manchester and Hamilton, including all the waters in all the streams, brooks, rivers or water courses, or any kind, whether natural or artificial, and all spring and subterranean sources and the watersheds within about seven thousand feet of the shores of either of said ponds." Additional land in the watershed was taken in 1949. In all, Manchester owns 250 acres in Hamilton including Gravelly and Round Ponds.[46]

3.2 Site-Specific Community Assets

In addition to the town-wide community assets discussed above, a list of 70 site-specific community assets were identified as being important to the character and function of Manchester-by-the-Sea. Critical infrastructure was included in the list of 70 community assets. Critical infrastructure includes facilities that are important for disaster response and evacuation (such as emergency operations centers, fire stations, hospitals, etc.) and facilities where additional assistance might be needed during an emergency (such as nursing homes, elderly housing, day care centers, etc.). It also includes facilities that might pose a particular danger during a natural disaster such as a sewage treatment plant or chemical facility.

FEMA defines a community asset as anything that is important to the character and function of a community. Community assets can be split up into 4 different categories: People, Economy, Built Environment, and Natural Environment. The People category includes populations that are more vulnerable to disaster (e.g., elderly, children, visiting populations) as well as densely populated areas.

Economy is included because economic drivers are a major part of disaster recovery. Community assets in the Economy category can include major employers, commercial centers, and primary economic sectors. The Built Environment is the largest category and includes existing structures, infrastructure, critical facilities (e.g., police and fire stations), cultural assets, and areas of future development. The Natural Environment category is meant to capture any natural resources important to the community's character, economy (tourism, recreation, and the protection of clean air and water), and ecosystem services (e.g., wetlands providing flood storage, coastal areas providing erosion control as a first line of defense from coastal storms).

Table 3.3 below summarizes the community asset categories included in FEMA guidelines, relevant critical sectors within each category, and the general characteristics that describe why these assets are important to include in a hazard mitigation plan. The complete list of identified facilities and sites for Manchester-by-the-Sea are listed by category in **Tables 3.4 through 3.7.**

Table 3.3

Community Asset Categories and Characteristics

FEMA Community Asset Categories	Critical Sectors	Characteristics of Community Assets
People	Schools, Vulnerable Populations, Cultural Facilities	Areas of greater population density, or population with unique vulnerabilities or less able to respond and recover during a disaster.
Built Environment	Critical Municipal Facilities, Water, Wastewater, Energy, Stormwater, Transportation, Cultural Resources	Critical facilities necessary for a community's response to and recovery from emergencies, infrastructure critical for public health and safety, economic viability, or for critical facilities to operate.
Economy	Marinas, Downtown Business District	Major employers, primary economic sectors and commercial centers where loss or inoperability would have severe impact on the community and ability to recover from a disaster.
Natural Environment	Natural Resources	Areas that provide protective function to reduce magnitude of hazard impact and increase resiliency. Areas of sensitive habitat that are vulnerable to hazard events, protection of areas that are important to community objectives, such as the protection of sensitive habitat, provide socio-economic benefits, etc.

Table 3.4
Community Assets in the People Category

Name	Address
Brookwood Elementary School	1 Brookwood Road
Manchester Memorial Elementary School	71 Lincoln Street
Manchester Essex Regional Middle High School	36 Lincoln Street
Landmark School	167 Bridge Street
Magic Years Nursery School	3 Chapel Lane
Hornet's After School Program	71 Lincoln Street
Tara Montessori School	60 School Street
The Plains Seniors Housing	The Plains Road
Newport Park Seniors Housing	Newport Park Road
Summer Street Apartments	12 Summer Street
Manchester Community Center	Beach Street
Manchester Public Library	15 Union Street
First Baptist Church	20 School Street
Sacred Heart Parish	58 School Street
Congregational Chapel	Chapel Lane
Masconomo Park	60 Beach St
Sweeney Park	113 Summer St
Manchester Historical Society	10 Union Street
Coach Field Playground	Norwood & Brook
Surf Park	Raymond Street
First Parish Church	Town Common
Manchester Masonic Building	26 Central street
Essex County Club	153 School Street

Table 3.5
Community Assets in the Built Environment Category

Name	Address
Manchester Fire Department	12 School Street
Manchester Police Headquarters	10 Central Street
Manchester-by-the-Sea Town Hall	10 Central Street
Manchester Wastewater Treatment	12 Church Street
DPW Garage	85 Pleasant Street
Emergency Operation Center Town Hall	10 Central Street
Manchester Wastewater Treatment Plant Parcel #2	12 Church Street
Lincoln Street Well & Pumping Station	40 Lincoln Street
Manchester Water Tower (tank)	139 Pine Street
Verizon- Switching Station	52 Summer Street, Unit R
National Grid	21 Summer Street
Vulnerable UST's	Downtown
Downtown Stormwater Drainage System	Central Street
School Street Bridge	School Street
Central Street Dam	Central Street
Small Brook Dam	22 Forster Road
Forster Road Dam	Forster Road
Sawmill Brook Dam	30 Mill Street
Gorman Pond Dam	4 Old Wenham Way
MBTA Tracks/Bridge	South Manchester
Route 127	South Manchester
School Street	N/S Route
Pine Street	N/S Route
Lincoln Street	N/S Route

Table 3.7
Community Assets in the Economy Category

Name	Address
MBTA Station	Beach Street
Manchester Marine	17 Ashland Ave
Crocker's Boat Yard	15 Ashland Ave
Downtown Businesses	Varies

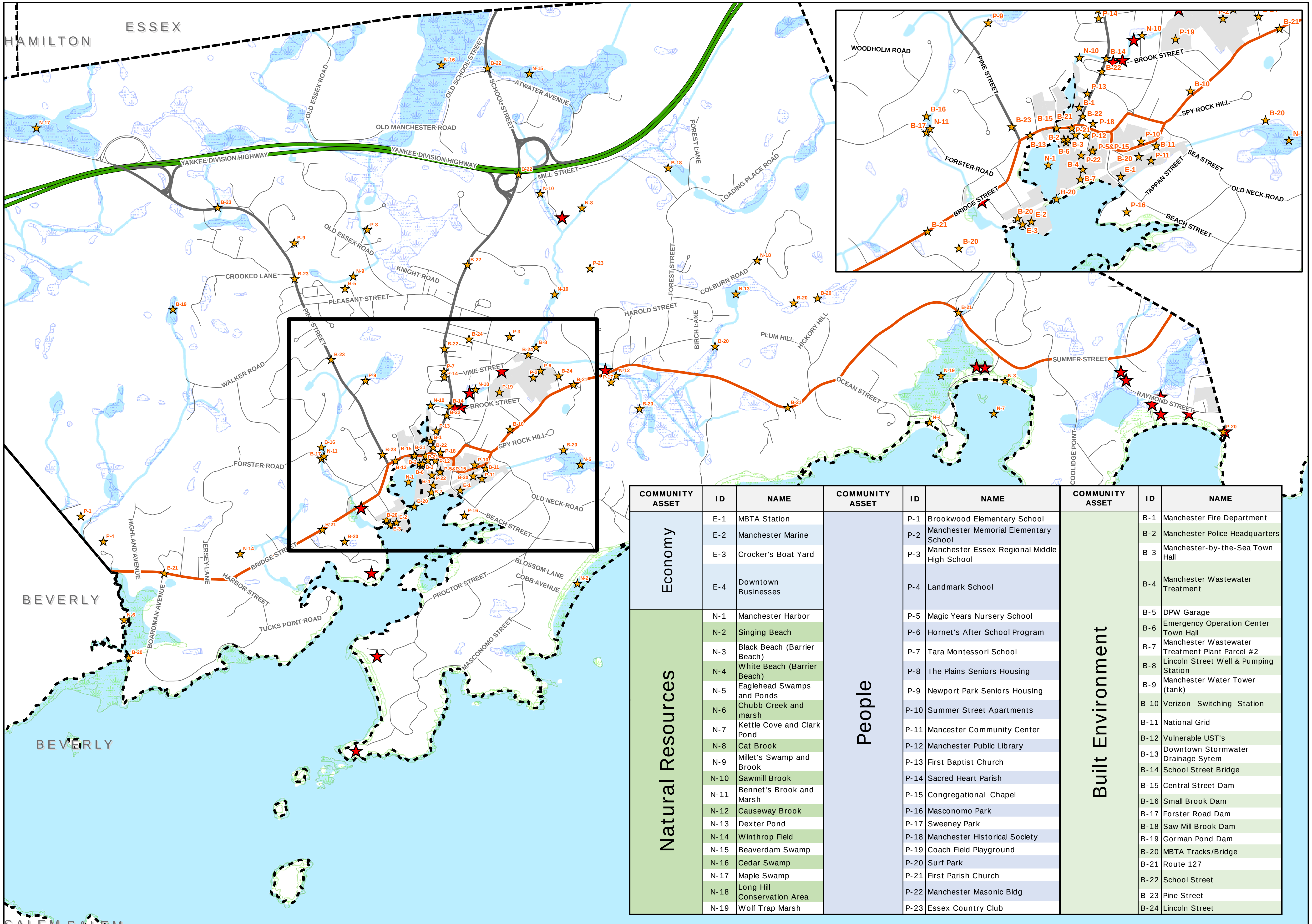
Table 3.6
Community Assets in the Natural Environment Category

Name
Manchester Harbor
Singing Beach
Black Beach (Barrier Beach)
White Beach (Barrier Beach)
Eaglehead Swamp and Ponds
Chubb Creek and marsh
Kettle Cove and Clark Pond
Cat Brook
Millet's Swamp and Brook
Sawmill Brook
Bennetts Brook and Marsh
Causeway Brook
Dexter Pond
Winthrop Field
Beaverdam Swamp
Cedar Swamp
Maple Swamp
Long Hill Conservation Area
Wolf Trap Marsh

Map 4 shows the location of all selected community assets.

Section 4 Vulnerability Risk Assessment provides a discussion on **natural hazards that may impact** the community assets and their vulnerability. See Appendix F Risk and Vulnerability Assessment for more discussion on the selection process of the 70 community assets

MAP 4 LOCATION OF COMMUNITY ASSETS



COMMUNITY ASSET	ID	NAME
Economy	E-1	MBTA Station
	E-2	Manchester Marine
	E-3	Crocker's Boat Yard
	E-4	Downtown Businesses
Natural Resources	N-1	Manchester Harbor
	N-2	Singing Beach
	N-3	Black Beach (Barrier Beach)
	N-4	White Beach (Barrier Beach)
	N-5	Eaglehead Swamps and Ponds
	N-6	Chubb Creek and marsh
	N-7	Kettle Cove and Clark Pond
	N-8	Cat Brook
	N-9	Millet's Swamp and Brook
	N-10	Sawmill Brook
	N-11	Bennet's Brook and Marsh
	N-12	Causeway Brook
	N-13	Dexter Pond
	N-14	Winthrop Field
	N-15	Beaverdam Swamp
	N-16	Cedar Swamp
	N-17	Maple Swamp
	N-18	Long Hill Conservation Area
	N-19	Wolf Trap Marsh
People	P-1	Brookwood Elementary School
	P-2	Manchester Memorial Elementary School
	P-3	Manchester Essex Regional Middle High School
	P-4	Landmark School
	P-5	Magic Years Nursery School
	P-6	Hornet's After School Program
	P-7	Tara Montessori School
	P-8	The Plains Seniors Housing
	P-9	Newport Park Seniors Housing
	P-10	Summer Street Apartments
	P-11	Mancester Community Center
	P-12	Manchester Public Library
	P-13	First Baptist Church
	P-14	Sacred Heart Parish
	P-15	Congregational Chapel
	P-16	Masconomo Park
	P-17	Sweeney Park
	P-18	Manchester Historical Society
	P-19	Coach Field Playground
	P-20	Surf Park
	P-21	First Parish Church
	P-22	Manchester Masonic Bldg
	P-23	Essex Country Club
Built Environment	B-1	Manchester Fire Department
	B-2	Manchester Police Headquarters
	B-3	Manchester-by-the-Sea Town Hall
	B-4	Manchester Wastewater Treatment
	B-5	DPW Garage
	B-6	Emergency Operation Center Town Hall
	B-7	Manchester Wastewater Treatment Plant Parcel #2
	B-8	Lincoln Street Well & Pumping Station
	B-9	Manchester Water Tower (tank)
	B-10	Verizon- Switching Station
	B-11	National Grid
	B-12	Vulnerable UST's
	B-13	Downtown Stormwater Drainage Sytem
	B-14	School Street Bridge
	B-15	Central Street Dam
	B-16	Small Brook Dam
	B-17	Forster Road Dam
	B-18	Saw Mill Brook Dam
	B-19	Gorman Pond Dam
	B-20	MBTA Tracks/Bridge
	B-21	Route 127
	B-22	School Street
	B-23	Pine Street
	B-24	Lincoln Street

LEGEND

- Repetitive Loss Structures
- Community Assets
- Downtown Businesses (E-4)
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP

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Feet

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DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.

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SECTION 4

VULNERABILITY ASSESSMENT

A vulnerability assessment is a methodology to estimate the extent or magnitude of potential damages from natural hazards of varying types and intensities. For the Manchester-Hazard Mitigation Plan, a variety of methodologies were used to evaluate hazards. Section 4 ties together the hazard profiles and asset inventories in order to estimate the potential losses that Manchester-by-the-Sea could experience from a natural hazard event. The results highlight the most significant risk and overall vulnerabilities of the community, which are subsequently used to develop the mitigation strategy.

Section 4
VULNERABILITY ASSESSMENT

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The purpose of the vulnerability assessment is to estimate the extent or magnitude of potential damages from natural hazards of varying types and intensities. Section 4 ties together the hazards identified in Section 2 and the community assets identified in Section 3 to estimate the potential losses that Manchester-by-the-Sea could experience during a natural hazard event. There are 3 assessments included in Section 4 of the 2017 Manchester-by-the-Sea Hazard Mitigation Plan:

- **HAZUS-MH Assessment**: this vulnerability assessment includes estimation of damages for hurricanes and earthquakes using HAZUS-MH software and is described in Section 4.1.

- **Exposure Assessment of Parcels and Building Flood Risk**: this assessment was completed using GIS analysis for flooding, and flooding due to climate change for the entire town, based on geographical areas, referred to as "hazard areas," assessor's data, the most recent FIRMs and results of the 2014 Flood Zone Expansion analysis. This assessment is described in Section 4.2.

- **Vulnerability and Risk Assessment (VRA) of Community Assets:** this assessment was completed to determine whether critical facilities and other identified community assets could be exposed to flooding, surge, sea level rise and coastal erosion based on modeling data from the PDM14 Hazard Mitigation Enhancement. The assessment looks at existing and future flood conditions due to climate change from sea level rise, storm surge and extreme precipitation for 3 planning periods: 2025, 2050, and 2100. This assessment is described in **Section 4.3**.

4.1 HAZUS-MH for Hurricanes and Earthquakes

4.1.1 Methodology

HAZUS-MH (multiple-hazards) is a computer program developed by FEMA to estimate losses due to a variety of natural hazards. For the purposes of this Plan, HAZUS-MH was used to estimate losses due to hurricane winds and earthquakes.

The following overview of HAZUS-MH is taken from the FEMA website:[52]

> "Hazus is a nationally applicable standardized methodology that estimates potential losses from earthquakes, hurricane winds and floods. FEMA developed Hazus under contract with the National Institute of Building Sciences (NIBS).
>
> Hazus uses state-of-the-art 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 earthquakes, hurricane winds, and floods on populations.

[52] For more information on the HAZUS-MH software, go to https://www.fema.gov/hazus.

> Estimating losses is essential to decision-making at all levels of government, providing a basis for developing mitigation plans and policies, emergency preparedness and response, and recovery planning."

There are 3 modules included with the HAZUS-MH software: hurricane wind, flooding, and earthquakes. There are also 3 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 in this Plan 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 community, 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 only 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. Therefore, this analysis should be considered to be a starting point for understanding potential damages from the hazards.

4.1.2 Results - Hurricanes

For the purposes of this Plan, a Category 2 and a Category 4 storm were chosen to illustrate damages. The reason is to present more of a "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 4.1** below presents estimated damages from hurricanes.

Table 4.1

Estimated Damages from Hurricanes

Categories of Damage	Category 2 (Historic Hurricane Floyd)	Category 4 (Historic Hurricane Donna)*
Building Characteristics		
Estimated total number of buildings	2,168	2,168
Estimated total building replacement value (thousands of dollars)	$856,233	$856,233
Building Damages		
# of buildings sustaining minor damage	1	239
# of buildings sustaining moderate damage	0	32
# of buildings sustaining severe damage	0	2
# of buildings destroyed	0	1
Population Needs		
# of households displaced	0	1
# of people seeking public shelter	0	0

Table 4.1

Estimated Damages from Hurricanes

Categories of Damage	Category 2 (Historic Hurricane Floyd)	Category 4 (Historic Hurricane Donna)*
Debris		
Building debris generated (tons)	0	871
Tree debris generated (tons)	94	4,793
Value of Damages (Thousands of dollars)		
Total property damage (building damage)	$52	$10,262
Total losses due to business interruption (content damage and income losses)	$66	$4,951

*No Category 4 or 5 hurricanes have been recorded in New England. However, a Category 4 hurricane was included to help the communities understand the impacts of a hurricane beyond what has historically occurred in New England.

4.1.3 Results - Earthquakes

The HAZUS earthquake module allows users to define a number of different types of earthquakes and to input a number of different parameters. The module is more useful where there is a great deal of data available on earthquakes. In New England, defining the parameters of a potential earthquake is much more difficult because there is little historical data. The earthquake module does offer the user the opportunity to select a number of historical earthquakes that occurred in Massachusetts. For the purposes of this Plan, 2 earthquakes were selected: an earthquake with a 5.1 magnitude and 10 fault depth and a 5.8 with 10 fault depth. **Table 4.2** below presents estimated damages from earthquakes.

Table 4.2

Estimated Damages from Earthquakes

Categories of Damage	Magnitude 5.1 (Historic Earthquake)	Magnitude 5.8 (Historic Earthquake)
Building Characteristics		
Estimated total number of buildings	2,168	2,168
Estimated total building replacement value (Millions of dollars)	$856,233	$856,233
Building Damages		
# of buildings sustaining slight damage	120	140
# of buildings sustaining moderate damage	29	36
# of buildings sustaining extensive damage	4	5
# of buildings completely damaged	0	0
Population Needs		
# of households displaced	4	4
# of people seeking public shelter	2	2
Debris		
Building debris generated (tons)	1	1

Value of Damages (Millions of dollars)		
Total property damage (building damage)	$3,470	$4,014
Total losses due to business interruption (content damage and income losses)	$2,258	$2,684

4.2 Exposure Assessment of Parcel and Building Flood Risk

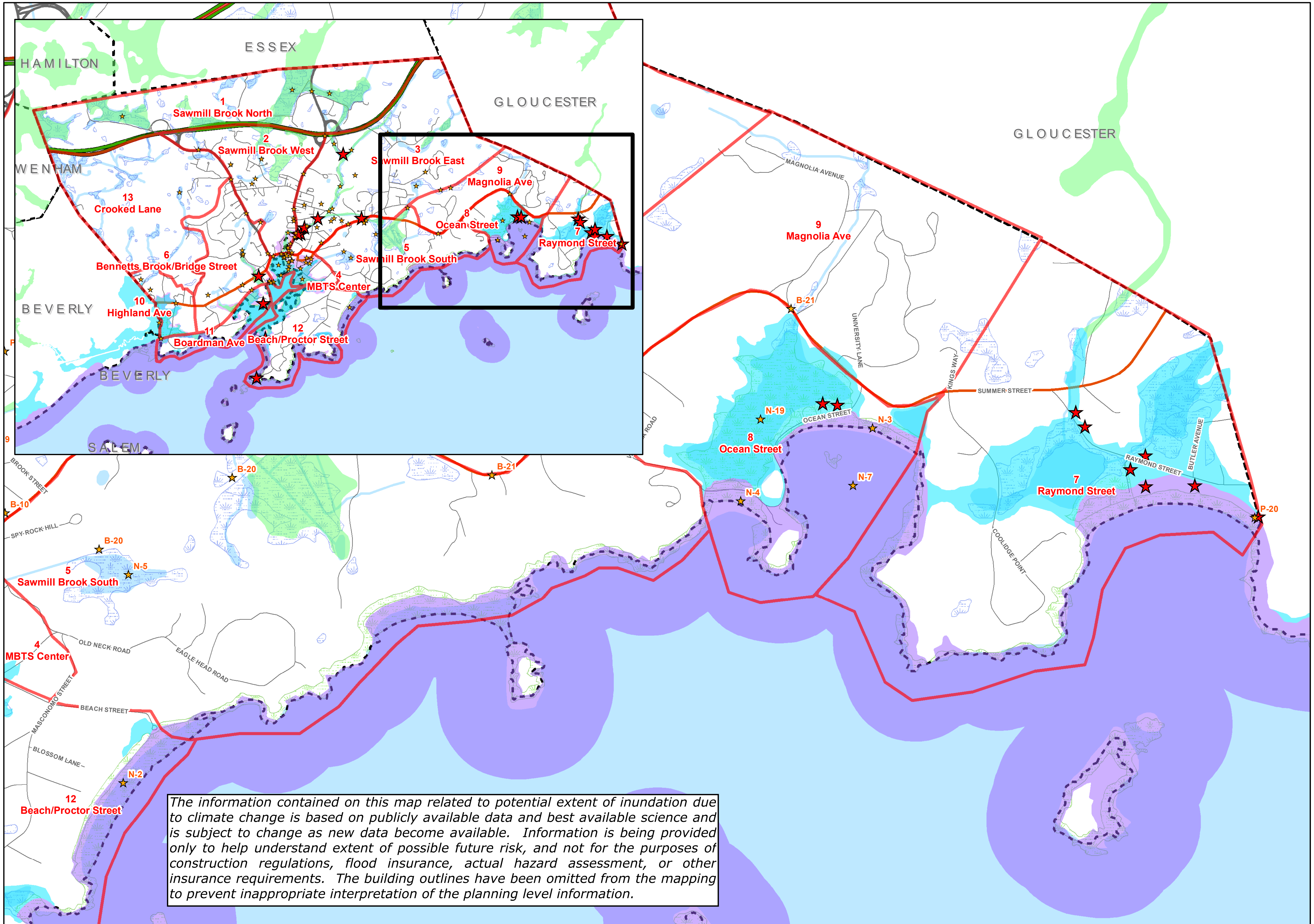
4.2.1 Methodology

An exposure assessment was used to estimate losses due to flooding. An exposure assessment is a geospatial evaluation where geographic areas and hazards are mapped together to show the physical relationship to one another. The geospatial relationship can also be used to quantify the number and value of parcels and structures within the hazard area to estimate losses. For flooding, a GIS-based exposure analysis was used to identify potential losses within FEMA flood zones A, AE, and VE as well as due to sea level rise. Data sources included results of a flood zone expansion model completed by the Town in 2014, 2015 Assessor's data, and FIRMs updated in 2016.

In order to compare the results of the exposure assessment for different areas of town, Manchester was split up into 13 different hazard areas (see **Figure 3.1**). The hazard areas were determined by first noting the areas of flooding highlighted in the 2012 Plan, adding additional areas of flooding identified by the Town (**Table 2.4**), and locations of FEMA repetitive loss claims. The 13 hazard area boundaries were then defined using roadways or parcel lines to capture flood sources, but were expanded to make sure that the entire town was captured. It is important to note that the boundaries are not strictly hydrologic or watershed based, but allow the Town to compare the areas of Manchester affected by flooding from geographically similar sources.

The Town's assessing data from 2015 was merged with 2 different inundation maps showing areas of exiting flooding based on FEMA flood zones (**Maps 2 East and West**) and future flooding with climate change due to sea level rise (**Maps 6 East and West**). The existing inundation analysis is presented in this section, and the future flooding with climate change is presented in **Section 4.3**.

The inundation map for areas of existing flooding was a composite of the 2015 published FIRMS, with most recent FEMA approved revisions from 2016 added. Assessor's data (2015) for land use, parcel size, building and parcel value were extracted for corresponding flood Zones A, AE and VE. The data was then sorted for the 13 hazard areas (see **Maps 5 East and West**). Only developed parcels were included in the flooding analysis. It was assumed that unimproved parcels did not have the same risk of flooding as a developed parcel. Finally, parcel data was aggregated for each of the 13 hazard areas, based on land use for the following categories: Developed Residential (including multi-family or mixed use where residential was the predominant use), Developed Commercial/ Industrial (including mixed use where commercial use was predominant), and Municipal/Government/Non-Profit. The data presented in **Tables 4.3 through 4.5** were handled in the following way:



MAP 5 EAST GEOGRAPHIC BASED HAZARD AREAS

LEGEND

- Community Assets
- Repetitive Loss Structures
- Hazard Areas

SFHA Inundated by 100-year Flood[2]

Flood Zone Designations

- A: 1% Annual Chance of Flooding, no BFE
- AE: 1% Annual Chance of Flooding, with BFE
- VE: High Risk Coastal Area
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP

N E S W

0 600 1,200
Feet

1:12,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. FEMA Flood Zones with revisions are based on FIRM panels for Manchester-by-the-Sea, effective date July 16, 2014 and approved Letter of Map Revisions for Manchester Bay via Manchester Harbor and Blacks Cove, effective date January 2, 2017. Special Flood Hazard Areas (SFHA) Inundated by 100-Year Flood Sources includes Zones A, AE, AH, AO, V and VE.

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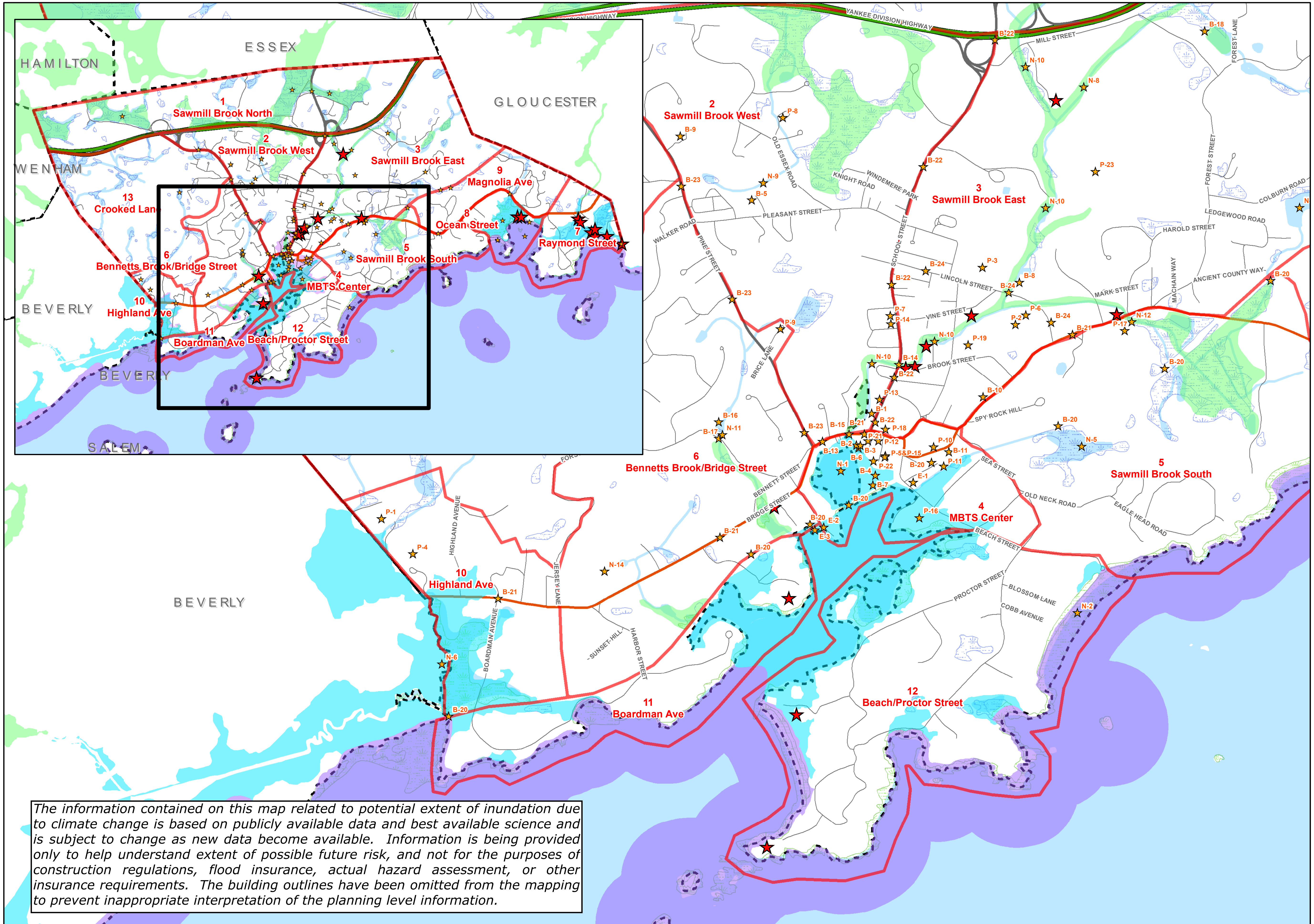
MAP 5 WEST GEOGRAPHIC BASED HAZARD AREAS



The information contained on this map related to potential extent of inundation due to climate change is based on publicly available data and best available science and is subject to change as new data become available. Information is being provided only to help understand extent of possible future risk, and not for the purposes of construction regulations, flood insurance, actual hazard assessment, or other insurance requirements. The building outlines have been omitted from the mapping to prevent inappropriate interpretation of the planning level information.

LEGEND

- Community Assets
- Repetitive Loss Structures
- Hazard Areas

SFHA Inundated by 100-year Flood[2]

Flood Zone Designations

- A: 1% Annual Chance of Flooding, no BFE
- AE: 1% Annual Chance of Flooding, with BFE
- VE: High Risk Coastal Area
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies

LOCUS MAP

0 625 1,250
Feet

1:15,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. FEMA Flood Zones with revisions are based on FIRM panels for Manchester-by-the-Sea, effective date July 16, 2014 and approved Letter of Map Revisions for Manchester Bay via Manchester Harbor and Blacks Cove, effective date January 2, 2017. Special Flood Hazard Areas (SFHA) Inundated by 100-Year Flood Sources includes Zones A, AE, AH, AO, V and VE.

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- To calculate the percentage of parcels in each hazard area, the number of parcels impacted by a selected flood zone was divided by the total number of developed parcels in that hazard area. If more than one flood zone impacted a parcel, that parcel was counted in subsequent tables. If a parcel was duplicated within the database (i.e. multiple owners on one parcel), the parcel was only counted once.

- To calculate the percentage of buildings in each hazard area, the value of buildings impacted by that flood zone was divided by the total value of buildings within the hazard area. If a parcel was intersected by more than one flood zone, the flood zone delineation was examined in greater detail. Only the zone that included the building was selected for use in determining the building values.

4.2.2 Results

Estimated losses are tabulated in **Tables 4.3 through 4.5** below. Losses were estimated for flooding within FEMA flood Zones A, AE, and VE.

Flooding within Zone A is primarily limited to inland areas in the Sawmill Brook North, West and East hazard areas, with limited impacts in the Bennetts Brook and other areas. In total, 121 residential parcels, 16 commercial/industrial and 40 governments/non-profits parcels are in the A flood hazard area with a total value of $15.3 million dollars. The town-wide percentage of parcels in the A flood hazard area is 8%.

Flooding within the AE flood zone includes the downtown area, Bennetts Brook/ Bridge Street, Raymond, Ocean, Beach and Proctor Streets, Magnolia, Highland and Boardman Avenues. In total, 170 residential parcels, 14 commercial and 38 government/non-profits parcels are in the AE flood hazard area with a total value of $62.8 million dollars. The town-wide percentage of parcels in the AE flood hazard area is 12%.

Flooding within the VE flood zone includes the downtown area, Raymond, Ocean, Beach and Proctor Streets, Magnolia, and Boardman Avenues. In total, 95 residential parcels, 5 commercial and 12 government/non-profits parcels are in the VE flood hazard area with a total value of $24.3 million dollars. The town-wide percentage of parcels in the VE flood hazard area is 5%.

An analysis was also completed for 1 foot, 2 feet, and 4 feet of sea level rise described in section 4.3.

Table 4.3

Estimated Losses due to Flooding - Zone A

Geographic Area	Land Use	No. of Parcels			Value of Buildings		
		In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area	In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area
Sawmill Brook North	Residential	3	1	33%	$32,400	$10,800	33%
	Com/Ind	24	10	42%	$4,685,600	$0	0%
	Gov't/Non-Profit	64	28	44%	$0	$0	0%
Sawmill Brook West	Residential	394	48	12%	$125,948,700	$3,131,100	2%
	Com/Ind	7	5	71%	$2,857,400	$723,300	25%
	Gov't/Non-Profit	30	8	27%	$10,981,100	$0	0%
Sawmill Brook East	Residential	463	48	10%	$155,110,400	$2,947,900	2%
	Com/Ind	10	1	10%	$9,636,600	$6,842,700	71%
	Gov't/Non-Profit	46	8	17%	$31,316,700	$0	0%
MBTS Center	Residential	86	0	0%	$39,324,000	$0	0%
	Com/Ind	21	0	0%	$10,065,100	$0	0%
	Gov't/Non-Profit	18	0	0%	$8,609,800	$0	0%
Sawmill Brook South	Residential	135	1	1%	$108,259,300	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	7	3	43%	$0	$0	0%
Bennetts Brook/Bridge Street	Residential	309	18	6%	$145,267,800	$1,738,200	1%
	Com/Ind	8	0	0%	$1,731,800	$0	0%
	Gov't/Non-Profit	5	1	20%	$1,896,000	$0	0%
Raymond Street	Residential	125	4	3%	$49,390,700	$0	0%
	Com/Ind	5	0	0%	$1,576,700	$0	0%
	Gov't/Non-Profit	12	0	0%	$240,800	$0	0%
Ocean Street	Residential	53	0	0%	$33,390,000	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	9	0	0%	$0	$0	0%
Magnolia Ave	Residential	156	1	1%	$77,459,100	$0	0%
	Com/Ind	1	0	0%	$0	$0	0%
	Gov't/Non-Profit	13	0	0%	$0	$0	0%
Highland Ave	Residential	47	0	0%	$31,327,200	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	10	0	0%	$16,721,100	$0	0%
Boardman Ave	Residential	51	0	0%	$69,212,300	$0	0%
	Com/Ind	2	0	0%	$293,300	$0	0%
	Gov't/Non-Profit	4	0	0%	$29,300	$0	0%
Beach/Proctor Street	Residential	119	0	0%	$149,258,800	$0	0%
	Com/Ind	1	0	0%	$407,400	$0	0%
	Gov't/Non-Profit	6	0	0%	$855,000	$0	0%
Crooked Lane	Residential	145	0	0%	$68,646,700	$0	0%
	Com/Ind	4	0	0%	$0	$0	0%
	Gov't/Non-Profit	36	0	0%	$2,185,700	$0	0%

Table 4.4

Estimated Losses due to Flooding - Zone AE

Geographic Area	Land Use	No. of Parcels			Value of Buildings		
		In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area	In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area
Sawmill Brook North	Residential	3	0	0%	$32,400	$0	0%
	Com/Ind	24	0	0%	$4,685,600	$0	0%
	Gov't/Non-Profit	64	0	0%	$0	$0	0%
Sawmill Brook West	Residential	394	0	0%	$125,948,700	$0	0%
	Com/Ind	7	0	0%	$2,857,400	$0	0%
	Gov't/Non-Profit	30	0	0%	$10,981,100	$0	0%
Sawmill Brook East	Residential	463	0	0%	$155,110,400	$0	0%
	Com/Ind	10	0	0%	$9,636,600	$0	0%
	Gov't/Non-Profit	46	0	0%	$31,316,700	$0	0%
MBTS Center	Residential	86	37	43%	$39,324,000	$10,201,800	26%
	Com/Ind	21	5	24%	$10,065,100	$2,358,000	23%
	Gov't/Non-Profit	18	13	72%	$8,609,800	$1,880,200	22%
Sawmill Brook South	Residential	135	0	0%	$108,259,300	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	7	0	0%	$0	$0	0%
Bennetts Brook/Bridge Street	Residential	309	5	2%	$145,267,800	$2,868,100	2%
	Com/Ind	8	1	13%	$1,731,800	$558,200	32%
	Gov't/Non-Profit	5	0	0%	$1,896,000	$0	0%
Raymond Street	Residential	125	79	63%	$49,390,700	$8,352,100	17%
	Com/Ind	5	5	100%	$1,576,700	$0	0%
	Gov't/Non-Profit	12	6	50%	$240,800	$0	0%
Ocean Street	Residential	53	23	43%	$33,390,000	$5,891,900	18%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	9	6	67%	$0	$0	0%
Magnolia Ave	Residential	156	8	5%	$77,459,100	$1,474,000	2%
	Com/Ind	1	0	0%	$0	$0	0%
	Gov't/Non-Profit	13	0	0%	$0	$0	0%-
Highland Ave	Residential	47	17	36%	$31,327,200	$985,200	3%
	Com/Ind	0	0	0%	$0	$0	0%-
	Gov't/Non-Profit	10	5	50%	$16,721,100	$11,723,000	70%
Boardman Ave	Residential	51	24	47%	$69,212,300	$16,309,900	24%
	Com/Ind	2	2	100%	$293,300	$225,800	77%
	Gov't/Non-Profit	4	4	100%	$29,300	$29,300	100%
Beach/Proctor Street	Residential	119	37	31%	$149,258,800	$13,858,500	9%
	Com/Ind	1	1	100%	$407,400	$407,400	100%
	Gov't/Non-Profit	6	4	67%	$855,000	$138,600	16%
Crooked Lane	Residential	145	0	0%	$68,646,700	$0	0%
	Com/Ind	4	0	0%	$0	$0	0%
	Gov't/Non-Profit	36	0	0%	$2,185,700	$0	0%

Table 4.5

Estimated Losses due to Flooding - Zone VE

Geographic Area	Land Use	No. of Parcels			Value of Buildings		
		In Geographic Area	No. in Flood Hazard Area	% in Flood Hazard Area	Value in Geographic Area	Value in Flood Hazard Area	% in Flood Hazard Area
Sawmill Brook North	Residential	3	0	0%	$32,400	$0	0%
	Com/Ind	24	0	0%	$4,685,600	$0	0%
	Gov't/Non-Profit	64	0	0%	$0	$0	0%
Sawmill Brook West	Residential	394	0	0%	$125,948,700	$0	0%
	Com/Ind	7	0	0%	$2,857,400	$0	0%
	Gov't/Non-Profit	30	0	0%	$10,981,100	$0	0%
Sawmill Brook East	Residential	463	0	0%	$155,110,400	$0	0%
	Com/Ind	10	0	0%	$9,636,600	$0	0%
	Gov't/Non-Profit	46	0	0%	$31,316,700	$0	0%
MBTS Center	Residential	86	0	0%	$39,324,000	$0	0%
	Com/Ind	21	0	0%	$10,065,100	$0	0%
	Gov't/Non-Profit	18	0	0%	$8,609,800	$0	0%
Sawmill Brook South	Residential	135	18	13%	$108,259,300	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	7	0	0%	$0	$0	0%
Bennetts Brook/Bridge Street	Residential	309	0	0%	$145,267,800	$0	0%
	Com/Ind	8	0	0%	$1,731,800	$0	0%
	Gov't/Non-Profit	5	0	0%	$1,896,000	$0	0%
Raymond Street	Residential	125	23	18%	$49,390,700	$3,785,400	8%
	Com/Ind	5	4	80%	$1,576,700	$352,100	22%
	Gov't/Non-Profit	12	3	25%	$240,800	$0	0%
Ocean Street	Residential	53	5	9%	$33,390,000	$5,719,200	17%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	9	6	67%	$0	$0	0%
Magnolia Ave	Residential	156	4	3%	$77,459,100	$1,800	0%
	Com/Ind	1	0	0%	$0	$0	0%-
	Gov't/Non-Profit	13	0	0%	$0	$0	0%
Highland Ave	Residential	47	0	0%	$31,327,200	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	10	0	0%	$16,721,100	$0	0%
Boardman Ave	Residential	51	19	37%	$69,212,300	$7,405,500	11%
	Com/Ind	2	1	50%	$293,300	$0	0%
	Gov't/Non-Profit	4	1	25%	$29,300	$0	0%
Beach/Proctor Street	Residential	119	31	26%	$149,258,800	$7,082,700	5%
	Com/Ind	1	0	0%	$407,400	$0	0%
	Gov't/Non-Profit	6	2	33%	$855,000	$0	0%
Crooked Lane	Residential	145	0	0%	$68,646,700	$0	0%
	Com/Ind	4	0	0%	$0	$0	0%
	Gov't/Non-Profit	36	0	0%	$2,185,700	$0	0%

4.3 Flooding due to Climate Change

4.3.1 Town-Wide Impacts

4.3.1.1 Methodology

The potential for Town-wide flooding due to sea level rise was evaluated using a GIS-based exposure analysis similar to the existing flood analysis described in **Section 4.2**, but using a flood zone expansion map based on the assumption that sea level will expand the FEMA base 100-year floodplain by 1 foot by the year 2025, 2 feet by 2050 and 4 feet by 2100.

The town-wide map for future flooding was derived from the 2014 Flood Zone Expansion Analysis, completed by the Town in 2014, shown in **Maps 6 East and West** and described in Section 2.2.12. This static, conservative model was used instead of the IRM model, which was focused on Sawmill Brook, in order to cover the entire town. Assessor data (2015) was linked to the corresponding 1, 2, and 4 feet of sea level rise areas of inundation and sorted for the 13 hazard areas described in **Section 4.2** to identify potential losses due to sea level rise.

Data was handled in a similar fashion to the inundation analysis in **Section 4.2**:

- To calculate the percentage of parcels in each hazard area, the number of parcels impacted by sea level rise (1, 2 or 4 feet) was divided by the total number of developed parcels. If more than one flood elevation zone impacted a parcel, that parcel was counted in subsequent tables. If a parcel was duplicated within the database (i.e. multiple owners on one parcel), the parcel was only counted once.

- To calculate the percentage of buildings in each hazard area, the value of buildings impacted by that flood elevation zone was divided by the total value of buildings within the hazard area. The building footprint was used to determine the elevation of the parcel. If a building was crossed with several flood plain elevations, the lowest elevation was used. Secondary or ancillary detached structures were ignored, and the property building value was assigned to the main structure. One exception was the 4 Town-owned recreational properties included values for secondary structures. Building value were only counted if a flood elevation zone touched the building.

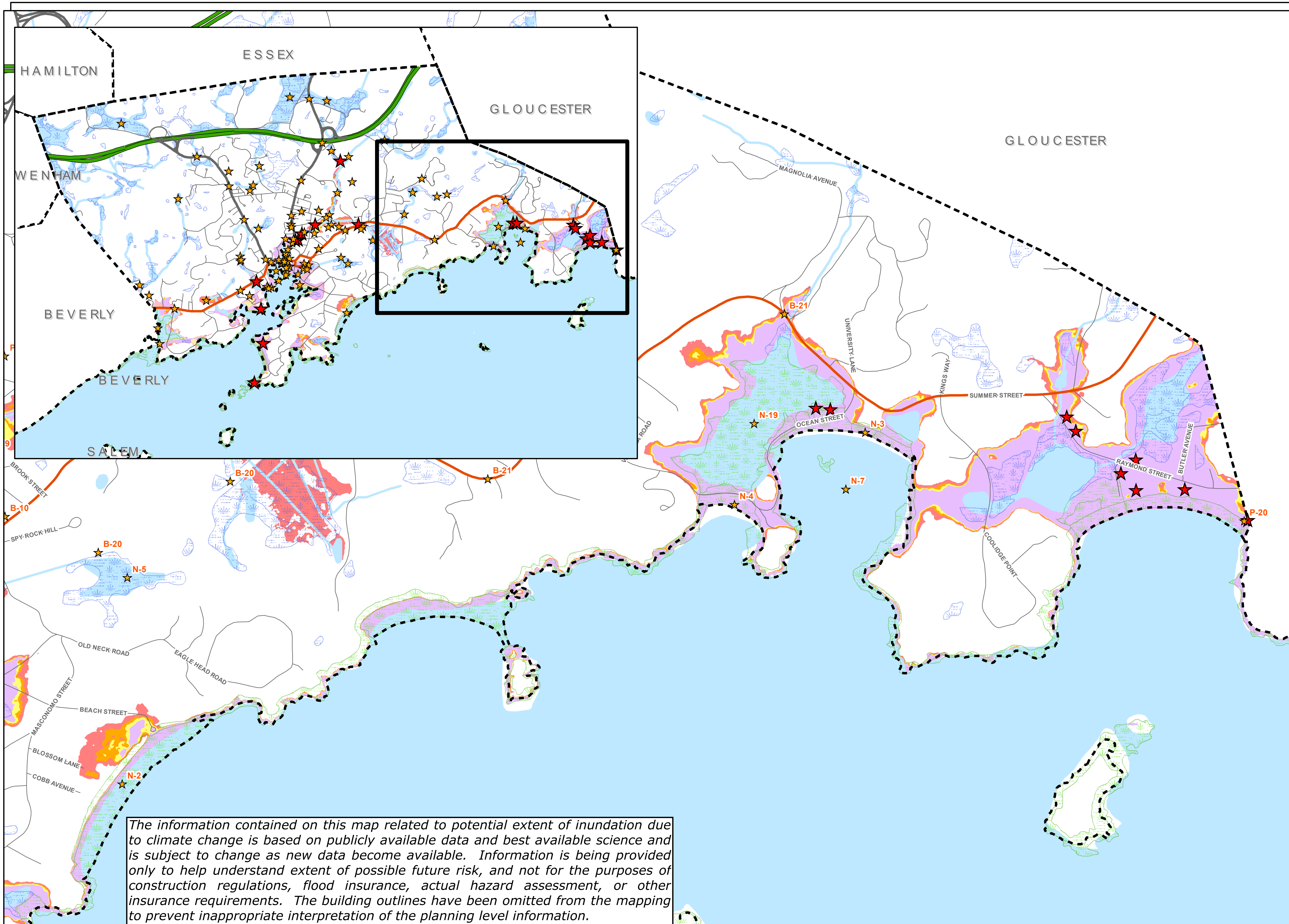
4.3.1.2 Results

Estimated losses are tabulated in **Tables 4.6 through 4.8** below.

Flooding within the 1-, 2-, and 4-foot flood zone includes areas of the town in almost all of the hazard areas except for Sawmill Brook North, Sawmill Brook South, and Crooked Lane.

Town-wide flooding impacts due to sea level rise include 256 developed parcels (10.5% of all developed parcels in Manchester) based on 1 foot of sea level rise above the current base flood zone, 275 (11.3%) parcels are impacted with a 2-foot rise, and 334 (13.8%) parcels are impacted with a 4-foot rise above the base flood zone.

Parcels impacted by a 1-foot expansion of the base flood elevation have an estimated building value of $168 million dollars. In total, 210 residential parcels, 27 commercial, and 19 government/non-profits parcels are in the 1-foot flood zone expansion area.



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MAP 6 EAST FLOOD ZONE EXPANSION MAPPING: SLR[2]

LEGEND

- Community Assets
- Repetitive Loss Structures
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies
- Adjusted Base Floodplain *
- 1' Sea Level Rise
- 2' Sea Level Rise
- 4' Sea Level Rise

* Adjusted Base Floodplain was created by matching FEMA 100-year base flood elevation to GIS Contours developed from LIDAR data. Areas experiencing flooding by 1, 2, and 4 feet of SLR are defined by adding elevation contours above the adjusted base floodplain.

LOCUS MAP

N
W E
S

0 600 1,200
Feet

1:12,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2 Flood Zone Expansion with Sea Level Rise Town of Manchester-by-the-Sea December 2014.

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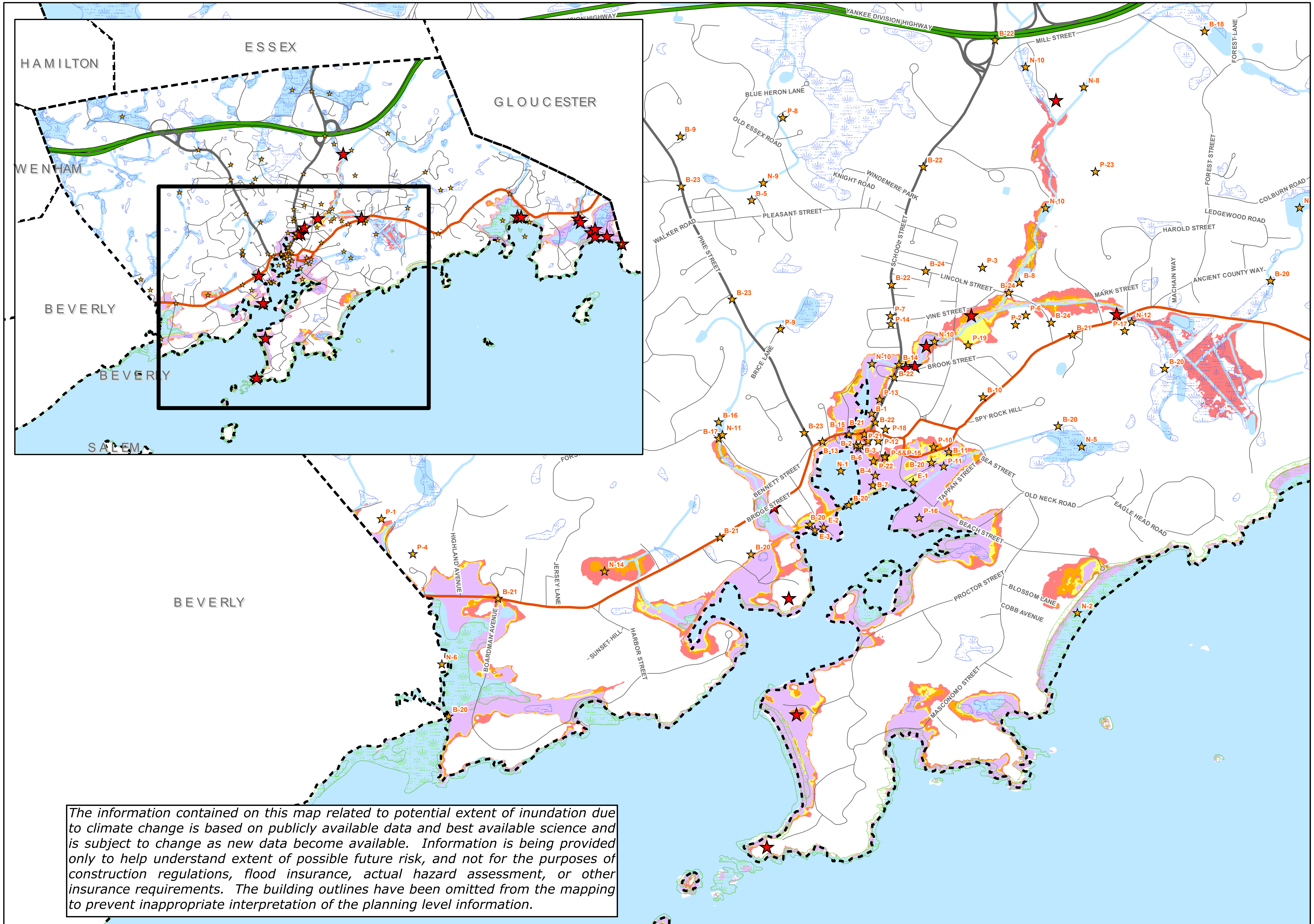
MAP 6 WEST FLOOD ZONE EXPANSION MAPPING: SLR[2]

LEGEND

- Community Assets
- Repetitive Loss Structures
- Town Boundary
- Stream, Brook
- Inland Wetlands
- Coastal Wetlands
- Waterbodies
- Adjusted Base Floodplain*
- 1' Sea Level Rise
- 2' Sea Level Rise
- 3' Sea Level Rise

* Adjusted Base Floodplain was created by matching FEMA 100-year base flood elevation to GIS Contours developed from LIDAR data. Areas experiencing flooding by 1, 2, and 4 feet of SLR are defined by adding elevation contours above the adjusted base floodplain.



The information contained on this map related to potential extent of inundation due to climate change is based on publicly available data and best available science and is subject to change as new data become available. Information is being provided only to help understand extent of possible future risk, and not for the purposes of construction regulations, flood insurance, actual hazard assessment, or other insurance requirements. The building outlines have been omitted from the mapping to prevent inappropriate interpretation of the planning level information.

LOCUS MAP

0 625 1,250 Feet

1:15,000

DATA SOURCES

1. Town of Manchester-by-the-Sea, Office of Geographic and EnvironmentalInformation (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs.
2. Flood Zone Expansion with Sea Level Rise Town of Manchester-by-the-Sea December 2014.

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Parcels impacted by a 2-foot expansion of the base flood elevation have an estimated building value of $174 million dollars. In total, 228 residential parcels, 27 commercial, and 20 government/non-profits parcels are in the 2- foot flood zone expansion area.

Parcels impacted by a 4-foot expansion of the base flood elevation have an estimated building value of $207 million dollars. In total, 282 residential parcels, 29 commercial, and 23 government/non-profits parcels are in the 4-foot flood zone expansion area.

Table 4.6

Estimated Losses due to Flooding - 1 Foot of Sea Level Rise

Geographic Area	Land Use	No. of Parcels			Value of Buildings		
		In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area	In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area
Sawmill Brook North	Residential	3	0	0%	$32,400	$0	0%
	Com/Ind	24	0	0%	$4,685,600	$0	0%
	Gov't/Non-Profit	64	0	0%	$0	$0	--
Sawmill Brook West	Residential	394	25	6%	$125,948,700	$8,586,800	7%
	Com/Ind	7	6	86%	$2,857,400	$2,857,400	100%
	Gov't/Non-Profit	30	1	3%	$10,981,100	$667,000	6%
Sawmill Brook East	Residential	463	30	6%	$155,110,400	$11,931,800	8%
	Com/Ind	10	1	10%	$9,636,600	$6,842,700	71%
	Gov't/Non-Profit	46	3	7%	$31,316,700	$4,939,200	16%
MBTS Center	Residential	86	33	38%	$39,324,000	$13,101,900	33%
	Com/Ind	21	14	67%	$10,065,100	$8,200,200	81%
	Gov't/Non-Profit	18	9	50%	$8,609,800	$7,803,000	91%
Sawmill Brook South	Residential	135	0	0%	$108,259,300	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	7	0	0%	$0	$0	0%
Bennetts Brook/Bridge Street	Residential	309	15	5%	$145,267,800	$9,604,500	7%
	Com/Ind	8	2	25%	$1,731,800	$793,200	46%
	Gov't/Non-Profit	5	0	0%	$1,896,000	$0	0%
Raymond Street	Residential	125	52	42%	$49,390,700	$11,743,700	24%
	Com/Ind	5	1	20%	$1,576,700	$352,100	22%
	Gov't/Non-Profit	12	0	0%	$240,800	$0	0%
Ocean Street	Residential	53	10	19%	$33,390,000	$12,367,300	37%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	9	0	0%	$0	$0	0%
Magnolia Ave	Residential	156	2	1%	$77,459,100	$3,761,200	5%
	Com/Ind	1	0	0%	$0	$0	0%
	Gov't/Non-Profit	13	0	0%	$0	$0	0%
Highland Ave	Residential	47	7	15%	$31,327,200	$2,582,900	8%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	10	2	20%	$16,721,100	$11,723,000	70%
Boardman Ave	Residential	51	13	25%	$69,212,300	$14,823,200	21%
	Com/Ind	2	2	100%	$293,300	$293,300	100%
	Gov't/Non-Profit	4	2	50%	$29,300	$29,300	100%
Beach/Proctor Street	Residential	119	23	19%	$149,258,800	$34,779,500	23%
	Com/Ind	1	1	100%	$407,400	$407,400	100%
	Gov't/Non-Profit	6	2	33%	$855,000	$138,600	16%
Crooked Lane	Residential	145	0	0%	$68,646,700	$0	0%
	Com/Ind	4	0	0%	$0	$0	0%
	Gov't/Non-Profit	36	0	0%	$2,185,700	$0	0%

Table 4.7

Estimated Losses due to Flooding - 2 Feet of Sea Level Rise

Geographic Area	Land Use	No. of Parcels			Value of Buildings		
		In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area	In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area
Sawmill Brook North	Residential	3	0	0%	$32,400	$0	0%
	Com/Ind	24	0	0%	$4,685,600	$0	0%
	Gov't/Non-Profit	64	0	0%	$0	$0	0%
Sawmill Brook West	Residential	394	27	7%	$125,948,700	$9,034,400	7%
	Com/Ind	7	6	86%	$2,857,400	$2,857,400	100%
	Gov't/Non-Profit	30	1	3%	$10,981,100	$667,000	6%
Sawmill Brook East	Residential	463	40	9%	$155,110,400	$14,382,000	9%
	Com/Ind	10	1	10%	$9,636,600	$6,842,700	71%
	Gov't/Non-Profit	46	3	7%	$31,316,700	$4,939,200	16%
MBTS Center	Residential	86	36	42%	$39,324,000	$14,318,500	36%
	Com/Ind	21	14	67%	$10,065,100	$8,200,200	81%
	Gov't/Non-Profit	18	9	50%	$8,609,800	$7,803,000	91%
Sawmill Brook South	Residential	135	0	0%	$108,259,300	$0	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	7	0	0%	$0	$0	0%
Bennetts Brook/Bridge Street	Residential	309	15	5%	$145,267,800	$9,604,500	7%
	Com/Ind	8	2	25%	$1,731,800	$793,200	46%
	Gov't/Non-Profit	5	0	0%	$1,896,000	$0	0%
Raymond Street	Residential	125	53	42%	$49,390,700	$11,909,900	24%
	Com/Ind	5	1	20%	$1,576,700	$352,100	22%
	Gov't/Non-Profit	12	0	0%	$240,800	$0	0%
Ocean Street	Residential	53	10	19%	$33,390,000	$12,367,300	37%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	9	0	0%	$0	$0	0%
Magnolia Ave	Residential	156	2	1%	$77,459,100	$3,761,200	5%
	Com/Ind	1	0	0%	$0	$0	0%
	Gov't/Non-Profit	13	0	0%	$0	$0	0%
Highland Ave	Residential	47	9	19%	$31,327,200	$3,841,400	12%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	10	3	30%	$16,721,100	$12,292,000	74%
Boardman Ave	Residential	51	13	25%	$69,212,300	$14,823,200	21%
	Com/Ind	2	2	100%	$293,300	$293,300	100%
	Gov't/Non-Profit	4	2	50%	$29,300	$29,300	100%
Beach/Proctor Street	Residential	119	23	19%	$149,258,800	$34,779,500	23%
	Com/Ind	1	1	100%	$407,400	$407,400	100%
	Gov't/Non-Profit	6	2	33%	$855,000	$138,600	16%
Crooked Lane	Residential	145	0	0%	$68,646,700	$0	0%
	Com/Ind	4	0	0%	$0	$0	0%
	Gov't/Non-Profit	36	0	0%	$2,185,700	$0	0%

Table 4.8

Estimated Losses due to Flooding - 4 Feet of Sea Level Rise

		No. of Parcels			Value of Buildings		
	Land Use	In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area	In Geographic Area	In Flood Hazard Area	% in Flood Hazard Area
Sawmill Brook North	Residential	3	0	0%	$32,400	$0	0%
	Com/Ind	24	0	0%	$4,685,600	$0	0%
	Gov't/Non-Profit	64	0	0%	$0	$0	0%
Sawmill Brook West	Residential	394	32	8%	$125,948,700	$10,318,600	7%
	Com/Ind	7	6	86%	$2,857,400	$2,857,400	100%
	Gov't/Non-Profit	30	1	3%	$10,981,100	$667,000	6%
Sawmill Brook East	Residential	463	67	14%	$155,110,400	$23,385,400	9%
	Com/Ind	10	1	10%	$9,636,600	$6,842,700	71%
	Gov't/Non-Profit	46	4	9%	$31,316,700	$5,927,900	16%
MBTS Center	Residential	86	42	49%	$39,324,000	$17,907,000	36%
	Com/Ind	21	15	71%	$10,065,100	$8,558,400	81%
	Gov't/Non-Profit	18	10	56%	$8,609,800	$8,609,800	91%
Sawmill Brook South	Residential	135	1	1%	$108,259,300	$137,200	0%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	7	1	14%	$0	$0	0%
Bennetts Brook/Bridge Street	Residential	309	16	5%	$145,267,800	$11,493,900	7%
	Com/Ind	8	2	25%	$1,731,800	$793,200	46%
	Gov't/Non-Profit	5	0	0%	$1,896,000	$0	0%
Raymond Street	Residential	125	55	44%	$49,390,700	$12,612,300	24%
	Com/Ind	5	2	40%	$1,576,700	$1,576,700	22%
	Gov't/Non-Profit	12	0	0%	$240,800	$0	0%
Ocean Street	Residential	53	11	21%	$33,390,000	$12,907,300	37%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	9	0	0%	$0	$0	0%
Magnolia Ave	Residential	156	3	2%	$77,459,100	$4,052,500	5%
	Com/Ind	1	0	0%	$0	$0	0%
	Gov't/Non-Profit	13	0	0%	$0	$0	0%
Highland Ave	Residential	47	10	21%	$31,327,200	$5,436,700	12%
	Com/Ind	0	0	0%	$0	$0	0%
	Gov't/Non-Profit	10	3	30%	$16,721,100	$12,292,000	74%
Boardman Ave	Residential	51	14	27%	$69,212,300	$15,947,300	21%
	Com/Ind	2	2	100%	$293,300	$293,300	100%
	Gov't/Non-Profit	4	2	50%	$29,300	$29,300	100%
Beach/Proctor Street	Residential	119	31	26%	$149,258,800	$43,553,800	23%
	Com/Ind	1	1	100%	$407,400	$407,400	100%
	Gov't/Non-Profit	6	2	33%	$855,000	$138,600	16%
Crooked Lane	Residential	145	0	0%	$68,646,700	$0	0%
	Com/Ind	4	0	0%	$0	$0	0%
	Gov't/Non-Profit	36	0	0%	$2,185,700	$0	0%

4.4 Future Development in Hazard Areas

D1 a

The Town of Manchester-by-the-Sea has identified parcels where development has been proposed, is underway or is expected to occur in the future. **Table 4.9** shows the relationship of these parcel to 3 of the mapped hazards. This information is provided so that planners can ensure that development proposals meet all floodplain zoning and that careful attention is paid to drainage issues.

Table 4.9
Relationship of Potential Development to Hazard Areas

Parcel	Landslide risk	Flood Zone	Wild or Urban Fire
Knight Circle	Low	Yes	Yes
Crooked Lane (Old Wenham Way)	Low	No	Yes
Elm Street Village	Low	Yes	Yes
601 Summer Street	Low	Yes	Yes

4.5 Impacts to Community Assets

4.5.1 Methodology

As described in Section 2.2.12, the 2014 PDM Grant evaluated flooding due to climate change as part of Manchester's Hazard Mitigation Plan Enhancement. As explained, Task 2 of the 2014 Grant was used to predict where, when, and to what degree future climate impacts related to flooding may be experienced (see **Section 2.2.12** for results). Task 3 was the development of a Vulnerability and Risk Assessment (VRA) for the selected community assets. The VRA builds directly off of the work completed in Task 2. See Appendix F for the complete VRA Technical Memorandum.

The modeling results from Task 2 were used to narrow down the list of sites for the VRA. Sites that were not impacted, or minimally impacted by coastal or upland flooding, are included in this Plan (see **Section 3**) but excluded from the focused VRA. Ultimately, the list of 70 community assets was reduced to 23 and these locations were further evaluated in the VRA described below.

The VRA was conducted using a methodology based on "Preparing for Climate Change, A Guidebook for Local, Regional, and State Governments," September 2007. Under this methodology, both risk and vulnerability are evaluated on a site-specific basis.

Risk is broken down into *Likelihood* of flooding and *Consequence* of flooding. Vulnerability is a function of *Sensitivity* of flooding and *Adaptive Capacity*. Each community asset was assigned a rating, ranging from 1 to 3, for Likelihood, Consequence, Sensitivity, and Adaptive Capacity. Brief definitions of each category is as follows:

1. Likelihood – each community asset was assigned a score based on the modeling results generated under the FEMA PDM grant described in **Section 2.2.12**.

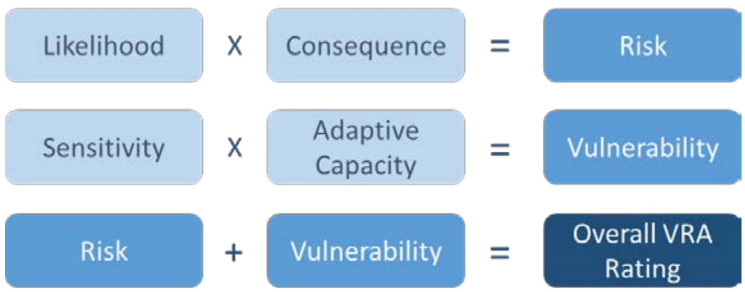
2. Consequence – estimated based on how a flood may affect the functionality of the community asset and the consequences that may arise if the asset were to be damaged or out of service and not functioning under normal operating conditions.

3. Sensitivity – evaluated based on the existing exposures to flood waters and any history of flooding.

4. Adaptive Capacity **–** evaluated based on a community asset's existing abilities to accommodate flooding with minimum loss of function or loss of value (value can be either monetary or a non-monetary value to the community). If an asset does not already have the ability to adapt to flooding, then it is assumed outside intervention will be required (e.g., upgrade requiring an investment).

Once a community asset is assigned ratings, they must be combined into an overall rating. Ratings for Likelihood and Consequence are multiplied for a total Risk Rating. Sensitivity and Adaptive Capacity are multiplied for a total Vulnerability Rating. The Risk and Vulnerability Ratings were then totaled for an Overall Rating. Therefore, at the end of the evaluation, each community asset is assigned one rating, summarizing its overall risk and vulnerability.

The complete process is shown below.



4.5.2 Results

The Overall Ratings are summarized in **Table 4.10**, which is sorted from highest to lowest based on the mid-term (2050) results. Basing the vulnerability risk assessment on anticipated mid-21st century flooding impacts was a decision made by the Town for planning purposes.

Rankings do not change dramatically over the course of the 3 time periods. The top 10 rated assets in all 3 time periods include: Central Street Dam, the Wastewater Treatment Plant, the Downtown Stormwater Drainage System, Town Hall/Police/Emergency Operations, the Fire Department, Route 127, the Downtown Businesses, Sawmill Brook, Manchester Harbor, and Singing Beach. The detailed VRA for the 10 rated assets was considered when developing the mitigation strategy in **Section 6**.

Table 4.10
Summary of Vulnerability and Risk Assessment Results

Category	Community Asset	Overall Rating 2025	Overall Rating 2050	Overall Rating 2100
Built Environment	Central Street Dam	15	18	18
Built Environment	Manchester Wastewater Treatment	12	15	15
Built Environment	Downtown Stormwater Drainage System	15	15	15
Built Environment	Town Hall / Police Headquarters / Emergency Operations	13	13	13
Built Environment	Manchester Fire Department	10	13	13
Built Environment	Route 127	12	12	12
Built Environment	MBTA Tracks/Bridge	9	9	9
Built Environment	School Street and Bridge	8	8	10
Built Environment	Lincoln Street Well & Pumping Station	7	7	10
Built Environment	Lincoln Street	4	4	6
Economy	Downtown Businesses	13	13	13
Economy	Manchester Marine	10	10	10
Economy	Crocker's Boat Yard	10	10	10
Natural Resources	Sawmill Brook	12	12	12
Natural Resources	Manchester Harbor	12	12	12
Natural Resources	Singing Beach	12	12	12
Natural Resources	Bennetts Brook and Marsh	10	10	10
Natural Resources	Millet's Swamp and Brook	6	6	6
People	First Baptist Church	5	5	5
People	First Parish Church and Magic Years School	4	4	4
People	The Plains Seniors Housing	3	3	3
People	Landmark School	2	3	3
People	Summer Street Apartments	3	3	4

4.6 Vulnerability Assessment Conclusions

B3

Based on the analysis of risk due to all hazards in Manchester by the Sea, **Table 4.11** was prepared to summarize town-wide and community asset vulnerability in Manchester-by-the-Sea. The table reflects the overall hazards ranking as presented in **Table 2.1**.

- Dam and culvert failure was rated as the hazard of greatest of concern to Manchester-by-the-Sea. Buildings and infrastructure adjacent to Sawmill Brook and roadways crossing waterways are most vulnerable assets that may be impacted. Property impacted by flooding are valued at over $14 million dollars. Considering the additional hydraulic load due to climate change, culvert failure impacts including property damage and roadway repairs are expected to increase in the future.

- Flooding has been identified as the most pervasive flood hazard risk in Manchester-by-the-Sea. Nearly every identified community asset is subject to either coastal or inland flooding with few exceptions (DPW garage and water tower). Crooked Lane is the only geographic hazard area without any flooding areas. Damages will be greatest where the impacts of coastal storm surge coincide with inland flooding areas, notably Manchester-by-the-Sea Town Center, Sawmill Brook East, Ocean Street, and Raymond Street.
- Other coastal hazards including coastal erosion and sea level rise impact parcels along the shoreline to varying degrees, requiring site specific analysis to evaluate vulnerability. Looking at these coastal hazards on a Town-wide basis, up to 75% of residential properties along the shoreline have experienced some form of shoreline changes, and sea level rise in the near term (2025) may impact over 256 residential, commercial, municipal and other government or non-profit locations. A refined sea level rise analysis completed for identified community assets using a probability based methodology indicates that 23%, or 16 of the 70 community assets, will be impacted by sea level rise in the near term. However, the assets impacted include the most critical facilities in the Town: the Wastewater Treatment Plant, Town Hall and the Emergency Operations Center, Fire Department, critical fuel supplies, and economic assets including the grocery store that supports emergency shelters.
- Hazards including severe winter weather, Nor'easters, hurricanes, tropical storms, high wind, and thunderstorms frequently impact the entire Town including all community assets. Based on the pervasive impact, high frequency of occurrence, and level of damages associated with these severe weather events, they remain at the top of the hazards index rating. Tornados are less likely to impact large areas of the community, but remain elevated on the hazards index rating due to the extreme damages associated with even small tornadoes.
- Drought was recognized as a hazard that impacts the entire Town. The year 2016 included one of the worst New England droughts in recent history. Manchester-by-the-Sea is located in the North Coastal Watershed, and this has not been defined as a stressed water basin. Manchester-by-the-Sea acknowledges its responsibility to mitigate impacts of these hazards, but determined that overall there was less impact to the community compared to other locations in Massachusetts where a more urban environment that precludes natural recharge or agricultural demands would elevate the community's vulnerability to drought.
- Earthquakes remain a valid hazard of concern for Manchester-by-the-Sea. Buildings are not generally designed to be earthquake resistant according to Massachusetts Building Codes. In the 2012 Plan, Manchester officials stated that earthquakes were the hazards that they were least prepared for, and this statement continues to be true.
- Urban and wildfires will continue to be an ongoing hazard and may be exacerbated by drought and extreme high temperatures predicted as global climate changes.
- Landsides have never occurred, but are included as a potential hazard, especially in connection with an earthquake. Steep rocky slopes found in central Manchester-by-the-Sea may be susceptible to landslides if a significant earthquake occurred.
- Tsunamis remain a threat for all but the highest locations of Manchester-by-the-Sea, where elevations over 100 feet about sea level would be safe from a tsunami flood event. The water tower may be the only community asset not vulnerable to a tsunami.

B3

Table 4.11
Vulnerability Summary for all Community Assets

Map ID/ Hazard Area	COMMUNITY ASSET	Dam and Culvert Failure	Severe Winter Weather	Nor'easters	Coastal Flooding	Upland Flooding	Severe Weather Wind	Coastal Erosion	Severe Weather Temperatures and Drought	Earthquakes	Sea Level Rise	Storm Surge	Tsunamis	Urban and Wildfires	Landslides
Buildings and Infrastructure- Built Environment Community Assets															
B-1/ 2	Manchester Fire Department	X	X	X		X	X		X	X	Y	X	X	X	
B-2/ 4	Manchester Police Headquarters	X	X	X	X	X	X		X	X	Y	X	X	X	
B-3/ 4	Manchester-by-the-Sea Town Hall	X	X	X	X		X		X	X	Y	X	X	X	
B-4/ 4	Manchester Wastewater Treatment		X	X	X		X	X	X	X	Y	X	X	X	
B-5/ 2	DPW Highway Garage		X	X			X		X	X	N		X	X	
B-6/ 2	Emergency Operation Center	X	X	X	X		X		X	X	Y	X	X	X	
B-7/ 4	Manchester WWTP Treatment Plant		X	X	X		X	X	X	X	Y	X	X	X	
B-8/ 3	Lincoln Street Well & Pumping Station	X	X	X		X	X		X	X	N		X	X	
B-9/ 2	Manchester Water Tower (tank)		X	X			X		X	X	N			X	
B-10/ 3	Verizon- Switching Station		X	X	X		X		X	X	Y		X	X	
B-11/ 4	National Grid		X	X	X		X		X	X	Y		X	X	
B-12/ 4	Vulnerable UST's		X	X	X		X		X	X	Y		X	X	
B-13/ 4	Downtown Stormwater Drainage System	X	X	X	X	X	X		X	X	X		X	X	
B-14/ 2	School Street Bridge	X	X	X	X	X	X		X	X	X		X	X	
B-15/ 4	Central Street Dam	X	X	X	X	X	X	X	X	X	YX	X	X	X	
B-16/ 6	Small Brook Dam	X	X	X		X	X		X	X			X	X	
B-17/ 6	Forster Road Dam	X	X	X		X	X		X	X			X	X	
B-18/ 3	Saw Mill Brook Dam	X	X	X	X	X	X		X	X	X		X	X	
B-19/ 13	Gorman Pond Dam	X	X	X		X	X		X	X			X	X	
B-20/ 11,4,5,9	MBTA Tracks/Bridge		X	X	X		X	X	X	X	X	X	X	X	
B-21/ 6,10	Route 127	X	X	X	X	X	X	X	X	X	X	X	X	X	
B-22/ 1,2,3	School Street	X	X	X	X	X	X		X	X	X		X	X	
B-23/ 2	Pine Street	X	X	X	X	X	X		X	X	X		X	X	
B-24/ 3	Lincoln Street	X	X	X	X	X	X		X	X	X		X	X	

Map ID/ Hazard Area	COMMUNITY ASSET	Dam and Culvert Failure	Severe Winter Weather	Nor'easters	Coastal Flooding	Upland Flooding	Severe Weather Wind	Coastal Erosion	Severe Weather Temperatures and Drought	Earthquakes	Sea Level Rise	Storm Surge	Tsunamis	Urban and Wildfires	Landslides
							Economic Based Community Assets								
E-1/ 4	MBTA Station		X	X	X		X		X	X	X	X	X	X	
E-2/ 4	Manchester Marine		X	X	X		X	X	X	X	X	X	X	X	
E-3/ 6	Crocker's Boat Yard		X	X	X		X	X	X	X	X	X	X	X	
E-4/ 4	Downtown Business		X	X	X		X		X	X	X		X	X	
							Natural Resource Based Community Assets								
N-1/ 4,11,12	Manchester Harbor	X	X	X	X		X	X	X	X	X	X	X	X	
N-2/ 12	Singing Beach		X	X	X		X	X	X	X	X	X	X	X	
N-3/ 8	Black Beach (Barrier Beach)		X	X	X		X	X	X	X	X	X	X	X	
N-4/ 8	White Beach (Barrier Beach)		X	X	X		X	X	X	X	X	X	X	X	
N-5/ 5	Eaglehead Swamps and Ponds		X	X	X	X	X		X	X			X	X	
N-6/ 10	Chubb Creek	X	X	X	X	X	X	X	X	X	X		X	X	
N-7/ 8	Kettle Cove Marsh and Clarks Pond		X	X	X	X	X		X	X	X		X	X	
N-8/ 3	Cat Brook and Marsh	X	X	X	X	X	X		X	X			X	X	
N-9/ 2	Millet's Swamp and Brook	X	X	X	X	X	X		X	X			X	X	
N-10/ 3	Sawmill Brook	X	X	X	X	X	X		X	X	X		X	X	
N-11/ 6	Bennetts Brook and Marsh	X	X	X	X	X	X	X	X	X	X		X	X	
N-12/ 5	Causeway Brook	X	X	X	X	X	X		X	X			X	X	
N-13/ 3	Dexter Pond		X	X	X	X	X		X	X			X	X	
N-14/ 6	Winthrop Field		X	X			X		X	X			X	X	
N-15/ 1	Beaverdam Swamp		X	X	X	X	X		X	X			X	X	
N-16/ 1	Cedar Swamp		X	X	X	X	X		X	X			X	X	
N-17/ 1	Maple Swamp		X	X	X	X	X		X	X			X	X	
N-18/ 3	Long Hill Conservation Area		X	X			X		X	X			X	X	
N-19/ 8	Wolf Trap Marsh		X	X	X	X	X		X	X			X	X	

Map ID/ Hazard Area	COMMUNITY ASSET	Dam and Culvert Failure	Severe Winter Weather	Nor'easters	Coastal Flooding	Upland Flooding	Severe Weather Wind	Coastal Erosion	Severe Weather Temperatures and Drought	Earthquakes	Sea Level Rise	Storm Surge	Tsunamis	Urban and Wildfires	Landslides
							People Based Community Assets								
P-1/ 10	Brookwood Elementary School		X	X	X		X		X	X	X		X	X	
P-2/ 3	Manchester Memorial Elementary School		X	X		X	X		X	X	X		X	X	
P-3/ 3	Manchester Essex Regional Middle High School	X	X	X		X	X		X	X			X	X	
P-4/ 10	Landmark School		X	X	X		X		X	X	X		X	X	
P-5/ 4	Magic Years Nursery School		X	X			X		X	X	X		X	X	
P-6/ 3	Hornet's After School Program		X	X			X		X	X	X		X	X	
P-7/ 4	Tara Montessori School		X	X			X		X	X			X	X	
P-8/ 6	The Plains Seniors Housing	X	X	X			X		X	X			X	X	
P-9/ 4	Newport Park Seniors Housing		X	X			X		X	X			X	X	
P-10 /4	Summer Street Apartments		X	X	X		X		X	X	X		X	X	
P-11/ 4	Manchester Community Center		X	X	X		X		X	X	X		X	X	
P-12/ 4	Manchester Public Library		X	X			X		X	X	X		X	X	
P-13/ 2	First Baptist Church		X	X			X		X	X	X		X	X	
P-14/ 4	Sacred Heart Parish		X	X			X		X	X	N		X	X	
P-15/ 4	Congregational Church														
P-16/ 4	Masconomo Park		X	X	X		X	X	X	X	X	X	X	X	
P-17/ 5	Sweeney Park		X	X		X	X		X	X			X	X	
P-18/ 3	Historical Society		X	X			X		X	X			X	X	
P-19/ 3	Coach Field Playground	X	X	X	X	X	X		X	X	X		X	X	
P-20/ 7	Surf Park		X	X	X		X	X	X	X		X	X	X	
P-21/ 4	First Parish Church		X	X			X		X	X			X	X	
P-22/ 4	Manchester Masonic Building		X	X	X		X	X	X	X			X	X	
P-23/ 3	Essex Country Club	X	X	X	X	X	X		X	X		X	X	X	

SECTION 5

CAPABILITY ASSESSMENT

Manchester-by-the-Sea has a unique set of capabilities including authority to enact regulations and policies, develop programs, hire staff, appropriate funding and other resources to accomplish mitigation and reduce long term vulnerability. By reviewing the existing capabilities in a community, the planning team can identify resources that currently reduce disaster losses of could be used to reduce disaster losses in the future. Section 5 includes a review of Manchester-by-the-Sea's existing planning mechanisms, administrative capacity, funding mechanisms, education and outreach and exiting mitigation measures specifically addressing natural hazards.

Section 5
CAPABILITY ASSESSMENT

5.1 Existing Planning Mechanism

C6 b.

C1 a

C6 d

The Planning Team updated information regarding existing planning mechanisms to mitigate natural hazards in the Town of Manchester-by-the-Sea**. Table 5.1** below summarized the Town Plans that include hazard mitigation elements.

Table 5.1
Summary of Current Planning Efforts related to Hazard Mitigation

Date of Plan	Status	Plan Name	Department Responsible for Update
2014	current	Comprehensive Emergency Management Plan (CEMP)	Police Department
2014	current	Open Space and Recreation Plan	Conservation Department
	ongoing	Master Plan	Planning Department
	yearly update	Capital Improvement Plan	Town Administrator
2010	final due 2018	Stormwater Management Plan	Public Works Department

The Town updated its Open Space and Recreation Plan in 2014. A new Open Space and Recreation Committee was formed in 2015 to oversee the plan, including following up on its 7-year Action Plan. The committee has identified several high priority parcels for potential acquisition, based on their location within Manchester's Gravelly and Round Pond watershed and their importance for protecting wildlife habitat. Local land protection non-profits have been the primary resource for land acquisition including the Manchester-Essex Conservation Trust, Essex County Greenbelt, and the Trustees of Reservations. The Town is interested in developing a comprehensive shoreline plan to include "living shorelines" as an alternative to armoring.

The Town is in the process of creating a new Master Plan (2017-2027), which will address climate resiliency, including the potential impacts of sea level rise, storm surge and increased precipitation. There is no Economic Development Plan, but topics will be discussed in the new Master Plan.

The Town maintains a spreadsheet of anticipated capital improvements for a period of 5 years. This is updated by each department during the annual budget process.

The Town updated its Comprehensive Emergency Management Plan in 2015. This plan addresses mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies.

5.2 Existing Administrative Capacity

The Town has multiple staff members that assist with planning, development, and implementation of hazard mitigation. **Table 5.2** provides a summary of the positions and the roles are further described below.

The Town has a Planning Board and a Zoning Board. In 2014 a Town Planner was hired to assist these boards and to lead the effort to create a new Master Plan.

The Town's DPW is working on formal maintenance plans but presently perform cleaning and leaf removal of catch basins in the fall and minor tree trimming as requested by the Tree Warden as needed. The DPW has also created a plan to fix all leaking fire hydrants in town and replace broken hydrants. The DPW also replaced the water main on Pine Street to ensure that hydrants would have enough water for fires. The water tower is inspected every 10 years.

Some maintenance is unplanned; for example, individual homeowners sometimes request work (e.g., removal of street trees). The adoption of a maintenance plan should help define DPW priorities.

The Town participates in the following regional emergency management initiatives: Cape Ann Emergency Management Team; Massachusetts Statewide Mutual Aid Agreement; the Public Works Mutual Aid Agreement; Essex County Mutual Aid Network; Region 1 Boston Network.

Table 5.2
Hazard Mitigation Staffing

Staff	Hazard Mitigation Role
Chief Building Official	The Town's building inspector is part-time and has very limited hours at Town Hall.
Floodplain Administrator	No one has been identified although the Conservation Administrator assists the public with flood maps, etc.
Emergency Manager	The Fire Chief is the Director of Emergency Management and there is an appointed Deputy Director.
Community Planner	A full time Town Planner was hired in 2014.
Grants Administrator	A part time grants administrator assists with funding and the implementation of grant projects.

5.3 Existing Funding Mechanisms

The Town has multiple funding mechanisms in place or planned to help fund mitigation projects.

- Capital Improvement Funding has been used for Town equipment and facility improvements.
- The Town charges users fees for water and sewer, including new hookups. Fees go towards maintaining these utilities.
- The Town is considering implementing a stormwater utility fee in the future.
- State funding has been used for a number of projects, including "Green Communities" and Coastal Zone Management Coastal Resiliency Grant Program. The Town was recently selected to participate in the Municipal Vulnerability Project.
- The Town has a Grants Administrator to assist with other funding opportunities.

- Community Preservation Act - Manchester-by-the-Sea first adopted the Community Preservation Act in 2005 with a local surcharge of 0.5 percent. In the years that followed, the surcharge was raised to a high of 3.0 percent and as of May 2015 has been reduced to 1.5 percent.

5.4 Education and Outreach Methods

The Town's existing public education and outreach methods include:

- The Manchester Fire Department participates in the SAFE (Student Awareness Fire Education) program and the Senior SAFE program.
- Police and Fire Departments regularly speak to senior citizens through the "Friends on the Council on Aging" group.

5.5 Existing Mitigation Measures

5.5.1 Flood Hazard Mitigation Measures

C2 a

Participation in the National Flood Insurance Program (NFIP)

The Town 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. FEMA maintains a database on flood insurance policies and claims. This database can be found on the FEMA website at https://www.fema.gov/policy-claim-statistics-flood-insurance. Data for Manchester-by-the-Sea is presented in **Table 5.3** including data through August 31, 2016.

Table 5.3
Flood Insurance Categories

Flood Insurance Categories	Values (units or $)
Flood insurance policies in force (as of 8/31/2016)	145
Coverage amount of flood insurance policies	$42,664,500
Premiums paid	$208,001
Total losses (all losses submitted regardless of the status)	84
Closed losses (Losses that have been paid)	72
Open losses (Losses that have not been paid in full)	0
CWOP losses (Losses that have been closed without payment)	12
Total payments (Total amount paid on losses)	$1,096,751.57

Department of Public Works Municipal Stormwater System Operation and Maintenance

- **Street sweeping** – Every street gets swept by contractor, once a year or as needed.
- **Catch basin cleaning** – All of the Town's approximately 635 catch basins are cleaned out once a year by contractor..

- **Roadway treatments** – The Town uses a 50/50 mixture of sand and salt.

Building Code-Effectiveness Grading Schedule (BCEGS) Score:

BCEGS Evaluation, dated 1/24/2012:

- Class 8 for 1 and 2 family dwellings
- Class 5 for all other construction

Town Regulations and Bylaws

A summary of the Town regulations and bylaws that provide flood mitigation benefits is provided in **Table 5.4** below.

Table 5.4

Regulations and Bylaws That Provide Flood Mitigation

Regulatory Category	Applicable Section	Flood Mitigation Benefit
Subdivision Rules and Regulation and Zoning	Protection of Natural Features	Preserves natural drainage.
	Lot Drainage	Provides adequate drainage for subdivisions.
	Drainage	Provides on-site drainage to avoid off-site flooding. Minimizes flood damage in Zone A.
Zoning Regulations	Flood Control District	Protect public health and safety in the Bennetts Brook area, a low lying area at risk for flooding.
	Flood Plain District	Overlay district for most vulnerable sections of Town, includes FEMA flood zones. Development must meet State Building Codes, Title V, Wetlands Protection Regulations, Inland and Coastal Wetlands Restrictions. The Town references the FIRMS in its zoning bylaw. The bylaw defines its Flood Plain District as special flood hazard areas as identified on the FIRMS for Essex County
	Ground and Surface Water Resource Protection Districts	Overlay district to protect water supplies. Hazardous materials prohibited and spills and discharges must be mitigated.
	Site Plan Approval	Ensures developments will not cause flooding and meets all applicable regulations.
	Open Space Planning Development	Special permit sets aside 30% opens pace and allows higher density on remaining parcels.
	Planned Residential Development	Special permit sets aside 70% open space and allows higher density on remaining parcels.
	Residential Conservation Cluster	Alternate method of subdivision development to save open space, preserve habitat, and reduce stormwater runoff and flooding.
	Stormwater Management Special Permit	Regulates discharges to Town's stormwater infrastructure for projects disturbing more than one acre of land.
General Bylaws	Earth Removal	Permit required for removing > 250 yards of earth.

Regulatory Category	Applicable Section	Flood Mitigation Benefit
	General Wetlands Bylaw	Provides protection for jurisdictional areas under the Massachusetts Wetland Protection Act. Town bylaw includes a more stringent no-build setback of 50 feet and a no-disturb setback of 30-feet within the 100-foot buffer. FIRMS are used to determine the extent of resource areas which are regulated by the state Wetlands Protection Act and local wetlands bylaw. The Conservation Commission enforces these regulations through their permitting.

5.5.2 Wind Hazard Mitigation Measures

Massachusetts State Building Code – The Town 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 high wind 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 Town hires outside contractors on occasion to help with tree maintenance. The electrical utility company National Grid does a full tree inspection of its power line corridors every 3 years and takes down problem trees as needed. The Town's Tree Warden identifies hazardous street trees for pruning or removal. Some of this work is performed by the Town's Department of Public Works; however, removal of large trees is contracted out.

5.5.3 Severe Winter Weather Hazard Mitigation Measures

Snow disposal –The Town conducts general snow removal operations with its own equipment and hires outside contractors as needed. The MassDOT handles snow removal for portions of State Highway Routes 128 and all of Route 127 except for downtown Manchester-by-the-Sea.

5.5.4 Urban and Wildfire Hazard Mitigation Measures

Permits Required for Outdoor Burning – The Fire Department requires a written permit for outdoor burning, which is permitted only between January 1 and April 30. It also issues a number of other permits related to fire safety. Go to http://www.manchester.ma.us/152/Permit-Fees for a list.

Subdivision Review – The Fire Department is involved in reviewing all subdivision plans.

In addition, the Fire Department advises the Planning Board regarding access to new developments for fire trucks and ambulances, location of fire hydrants, and identification of properties that may lie outside the fire hydrant zone.

Members of the Fire Department meet every spring for a state Wildland-Urban Interface workshop. The Fire Chief plans to implement Standard Operating Guidelines (SOP) for all hazards including brush fires.

5.5.5 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. Group II includes buildings that have a substantial public hazard due to occupancy or use and Group III are those buildings having essential facilities that are required for post-earthquake recovery, including fire, rescue and police stations, emergency rooms, power-generating facilities, and communications facilities.

5.5.6 Multi-Hazard Mitigation Measures

There are several mitigation measures that impact more than one hazard. These include the Comprehensive Emergency Management Plan (CEMP), the Massachusetts State Building Code and participation in a local Emergency Planning Committee. A summary of the all hazards mitigation measures are provided in **Table 5.5**.

Comprehensive Emergency Management Plan (CEMP) – Every community in Massachusetts is required to have a CEMP. These plans address mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, dam failures, and winter storms. Therefore, the CEMP is a mitigation measure that is relevant to many of the hazards discussed in this Plan. Manchester updated its CEMP in 2015.

Massachusetts State Building Code- The Massachusetts State Building Code is enforced by the building inspector, including many detailed regulations regarding wind loads, earthquake resistant design, flood-proofing, and snow loads.

Local Emergency Planning –Town staff participate in the Local Emergency Management Planning Committee (LEPC) and the Cape Ann Emergency Planning Team (CAEPT).

Manchester-by-the-Sea has its own Local Emergency Planning Committee, comprised of the Fire Chief who acts as the Town's Emergency Management Director and the Deputy Emergency Management Director. This committee is part of the CAEPT, which holds monthly meetings. Other towns that participate in CAEPT include Essex, Gloucester, Rockport and Ipswich.

Warning System/ Services- The Town has warning systems currently in place. SOPs are planned to ensure each system's proper functions and usage.

- Code Red reverse 911
- Snow Parking Ban - blue lights

Table 5.5

All Hazard Mitigation Measures

Hazard	Area	Mitigation Measure
Flood-Related	Town-Wide	1. The Town participates in the National Flood Insurance Program and adopted the FIRM maps. There are 145 policies in force. The Town actively enforces floodplain regulations. 2. All streets and catch basins (635) are cleaned annually. 3. 50/50 sand/salt mix is used for winter road treatments. 4. Drainage infrastructure performed using MA Chapter 90 funds. 5. Subdivision Rules for drainage 6. Flood Control and Floodplain Overlay Districts 7. Site Plan Review for stormwater and erosion 8. Residential Conservation Cluster for developments over 5 acres or 6 lots 9. Open Space and Planned Residential Developments allowed 10. Ground/Surface Water Resource Districts 11. Stormwater Management regulations are included in the Town's Zoning Bylaw. 12. New *Open Space and Recreation Plan* adopted in 2014 13. Community Preservation Act adopted in 2005 and re-adopted at 1.5% in 2010, 3.0% in 2015, and 1.5% in 2016. 14. Revised Wetlands Bylaw adopted in 2010 15. Revised Wetland Bylaw Regulations adopted in 2013
Dams	Town-Wide	1. DCR Dam Safety Regulations 2. State permits required for dam construction 3. Comprehensive Emergency Management Plan addresses dam safety and was updated in 2015.
Wind-Related	Town-Wide	1. Outside contract for tree trimming 2. National Grid maintains trees within its power line corridors 3. The Town enforces the MA State Building Code.
Winter-Related	Town-Wide	1. Standard snow operations with 50/50 salt/sand mix.
Brush Fire-Related	Town-Wide	1. The Fire Department requires a written permit for outdoor burning. 2. The Fire Department reviews all subdivision development plans.
Geologic-*Earthquake*	Town-Wide	1. The Town enforces the MA State Building Code. 2. Evacuation plans in CEMP 3. Shelters and backup facilities available
Geologic-*Landslide*	Town-Wide	1. Maximum slope for subdivision roads 2. Earth Removal Bylaw
Multi-Hazard	Town-Wide	1. The Town enforces the MA State Building Code. 2. Comprehensive Emergency Management Plan is up to date 3. Town utilizes the MA Emergency Incident Command Unit. 4. Town has Code Red, a form of Reverse 911. 5. Manchester-by-the-Sea is a member of the Region One Boston Network (BAPERN). 6. The Town has its own Local Emergency Planning Committee and is a member of the Cape Ann Emergency Planning Team. 7. Fire Station has a fixed, diesel generator. Police Station has a fixed, diesel generator. 8. Multi department review of all developments.

SECTION 6

MITIGATION STRATEGY

The Mitigation Strategy is the most important part of the Hazard Mitigation Plan. It serves as the blueprint for reducing the potential losses identified in the risk assessment. The Mitigation Strategy includes goals, mitigation actions, and an action plan for implementation. This provides a framework to identify, prioritize and implement actions to reduce risks to hazards. Section 6 reviews the mitigation strategy created in 2011 and outlines a mitigation strategy for Manchester-by-the-Sea for the next five years.

Section 6
MITIGATION STRATEGY

6.1 Mitigation Goals and Objectives

C3 a b

D3 a

The Planning Team reviewed and updated the 2012 Hazard Mitigation Plan Goals. The 2017 Hazard Mitigation Plan includes specific plan goals objectives and addresses additional community assets including the environment, economy and cultural facilities.

Table 6.1

Hazard Mitigation Plan Goals and Objectives

Mitigation Goals	Mitigation Objectives
1. Reduce the potential for loss of life and damages to property, public infrastructure, and environmental, cultural, and economic resources in Manchester-by-the-Sea resulting from natural disasters.	1. Protect Manchester-by-the-Sea residents, businesses, visitors, property, critical facilities, infrastructure, economy, and natural resource through implementation of cost effective and feasible hazard mitigation projects
2. Mitigate repetitive damage caused by natural hazards.	2. Identify and seek funding for measures to implement hazard mitigation actions identified in the 2017 Hazard Mitigation Plan
3. Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea	3. Ensure that future development meets federal, state, and local standards for preventing and reducing the impacts of natural hazards including impacts due to climate change on natural and historic resources
4. Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.	4.Encourage the business community and local agencies representing vulnerable populations to work with the Town to develop, review, and implement the hazard mitigation plan. Take maximum advantage of resources from FEMA and MEMA to educate Town staff and the public about hazard mitigation
5. Ensure individual safety, reduce damage to public buildings and ensure continuity of emergency services	5.Build and enhance local mitigation capabilities and increase the resilience of critical facilities and infrastructure so that it is capable of withstanding the impacts of natural hazards
6. Work with surrounding communities, state, regional, and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities	6.Communicate local hazard mitigation planning activities with surrounding communities, the Cape Ann Emergency Management Team, and MEMA to ensure regional cooperation and solutions for hazards affecting multiple communities

Mitigation Goals	Mitigation Objectives
7. Identify adaption priorities to address impacts of climate change and incorporate these into existing and future projects and policies.	7.Develop and prioritize adaptation strategies to decrease the vulnerability of municipal infrastructure to the stresses of climate change as the science evolves

C4 abc

6.2 Mitigation Actions

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.

Hazard mitigation measures can generally be sorted into 6 categories, according to FEMA's Local Multi-Hazard Mitigation Planning Guidance:

1. Prevention: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built, and direct public activities to reduce hazard losses. Examples include planning and zoning, building codes, capital improvement programs, open space preservation, and stormwater management regulations.
2. Property Protection: Modification or removal of existing buildings or infrastructure to protect them from a hazard. Examples include acquisition, elevation, relocation, structural retrofits, flood proofing, storm shutters, and shatter resistant glass.
3. Public Education and Awareness: Actions to inform and educate citizens, elected officials, and property owners about the potential risks from hazards and ways to mitigate them. Such actions include outreach projects, real estate disclosure requirements, hazard information centers, and school-age and adult education programs.
4. Natural Resource Protection and Green Infrastructure: Actions that, in addition to minimizing hazard losses, preserve or restore the functions of natural systems. These actions include low impact development, sediment and erosion control, stream corridor restoration, watershed management, urban forest and vegetation management, and wetland restoration and preservation.
5. 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.
6. 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.

Funding to implement hazard mitigation projects may come from a variety of federal, state, and local sources. FEMA currently has 3 mitigation grant programs: the Hazards Mitigation Grant Program (HGMP), the Pre-Disaster Mitigation program (PDM), and the Flood Mitigation Assistance (FMA) program. The 3 links below provide additional information on these programs.

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

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

Other potential funding sources include the Massachusetts Coastal Zone Management, Massachusetts Executive Office of Energy and the Environmental Dam and Seawall Removal and Repair Fund, Massachusetts State Revolving Funds, U.S. Army Corps of Engineers, and the Small Business Administration.

6.2.1 Progress on Prior Actions

D2a

The Planning Team reviewed the 2012 Mitigation Actions to determine what progress had been made towards implementation. **Table 6.2** provides an update on all previous mitigation actions including the description, responsible department, implementation status, and comments to describe the status. Of the 28 mitigation actions from the 2012 Hazard Plan, 19 are still in progress or are an existing capability, 6 were completed or deleted, and 3 were deferred but were retained in the Plan for potential reactivation in the next 5-year Plan Update (2022).

D2a

Table 6.2
Review of 2012 Mitigation Actions

Hazard(s) to Mitigate	Action Item # and Description	Responsible Department	Status: Completed/ Existing Capability/ In Progress/ Deferred/ Deleted	Explanation of Status
Flooding	#1- Survey, design and implement comprehensive downtown/central Manchester-by-the-Sea drainage and stormwater action plan.	DPW/MA DOT	In Progress	Under a 2015 CZM Coastal Resiliency (CR) Grant, a plan for flood mitigation within Sawmill Brook was completed, which included the following: modeling coastal and inland flooding under current and future conditions, evaluating culvert capacities, and developing conceptual mitigation projects throughout the watershed. Survey of the downtown drainage system and conceptual design of green infrastructure upgrades was completed under a 2015 CZM Coastal Pollution Remediation (CPR) Grant. More work is needed to complete the design and implementation of the mitigation projects. Projects recommended for the 5-year planning period have been included as mitigation actions within this Hazard Mitigation Plan Update (see Table 6-2).
Dams and Culverts	#2- Include the enlargement or replacement of the Sawmill Brook Dam as part of the overall downtown drainage plan.	DPW	Completed	Under the 2015 CZM CR Grant, alternatives to enlarge or replace Sawmill Brook dam and tide gate were evaluated.
Dam and Culvert Failure	#3- Replace Sawmill Brook Culvert (at Central Street) and bridge deck	DPW/MA DOT	In Progress	Under the 2015 CZM CR Grant, alternatives to enlarge or replace Sawmill Brook dam and tide gate were evaluated. Tasks to advance design to the permitting level have been added as a new project in Table 6-2.

Hazard(s) to Mitigate	Action Item # and Description	Responsible Department	Status: Completed/ Existing Capability/ In Progress/ Deferred/ Deleted	Explanation of Status
Flooding	#4- Include Old Essex Road in the overall downtown drainage plan	DPW	In Progress	Old Essex Road is part of the Sawmill Brook watershed and was included in the 2015 CZM CR Grant study, although no specific projects have been identified to alleviate flooding in that neighborhood.
Flooding	#5- Include School Street in overall downtown drainage plan	DPW	In Progress	Under a 2015 CZM CR Grant, culvert capacity and alternatives to mitigate existing and future flooding were evaluated. Culvert improvements were identified and included as a new project in Table 6-2.
Flooding	#6-Install sewer cut-off at intersection of School and Brook Street	DPW/MA DOT	In Progress	This project will be revised to included I/I improvements during implementation of School Street culvert improvements.
Flooding	#7- Include Sewage Treatment Plant in overall downtown drainage plan.	DPW/MA DOT	Deleted	The Sewage Treatment plant is within the Sawmill Brook Watershed, but was not specifically included in the 2015 CZM CR Grant study. It has been identified as a vulnerable asset under the HMP Enhancement and was also a pilot project for the EPA's The Climate Resilience Evaluation and Awareness Tool (CREAT), which identified issues with the resiliency of the plant. This high priority project will be addressed separately and new projects to improve resiliency of the facility have been added to Table 6-2.
Flooding	#8- Make improvements to Sawmill Brook drainage system	DPW	In Progress	Based on the 2015 CZM CR Grant findings, 3 proposed projects on Sawmill Brook have been identified as high priority: removal of tide gate at Central Street and culvert enlargement plus enlargement of two upstream culverts at School Street and Norwood Ave. The Town is actively pursuing technical assistance and funding to perform additional studies needed for permitting. The 3 projects have been separated as individual mitigation actions in Table 6-2 as revised projects #3, #5 and #8.

Hazard(s) to Mitigate	Action Item # and Description	Responsible Department	Status: Completed/ Existing Capability/ In Progress/ Deferred/ Deleted	Explanation of Status
Flooding	#9- Include Blue Heron Lane in overall drainage plan.	DPW/MA DOT	In Progress	Blue Heron Lane is part of the Sawmill Brook watershed and was included in the 2015 CZM CR Grant study, although no specific projects have been identified to alleviate flooding in that neighborhood.
Flooding	#10- Survey, design and implement comprehensive downtown/central Bennetts Brook watershed drainage and stormwater action plan for Bennetts Brook neighborhood.	DPW	In Progress	The Town is enforcing zoning bylaws and repairing infrastructure to help mitigate periodic flooding, however a comprehensive stormwater action plan is still needed.
Flooding	#11- Purchase six additional portable water pumps for the DPW Departments: (1) 6-inch, (1) 4-inch, and Fire Department: (3) 1.5-inch, (1) 2.5-inch	DPW/Fire Department	In Progress	The DPW has not yet purchased new water pumps. The Fire Department has purchased 2-1.5" electric pumps and 2-2" gasoline powered pumps.
All Hazards	#12- Complete update of Manchester-by-the-Sea Open Space and Recreation Plan	Conservation Commission	Completed	The new Open Space and Recreation Plan was completed and accepted by the State in 2014 and will be valid for 7 years (2021).
All Hazards	#13- Acquire priority open space parcels.	Community Preservation Committee/Conservation Commission	In Progress	The Town worked with the owner of the Manchester Athletic Club to donate/purchase land abutting the club, putting a portion of it in Conservation and another portion towards Town playing fields. Although, the Town didn't receive the parcels, a portion (30 acres) was given to the Trustees of Reservations since it abuts another one of their properties. Other parcels are being identified by the Open Space and Recreation Committee for protection including areas within flood zones.
Winter Storms	#14- Purchase two new snow blowers and one sidewalk plow.	DPW	Completed	All have been purchased.

Hazard(s) to Mitigate	Action Item # and Description	Responsible Department	Status: Completed/ Existing Capability/ In Progress/ Deferred/ Deleted	Explanation of Status
Fire	#15- Purchase two new pumper trucks and 6,000 feet of new 4-inch hose.	Fire Department	In Progress	Equipment no longer recommended
High Winds	#16- Purchase new bucket truck and tub grinder for tree maintenance.	DPW	Deleted	A decision by DPW was made to not purchase the bucket truck or tub grinder for tree maintenance. The Town contracts this work out.
Fire	#17- • A new multi-role mini-pumper capable of urban, wildland urban interface (WUI), and wildland operations. • 3000 feet of new 4-inch hose. • 1000 feet of new 1.5-inch light-weight forestry hose. • A new portable, floating pump. • Three wildland chain saws • A variety of hand tools and back-pack pumps. • A forestry skid unit for the FD's existing utility pickup truck.	Fire Department	In Progress- Updated Description	Brush fire equipment is old and needs to be upgraded. The new equipment continues to be a high priority need. (Note that the Mitigation Action description was modified to provide clarification of the equipment needed).
All Hazards	#18- Purchase and install fixed, multi-fuel generators for backup power at Memorial School, and DPW building. Upgrade Police Station generator to serve both Police and Town Hall. Upgrade Fire Station generator.	School District/Fire Department/ DPW/ Police Department	In Progress	Fire Department: The generator was not upgraded but electrical panel upgrades occurred to power more circuits when on generator power. All other generator upgrades are still needed.
All Hazards	#19- Install 480-phase backup generators at sewage pump stations.	DPW	In Progress	DPW has plans to install backup generators at 3 pump stations when they are rebuilt in the summer of 2017.

Hazard(s) to Mitigate	Action Item # and Description	Responsible Department	Status: Completed/ Existing Capability/ In Progress/ Deferred/ Deleted	Explanation of Status
All Hazards	#20- Acquire one, trailer-mounted, single-phase, 10 Kw generator for the Fire Department. Acquire four, 3-5 Kw, trailer mounted generators.	Fire Department	Deleted	Equipment no longer recommended
All Hazards	#21- Develop a reliable and modern radio and dispatch system for the DPW, Police Dept, and Fire Dept	Police/Fire/DPW	In Progress/ Updated Description	An improved emergency communication system continues to be a priority; Fire Dept is taking the lead with Police. DPW now depends on cell phones.
		MEDIUM PRIORITY		
Flooding	#22- Create more resources for more frequent maintenance of Town-owned drainage facilities such as more frequent catch basin cleaning and replacement, culvert replacement, stormwater attenuation and treatment.	DPW	Existing Capability* See Explanation of Status	To comply with the 2016 USEPA NPDES Small Municipal Separate Storm Sewer System general permit, the Town cleans catch basins annually and tracks the amount of material removed. DPW has performed repairs on these structures over the past few years. This was not carried over into the HMP as the requirements are covered by the NPDES small MS4 permit
Flooding	#23- Continue to implement requirements for Raymond Street Title V Inspections and upgrades	DPW/BOH	In Progress/ Updated Description	The Town is not investigating connecting the existing septic systems into Gloucester's sewage treatment; however, the Town is requiring residents to have Title V Inspections (first phase is underway) and is offering a state loan program for septic replacement at 4% for 20 years.
Flooding	#24- Determine options for preventing street washout by ocean surge and tidal flooding on Ocean Street.	DPW	Deferred	No action has been taken.
Flooding	#25- Install roadside berms and additional catch basins on Highland Ave.	DPW	Deferred	No action has been taken.

Hazard(s) to Mitigate	Action Item # and Description	Responsible Department	Status: Completed/ Existing Capability/ In Progress/ Deferred/ Deleted	Explanation of Status
Flooding	#26- Provide Public Information on NFIP Compliance	DPW/Conservation Office	Existing Capability	Conservation and Planning have taken the lead in providing FEMA flood map information to residents. Information on NFIP has been made available at Town Hall to residents.
Flooding	#27- Update town Flood Information Rate Maps (FIRM) maps and update the town bylaw as needed.	Planning	Completed	The Town adopted new FEMA FIRMs (dated July 16, 2014) and amended Town zoning bylaws accordingly.
		LOW PRIORITY		
Earthquakes	#28- Investigate options to make all public safety buildings earthquake resistant.	Fire Department	Deferred	No action has been taken.

Projects **In Progress or Existing Capabilities** have been included in Future Actions Table

Projects that have been **Deferred** will be included on a separate list with instruction to revisit as part of the 2022 update

Projects that have been **Deleted or Completed** are removed from the Future Action Table

6.2.2 Mitigation Action and Adaptation Strategy for 2017

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The Planning Team developed a revised Mitigation Action Plan for the 2017 Plan. The revised plan includes 19 projects carried over from the 2012 Plan many of which were substantially revised, 12 adaptation projects for the most vulnerable sites and facilities identified in the vulnerability risk assessment described in **Section 5** and 11 new projects identified by Town department staff members. The completed list of 42 projects was reviewed and refined by members of Town staff who would have a lead role in implementing the action.

The goal of the Plan is to reduce Manchester-by-the-Sea's vulnerability to hazards, and by selecting and implementing the most costs effective mitigation actions the Town will be on the road toward implementing that goal. The Planning Team completed a Risk and Benefit Assessment to prioritize the most cost effective mitigation actions, as described in section 6.2.3 below.

6.2.3 Benefit Cost Review Methodology

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The cost benefit review is the first step in completing a prioritization of mitigation projects. FEMA does not dictate how the cost benefit review is completed, however it is a required element for the plan. For the Manchester-By-the-Sea HMP, we based the benefit cost review on the FEMA STAPLEE method. STAPLEE is a cost/benefit analysis tool that includes considerations for **S**ocial, **T**echnical, **A**dministrative, **P**olitical, **L**egal, **E**nvironmental and **E**conomic issues.

In its simplest application, the STAPLEE method consists of a table where actions (and mitigation options) are shown along the vertical axis and the STAPLEE categories along the horizontal axis (see inset below). Each action is analyzed per the categories in STAPLEE and a mark is placed in each category that the action affects in a positive way. The action with the most marks achieves a higher priority.

For Manchester's HMP, the basic STAPLEE basic method was modified to allow for a more detailed evaluation accounting for both **benefits** and **costs** and reflects the types of mitigation actions being considered for Manchester-by-the-Sea. For many of the criterion values, a range of scores were assigned. **Table 6.3** below, includes the values that were considered for each STAPLEE criteria and potential scores. A final score for each mitigation action was tabulated as the sum of the cost score and the benefit score.

STAPLEE Criteria	S (Social)		T (Technical)			A (Administrative)			P (Political)			L (Legal)			E (Economic)				E (Environmental)				
Considerations → for Alternative Actions ↓	Community Acceptance	Effect on Segment of Population	Technical Feasibility	Long-term Solution	Secondary Impacts	Staffing	Funding Allocated	Maintenance/ Operations	Political Support	Local Champion	Public Support	State Authority	Existing Local Authority	Potential Legal Challenge	Benefit of Action	Cost of Action	Contributes to Economic Goals	Outside Funding Required	Effect on Land/ Water	Effect on Endangered Species	Effect on HAZMAT/ Waste Sites	Consistent with Community Environmental Goals	Consistent with Federal Laws

Table 6.3
STAPLEE Benefit Cost Review: Criteria, Considered Values and Rating Scores

	COSTS		BENEFITS	
	Cost Values	**Cost Rating Scores**	**Benefit Values**	**Benefit Rating Scores**
Social	Adversely Affects Segment of the Population or Community Values	-3=yes -2=maybe -1=no	Benefits a Large Segment of the Population	3=large 2=med 1=small
Technical	Years to Implement Project	-1=1 year -2= 2-3 years -3= 4 or more	Easy to Implement with Local Resources	3= yes
Administrative	Operations and Maintenance $$ Required	-3=high -2=med -1=low or none	Sufficient Staffing Available	3=yes 2=maybe 1=no
Political	Public Opposition	-3=high -2=med -1=low	Local Champion-Politically Acceptable	3= yes
Legal	Action Potentially Subject to Legal Challenge	-3 Subject to legal challenge	Existing Local Authority to Implement	3= state or local authority
Economic	Approximate Cost	$=$5,000-$25,000 $$= $25,000-$100,000 $$$ = $100,000-$500,000 $$$$= >$500,000	Funding Available	3= yes
Environmental	Adverse Environmental Impacts	-3=high -2=med -1=low	Other Community Goals Achieved	3=yes

Once a total cost benefit rating score was calculated for each mitigation action, all of the mitigation actions were ranked as high, medium and low priority for implementation by hazard category based on the range of scores for each hazard.

Table 6.4 includes the revised mitigation actions and adaptation projects sorted by type of hazard including the total benefit cost rating score and final overall ranking.

Table 6.4
2017 Mitigation Action Plan

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
All Hazards	**#21-** Develop a reliable and modern radio and dispatch system for the DPW, Police Dept, and Fire Dept	FEMA Grants, Town Budget for 25% match	$$$	year 1	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvements Plan. Emergency Management Plan	11	High
All Hazards	**#18B-** Upgrade Fire Department Emergency Generator	FEMA Grants, Town Budget for 25% match	$$	years 1-2	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvements Plan, Emergency Management Plan	11	High
All Hazards	**#18A-** Upgrade Town Hall Emergency Generator	FEMA Grants, Town Budget for 25% match	$$	years 1-2	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvements Plan, Emergency Management Plan	9	High
All Hazards	**#11-** Purchase six additional portable water pumps. (1) 6-inch and (1) 4-inch for the DPW. (3) 1.5-inch and (1) 2.5-inch for the Fire Department.	Grants, Town Budget for 25% match	$$	years 3-5	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvements Plan, Emergency Management Plan	9	High

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
All Hazards	**#18C-** Purchase and install fixed, multi-fuel generators for backup power at Memorial School, and DPW building	FEMA Grants, Town Budget for 25% match	$$	year 1	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvements Plan, Emergency Management Plan	9	High
All Hazards	**#19-** Purchase and install 480-phase backup generators at sewage pump stations.	FEMA Grants, Town Budget for 25% match	$$	year 1	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvements Plan, Emergency Management Plan	9	High
All Hazards	**#13-** Acquire priority open space parcels or secure protection through conservation easements/restrictions.	Community Preservation Funds, Grants, Town Budget for 25% match	$$$	years 1-5	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Open Space Plan, Master Plan	7	Medium
All Hazards	**NEW** Designate evacuation pick up points	Town Budget	$	years 1-2	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Emergency Management Plan	6	Medium
All Hazards	**NEW** Continue to document information on the location, history, extent and impact of natural hazards in MBTS	Town Budget	$	years 1-5	Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.	Master Plan, Hazard Mitigation Plan	5	Low

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
All Hazards	**NEW** Create a floor plan that indicates where essential Department records are located	Town Budget	$	years 2-3	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Emergency Management Plan	5	Low
All Hazards	**NEW** Develop steps to mitigate damage to records in advance of a storm	Town Budget	$	years 3-4	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Emergency Management Plan	5	Low
All Hazards	**NEW** Provide business community with education on how to maintain structures/buildings to support a resilient economy in the downtown area	FEMA Grants, Town Budget for 25% match	$	years 1-5	Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.	Master Plan	5	Low
All Hazards	**NEW** Pre-plan a rapid assessment of post storm structure damages	Town Budget	$	years 4-5	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Emergency Management Plan	4	Low
Coastal Erosion and Shoreline Change	**NEW** Develop Sediment Transport Management Plan for Town Beaches	Grants, Town Budget for 25% match	$$	years 2-5	Identify adaption priorities to address impacts of climate change and incorporate these into existing and future projects and policies.	Harbor Master Plan	7	High

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Coastal Erosion and Shoreline Change	**NEW** Identify improvements needed for seawalls, docks and piers with prioritization for funding	EOEA Seawall Repair Fund, Seaport Economic Council, Town Budget for 25% match	$$	years 1-3	Mitigate repetitive damage caused by natural hazards.	Capital Improvements Plan, Master Plan	5	Medium
Coastal Erosion and Shoreline Change	**NEW** Fund improvements for identified seawalls and bulkheads at risk, including those in Manchester Harbor and Beach Street (along Reed and Masconomo Park)	FEMA Grants, Town Budget for 25% match	$$$$	years 2-5	Mitigate repetitive damage caused by natural hazards.	Capital Improvements Plan, Master Plan	4	Medium
Coastal Erosion and Shoreline Change	**NEW** Design, Permit and Construct Parking Lot LID Retrofit at Singing Beach	NOAA Grants, Town Budget for 25% match	$$$	years 2-4	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Capital Improvements Plan	3	Low

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Dam and Culvert Failure	**#3 REVISED -** Complete final design and permitting for Central Street culvert replacement Tidegate removal	Grants, MassDOT, EEA Seawall and Dam Removal Fund	$$$	years 1-3	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Sawmill Brook Watershed Plan	4	High
Dam and Culvert Failure	**#3A NEW -** Obtain funding for construction of Central Street Culvert and Tidegate replacement	Grants, MassDOT, EEA Seawall and Dam Removal Fund	$$$$	years 2-3	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Sawmill Brook Watershed Plan	4	High
Dam and Culvert Failure	**#5 REVISED -** Complete final design and permitting for School Street culvert upgrades	Grants, MassDOT, EEA Seawall and Dam Removal Fund	$$$	years 2-4	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Sawmill Brook Watershed Plan	3	Medium
Dam and Culvert Failure	**#8 REVISED-** Complete final design and permitting for Norwood Ave culvert upgrades	Grants, MassDOT, EEA Seawall and Dam Removal Fund	$$$	years 3-5	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Sawmill Brook Watershed Plan	2	Medium

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Fire	**#17 REVISED**- Purchase equipment: •New multi-role mini-pumper capable of urban, wildland urban interface (WUI), and wildland operations. • 6000 feet of new 4-inch hose. • 1000 feet of new 1.5-inch light-weight forestry hose. • New portable, floating pump. • Three wildland chain saws • Variety of hand tools and back-pack pumps. • Forestry skid unit for the FD's existing utility pickup truck.	Grants, Town Budget for 25% match	$$$$	years 2-4	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvement Plan, Emergency Management Plan	10	High
Flooding	**#26-** Provide Public Information on NFIP Compliance	Town Budget	$	year 1	Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.	Master Plan	12	High

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Flooding	**NEW** Complete WWTP elevation survey for adaptation projects	FEMA Grants, Town Budget for 25% match	$$	years 1-2	Reduce the potential for loss of life and damages to property, public infrastructure, and environmental, cultural, and economic resources in Manchester-by-the-Sea resulting from natural disasters.	Wastewater Facilities Plan	9	High
Flooding	**NEW** Develop costs and prioritize stormwater harbor outfall retrofits for implementation	CZM Coastal Pollution Remediation Grants, Town Budget for 25% match	$	year 2	Mitigate repetitive damage caused by natural hazards.	Harbor Master Plan, Master Plan	9	High
Flooding	**#1 REVISED-** Complete Baseline Assessment for Culvert Improvements at Sawmill Brook from Central Street to Norwood Ave	FEMA Grants, Town Budget for 25% match	$$	year 1	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Master Plan	8	High
Flooding	**#6 REVISED-** Include sewer I/I improvements in upgrades to culvert and roadway improvements at School Street	FEMA Grants, Town Budget for 25% match	$$$	year 5	Mitigate repetitive damage caused by natural hazards.	Wastewater Facilities Plan, Capital Improvement Plan	8	High

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Flooding	**NEW** Encourage MassDOT to complete a drainage survey and retrofit feasibility evaluation for areas that flood along Route 127 and to evaluate improvements for a section of Bridge Street (Route 127) near Beverly city line (at Chubb Creek)	MassDOT	Funded by Mass DOT	years 2-4	Mitigate repetitive damage caused by natural hazards.	Master Plan	8	High
Flooding	**NEW** Evaluate and implement flood proofing mitigation measures for Town Hall and Emergency Operations including the Fire Station	FEMA Grants, Community Preservation Funds	$$$	years 1-3	Reduce the potential for loss of life and damages to property, public infrastructure, and environmental, cultural, and economic resources in Manchester-by-the-Sea resulting from natural disasters.	Emergency Management Plan, Master Plan	7	Medium
Flooding	**NEW** Improve Fire Department Parking Drainage	FEMA Grants, Town Budget for 25% match	$$	year 1	Ensure individual safety, reduce damage to public buildings, and ensure continuity of emergency services.	Capital Improvement Plan	6	Medium

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Flooding	**#3C NEW -** Obtain funding for restoration of Central Street Pond and Sawmill Brook to School Street	Grants, MassDOT, EEA Seawall and Dam Removal Fund	$$$$	years 3-5	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Sawmill Brook Watershed Plan	5	Medium
Flooding	**NEW** Explore adopting stricter building code construction requirements in flood prone areas.	Town Budget	$	years 2-5	Reduce the potential for loss of life and damages to property, public infrastructure, and environmental, cultural, and economic resources in Manchester-by-the-Sea resulting from natural disasters.	Master Plan	5	Medium
Flooding	**#4 REVISED-** Revisit watershed model to refine neighborhood solutions for Old Essex Rd. neighborhood	Grants, MassDOT, Community Preservation Funds	$$	year 2-5	Mitigate repetitive damage caused by natural hazards.	Capital Improvements Plan	4	Medium
Flooding	**#9 REVISED-** Revisit watershed model to refine neighborhood solutions for Blue Heron Lane neighborhood	Grants, MassDOT, Community Preservation Funds	$$	year 2-4	Mitigate repetitive damage caused by natural hazards.	Capital Improvements Plan	4	Medium

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Flooding	**#3B NEW -** Complete final design and permitting for Central Street Pond and Sawmill Brook restoration	Grants, MassDOT, EEA Seawall and Dam Removal Fund	$$	years 2-4	Ensure that mitigation measures are sensitive to the natural features, historic resources, and the community character of Manchester-by-the-Sea.	Sawmill Brook Watershed Plan	3	Low
Flooding	**#23-** Continue to implement requirements for Raymond Street Title V Inspections and upgrades	State loan program for septic replacement at 4% for 20 years	$$	years 1-5	Mitigate repetitive damage caused by natural hazards.	Comprehensive Water Management Plan	2	Low
Flooding	**NEW** Assess the Ocean Street area to understand impacts to residential structures, roads, culverts and sea walls. Create a draft mitigation plan.	CZM Coastal Resiliency Grants, Town Budget for 25% match	$$	year 2-5	Mitigate repetitive damage caused by natural hazards.	Master Plan	2	Low
Flooding	**NEW** Assess the Raymond St/Butler Ave area to understand impacts to residential structures, roads, culverts and sea walls. Create a draft mitigation plan.	CZM Coastal Resiliency Grants, Town Budget for 25% match	$$	year 2-5	Mitigate repetitive damage caused by natural hazards.	Master Plan	2	Low

Hazard	Mitigation Action #	Funding Source	Approximate Cost	Timeframe	Consistency with Mitigation Goals	Consistency with other Town Plans	Benefit Cost Review Rating	Priority Ranking
Flooding	**#10-** Survey, design and implement comprehensive downtown/central Bennetts Brook watershed drainage and stormwater action plan for Bennetts Brook neighborhood.	MassDOT, Grants, Town Budget for 25% match	$$	years 3-5	Mitigate repetitive damage caused by natural hazards.	Capital Improvement s Plan	0	Low
Nor'easters, Flooding, Hurricane/ Tropical Storms, Severe Winter Weather	**NEW** Continue to discuss benefits of surge barrier as an aggressive mitigation effort to prevent flooding in downtown Manchester-by-the-Sea	NOAA Grants, Town Budget for 25% match	$	years 2-5	Identify adaption priorities to address impacts of climate change and incorporate these into existing and future projects and policies.	Harbor Master Plan, Master Plan	13	High
Nor'easters, Flooding, Hurricane/ Tropical Storms, Severe Winter Weather	**NEW** Educate the public about MEMA's "Know Your Zone" Campaign and sheltering in place	Town Budget	$	years 2-3	Increase public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.	Emergency Management Plan	10	Medium
Nor'easters, Flooding, Hurricane/ Tropical Storms, Severe Winter Weather	**NEW** Obtain solar traffic notification system to alert detour routes	FEMA Grants, Town Budget for 25% match	$$	years 1-2	Work with surrounding communities, state, regional, and federal agencies to ensure regional cooperation and solutions for hazards affecting multiple communities.	Emergency Management Plan	9	Low

Projects that were continued from the 2012 Plan are coded to reflect the 2012 action item # and whether the project was revised (i.e**. #3 REVISED**) from the original description.

Projects that were identified from research on resiliency and community need are coded as **NEW.**

6.3 Project Timeline for 2017 Mitigation Actions

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Table 6.2 includes 18 projects ranked with a high priority, 12 with a medium priority and 12 with a lower priority for all hazard categories. Although all of the projects are important to the town, the high priority projects are summarized below relative to recommended timing of the individual mitigation actions. The town has identified its Capital Improvement Plan, Comprehensive Wastewater Management Plan, Harbor Master Plan, Town Master Plan, Open Space Plan and Emergency Management Plan as mechanisms to integrate mitigation actions over the next five years.

Five high priority mitigation actions are identified for year one including:

- Develop a reliable and modern radio and dispatch system for the DPW, Police Dept, and Fire Dept
- Purchase and install fixed, multi-fuel generators for backup power at Memorial School, and DPW building
- Purchase and install 480-phase backup generators at sewage pump stations
- Provide Public Information on NFIP Compliance
- Complete Baseline Assessment for Culvert Improvements at Sawmill Brook from Central Street to Norwood Ave

Five high priority projects are identified to begin in year one requiring 2 or more years to complete include:

- Upgrade Town Hall Emergency Generator
- Upgrade Fire Department Emergency Generator
- Complete final design and permitting for Central Street culvert replacement Tidegate removal
- Complete WWTP elevation survey for adaptation projects
- Evaluate and implement flood proofing mitigation measures for Town Hall and Emergency Operations including the Fire Station

Six high priority projects identified to begin in year two include:

- Purchase Fire Equipment listed in project #17
- Develop Sediment Transport Management Plan for Town Beaches
- Obtain funding for construction of Central Street Culvert and Tidegate replacement
- Develop costs and prioritize stormwater harbor outfall retrofits for implementation
- Encourage MassDOT to complete a drainage survey and retrofit feasibility evaluation for areas that flood along Route 127 and to evaluate improvements for a section of Bridge Street (Route 127) near Beverly city line (at Chubb Creek)
- Continue to discuss benefits of surge barrier as an aggressive mitigation effort to prevent flooding in downtown Manchester-by-the-Sea

Two high priority projects identified to begin in three to five years include:

- Purchase six additional portable water pumps:
    - (1) 6-inch and (1) 4-inch for the DPW
    - (3) 1.5-inch and (1) 2.5-inch for the Fire Department
- Include sewer I/I improvements in upgrades to culvert and roadway improvements at School Street

6.4 Continued Compliance with NFIP

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The town continues to enforce required elements of the National Flood Insurance Program so that the Town may continue to participate in the program including:

- Issuing or denying floodplain development/ building permits
- Inspecting all development to assure compliance with the local floodplain zoning by-law
- Maintaining records of floodplain development
- Assisting in the preparation and revision of floodplain maps
- Helping residents obtain information on flood hazards, floodplain map data, flood insurance and proper construction measures.

The Town periodically reviews the zoning by-law for consistency, and uses the most recent FIRM data to determine base flood elevation or the best available scientific data for determinations of base flood elevation if no FIRM data is available to achieve a reasonable measure of flood protection.

6.5 Changes in Priority from 2012 to 2017

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While flooding continues to be the number one priority for Manchester-by-the-Sea, the 2017 risk and vulnerably analysis have shifted priorities to include addressing the full range of identified natural hazards. Climate change was considered in relation to inland and coastal flooding and adaptation projects were recommended based on potential inundation related to storm surge, sea level rise and extreme precipitation. Mitigation projects were included for the following natural hazards that were not part of the 2012 Plan:

- Coastal Erosion and Shoreline Change
- Nor'easters, Flooding, Hurricane/ Tropical Storms, Severe Winter Weather

6.6 Resiliency Vision for Manchester-by-the-Sea

Manchester-by-the-Sea is a forward-thinking community and recognizes climate change as a factor that will change weather patterns, flooding extent, habitat and species distribution, and ultimately impact its ability to recover from disaster and risk to the economic well-being of the Town. The Town’s Master Planning, Open Space and Capital Improvement Plans all include specific goals and objectives recognizing the need to plan for and adapt to natural hazards affected by climate change, thus improving the resiliency of the Town.

A resiliency vision for Manchester-by-the- Sea includes empowering the residents, business community and Town Leaders to make near, mid and long term changes that will reduce future climate change impacts, protect its vital community assets, and adapt to changes already occurring. The mitigation actions included in the 2017 Hazard Mitigation Plan complement and support this resiliency vision.

SECTION 7

PLAN EVALUATION AND MAINTENANCE

Once the 2017 Manchester-by-the-Sea is adopted by the Board of Selectmen, the plan enters into a five-year "maintenance" phase. Section 7 describes how the Manchester-by-the-Sea Hazard Mitigation Plan will be evaluated, updated and enhances over the next five years.

Section 7
Plan Evaluation and Maintenance

7.1 Who is Involved?

Each department identified in the Manchester-by-the-Sea Hazard Mitigation Plan is responsible for implementing specific mitigation actions detailed in the Mitigation Actions section of the plan (Section 6). Every proposed action listed in the Future Mitigation Action section is assigned to a specific "lead" department as a way to assign responsibility and accountability and increase the likelihood of subsequent implementation. Annual presentation to the Board of Selectmen will enable specific actions to be modified, if needed, rather than wait until the 5-year update, allowing adaptation projects to evolve in a more timely manner as circumstances dictate.

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Manchester-by-the-Sea's Town Administrator, Greg Federspiel, will be responsible for ensuring that the Plan is monitored, evaluated, and updated throughout the next 5 years.

7.2 How Will the Plan be Maintained?

The following activities describe how the plan will be maintained and updated over the next 5 years:

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- Plan Monitoring:

  Members of the Planning Team will meet annually to discuss the implementation status of each Mitigation Action identified in Section 6, noting accomplishments, challenges, and recommended modifications to identified actions. During these meetings, the Planning Team will also describe and document any new hazard data that can be incorporated in the Hazard Profile section of the Plan, noting any new hazard location, extent, and impact.

  After the annual meeting, members of the Planning Team will update the Board of Selectmen on the implementation status of Mitigation Actions and an evaluation of the appropriateness of the actions, noting any changes warranted. The Board of Selectmen can vote to adopt the change and amend the Hazard Mitigation Plan.

- Plan Evaluation:

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  A sub-committee of the Planning Team will meet annually to evaluate the purpose and goals of the Hazard Mitigation Plan to ensure the Plan continues to serve its purpose. The annual review will include the following activities:

  - Review the Mitigation Goals in the 2017 Manchester-by-the-Sea Hazard Mitigation Plan
  - Discuss recent activities to reduce loss of life and property such as grants received/applied for and any completed Mitigation Actions
  - Discuss ongoing or recent planning efforts that are consistent with the Mitigation Goals and Actions of the 2017 Manchester-by-the-Sea Hazard Mitigation Plan

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- Plan Update:

The 2017 Manchester-by-the-Sea Hazard Mitigation Plan will be reviewed and updated every 5 years to ensure there is no lapse in Plan coverage. The Plan update process will be scheduled one to one and a half years before the Plan is set to expire.

7.3 When Will the Plan be Maintained?

A start date and time periods were assigned to each Mitigation Action in Section 6 to assess whether actions are being implemented in a timely fashion. Also, the Planning Team will meet annually to discuss progress on Mitigation Actions.

Following a disaster declaration, the 2017 Manchester-by-the-Sea Hazard Mitigation Plan will be revised as necessary to reflect lessons learned or to address specific issues and circumstances arising from the event. It will be the responsibility of the Town Administrator to reconvene the Planning Team and ensure that appropriate stakeholders are invited to participate in the plan revision and update process following a declared disaster event.

7.4 Incorporation with Other Plans

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Upon approval of the Manchester-by-the-Sea Hazard Mitigation Plan by FEMA, the Planning Team 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. At a minimum, the Plan will be reviewed and discussed with the following departments:

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

The Plan will also be posted on the community's website. The posting of the Plan on the website will include a mechanism for citizen feedback such as an e-mail address to send comments.

SECTION 8

PLAN ADOPTION

Once the draft of the Manchester-by-the-Sea is reviewed by the Planning Team, stakeholders and the general public, the plan is reviewed by the Massachusetts Emergency Management Agency (MEMA) and the Federal Emergency Management Agency (FEMA). If approved by MEMA and FEMA, the Manchester-by-the-Sea Board of Selectmen can officially adopt the plan. Once the plan is approved, in enters into the five year "maintenance" phase described in Section 7. Section 8 describes the timeline for plan adoption and includes documentation for future plan adoption by the Board of Selectmen.

Section 8
PLAN ADOPTION

Once the draft of the Manchester-by-the-Sea Hazard Plan is reviewed by the Planning Team, stakeholders, and the general public, the Plan is reviewed by MEMA and FEMA. If approved by MEMA and FEMA, the Manchester-by-the-Sea Board of Selectmen can officially adopt the Plan. If and when the Plan is approved, it enters into the 5 year "maintenance" phase. This Section describes the timeline for plan adoption and includes documentation of the Plan adoption by the Board of Selectmen.

8.1 Timeline for Plan Adoption

The timeline for Plan Adoption is as follows:

November, 2017: After initial approval by the Board of Selectmen at its meeting on November 6, 2017 the Planning Team submitted the Manchester-by-the-Sea Hazard Mitigation Plan to MEMA on November 13, 2017. MEMA reviewed the Plan and returned it to the Town with required edits. The Manchester-by-the-Sea Hazard Mitigation Plan was then submitted to FEMA for final review.

February, 2018: FEMA issued an Approved Pending Adoption status on February 21, 2018.

April, 2018: The Manchester-by-the-Sea Board of Selectman officially adopted the Hazard Mitigation Plan on April 17, 2018 during a regularly scheduled meeting.

8.2 Plan Adoption

E1 a

The Certificate of Adoptions is provided in this section.

MANCHESTER-BY-THE-SEA

BOARD OF SELECTMEN • TOWN HALL
Manchester-by-the-Sea, Massachusetts 01944-1399

CERTIFICATE OF ADOPTION
BOARD OF SELECTMEN

A RESOLUTION ADOPTING THE TOWN OF MANCHESTER-BY-THE-SEA
HAZARD MITIGATION PLAN

WHEREAS the Town of Manchester-by-the-Sea established a Committee to prepare the *Hazard Mitigation Plan*; and

WHEREAS the *Hazard Mitigation Plan* contains several potential future projects to mitigate potential impacts from natural hazards in the Town of Manchester-by-the-Sea, and

WHEREAS duly-noticed public meetings were held by the Board of Selectmen on August 21st, 2017 and November 6th, 2017 and

WHEREAS the Town of Manchester-by-the-Sea authorizes responsible departments and/or agencies to execute their responsibilities demonstrated in the plan, and

NOW, THEREFORE BE IT RESOLVED that the Town of Manchester-by-the-Sea Board of Selectman formally approves and adopts the *Hazard Mitigation Plan* in accordance with M.G.L. 40 §4 or the charter or the bylaws of the Town of Manchester-by-the-Sea.

ADOPTED AND SIGNED ON April 17, 2018.

Board of Selectmen

Eli G. Boling, Chair

Susan Beckmann, Vice Chair

Margaret F. Driscoll

Arthur Steinert

Thomas P. Kehoe