TOWN OF MARBLEHEAD, MA HAZARD MITIGATION PLAN UPDATE

OCTOBER 2023

Town of Marblehead
188 Washington Street
Marblehead, MA 01945

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https://www.marblehead.org

Prepared by:

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Acknowledgements

The Town of Marblehead would like to thank the following people for supporting the development of this plan. This group was considered the Hazard Mitigation Planning Committee (HMPC) throughout the planning process.

- John Albright, Building Commissioner, Town of Marblehead
- Todd Bloodgood, Facilities Director, Town of Marblehead
- Charles Cerrutti, Emergency Management Director, Town of Marblehead
- Rebecca Curran, Town Planner, Town of Marblehead
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- Jason Gilliland, Fire Chief/Emergency Management Director, Town of Marblehead
- Jimmy Johnson, Department of Public Works, Utilities Coordinator, Town of Marblehead
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- Joe Kowalik, Manager, Marblehead Municipal Light Department, Town of Marblehead
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- Mark Souza, Harbormaster, Town of Marblehead
- Bethany Spangler, Water and Sewer Assistant Superintendent, Town of Marblehead
- Maggie Wheeler, Department of Public Works, Engineer, Town of Marblehead
- Jeffrey Zukowski, Hazard Mitigation Planner, MA Emergency Management Agency

F1. For single-jurisdictional plans, has the governing body of the jurisdiction formally adopted the plan to be eligible for certain FEMA assistance? (Requirement §201.6(c)(5))

Local Adoption Resolution

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TOWN OF MARBLEHEAD, MASSACHUSETTS
SELECT BOARD
A RESOLUTION ADOPTING THE
TOWN OF MARBLEHEAD, MA HAZARD MITIGATION PLAN UPDATE 2023
RESOLUTION NO. ________

WHEREAS the Town of Marblehead recognizes the threat that natural hazards pose to people and property within the Town of Marblehead; and

WHEREAS the Town of Marblehead has prepared a multi-hazard mitigation plan, hereby known as TOWN OF MARBLEHEAD, MA HAZARD MITIGATION PLAN UPDATE 2023 in accordance with federal laws, including the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended; the National Flood Insurance Act of 1968, as amended; and the National Dam Safety Program Act, as amended; and

WHEREAS the TOWN OF MARBLEHEAD, MA HAZARD MITIGATION PLAN UPDATE 2023 identifies mitigation goals and actions to reduce or eliminate long-term risk to people and property in the Town of Marblehead from the impacts of future hazards and disasters; and

WHEREAS adoption by the Town of Marblehead Select Board demonstrates its commitment to hazard mitigation and achieving the goals outlined in the TOWN OF MARBLEHEAD, MA HAZARD MITIGATION PLAN UPDATE 2023.

NOW THEREFORE, BE IT RESOLVED BY THE TOWN OF MARBLEHEAD, MA, THAT:

Section 1. In accordance with M.G.L. c. 40, the Town of Marblehead Select Board adopts the TOWN OF MARBLEHEAD, MA HAZARD MITIGATION PLAN UPDATE 2023. While content related to the Town of Marblehead may require revisions to meet the plan approval requirements, changes occurring after adoption will not require Town of Marblehead to re-adopt any further iterations of the plan. Subsequent plan updates following the approval period for this plan will require separate adoption resolutions.

ADOPTED by a vote of 5 in favor and 0 against, and 0 abstaining, this 27 day of March 2024.

By: ____________ Erin Noonan, Chair

ATTEST: By: ____________ Member

APPROVED AS TO FORM: By: DocuSigned by: Lisa Mead EEBAACE2A03242A... ____________ Lisa Mead, Special Town Counsel

Record of Changes

This Town of Marblehead, MA Hazard Mitigation Plan Update will be reviewed and approved on a biannual basis by the HMPC and following any major disasters. All updates and revisions to the plan will be tracked and recorded in the following table. This process will ensure the most recent version of the plan is disseminated and implemented by the Town.

Table 1. Summary of Changes.

Date of Change	Entered By	Summary of Changes

Chapter 1. Introduction

The Federal Emergency Management Agency (FEMA) defines hazard mitigation per the Code of Federal Regulations (CFR) 44 Section 201.2 as "any **sustained** action taken to reduce **or eliminate** the **long-term risk** to human life and property from hazards."

"Disaster Mitigation Act (DMA) 2000 (Public Law 106-390)[1] provides the legal basis for FEMA mitigation planning requirements for State, local and Indian Tribal governments as a condition of mitigation grant assistance. DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act by repealing the previous mitigation planning provisions and replacing them with a new set of requirements that emphasize the need for State, local, and Indian Tribal entities to closely coordinate mitigation planning and implementation efforts."[2]

The Town of Marblehead, Massachusetts created this plan as part of an ongoing effort to reduce the negative impacts and costs from damages associated with natural hazards, such as nor'easters, floods, and hurricanes. This plan meets the requirements of the Disaster Mitigation Act 2000. More importantly, the plan was created to reduce loss of life, land, and property due to natural hazards that affect the Town of Marblehead. It is difficult to predict when natural hazards will impact the planning area, but it is accurate to say that they will. By implementing the mitigation actions listed in this plan, the impact of natural hazards will be lessened.

Local Mitigation Plans must be updated at least once every five years to remain eligible for FEMA hazard mitigation project grants. A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five (5) years to continue to be eligible for mitigation project grants.

Purpose of the Plan

The purpose of the Local Hazard Mitigation Plan is to provide the Town of Marblehead with a comprehensive examination of all natural hazards affecting the area, as well as a framework for informed decision-making regarding the selection of cost-effective mitigation actions. When implemented, these mitigation actions will reduce the Town's risk and vulnerability to natural hazards.

This plan is a result of a collaborative effort between the Town of Marblehead and several key stakeholders. Throughout the development of the plan, the Hazard Mitigation Planning Committee (HMPC) consulted the public and key stakeholders for input regarding identified goals, mitigation actions, risk assessment, and mitigation implementation strategy. A sample of key stakeholders who

[1] Disaster Mitigation Act of 2000, Pub. L. 106-390, as amended

[2] Disaster Mitigation Act of 2000. https://www.congress.gov/106/plaws/publ390/PLAW-106publ390.pdf

participated, included the Massachusetts Emergency Management Agency (MEMA), the Salem Coast Watch, the Northeast Regional Security Council, the South Essex Sewerage District (SESD).

Guiding principles for plan development

The HMPC adhered to the following guiding principles in the plan's development.[3]

- Plan and invest for the future.
- Collaborate and engage early.
- Integrate community planning.

This plan update meets the requirements outlined 44 CFR § 201.6(d)(3). These requirements are included in the plan in the green call-out boxes, like the one below.

> A local jurisdiction must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within 5 years in order to continue to be eligible for mitigation project grant funding.

Yellow call-out boxes like the one to the right, are definitions taken from the Federal Emergency Management Agency Local Policy Guide, April 2023. These are included throughout the plan for reference and explanation.

> ***COMMUNITY RESILIENCE*** *is the ability of a community to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. Activities such as disaster preparedness (which includes prevention, protection, mitigation, response and recovery) and reducing community stressors (the underlying social, economic and environmental conditions that can weaken a community) are key steps to resilience.*[1]

The HMPC prioritized mitigating impacts of climate change, mitigating risk to vulnerable communities, and protecting the built environment both today and in the future.

The HMPC identified the following list of hazards to profile. They are shown in order of climate change interaction for consistency with the State Hazard Mitigation and Climate Adaptation Plan (SHMCAP).

[3] Federal Emergency Management Agency. (April 19, 2022). Local Mitigation Planning Policy Guide, p.13.

Table 2. Town of Marblehead Hazards.

Primary Climate Change Interactions	Hazards
Changes in Precipitation	1. Flooding *(including riverine, dam failures, ice jams, etc.)* 2. Drought
Sea Level Rise	3. Coastal Flooding 4. Coastal Erosion
Rising Temperatures	5. Extreme Temperatures 6. Wildfires *(including brush fires)* 7. Infectious Disease 8. Invasive Species
Extreme Weather	9. Hurricanes/Tropical Storms 10. Severe Winter Storm/Nor'easter *(including blizzard, ice storm, etc.)* 11. Tornadoes 12. Other Severe Weather *(including thunderstorms, etc.)*
Non-Climate Influenced Hazards	13. Earthquake

Mitigation Strategy

C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))

The hazard mitigation strategy is the culmination of work presented in the Planning Area Profile (Chapter 2), Risk Assessment (Chapter 4), and Capability Assessment (Chapter 5). It is also the result of multiple meetings and sustained public outreach. The HMPC developed the goals shown below. The goals from the previous Town of Marblehead, Natural Hazards Mitigation Plan 2015, and the Town's Municipal Vulnerability Preparedness Plan, 2018 were revised to develop this current list. Information about the goal development process is in Chapter 6: Mitigation Strategy. The goals are considered "broad policy-type statements"[4] that represent the long-term vision for mitigating risk to natural hazards in the Town of Marblehead.

Save Lives	• Reduce risk to people, property, infrastructure, and natural resources from natural hazards and climate change.
Infrastructure	• Mitigate risk to critical facilities and infrastructure from natural hazards and climate change.
Capacity	• Increase the Town's capacity to mitigate risk through regulations, planning, and regional collaboration.
Education	• Educate all stakeholders about the value of hazard mitigation and how to implement it in their work, businesses, and homes.

Figure 1. Mitigation Plan Goal Statements.

Land Use and Development

Changes in Development

E1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))

Marblehead has not seen any significant changes in development since the last plan update, primarily since the community is already at near maximum build-out. Current land use is primarily residential (approximately 70 percent) with two small business districts and a small industrial park, and there are very little privately-owned large parcels of land available for new development. Marblehead's long-term development pattern is therefore largely established.

[4] Federal Emergency Management Agency. (2013). *Local Mitigation Planning Handbook,* p. 6.

> ***CHANGES IN DEVELOPMENT*** *means recent development (for example, construction completed since the last plan was approved), potential development (for example, development planned or under consideration by the jurisdiction), or conditions that may affect the risks and vulnerabilities of the jurisdictions (for example, climate change, declining populations or projected increases in population, or foreclosures) or shifts in the needs of underserved communities or gaps in social equity. This can also include changes in local policies, standards, codes, regulations, land use regulations and other conditions.*

Any future changes in development will likely to continue a pattern of in-fill construction of single-family homes, reuse or replacement of existing structures, and small non-residential developments. Any of these types of changes to existing development may result in some decreased hazard vulnerabilities to specific properties (e.g., reconstruction of non-conforming structures that are substantially improved or rebuilt to current regulatory standards), however they will likely not affect the community's overall vulnerability to hazards. While climate change, sea level rise, increased storminess, and other future conditions are projected to increase the frequency and severity of coastal hazards, the Town's continued investments in protective infrastructure and other coastal resiliency projects will help the community mitigate and adapt over time. In addition, the Town's higher regulatory standards for any new or improved development in hazard areas will require specific design and construction standards that support risk reduction.

More detailed information on the administration and effectiveness of these and other development regulations is provided in Chapter 5, and the combination of these local mitigation investments and capabilities should help limit any significant increases to the community's overall hazard vulnerability for the foreseeable future.

Progress in Mitigation Efforts

> E2. Was the plan revised to reflect changes in priorities and progress in local mitigation efforts? (Requirement §201.6(d)(3))

This plan includes the Town's current priorities of climate adaptation, inclusion of vulnerable communities, plan implementation. It also reflects the current challenge in funding capital improvement projects. The Town has had two override votes in recent years that have failed. Capital improvement projects are prioritized and funded when a critical need arises.

The Town has implemented parts of their Municipal Vulnerability Preparedness Plan with the implementation of three coastal resilience projects. Climate adaptation has become an increasing priority throughout Town and is reflected in the updated list of hazard mitigation actions.

In 2015, when the previous Hazard Mitigation Plan was written, the Town did not have a recognized Environmental Justice (EJ) Population. It does have one now which has forced the Town to discover ways to conduct outreach to this population. The Massachusetts Environmental Policy Act (MEPA) permitting regulations require outreach to Environmental Justice Communities. As the Town implements projects that meet the MEPA threshold, they are conducting outreach to their EJ community.

The other significant priority change is the Town's developed a system for plan implementation. Previously when plans were developed, implementation fell solely to overburdened staff members. Now, the planning committee becomes the Implementation Committee and continues to meet after a plan is developed. This policy shift has resulted in effective plan implementation.

The Town did implement several mitigation actions from the 2015 Hazard Mitigation Plan. The previous plan was not fully utilized, a fact recognized by the HMPC. The Town anticipates implementing more actions from this plan as well as integrating this plan's goals and priorities through the Hazard Mitigation Plan Implementation Committee formed following Town adoption of the plan.

Authority and Assurances

The Town of Marblehead will continue to comply with all applicable Federal laws and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 201.6. It will amend its plan whenever necessary to reflect changes in City, State or Federal laws and regulations, as required in 44 CFR 201.6. The list of laws and regulations the Town with adhere to is below.

- Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended.
- National Flood Insurance Act of 1968, as amended.
- National Dam Safety Program Act (Pub. L. 92-367), as amended.
- 44 CFR Part 201 Mitigation Planning.
- 44 CFR, Part 60, Subpart A, including § 60.3 Flood plain management criteria for flood-prone areas.
- 44 CFR Part 77 Flood Mitigation Grants[10].
- 44 CFR Part 206 Subpart N. Hazard Mitigation Grant Program.

Plan Adoption

The Town of Marblehead will adopt the Plan when it has received "approved-pending adoption" status from the Federal Emergency Management Agency (FEMA). The Certificate of Adoption is included on page 7.

Document Overview

Below is a summary of the Town of Marblehead, MA Hazard Mitigation Plan Update chapters, including appendices. The planning process closely adhered to FEMA guidelines and to the intent of those guidelines.

Chapter 2: Planning Area Profile
The Planning Area Profile chapter describes the Town of Marblehead, including history, population, government, and infrastructure.

Chapter 3: Planning Process
The Planning Process chapter documents the methodology and approach of the hazard mitigation planning process. The chapter summarizes the HMPC meetings and the public outreach process (including public meetings). This chapter guides the reader through the process of generating this plan and reflects its open and inclusive public involvement process.

Chapter 4: Risk Assessment
The Risk Assessment identifies the natural hazard risks to the Town of Marblehead and its residents. The risk assessment looks at current and future vulnerabilities based on land use development including structures and infrastructure. Included in this chapter is a list of critical facilities identified by the HMPC.

Chapter 5: Capability Assessment
The Capability Assessment looks at the Town's ability to mitigate risk prior to and following disaster. This chapter is structured around the following four categories: planning and regulatory, administrative, and technical, financial, as well as education and outreach. The chapter concludes with information regarding the National Flood Insurance Program (NFIP).

Chapter 6: Mitigation Strategy
This chapter provides a blueprint for reducing losses identified in the Risk Assessment. The chapter presents the hazard mitigation goals and identifies mitigation actions in priority groupings. Each mitigation action includes essential details, such as Town lead, potential funding sources, and implementation timeframe.

Chapter 7: Plan Implementation and Maintenance
The Plan Implementation and Maintenance establishes a system and mechanism for periodically monitoring, evaluating, and updating the Town of Marblehead Hazard Mitigation Plan Update. It also includes a plan for continuing public outreach and monitoring the implementation of the identified mitigation actions.

Appendices
The Appendices includes documentation regarding the planning process, the list of mitigation actions and the *Hazus* Reports.

Chapter 2: Planning Area Profile

The Town of Marblehead, with a population of 20,530[5], was founded in 1629. For over two centuries, Marblehead was known for its commercial fishing.[6] Marblehead is a coastal community located on a peninsula just 17 miles northeast of Boston in Essex County.[7]

Prior to European settlers arriving, the Naumkeag Tribe, a group of Native Americans that belong to the Algonquin Nation, lived in the area. They named their settlement “Massebequash,” which eventually changed to Marblehead. British settlers then migrated to Massebequash in the 1600s to escape Puritan discipline in Salem. Several epidemics devastated the Naumkeag Tribe, and their population declined after 1633. Eventually, Marblehead became completely independent from the neighboring Salem in 1648.[8]

As time went on, Marblehead prospered as a fishing port due to its readily available fish off the coast. Many vessels with fishermen and other passengers settled in the Town upon their arrival. In 1837, Marblehead had its own local fleet of 98 vessels; however, after a major storm caught the fleet out at sea, many boats, and the fishermen on them had been lost. This led to the decline of the fishing industry in the area. Despite this decline, many residents still make their living as fishermen and lobstermen to this day.[9]

The connection between Marblehead residents and the ocean continues and has slowly transitioned away from fishing towards recreational and competitive sailing. Marblehead Harbor displays some of the finest sailing crafts and has been a port for many international races over the years. An annual race that began back in 1905 still continues to this day. Marblehead has also attracted yachtsmen from around the world and is known as the “Yachting Capital of the World.”[10] The Town also claims the title of the “Birthplace of the American Navy.”[11] So it is clear that the Town’s origins and relationship with the ocean are still being threaded within the community’s fabric.

In addition to being a coastal town, Marblehead has some higher elevations in the conservation area along Salem Harbor called Wyman Woods and the terrain rises to 108 feet above sea level. The west side of Marblehead has a higher elevation in general as compared to the east side.[12]

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[5] “ACS Demographic & Housing 5 Year Estimates.” (2020). U.S. Census Bureau.
[6] “Marblehead Open Space and Recreation Plan.” (2012). Town of Marblehead, Massachusetts.
[7] “Marblehead Open Space and Recreation Plan.” (2012). Town of Marblehead, Massachusetts.
[8] “Visiting & Town History.” (n.d.). Town of Marblehead, Massachusetts.
[9] “Visiting & Town History.” (n.d.). Town of Marblehead, Massachusetts.
[10] “Visiting & Town History.” (n.d.). Town of Marblehead, Massachusetts.
[11] “Visiting & Town History.” (n.d.). Town of Marblehead, Massachusetts.
[12] “Marblehead Open Space and Recreation Plan.” (2012). Town of Marblehead, Massachusetts.

The Town of Marblehead falls within the North Coastal Basin. The issue with Marblehead and its climate is precisely due to its coastal location, there will be variation in changing temperature and weather patterns. In general, through the end of the century, the average temperature will increase. Maximum summer and fall temperatures are expected to see the highest projected increase. Due to these projections, the North Coastal Basin is expected to see an increase in the number of days with daily maximum temperatures over 90 °F, 95 °F, and 100 °F. The winter season will generally see the highest projected increase in precipitation, but the basin's climate will fluctuate between dry and wet periods.[13] This will be considered when planning for Marblehead's future and the implications of new weather events and patterns for residents, visitors, habitats, ecosystems, and local natural resources.

Marblehead operates in an Open Town Meeting form of government. In doing so, all registered voters of the Town are eligible to participate. The Town Meeting convenes annually on the first Monday in May and continues successive nights until all business is concluded.[14]

People

As of 2020, 95.8% of the Town identified as White, while 0.4% identified as Black or African American. Additionally, 1.6% of the population identified as Asian and 4.4% identified as Hispanic or Latino.[15] These demographics highlight the lack of diversity that the Town of Marblehead has recognized. This lack of diversity can also be an opportunity for change and reflection on how the community has been shaped and continued to be maintained. The median age in Marblehead is 48.8 years old, which is almost a decade older than the State's median age of 39.6 years old.[16][17] The senior population is growing in Marblehead.

According to Marblehead's 2012 Open Space and Recreation Plan, the Town had no environmental justice populations at the time.[18] As of 2020, Marblehead has 3 EJ Block Groups that meet the Minority and Low-Income Populations Criterion and there are 2,637 people in those block groups.[19]

The foreign-born population in Town is 8.6% and the median household income is $131,293. The number of persons living in poverty is 3.3%.[20] The higher household incomes of the residents and relatively low number of people living in poverty is a positive for the Town.

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[13] "Massachusetts Climate Change Projections." (2018).

[14] "Town Meeting." (n.d.) Town of Marblehead, Massachusetts.

[15] "ACS Demographic & Housing 5 Year Estimates." (2020). U.S. Census Bureau.

[16] "ACS Age and Sex 5-Year Estimates." (2020). U.S. Census Bureau.

[17] "ACS Age & Sex 5 Year Estimates." (2020). U.S. Census Bureau.

[18] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.

[19] "Massachusetts Cities & Towns with Environmental Justice Populations." (2021). Executive Office of Energy and Environmental Affairs.

[20] "QuickFacts Marblehead town, Essex County, Massachusetts." (2020). U.S. Census Bureau.

The figure below from the 2020 Massachusetts EJ Communities Map Viewer shows the location of Marblehead EJ Communities which are located near Marblehead Harbor. These communities have a at least 25% of households with a median household income 65% or less than the state median household income.

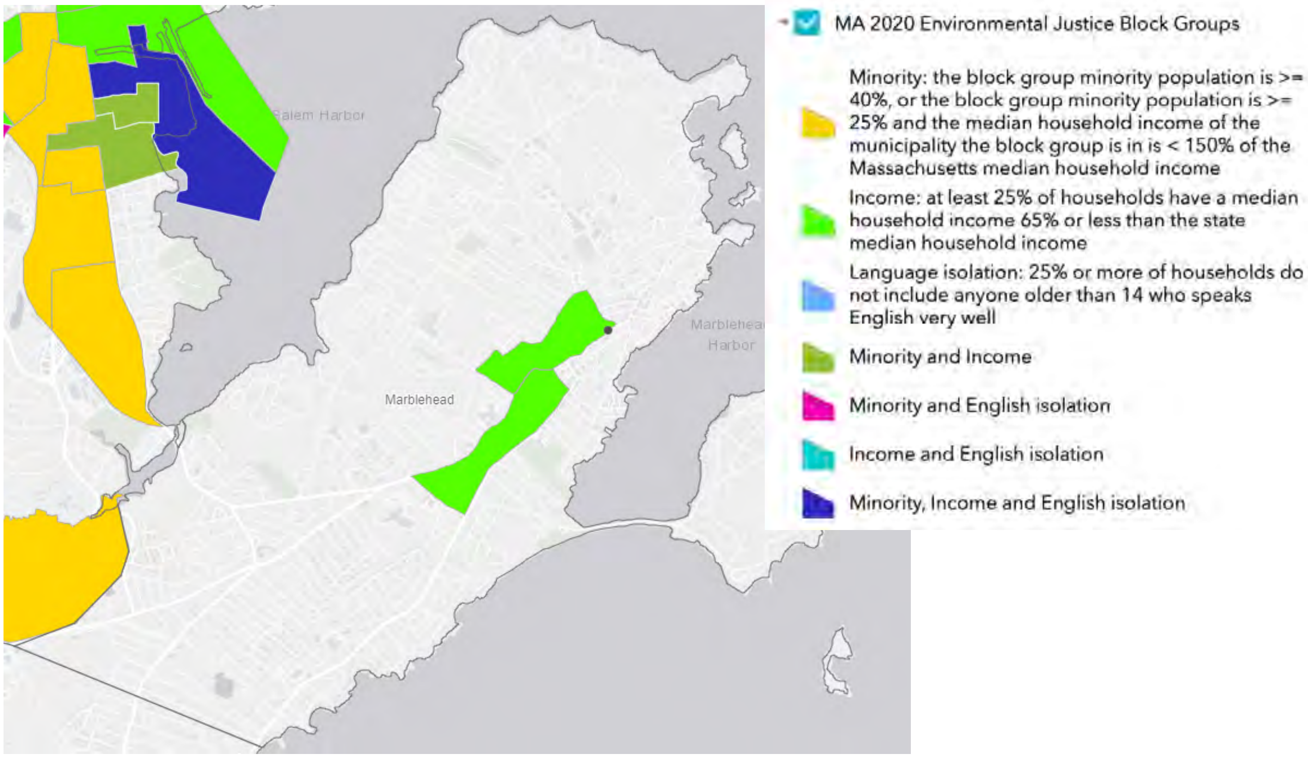

Figure 2. Marblehead Environmental Justice Communities.

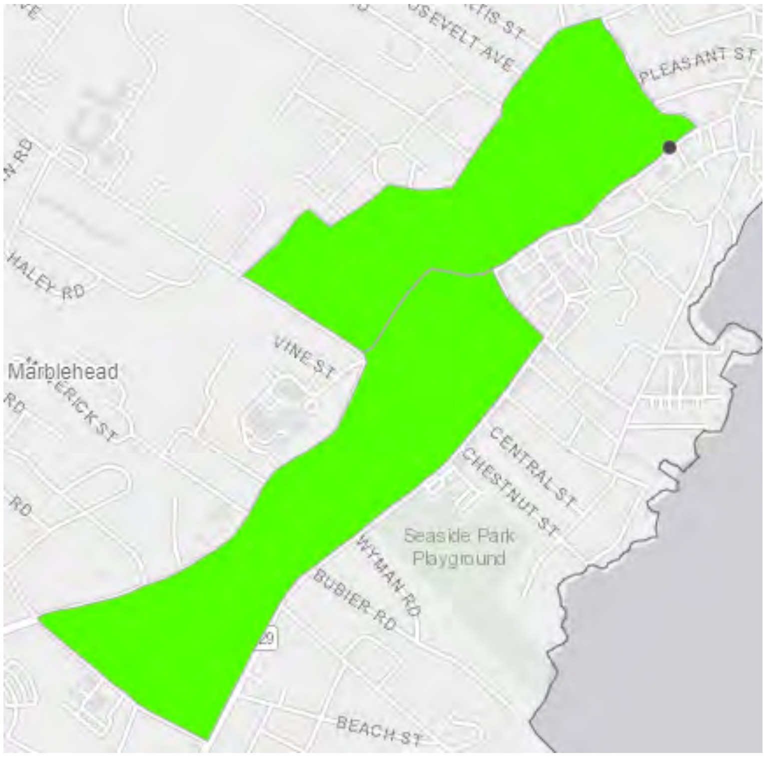

Figure 3. Marblehead Environmental Justice Census Block Groups.

Marblehead's easternmost EJ Block Group, Block Group 3 (Census Tract 2033.01) fits the "Income" criteria. The characteristics of this block group include the median household income being $48,750 which is 57.8% of the State's median household income. The total minority population in this block group is 16.4% and there are 0.0% of households with language isolation.[21]

Marblehead's westernmost EJ Block Group, Block Group 1 (Census Tract 2032) fits the "Income" criteria. The characteristics of this block group include the median household income being $51,694 which is 61.3% of the State's median household income. The total minority population in this block group is 12.2% and there are 0.0% of households with language isolation.[22]

According to the U.S. Census 2020 5-Year ACS Estimates the languages spoken at home, there are 588 people that speak Spanish, 1,336 people who speak Other Indo-European languages, and 303 people who speak Asian and Pacific Islander.[23]

Additionally, according to the U.S. Census 2020 5-Year ACS Estimates, the continents Marblehead's foreign-born populations are from are as follows:

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[21] Massachusetts 2020 Environmental Justice Communities Map Viewer. (2022). State of Massachusetts.
[22] Massachusetts 2020 Environmental Justice Communities Map Viewer. (2022). State of Massachusetts.
[23] "ACS Language Spoken at Home 5- Year Estimates." (2020). U.S. Census Bureau.

- Europe – 1,072 (60.5% of Foreign-Born Population)
- Asia – 268 (15.1% of Foreign-Born Population)
- Africa – 20 (1.1% of Foreign-Born Population)
- Oceania – 8 (0.5% of Foreign-Born Population)
- Latin America – 356 (20.1% of Foreign-Born Population).[24]

Land Use and Development (Structures)

The Town of Marblehead is surrounded by water and that has always shaped its development patterns. The Town has three harbors which include the main harbor, "Little Harbor," and Salem Harbor which is located on the western shore.[25]

The harbors are very active in the summer months with over 2,500 boats moored within the Town's waters. The harbors and proximity to water attracts a large tourist population and the commercial districts in Marblehead have geared themselves towards this population with many shops, restaurants, and businesses. The recreational properties in Town attracts boaters, swimmers, sunbathers, divers, and other visitors from all over the region. Commercial properties like the shopping center Vinnin Square located near the bordering communities of Salem and Swampscott also attract visitors.[26]

The earliest area of Marblehead that was settled was in the northern part of the mainland peninsula along the Little Harbor. Large tracts of farmland also exist in the Town. Two offshore islands east of the peninsula in Little Harbor remained undeveloped until after the Civil War. At one point, Gerry's Island (in the southwest) had up to three dwellings on it, but only until the 1970s. Currently, they remain undeveloped.[27]

The Town of Marblehead is relatively small with a land area of only 4.38 square miles and approximately 8,126 households.[28] Looking back to the 1700s and 1800s, the Town's development was concentrated in the northeast area of the peninsula along Marblehead Harbor to the east. The Town's network of roads were named in 1834 and many street names survive today. Residential properties increased throughout the downtown during the 1700s and 1800s in waves, but eventually plateaued. Many houses during this time were often replaced and lots were subdivided, but teardowns of houses rarely occurred, especially now due to regulations that were put in place in 1968. In the 1970s, homes were built in smaller areas outside of the downtown Historic District. The following decade, larger houses were developed at the end of the peninsula between the Little Harbor and the main harbor. After 2000, some clusters of very large houses and a large condominium complex were built in the center of the peninsula on vacant land.

[24] "ACS Characteristics of People By Language Spoken at Home 5- Year Estimates." (2020). U.S. Census Bureau.
[25] "History." (2021). Marblehead Historical Commission.
[26] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[27] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[28] "QuickFacts Marblehead town, Essex County, Massachusetts." (2020). U.S. Census Bureau.

Most of the development over the years seemed to be primarily residential since only a minimal amount of small office buildings and business parks were developed towards the end of the 20th century. However, in 2007-2009, a large YMCA complex was developed on open space at the top of Legg's Hill, near the Forest River tidal area and has road access through wetland zones.[29]

As a primarily residential town, Marblehead has two small business districts and a small industrial park. When looking at land use make-up, 70% of the Marblehead's land use is residential and there remains very little undeveloped land. The majority of Marblehead was developed in a suburban style with single-family homes on larger lots with wider uniform streets. Many historic buildings still remain standing in the downtown area and help to showcase the historic character of the Town. There are, however, newer developments that have been rehabilitated and expanded over the years which serve as summer communities with large homes on large lots for wealthy summer residents.[30]

Marblehead has 15 zoning districts though the majority of Town is zoned as a single residential district. There are small business districts, and the small industrial park is zoned as "unrestricted." There are five shoreline zoning districts. The shoreline districts have increased sideline requirements, a waterfront setback requirement, and a lower maximum height restriction. The regulations for the shoreline districts are meant to protect the views from and towards the shoreline. Marblehead also has a harbor front district that helps to maintain and promote waterfront development.[31]

Natural Resources

Estuaries

There are no major rivers that flow through Marblehead; however, there are two major estuaries that mark where a freshwater waterbody meets the ocean. The first is the Forest River Estuary which is a 30-acre area located on the northwestern boundary of Marblehead and Salem. The landscape of the area is diverse with steep and exposed bedrock at the former sand and gravel excavation site. There are also poorly drained soils in the south and salt marshes bordering the river. There is a variety of vegetation that includes grasses, weeds, shrubs, and sumac, while red maple, bigtooth aspen, and black cherry can be found in the more wooded areas. The salt marsh is filled with Spartina patens, which is a saltwater grass. The site can be accessed by a trail system.[32]

The second estuary is the Goldthwait Reservation. This was originally the site of the Devereux Pond which was a large pond in the middle of a saltwater marsh which no longer exists since about 1900. The area today is about 12 acres of salt marsh and salt meadow near Devereux Beach. The marsh connects to Riverhead Beach through a series of 48-inch culverts. There is also a small tidal creek that runs

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[29] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[30] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[31] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[32] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.

through the area. The vegetation on the site includes some *s*alt marsh cordgrass (Spartina Alterna flora) but is primarily filled with denser salt meadow grass (Spartina patens).[33]

Beaches

As a coastal community, there are several beaches in Marblehead that are visited year round by residents and visitors alike. A list of the beaches and their characteristics provided on the Town's website can be found below.

The beaches include:

- **Devereux Beach** - the Town's premier beach with 5.48 acres of waterfront against the Atlantic Ocean. There are pavilions, benches, tables, restroom facilities, a restaurant, and parking. It's located off of Ocean Avenue.
- **Fort Beach & Lovis Cove** - Fort Beach is located at the entrance of Fort Sewall and offers a view of Marblehead Neck and Chandler Hovey Park. Many local fishermen still moor their small boats in the area. Lovis Cove is located several yards from Fort Beach.
- **Gas House Beach** - a small-community beach in Little Harbor with a history dating back to 1629. It is located on Gashouse Lane and named after the gas generating plant that was present into the 1800s.
- **Grace Oliver Beach -** a community beach that is less than one acre and located off Beacon Street. The beach has shallow water and is well-protected which makes it ideal for families with young children to visit.
- **Riverhead Beach -** located on Marblehead Harbor, the beach is 1.65 acres and includes a boat ramp.
- **Stramski's Beach -** located on Salem Harbor and at Gerry Playground. The beach can be accessed at the end of Stramski Way off of West Shore Drive.[34]

Conservation Areas and Walking Trails

Along with an abundance of beaches, Marblehead has several conservation areas and walking trails. These sites are listed out on the Town's website and offer many places to explore. The areas and trails include:

- **Forest River -** the area is about 25 acres and includes forest, meadows, wetlands, the estuary, salt marsh, small ponds, and a small river. There are walking trails available throughout the site.

[33] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.

[34] "Beaches." (n.d.). Town of Marblehead, Massachusetts.

- **Hawthorn Pond -** the area is about ten acres and is accessed through a walking path to a small pond and swamp. The site is a prime ecological study area and provides a natural area for ice-skating in the winter months.
- **Steer Swamp -** the Conservation Area is about 43 acres and includes vistas in the higher elevations with meadows, swamps, ponds, brooks, native plants, and wildflowers in the lowlands. Many wild birds and small game can be observed in the area.
- **Ware Pond -** the area is about 8.5 acres, and the Conservation Area is near the Clifton section of Marblehead. The pond occupies approximately half of the area and there is also a wildlife refuge for waterfowl. The area also supports various plants and animal life which include water lilies, swamp-dwelling bushes and trees, as well as turtles, and muskrats. The pond freezes over the winter by ice skaters. There is an extensive trail network available.
- **Wyman Woods -** this area is approximately 33.5 acres and extends from Gatchell's Playground to Salem Harbor. The Conservation Area is an undeveloped upland with ideal hiking trails that can be easily followed. In the lower elevations there is a wide variety of trees, shrubs, and wildflowers and a viewing point on the edge of Salem Harbor.
- **Robinson Farm -** this is the newest addition to Marblehead's conservation areas and the farm was purchased by the Town in 2005. The 3.5-acre site was a working dairy farm for almost 200 years, but there are no longer any standing buildings. The site is open to passive public recreation and there is some parking available.[35]

Parks

There are several parks in the Town of Marblehead further highlighting the large amount of open space and recreation available for residents and visitors in the region. A full list of the Town parks can be found on the Town's website and include:

- Castle Rock Park
- Chandler Hovey Park
- Crocker Park
- Fort Sewall
- Fountain Park
- Hammond Park
- Memorial Park
- Seaside Park.[36]

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[35] "Conservation & Walking Trails." (n.d.). Town of Marblehead, Massachusetts.

[36] "Parks." (n.d.). Town of Marblehead, Massachusetts.

There are also several recreational playgrounds in the community which include:

- Gatchell Playground - 8.33 acres
- Gerry Playground - 6.85 acres
- Hobbs Playground - 1.14 acre
- Orne Playground - 5.22 acres
- Reynolds Playground - 5.45 acres.[37]

With so many conservation areas, public open spaces, parks, playgrounds, and beaches, the need for protection and management of these sites is critical. The Marblehead Conservancy, Inc. was founded in 2001 to protect, acquire, and enhance the natural resources of the Town. According to the Marblehead Conservancy, their two primary focus areas are, "the restoration of access to and through public natural open spaces and working to secure additional open space through land acquisition and conservation restrictions on private property." The Conservancy works with various Town departments in order to improve the natural areas and more specifically the trails, ponds, wetlands, and forested areas in Marblehead. The Conservancy has a Board of Trustees which includes 5-15 area residents and is built on the work of volunteers with various backgrounds, skills, and interests.[38]

The Conservancy focuses on three strategic areas: trails, land, and education. There are five miles of trails on about 165 acres of land that must be maintained. In regard to education, the aim is to engage the public in major events like Earth and Arbor Days, but also in campaigns and a present at the local Farmers' Market, having an education booth, holding exhibitions, and working with the Abbot Public Library. The Trustees were involved in updating the 2012 Marblehead Open Space and Recreation Plan.[39] The Conservancy looks to preserve, conserve, and encourage public engagement with the natural landscape so readily available to those who visit the Town.

Critical Facilities and Infrastructure

Community Lifelines

Water and Sewer Service

Water is provided by the Marblehead Water Department. They deliver water to individual customers and businesses. There are 8,000 meters in the Town and two pump stations (one on Tedesco Street and one on Loring Avenue). The two pump stations maintain water pressure during high-use periods. There is one water storage tank located on Burke's Hill.

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[37] "Playgrounds." (n.d.). Town of Marblehead, Massachusetts.
[38] "About Us." (2020). Marblehead Conservancy Inc.
[39] "About Us." (2020). Marblehead Conservancy Inc.

All the water is supplied by the Massachusetts Water Resources Authority (MWRA). Marblehead is a member of the MWRA and buys its water from the MWRA. The Town is said to be at the "end of the MWRA line." The water system includes over 100 miles of water mains and 815 hydrants. The entirety of the town has access to year-round water supply.[40] The water is primarily from the Quabbin and Wachusett Reservoirs. It is then treated at the John Carroll Treatment Facility before moving to MWRA communities.

The Local Mitigation Planning Handbook (FEMA, 2013) explains that *"Critical facilities are structures and institutions necessary for a community's response to and recovery from emergencies. Critical facilities must continue to operate during and following a disaster to reduce the severity of impacts and accelerate recovery. When identifying vulnerabilities, it is important to consider both the structural integrity and content value of critical facilities and the effects of interrupting their services to the community."*

The Marblehead Sewer Department maintains over 100 miles of sewer mains, 3,000 structures, and 28 pump stations in the Town. The sewerage system services about 7,800 buildings. Sewage is pumped from the South Essex Sewage District Beach Street Pumping Station to the SESD Treatment Plant in Salem, MA for treatment. Marblehead has been a member of SESD since 1972 when it was voted on in a Town Meeting.[41] SESD is made up of five communities that include Salem, Beverly, Danvers, Peabody, and Marblehead. The primary and secondary treatment plants are in Salem. Marblehead accounts for 7.8% of the wastewater processed. Ninety-nine percent of the Town uses the Town's Sanitary Sewer System.

Electric

Marblehead has its own electric company called Marblehead Municipal Light. They oversee the 4.3 square miles of service area, 88 miles of overhead lines, 20.6 miles of underground conduit, 3,800 poles, 2,019 streetlights, and 9,957 watt-hour meters.[42]

Critical Facilities

The term "critical facilities" is often used to describe structures necessary for a community to respond and recover in emergency situations. These facilities often include emergency response facilities (fire stations, police stations, rescue squads, and emergency operation centers [EOCs]), custodial facilities (jails and other detention centers, long-term care facilities, hospitals, and other health care facilities), schools, emergency shelters, utilities (water supply, wastewater treatment facilities, and power), communications facilities, and any other assets determined by the community to be of critical importance for the protection of the health and safety of the population. The adverse effects of

- [40] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
- [41] "Sewer Department" (n.d.) Town of Marblehead, Massachusetts.
- [42] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.

damaged critical facilities can extend far beyond direct physical damage. Disruption of health care, fire, and police services can impair search and rescue, emergency medical care, and even access to damaged areas.

The number and nature of critical facilities in a community can differ greatly from one jurisdiction to another, and usually includes both public and private facilities. Each community needs to determine the relative importance of the publicly and privately owned facilities that deliver vital services, provide important functions, and protect special populations.

A list of the critical facilities in Marblehead is provided in the table below. This list was obtained from the previous edition of the hazard mitigation plan and the MVP-funded Community Resilience Building (CRB) plan; and reviewed by the HMPC throughout the planning process.

Table 3. Critical Facilities.

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
Marblehead Children's Center	21 Tioga Way	Y	Building
US Post Office	27 Smith Street	Y	Building
Farrell Court Elderly Housing	2 Farrell Court	Y	Building
Marblehead Community Charter School	17 Lime Street	Y	Building
Old North Nursery School	35 Washinton Street	Y	Building
Powder House Court		Y	Building
St. Michael's Day Care	26 Pleasant Street	Y	Building
Marblehead Trading Company	89 Front Street	Y	Building
Abbot Hall	188 Washington Street	Y	Building
Amy's Cozy Corner	13 Bessom Street	Y	Building
Roads Elderly Housing		Y	Building
Unitarian-Universalist Church	28 Mugford Street	Y	Building
Amy's Play School	14 Prospect Street	Y	Building

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
St. Michael's Episcopal Church	26 Pleasant Street	Y	Building
Old North Congregation Church	35 Washinton Street	Y	Building
Marblehead Arts Festival July 4th		Y	Building
Christian Science	134 Elm Street	Y	Building
Our Lady Star of the Sea Catholic Church	85 Atlantic Avenue	Y	Building
National Historic District		Y	Building
St. Andrew's Episcopal Church	135 Lafayette Street	Y	Building
Harbor Fireworks Display July 4th		Y	Building
Temple Sinai	1 Community Road	Y	Building
Mary Alley Building	7 Widger Road	Y	Building
Lutheran Church	150 Humphrey Street	Y	Building
Temple Emanual	393 Atlantic Avenue	Y	Building
Green Street Court Elderly Housing	26 Rowland Street	Y	Building
Boston Yacht Club	1 Front Street	Y	Building
Spirit of '76 Painting		Y	Building
Tucker's Wharf Sea Wall		Y	Building
Marblehead Police Dept.	11 Gerry Street	Y	Building
Marblehead High School	2 Humphrey Street	Y	Building
Marblehead Veteran's Middle School	217 Pleasant Street	Y	Building
Pleon Yacht Club	42 Foster Street	Y	Building
Seaside Nursery School	80 Atlantic Avenue	Y	Building

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
Eastern Yacht Club	47 Foster Street	Y	Building
Tower Elementary School	75 West Shore Drive	Y	Building
Corinthian Yacht Club	1 Nahant Street	Y	Building
Dolphin Yacht Club	11 Alerton Pl	Y	Building
Marblehead Yacht Club	4 Cliff Street	Y	Building
Marblehead Fire Dept.	1 Ocean Avenue	Y	Building
Montessori School		Y	Building
St. Stephens Day Care	67 Cornell Road	Y	Building
St. Andrews Co-op Nursery School	Lafayette Street	Y	Building
Lafayette Nursing Home	25 Lafayette Street	Y	Building
Marblehead COA/Park and Rec. Bldg	10 Humphrey Street	Y	Building
Devereux School	44 Smith Street	Y	Building
Glover Elementary School	9 Maple Street	Y	Building
Cohen Hillel Academy	Six community Road	Y	Building
North Shore JCC Nursery School	4 Community Road	Y	Building
YMCA Day Care	40 Leggs Hill Road	Y	Building
Dr. Samuel C Eveleth Elementary School	3 Brook Road	Y	Building
Green Street Court		Y	Building
EOC		Y	Building
Sundance Day Care	328 West Shore Drive	Y	Building
St. Stephen's Church	67 Cornell Road	Y	Building

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
Abbot Public Library	235 Pleasant Street	Y	Building
Village Pharmacy	1 Village Plaza	Y	Building
Franklin Fire House	1 Ocean Avenue	Y	Building
CVS	45 Atlantic Avenue	Y	Building
Municipal Garages (Tower Way Garage)	3 Tower Way	Y	Building
Water and Sewer Office (Main SCADA location)	100 Tower Way Bldg 11	Y	Building
Electrical Substation		Y	Infrastructure
Generating Electrical Station		Y	Infrastructure
Marblehead Municipal Light Dept.	80 Commercial Street	Y	Infrastructure
Electrical Substation		Y	Infrastructure
Gas Pumping Station		Y	Infrastructure
Harold Breare Bridge		Y	Infrastructure
Causeway Sea Wall		Y	Infrastructure
Gas Booster Station		Y	Infrastructure
Marblehead Harbor		Y	Infrastructure
Clark Landing		Y	Infrastructure
Sea Wall at Clark Landing		Y	Infrastructure
Sea Wall at Parker's Boatyard		Y	Infrastructure
Verizon		Y	Infrastructure
Sea Wall at Cliff Street Boatyard		Y	Infrastructure
Sea Wall at O'Brien's Landing		Y	Infrastructure

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
Rocket Landing Pier		Y	Infrastructure
Cliff Street Boatyard		Y	Infrastructure
Parker's Boatyard	3R Redstone Lane	Y	Infrastructure
Sea Wall at Parker's Boatyard		Y	Infrastructure
Tucker's Wharf		Y	Infrastructure
O'Brien Landing		Y	Infrastructure
Sea Wall at Grace Oliver Beach		Y	Infrastructure
Devereux Beach Heliport		Y	Infrastructure
Heliport at Tucker's Beach		Y	Infrastructure
Tucker's Beach		Y	Infrastructure
Heliport at Catchell Playground	63 Lafayette Street	Y	Infrastructure
Heliport at Goldthwait Reservation		Y	Infrastructure
Heliport at Reynolds Playground	80 Hoods Lane	Y	Infrastructure
Grace Oliver Beach		Y	Infrastructure
Heliport at Seaside School	80 Atlantic Avenue	Y	Infrastructure
River Head Beach		Y	Infrastructure
Gas House Beach		Y	Infrastructure
Fort Beach		Y	Infrastructure
Star of the Sea RC Cemetery		Y	Infrastructure
Green Street Cemetery	Green Street	Y	Infrastructure
Harbor View Cemetery		Y	Infrastructure

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
Hobbs Memorial		Y	Infrastructure
Waterside Cemetery		Y	Infrastructure
Cell Tower		Y	Infrastructure
Unitarian Cemetery		Y	Infrastructure
Stand Pipe		Y	Infrastructure
Old Burial Hill Cemetery		Y	Infrastructure
Crosby's Supermarket	118 Washington Street	Y - narrative	Infrastructure
Baptist Church	17 Pleasant Street	Y - narrative	Infrastructure
Sargent Road Emergency Outfall		Y - narrative	Infrastructure
Transfer Station	5 Woodfin Terrace		Infrastructure
Fort Seawall			Infrastructure
Fort Beach Pump Station	11 Fort Beach Lane	Y	Infrastructure
Norman Street Pump Station	61 Norman Street	Y	Infrastructure
Crowninshield Pump Station	15 Crowninshield Road	Y	Infrastructure
Corn Point Pump Station	15 Corn Point Road	Y	Infrastructure
Mooring Road Pump Station	8 Mooring Road	Y	Infrastructure
Edgemere Pump Station	21 Edgemere Road	Y	Infrastructure
Naugus Ave Pump Station	91 Naugus Ave	Y	Infrastructure
Kenneth Road Pump Station	250 Green Street	Y	Infrastructure
Green Street Pump Station	132 Green Street	Y	Infrastructure
Liberty Road Pump Station	15 Liberty Road	Y	Infrastructure

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
Sunset Road Pump Station	11 Sunset Road	Y	Infrastructure
Neptune Road Pump Station	6 Neptune Road	Y	Infrastructure
Village Street Pump Station	169 Village Street	Y	Infrastructure
Shorewood Road Pump Station	40 Shorewood Road	Y	Infrastructure
Bubier Road Pump Station	41 Bubier Road	Y	Infrastructure
Sargent Road Pump Station	20 Sargent Road	Y	Infrastructure
Nahant Street Pump Station	1 Nahant Street	Y	Infrastructure
Sumac Pump Station	99 Harbor Ave	Y	Infrastructure
Foster Street Pump Station	47 Foster Street	Y	Infrastructure
Harbor Ave Pump Station	26 Harbor Ave	Y	Infrastructure
Phillips Street Pump Station	15 Goldthwait Road	Y	Infrastructure
Clifton Pump Station	383 Atlantic Ave	Y	Infrastructure
Seaview Ave Pump Station	100 Seaview Ave	Y	Infrastructure
May Street Pump Station	13 May Street	Y	Infrastructure
Wilson Road Pump Station	6 Wilson Road	Y	Infrastructure
Lafayette Street Pump Station	159 Lafayette Street	Y	Infrastructure
Driftwood Road Pump Station	2 Driftwood Road	Y	Infrastructure
Riverside Road Pump Station	18 Yorkshire Road	Y	Infrastructure
SESD Beach Street Pump Station		Y	Infrastructure
Tedesco Street Pump Station		Y	Infrastructure
Loring Ave Pump Station		Y	Infrastructure

Facility	Address	Listed in Previous Plan?	Building or Infrastructure
Burkes Hill Stand Pipe		Y	Infrastructure
Monopole	100 Tower Way	Y	Infrastructure
Riverhead Boat Ramp			
Little Harbor Boat Ramp			

Critical Transportation Infrastructure

The Massachusetts Bay Transit Authority (MBTA) services Marblehead. The bus lines 441, 442, 448, and 449 go into Boston via Lynn. A commuter rail service to North Station in Boston is also available on the Rockport line from Salem Station and Swampscott Station. The average travel time from Salem to North Station via the train is about 25-34 minutes and 25-27 minutes from the Swampscott Station making the route useful for commuters needing access to surrounding communities.[43]

There is also a seasonal ferry that runs from Salem to Boston and Logan Airport which can be accessed by Marblehead residents and visitors. There are many parking spots available at all the transportation services stations whether you travel by land or sea.[44]

If residents and visitors want to experience the coastal scenery in the area, a Scenic Byway was established in 2010 that travels from Lynn to Newburyport and provides access to downtown Marblehead.[45]

There are many "public ways" in Marblehead that were established in the early days to maintain the rights of public passage through the Town. These public ways count as any passageway that allows for vehicles, bicycles, pedestrians, and those taking alternative modes of transport to readily access it for travel. There are 18 public ways still open for public use which include eight in downtown Marblehead and ten on Marblehead Neck.

The eight public ways in Downtown Marblehead include:

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[43] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.

[44] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.

[45] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.

1. Lookout Court
2. Prospect Alley
3. Hollyhock Lane
4. Alley Steps
5. Gingerbread Lane
6. Knight's Hill Road
7. Elm Street to High Street Alley
8. Washington Street to Mechanic Street Alley.[46]

The ten public ways in Marblehead Neck include:

1. Desmoulin Lane
2. Fuller Lane
3. Castle Rock Lane
4. Point-o-Rocks Lane
5. Lighthouse Lane
6. Cove Lane
7. Nahant Street
8. Peabody Lane
9. Harvard Street
10. Parker Lane.[47]

Dams

There are no major dams in Marblehead; however, the Town relies on the Quabbin Reservoir and the Wachusett Reservoir for water supply. The Quabbin Reservoir is one of the largest unfiltered water supplies in the United States. Quabbin and the Wachusetts Reservoir, as well as the Ware River, source high quality water for the Massachusetts Water Resources Authority water supply system. Quabbin Reservoir holds 412 billion gallons and covers 39 square miles with 181 miles of shoreline. Recreational activities are regulated, and 3 million people receive their drinking water from the Quabbin Reservoir.[48]

[46] "Public Ways." (n.d.). Town of Marblehead, Massachusetts.
[47] "Public Ways." (n.d.). Town of Marblehead, Massachusetts.
[48] "Quabbin Reservoir." (2022). Commonwealth of Massachusetts.

According to the Marblehead's 2013 Natural Hazards Mitigation Plan there are no identified dams at risk of failure within Marblehead.[49]

Economy

Marblehead's top three industries by occupation according to the United States Census include:

1. Educational services, healthcare and social assistance
2. Professional, scientific, and management, and administrative and waste management services
3. Finance and insurance, and real estate and rental and leasing.[50]

According to the 2012 Marblehead Open Space and Recreation Plan, it was stated that, "Marblehead's long-term development pattern is largely established. The future is likely to continue the pattern of in-fill construction of single-family homes, reuse or replacement of existing structures, and small nonresidential developments because of its proximity to Boston, its strong economy, and its desirable location for young families."[51]

In the later 20th-century, many small companies developed. As they occupied small office buildings nestled among residentials areas in the outer areas of Town, many independent businesses continue to thrive in former or current residential buildings.[52]

Historic and Cultural Resources

With such a longstanding history, the Town of Marblehead has many historic and cultural resources. It is part of the Essex National Heritage area, which is a federally designated region comprising 34 historic and naturally rich communities. Marblehead is also part of the Essex County Scenic Byway route which was established in 2011 and runs along the coast on Routes 129 and Route 1A from Lynn to Newburyport.[53]

Many historic sites can be encountered throughout the Town like Old Burial Hill, Fort Sewall, Old Powder House, Jeremiah Lee Mansion, and others. The Town also has a reenactment by the present-day Glover's Marblehead Regiment to remember and honor the past. Marblehead is home to several historic churches as well as historic paintings like the famous "Spirit of '76'" by Archibald Willard.[54] The

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[49] "Natural Hazards Mitigation Plan." (2013). Town of Marblehead, Massachusetts.
[50] "Industry By Occupation for the Civilian Employed Population 2020 ACS 5-Year Estimates." (2022). United States Census Bureau
[51] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[52] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[53] "Marblehead Open Space and Recreation Plan." (2012). Town of Marblehead, Massachusetts.
[54] "Visiting & Town History." (n.d.). Town of Marblehead, Massachusetts.

Town's Website showcases "Hidden Jewels" that residents and visitors may not necessarily know about or think to visit. These include:

- Old Burial Hill
- Rail Trail
- Redd's Pond
- Marblehead Neck Wildlife Sanctuary.[55]

The 14 National Register Buildings and Sites List in Marblehead include:

1. General John Glover House
2. Elbridge Gerry House
3. Robert "King" Hooper Mansion
4. Old Town House
5. St. Michael's Church
6. Fort Sewall
7. Abbot Hall
8. Jeremiah Lee House
9. Marblehead Historic District
10. Story Grammar School
11. Marblehead Light
12. Harris Farm
13. Seaside Park
14. JOFFREE (Shipwreck).
15. Black Joes Tavern[56]

[55] "'Hidden' Town Jewels." (n.d.). Town of Marblehead, Massachusetts.

[56] "Historic Places." (2021). Marblehead Historical Commission.

Chapter 3. Planning Process

The planning process was developed in full compliance with the current planning requirements of the Federal Emergency Management Agency (FEMA) per the following rules and regulations:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288), as amended by the Disaster Mitigation Act of 2000
- Code of Federal Regulations – Title 44, Chapter 1, Part 201 (§201.6: Local Mitigation Plans)
- Federal Emergency Management Agency Local Mitigation Planning Policy Guide, (Released April 19, 2022, Effective April 19, 2023)
- In addition, the plan was prepared with the suggestions found in the Demonstrating Good Practices Within Local Hazard Mitigation Plans, FEMA Region 1, January 2017.

A1. Does the Plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))

A priority through the planning process was equity, which FEMA defines as the "consistent and systematic fair, just and impartial treatment for all individuals." This was a central theme through the planning process and effort was made to develop an inclusive planning process. The whole community (individuals, communities, private and nonprofit sectors, faith-based organizations, and all levels of government) were given an opportunity to participate.

The planning process for this updated mitigation plan began in August 2022 and concluded in June 2023 (this does not include the months of plan review and adoption). The Town developed a Municipal Vulnerability Preparedness (MVP) Program summary of findings in 2018. This planning effort contributed to the update of the mitigation plan. Below is a graphical display of the plan development timeline. The months with one check mark indicate a Hazard Mitigation Planning Committee (HMPC) meeting was held and the months with two check marks indicate that a public meeting was also held. Rebecca Curran Cutting, Town Planner was the Chair of the HMPC and the primary contact for the consulting team. Rebecca Curran Cutting facilitated all activities related to the mitigation plan update, including meeting logistics, data gathering, and public outreach. The Consulting Team met with Rebecca Curran Cutting on August 23, 2022, to review the planning process and timeline, and to discuss developing the HMPC, collecting GIS data, and determining the status of previously identified mitigation actions.

Table 4. Planning Process Timeline.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Task 1. Convene Local HMPC	Kick-off Meeting	HMPC Meeting	HMPC Meeting	Public Meeting		HMPC Meeting		HMPC Meeting	Public Meeting
Task 2. Update Hazard Profiles									
Task 3. Update Critical Facility Inventory									
Task 4. Update Mitigation Goals									
Task 5. Update Mitigation Actions									
Task 6. Plan Review, Evaluation, and Implementation									
Task 7. Public Review of Draft									
Task 8. Review and Approval									

Hazard Mitigation Planning Committee

The Town Planner developed the Hazard Mitigation Planning Committee (HMPC) to support the planning process. This team included Town employees who represented six sectors of the community shown in Table 5. A full list of HMPC members is shown in Table 6. The HMPC met four times, September 21, 2022, October 26, 2022, January 12, 2023, and March 30, 2023. All the meetings were conducted via Zoom due to the Covid-19 Pandemic, however sometimes Town employees gathered at the Town offices. A list of participants at each of these meetings is included in Appendix A.

Table 5. Sectors of the Community represented on the HMPC.

Sectors of the Community	HMPC Members
1. Emergency Management	• Fire Chief • Emergency Management Director • Policy Chief • Director of Public Works • Superintendent of Water and Sewer
2. Economic Development	• Town Planner and Assistant Town Planner

Sectors of the Community	HMPC Members
	• Town Administrator
3. Land Use and Development	• Town Planner and Assistant Town Planner • Town Engineer and Conservation Administrator • Town Administrator
4. Health and Social Services	• Director of Public Health
5. Infrastructure	• Planning and Community Development Director • Department of Public Works Utilities Director • Department of Public Works Engineer • Water and Sewer Superintendent & Assistant Superintendent • School Superintendent • Building Commissioner • Facilities Director • Municipal Light Department Manager
6. Natural and Cultural Resources	• Tree Warden • Town Planner • Town Engineer and Conservation Administrator • Town Administrator • Harbormaster

Table 6. HMPC Members.

First Name	Last Name	Title	Affiliation	Phone	Email
John	Albright	Building Commissioner	Town of Marblehead	781-631-2220	albrightj@marblehead.org
Todd	Bloodgood	Facilities Director	Town of Marblehead	781-639-3140	bloodgood.todd@marbleheadschools.org
Charles	Cerrutti	Emergency Management Director	Town of Marblehead	781-631-0421	cerruttic@marblehead.org
Rebecca	Curran	Town Planner	Town of Marblehead	781-631-1529	rebeccac@marblehead.org
Jonathan	Fobert	Tree Warden	Town of Marblehead	781 631-2721	jfobert@marblehead.org
Jason	Gilliland	Fire Chief/Emergency Management Director	Town of Marblehead	781-631-0421	gillilandj@marblehead.org
Jimmy	Johnson	Department of Public Works Utilities Coordinator	Town of Marblehead	781-631-1750	johnsonj@marblehead.org
Thatcher	Kezer	Town Administrator	Town of Marblehead	781-631-0000	kezert@marblehead.org
Dennis	King	Police Chief	Town of Marblehead	781-631-1212	kingd@marblehead.org
Joe	Kowalik	Manager, Marblehead Municipal Light Department	Town of Marblehead	781-631-5600	jkowalik@marblehead.org
Amy	McHugh	DPW Director & Water and Sewer Superintendent	Town of Marblehead	781-631-1750	mchugha@marblehead.org
Andrew	Petty	Director of Public Health	Town of Marblehead	781-631-0212	pettya@marblehead.org
Charlie	Quigley	Town Engineer, Conservation Administrator	Town of Marblehead	781-631-1529	quigleyc@marblehead.org

Mark	Souza	Harbormaster	Town of Marblehead	781-631-2386	souzam@marblehead.org
Bethany	Spangler	Water and Sewer Assistant Superintendent	Town of Marblehead	781-631-0102	spanglerb@marblehead.org
Maggie	Wheeler	Department of Public Works Engineer	Town of Marblehead	781-631-1750	wheelerm@marblehead.org
Jeffrey	Zukowski	Hazard Mitigation Planner	MA Emergency Management Agency	508-820-1422	jeffrey.zukowski@state.mas.us

A2. Does the Plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2))

The first HMPC Meeting was held on September 21, 2022, provided an opportunity for the consulting team and the Town Planner to introduce the HMPC to the mitigation planning process. After an introduction to the plan, the HMPC identified natural hazards and critical facilities. They then discussed public engagement. The HMPC members mentioned including additional stakeholders into the planning process like the Metropolitan Area Planning Council (MAPC), Salem Coast Watch, Barbara Warren Environmental Group, Northeast Regional Security Council, South Essex Sewer District Watershed, North Shore Transportation Task Force, Northeastern Massachusetts Aquaculture Center (NEMAC), and Mutual Aid with the Fire District.

When considering infrastructure, Marblehead has emergency shelters at the Veteran's Middle School and Brown Elementary School and the Emergency Operation Center is at the Police Station. The Town also has a Tree Warden. The Town has applied for work on their pump station. Regarding environmental justice communities, the HMPC mentioned "The Shipyard" which has an active neighborhood association that should be included in outreach. This area has a non-native English-speaking population, as well. The Town has its own Electric Light Department.

Regarding natural hazards, the HMPC said that infectious diseases are well covered by the Public Health Emergency Preparedness Group which receives grants from the Center for Disease Control and Prevention (CDC) – the Town is part of Region 3D. For invasive species, the Town is overrun with some vegetation that "chokes out" native species.

The second HMPC meeting, held on October 26, 2022, began with a discussion of how the prior Hazard Mitigation Plan was used. The plan was integrated in instances where someone built in designated high hazard areas, they had to follow the building code. The HMPC mentioned that private property makes flood management "tricky," particularly with flood estimates on properties. Flood zones are present throughout the Town and there was a discussion about the Shoreline District expanding by an addition of over 500 feet.

The HMPC then discussed each natural hazard and reviewed impacts over the last five to ten years. They mentioned coastal and non-coastal flooding primarily at the entrances of the Town, times of drought, erosion that has caused "big issues" for the Municipal Electric Light Department and Salem Harbor. Extreme temperatures seem to be managed well with the Electric Light Department asking residents to self-reduce which works well for the municipality. They also maintain poison ivy and overgrown brush to protect poles. Regarding hurricanes and severe storms, the Electric Light Department is concerned with local storms that have downed trees, wires, and shut down the Town for hours, particularly in Fall 2021.

A microburst several years ago (perhaps 2017), caused damaged to the Corinthian Yacht Club where many boats were destroyed.

The meeting ended with brainstorming potential mitigation actions that include taking part in the Community Ranting System (CRS,) bringing supply lines underground, adding supply lines from a second direction, working with the Tree Warden, Department of Public Works, and Town Engineer, and adding substations and a generator. There was a Community Development Plan as it related to COVID-19 created; however, the last updated Community Development Plan was in 1988. The Town is currently working on a Harbor Management Plan and have updated their Zoning Bylaws in 2020.

The third HMPC meeting, held on January 12, 2023, began with a discussion update getting data from the Woods Hole Group. The HMPC mentioned that flooding and coastal winds are their biggest concerns. They have already identified areas of flooding and mitigated them accordingly. They want to turn their attention to wind through mitigation actions such as incentives and education. The Town experienced a storm on December 23, 2022, and they were interested in the windspeeds that occurred during the storm because of their unique coastal location. Information like this could be provided via an application like Ventusky that offers data in real time. Additional tools like anemometers would also be beneficial.

The conversation turned to Town-wide plan updates and capabilities. During the pandemic, there were food security concerns, but the Town has adjusted since then, for instance people put freezers in the homes for supplies and they built pantries. The local electric and light utility is very valuable for the Town, as well. The HMPC stated undergoing a Drainage Project on Pleasant Street and Capital Improvement Planning. They would like additional funding for their Public Assistant 406 Program. The HMPC also wants to develop and implement a sustained engagement process.

The focus for the fourth HMPC meeting, held on March 30, 2023, was spent reviewing the public meeting and planning mitigation actions. The HMPC found that major points of interest included having an Online Open House, supporting vulnerable populations, putting emergency notification systems in place for all residents, and engaging with stakeholders that are part of environmental justice communities and other vulnerable populations. Regarding mitigation actions, the HMPC wanted to integrate the Coastal Resiliency Study and Harbor Plan's actions, along with managed of infiltration and inflow in sewers.

The HMPC also participated in two public meetings, one on November 21, 2022, and one on March 21, 2023. Finally, the HMPC reviewed the draft Town of Marblehead, MA Hazard Mitigation Plan Update prior to sending it to the Massachusetts Emergency Management Agency (MEMA) for their review in July 2023.

Public Outreach

A3. Does the Plan document how the public was involved in the planning process during the drafting stage? (Requirement §201.6(b)(1))

The Public Outreach Strategy was designed to involve the whole community in the mitigation planning process. The public was engaged in the planning process during the drafting of the plan and prior to plan approval through two public workshops (a flyer for the first workshop is shown below). Each public meeting was held virtually due to the Covid-19 Pandemic. The public was also given a chance to review the plan prior to its review by MEMA or FEMA. The purpose of public engagement was to:

- Generate public interest in mitigation planning.
- Identify and accommodate special populations.
- Solicit public input.
- Engage local stakeholders.
- Create opportunities for public and local stakeholders to be actively involved in the mitigation planning process.

Each public meeting included a PowerPoint presentation and plenty of opportunity for questions and discussion. In addition, Mentimeter was used to facilitate input from meeting participants. This has proven to be an effective tool when engaging people who may not be comfortable speaking up in a virtual meeting. The HMPC participated in each meeting. Both meetings were recorded for posting on public broadcasting.

__COMMUNITY LIFELINES__ are the most fundamental services in the community that, when stabilized, enable all other aspects of society.

Representatives from all community lifelines were included in public engagement efforts. Community lifelines are a driving force behind FEMA's strategic goals for building a culture of preparedness and readying the nation for catastrophic disasters. The seven community lifelines can be a powerful tool for local governments when evaluating risk and developing mitigation actions. The HMPC considered the seven community lifelines when conducting outreach through this planning process. The seven community lifelines and their respective components are shown in the figure below.

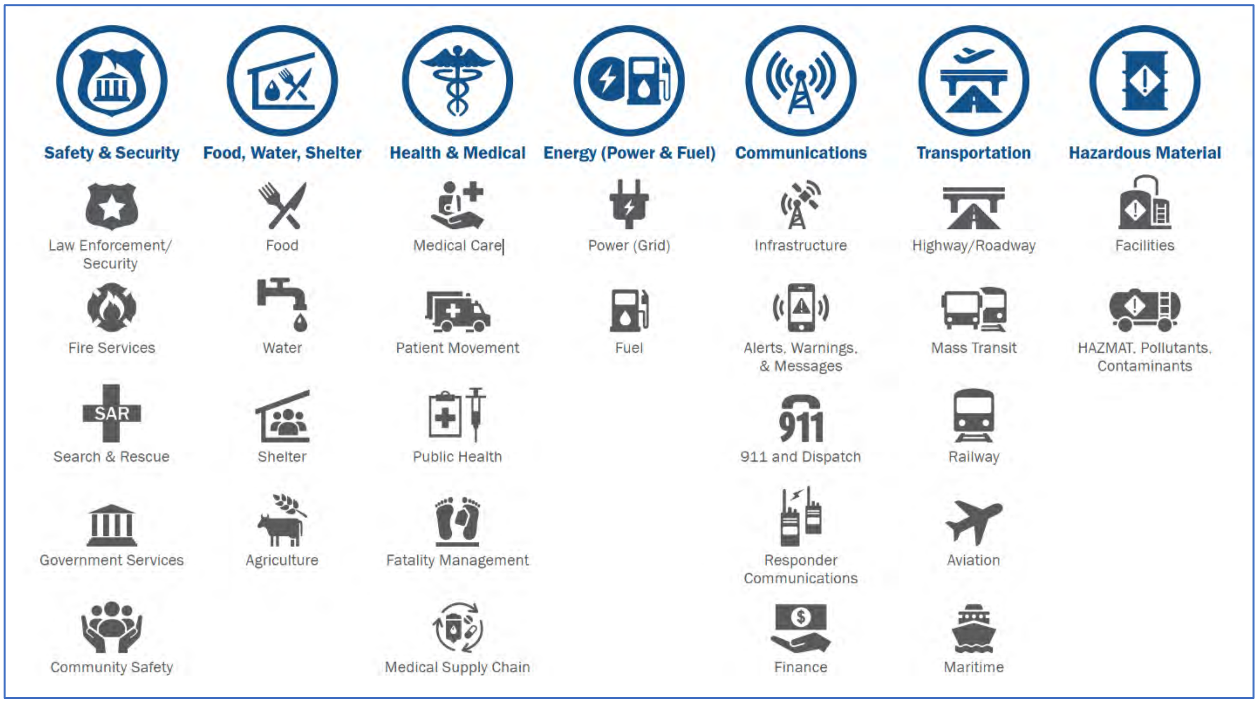


Figure 4. Community Lifelines.

Outreach for the public meetings and for plan review was sent via press release, email blasts, and news postings. The https://www.marblehead.org/ website included announcements for meetings, the press releases were sent to local organizations. The Town Planner worked with the Board of Health to reach out to vulnerable populations through a Code Red Blast, while also posting flyers in the library, community rooms in the Housing Authority, and businesses within the Environmental Justice Area.

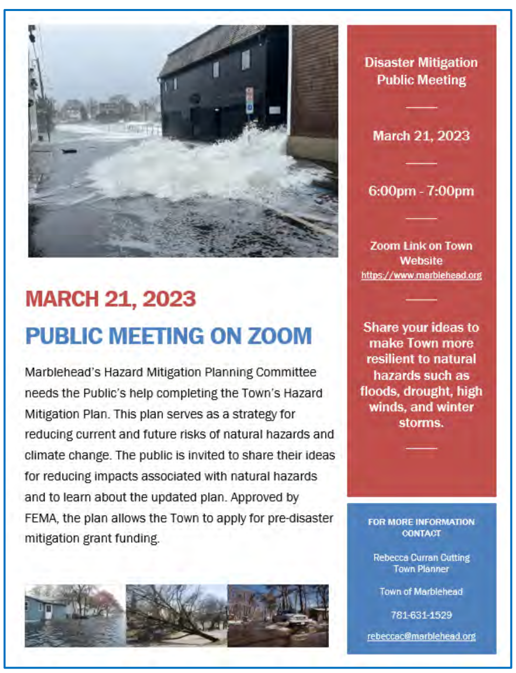


Figure 5. Public Workshop Flyer.

Additional outreach efforts included sending the flyers and press releases to listservs, schools, MAPC, regional partners, adjacent communities, and large developers in Town. Beyond specific outreach to vulnerable populations, the Emergency Management Director and the Director of Public Health represented vulnerable populations on the HMPC. Copies of the outreach materials are in Appendix A.

Information gathered during the public meetings contributed to the plan's development. The first public meeting was held on **November 21, 2022**. Concerns about private sea walls and breakwaters were discussed. One resident stated that the issue of private sea walls relates to threatening underground water, sewer, and power and because of the adjacent road being built on peat, it will be a reoccurring threat. Another resident encouraged repairing and elevating protective structures, especially during nor'easters when they are needed most. Hazards that were discussed included flooding, super storms, issues with storm drains and infiltration, and invasive species.

The public meeting was held via Zoom and there were approximately 26 people in the meeting. The meeting asked participants a series of questions to engage them and help them understand the process of developing a hazard mitigation plan. The questions are listed below.

1. Who lives and works in your community?
2. What buildings and infrastructure are critical to your community?
3. What weather related hazards can impact your community
4. Name specific locations in your community that flood or are vulnerable to natural hazards.
5. What can be done to mitigate risks you have identified? Think of activities to protect the people, buildings, and infrastructure named previously.

Answers were given through Mentimeter and verbally. Key responses to the first question included the identification of small businesses owners, the Town's aging population, students, commuters, municipal employees, healthcare workers, and boaters.

When asked about weather related hazards the word cloud below was generated.

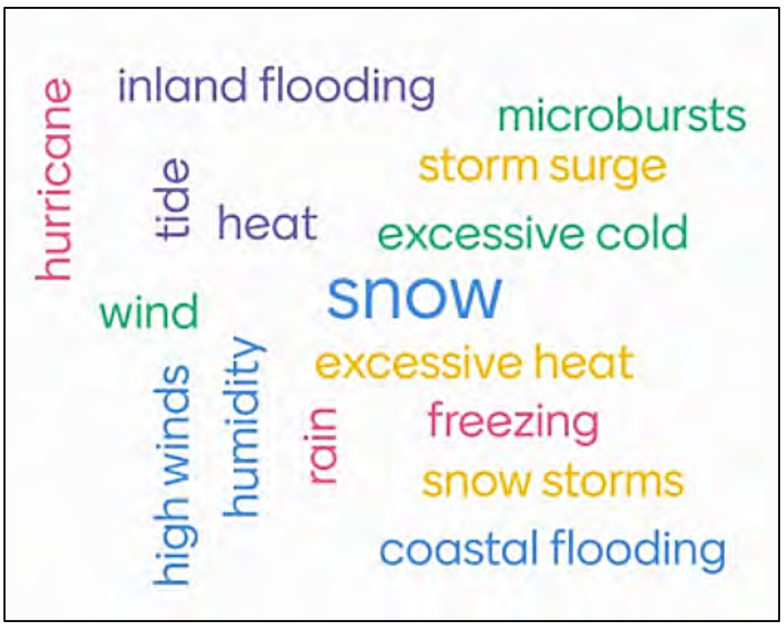


Figure 6. Types of Natural Hazards Word Cloud.

When asked about how to protect natural resources from natural hazards and climate change, public meeting participants gave the following responses:

- Breakwater
- Early Warning to Public
- Seawall

- Adopt Stretch Building Code
- Higher Sea Walls
- Public Education as to the Extent of the Risk
- Underground Power
- Put Electric Lines Underground
- Flood Plain Regulations
- Understand Evacuation Routes
- Water Removal Capability

The meeting concluded with the discussion about the potential mitigation actions listed above. Members of the community were adamant about addressing flooding along the coastline and working on mitigation actions that would protect damage during storms. The recording of the meeting can be found on the Town's website.

A response to the article about the first public meet meeting was sent in by Judy Allen, a resident of Marblehead. It was as follows:

> *"Responding to the newspaper article (Nov. 25) about Marblehead's hazard mitigation plan -- and in response to widespread enthusiasm for a breakwater across the wide expanse of Marblehead Harbor --*
>
> *It seems to me that a breakwater across Marblehead Harbor would be horrendous, and would allow further (even if different) damage to the harbor floor etc., and would create far more problems than it would solve (including hugely negative impact on repeated need for costly repairs). ... Not to mention how incredibly ugly it would make a harbor that is truly among the most beautiful on the eastern seaboard, just for the sake of occasional annual storms ...*
> *To be effective (and to not funnel the wave force into even narrower access points instead), a breakwater would need to stretch all the way across from the tip of Peach's Point to the tip of Marblehead Neck. ... That seems ludicrous, and financially prohibitive -- unless it was a floating breakwater of some type that could be deployed before a storm and removed afterward. (But storage becomes a secondary problem.)*
>
> *No doubt there are other, less invasive and more localized mitigation options, which I hope common sense will prioritize over a potential breakwater, which would still fail to protect from catastrophic storms.*
>
> *I hope your consultation can recommend other more practical and feasible options that people would embrace, in order for so many residents to let go of a widespread infatuation with the concept of a breakwater."*

The second public meeting held on **March 21, 2023,** had approximately 18 meeting participants. During this meeting, participants emphasized the many locations that should be considered in the Hazard Mitigation Plan such as the coastline, housing on low coastal areas, the bridge to Swampscott, and reducing impermeable surfaces. One resident suggested "[to] enforce buffer zones around water resources," while another stated to "prepare for isolation" in a major event. A request for educational materials was also brought into the conversation.

Figure 7. Mentimeter Result from Public Meeting.

Contributions from the HMPC and public engagement impacted the plan in multiple ways. The table below indicates some of the contributions, others are included above and throughout the plan.

Table 7. Where Public Engagement Informed the Plan.

Area of the Plan Impacted	Contributions
Planning Area Profile	• The HMPC updated the list of critical facilities, shown in Chapter 2. They also contributed information regarding current land use practices.
Planning Process	• Participated in every aspect of the planning process and made recommendations regarding how to engage the public and key stakeholders to include.
Risk Assessment	• Described extent of hazard impacts based on previous events and the individual impacts on residents and visitors. • Added the qualitative review to the risk analysis for determination of the hazard risk ranking.
Capability Assessment	• Contributed plans, bylaws, and reports for review. • Informed which plans or guidelines were a priority for the community. • Completed three Capability Assessment questionnaires including the National Flood Insurance survey and the Safe Growth survey.

Area of the Plan Impacted	Contributions
Mitigation Strategy	• Identified and prioritized mitigation actions based on public meeting participants' concerns. • Added specificity to mitigation action locations and impacted communities.
Implementation Plan	• Committed to integrating this plan more thoroughly throughout Town government and to posting the plan on the Town's website.

Review of Draft Plan

The Town made the plan available for public review in November and December 2023. A press release announcing the availability to review the plan was sent and the announcement was posted to the Town website. The HMPC sent emails to specific stakeholders in Town and in the adjacent communities. Announcements were also posted on social media and mentioned in meetings with stakeholders and the public. Hard copies of the plan were kept in the Town Planner's office. Comments from the public were collected by the Town Planner or sent to the Principal, Jamie Caplan of Jamie Caplan Consulting, LLC.

Several comments were received from the public and edits to the plan were made. Below are a couple of the comments received.

> Just as Sustainable Marblehead (SM) is listed as a partner in the Net Zero Plan Appendix on issues related to education and outreach, I would submit that SM is also able to do the same to help implement this plan. Generally, if the goal is to "educate all stakeholders about the value of hazard mitigation and how to implement it in their work, businesses, and homes," this is something we can help you accomplish. I have already worked with Thatcher Kezer and Amy McHugh on educational articles in our monthly newsletter to reach our 1,300 subscribers and would be interested in disseminating additional educational materials and information related to hazard mitigation. We also have a monthly column in the *Marblehead Current* that could be used to spread this information to a larger readership.

> Consider moving "Coastal Erosion" to the red category. (The HMPC will convene and consider this after FEMA approval.)

Chapter 4. Risk Assessment

Hazard Identification

> ***RISK** for the purpose of hazard mitigation planning, is the potential for damage or loss created by the interaction of natural hazards with assets, such as buildings, infrastructure, or natural and cultural resources.*

The first step in the risk assessment was to revisit and evaluate the hazards identified for study and inclusion in the Town's previous draft hazard mitigation plan. This was a key topic of discussion at the first Hazard Mitigation Planning Committee (HMPC) meeting, along with the consideration of any additional hazards to include in the updated risk assessment. While only natural hazards are required to be addressed by FEMA, other hazards such as technological and human-caused hazards may be included if they are of significant concern to the community and determined to be a mitigation priority.

In completing the updated hazard identification process, the HMPC considered the results of the Town's Municipal Vulnerability Preparedness (MVP) planning effort (completed in 2018), as well as the 2018 State Hazard Mitigation and Adaptation Plan (SHMCAP).[57] As a result of this process all hazards from the prior hazard mitigation plan (adopted in 2013) remain in this updated risk assessment. For this updated assessment, some hazards have been consolidated or renamed to be consistent with the SHMCAP, as further described below.

The top four natural hazards identified for the MVP effort are thoroughly covered in this assessment, which are coastal flooding, inland flooding from intense precipitation, high wind events, and coastal erosion. In addition, the hazards infectious disease (somewhat broader than vector borne diseases) and invasive species are profiled in this plan. Infectious disease was added based on the impacts of the Covid-19 pandemic as well the Commonwealth's growing concern for the increased prevalence of vector-borne diseases. Invasive species as a hazard was added to reflect the concern for this becoming a more prevalent challenge with projected climate change; and to ensure that the risk assessment is aligned with the SHMCAP.

All relevant hazards as identified in the SHMCAP were therefore considered and addressed in this risk assessment.

The Town of Marblehead has been subject to numerous federal disaster declarations along with the entirety of Essex County. Some of these disaster declarations correspond to emergency declarations in portions of Massachusetts. The following table cross-references the 13 Massachusetts emergency declarations starting in 2011 with the corresponding federal disaster declarations. All the Massachusetts emergency declarations corresponding to Marblehead have involved natural hazards addressed in this plan except for the shelter capacity crisis, which is not a natural hazard and not

[57] Massachusetts State Hazard Mitigation and Climate Adaptation Plan. 2018.

profiled in this plan. Hazards that do not appear in this table (i.e., earthquakes) have not been subject to Massachusetts emergency declarations.

Table 8. Massachusetts Emergency Declarations.

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Marblehead?
Storm Lee	9/15/2023	9/16/2023	Not applicable	Not applicable	Yes
Severe Weather and Flooding	9/12/2023	9/16/2023	Not applicable	Not applicable	Yes
Shelter Capacity Crisis	8/8/2023	Pending	Not applicable	Not applicable	Yes, but not a natural hazard and not a FEMA declaration for Massachusetts
COVID-19	3/10/2020	5/11/2023	DR-4496-MA	All counties	Yes
Merrimack Valley Gas Explosion	9/14/2018	10/4/2018	Not applicable	Not applicable	No
Coastal Storm	3/3/2018	3/6/2018	DR-4372-MA	Essex, Norfolk, Plymouth, Bristol, Barnstable, and Nantucket Counties	Yes
Winter Storm	2/9/2015	2/25/2015	Not applicable	Not applicable	No
Winter Storm	1/26/2015	1/28/2015	DR-4214-MA	Worcester County and eastward	Yes
Winter Storm	2/8/2013	2/13/2013	DR-4110-MA	All counties	Yes
Hurricane Sandy	10/27/2012	11/1/2012	DR-4097-MA	Suffolk, Bristol, Plymouth,	No

Massachusetts Emergency	Start	Termination	Corresponding Federal Disaster Declaration	FEMA Public Assistance Available	Applicable to Marblehead?
				Barnstable, Dukes, and Nantucket Counties	
Nor'easter	10/29/2011	11/7/2011	DR-4051-MA	Berkshire, Franklin, Hampshire, Hampden, Worcester, and Middlesex Counties	No
Hurricane Irene	8/26/2011	9/6/2011	DR-4028-MA	Berkshire, Franklin, Hampshire, Hampden, Norfolk, Bristol, Plymouth, Barnstable, and Dukes Counties	No
Tornadoes	6/1/2011	6/19/2011	DR-1994-MA	Hampden and Worcester Counties	No

To better reflect the relationship between natural hazards and changing climate and weather patterns, each of the individual hazards identified for the updated risk assessment have been reorganized and categorized according to their primary interaction with climate change. These new categories are consistent with the SHMCAP and include the following:

- Changes in Precipitation
- Sea Level Rise
- Rising Temperatures
- Extreme Weather
- Non-Climate Influenced Hazards

This new classification for identified hazards was utilized for the plan update to consolidate and be consistent with the state's current hazard classification scheme per the SHMCAP, which is anticipated to be the same when the new edition of the SHMCAP is published in the second half of 2023.

Table 9 provides an abbreviated list of the 13 primary hazards included in the update risk assessment.

Table 9. Town of Marblehead Hazards.

Primary Climate Change Interactions	Hazards
Changes in Precipitation	1. Flooding *(including riverine, dam failures, ice jams, etc.)* 2. Drought
Sea Level Rise	3. Coastal Flooding 4. Coastal Erosion
Rising Temperatures	5. Extreme Temperatures 6. Wildfires *(including brush fires)* 7. Infectious Disease 8. Invasive Species
Extreme Weather	9. Hurricanes/Tropical Storms 10. Severe Winter Storm/Nor'easter *(including blizzard, ice storm, etc.)* 11. Tornadoes 12. Other Severe Weather *(including thunderstorms, etc.)*
Non-Climate Influenced Hazards	13. Earthquake

Link to Massachusetts Climate Change Assessment

The 2022 Massachusetts Climate Change Assessment report was issued in December 2022 (https://www.mass.gov/info-details/massachusetts-climate-change-assessment#read-the-report-). This report provided statements about the impacts of climate change in five sectors within each of seven designated regions of Massachusetts. Marblehead is in the "North and South Shores" region shown in dark blue in the figure below. The table below lists the top two or three impacts of climate change in each of the five sectors within this region.

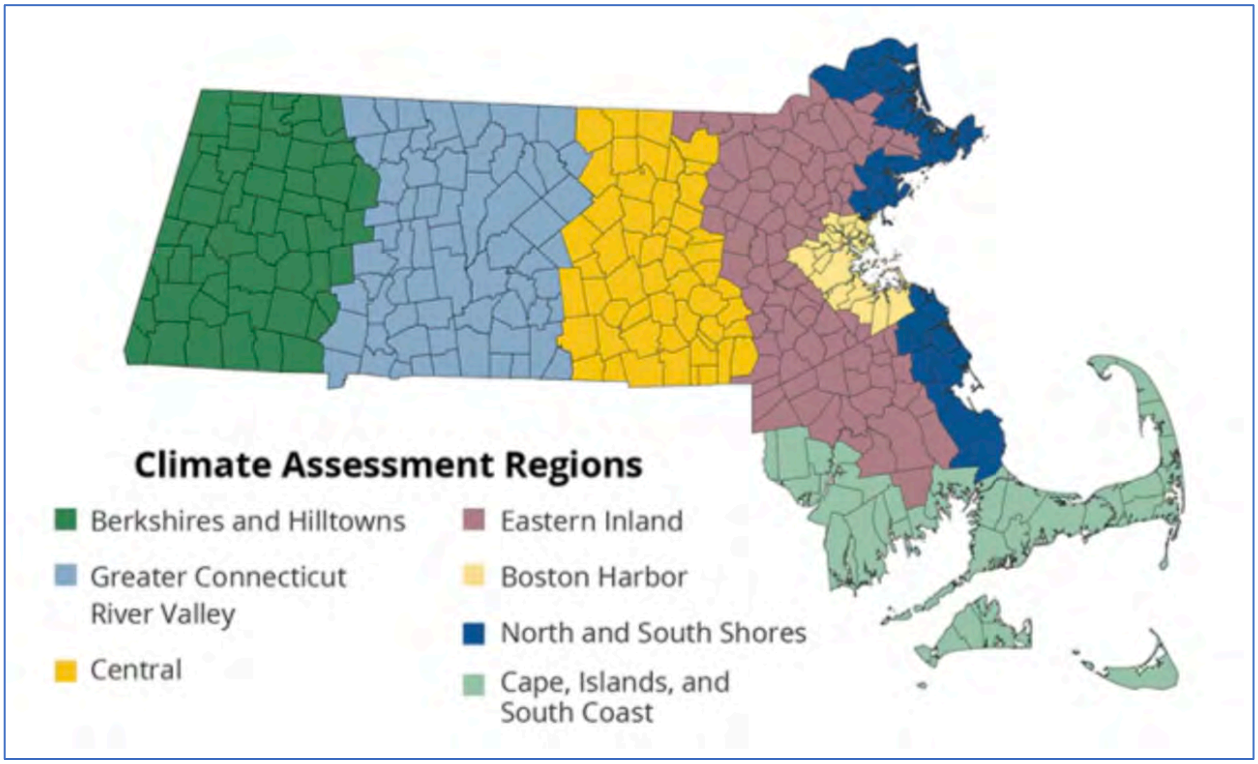


Figure 8. Climate Assessment Regions. Marblehead is in the North and South Shores Area.

Table 10. Top Impacts of Climate Change per Sector in North and South Shores Region.

Sector	Top Impacts per Sector	Comments
Human	Emergency service response delays and evacuation disruptions	During coastal storm surge and inland floods
	Health effects from degraded air quality	Includes childhood asthma and premature death from climate impact on particulate matter and ozone
	Reduction in food safety and security	Causes are production and supply chain issues as well as spoilage during outages
Infrastructure	Damage to electric transmission and distribution	From heat stress and extreme storms
	Damage to coastal buildings and ports	Causes are sea level rise, storm surge, erosion, and wind

Sector	Top Impacts per Sector	Comments
Natural Environment	Marine ecosystem degradation	Causes are warming waters and ocean acidification
	Coastal wetland degradation	Causes are sea level rise and storm surge
Governance	Reduction in State and municipal revenues	Causes are reduced property tax base due to coastal floods
	Increase in costs of responding to climate migration	Includes planning for abrupt increases in local populations
	Increase in demand for State and municipal services	Includes emergency response, food assistance, and health care
Economy	Reduced ability to work	For outdoor workers during extreme heat events, as well as delays in commute times
	Reduction in availability of affordably priced housing	Causes are direct damage (floods) and scarcity caused by demand

Eventually, these impacts will be incorporated into the SHMCAP update scheduled for release in late 2023. The Town assumes that the SHMCAP will provide guidance about how to link the top climate impacts with the profiling of specific hazards. In the meantime, the Town proposes to incorporate these top climate change impacts in this edition of its plan as outlined below.

Table 11. How This Plan Addresses the Top Impacts of Climate Change per Sector.

Sector	Top Impacts per Sector	Approach to Incorporating Impacts
Human	Emergency service response delays and evacuation disruptions	The events that cause delays and disruptions (severe storms, floods, etc.) are the hazards profiled in this plan.
	Health effects from degraded air quality	One hazard that affects air quality (i.e., extreme heat) is profiled in this plan.
	Reduction in food safety and security	Some of the hazards that affect food security (i.e., droughts) are profiled in this plan. However, Marblehead depends on food from other regions, and additional efforts beyond the scope of this plan will be needed to protect food safety and security.
Infrastructure	Damage to electric transmission and distribution	Severe weather events that damage transmission and distribution are hazards profiled in this plan.

Sector	Top Impacts per Sector	Approach to Incorporating Impacts
	Damage to coastal buildings	Severe coastal storm events and coastal floods that damage coastal buildings are hazards profiled in this plan.
Natural Environment	Marine ecosystem degradation	Additional efforts beyond the scope of this plan will be needed to address the warming ocean waters and acidification cited as the causes of degradation.
	Coastal wetland degradation	Sea level rise, storm surge, and erosion are hazards profiled in this plan.
Governance	Reduction in State and municipal revenues	The capability assessment and related mitigation actions will help address increased demands for municipal revenues.
	Increase in costs of responding to climate migration	The capability assessment and related mitigation actions will help address increased costs related to responding to climate migration.
	Increase in demand for State and municipal services	The capability assessment and related mitigation actions will help address increased demands for municipal services.
Economy	Reduced ability to work	The individual hazards addressed in this plan can reduce ability to work, and the specific actions for each hazard will help protect lifelines and systems needed for work.
	Reduction in availability of affordably priced housing	The individual hazards addressed in this plan can reduce the availability of affordably priced housing, and the specific actions for each hazard will help protect housing options and opportunities.

Hazard Profiles

B1. Does the plan include a description of the type, location, and extent of all natural hazards that can affect the jurisdiction? Does the plan also include information on previous occurrences of hazard events and on the probability of future hazard events? (Requirement 44 CFR §201.6(c)(s)(i))

B2. Does the plan include a summary of the jurisdiction's vulnerability and the impacts on the community from the identified hazards? Does the summary also address NFIP-insured structures that have been repetitively damaged by floods? (Requirement 44 CFR §201.6(c)(s)(ii))

The risk assessment for the SHMCAP describes the natural hazards that have the potential to impact the Commonwealth and provides the underlying narrative for this hazard profile for the Town of Marblehead. This section is organized by climate change interaction category, consistent with the SHMCAP. Because this section repeats information from the SHMCAP, some citations have been removed for brevity. The original citations can be found in the SHMCAP.

Profiles have been developed for each identified hazard, organized by primary climate change interaction. Hazard profiles include the following sections: Hazard Description, Location, Previous Occurrences, Extent, Probability of Future Events, and Vulnerability Assessment; these are described in the table below.

Table 12. Hazard Characterization.

Category/Method	Definition
Description	Description of hazard, its characteristics, and potential effects.
Location	Describes geographic areas within the town that are affected by the hazard.
Previous Occurrences	Provides information on the history of previous hazard events for the region, including their impacts on people and property.
Extent	Describes potential strength or magnitude of a hazard. Where possible, extent is described using established scales.
Probability of Future Events	Describes likelihood of future hazard occurrences in the town based on best available and climate-informed science.
Vulnerability Assessment	Describes potential impact on the community, including estimated potential losses and the anticipated effects of climate change.

***VULNERABILITY** is a description of which assets, including structures, systems, populations and other assets as defined by the community, within locations identified to be hazard prone, are at risk from the effects of the identified hazard(s).*

To describe previous occurrences, this plan update highlights major events from history but relies primarily on a roughly ten-year lookback (2012 through 2022) ending with any events from the date of plan development (2023). This helps maintain a concise narrative. Where applicable, narratives about warning times (i.e., floods, heat advisories, and wildfires) are incorporated into the *"Extent"* subsections.

The vulnerability assessment characterizes how hazards have impacted and may impact the different aspects of the community. In the vulnerability assessment sub-sections, the magnitude and likelihood of a hazard event are evaluated, and impacts are quantified using hazard models. Some hazards, like earthquakes and winter storms, will impact the entire community while other hazards, like floods and landslides, impact specific locations in the community. The areas that could be impacted are defined as the community's exposure. The results of the vulnerability assessment are used to help identify mitigation measures the community may take to lessen the impact and better understand their benefits.

Primary Climate Change Interaction: Changes in Precipitation

Flooding Including Dam Failures and Ice Jams

Nationally, flooding causes more damage annually than any other severe weather event. Flooding in Massachusetts is often the direct result of frequent weather events such as coastal storms, nor'easters, tropical storms, hurricanes, heavy rains, and snowmelt. Increases in precipitation and extreme storm events will result in increased inland flooding. Common types of flooding are described below.

The Town of Marblehead Community Resilience Building Workshop Summary of Findings (2018) lists "Inland flooding from precipitation" as one of the top four hazards of concern.

Description

River and Stream Flooding: River and stream flooding often occurs after heavy rain. Areas of the state with high slopes and minimal soil cover (such as found in western Massachusetts) are particularly susceptible to flash flooding caused by rapid runoff that occurs in heavy precipitation events and in combination with spring snowmelt, which can contribute to riverine flooding. Frozen ground conditions can also contribute to low rainfall infiltration and high runoff events that may result in riverine flooding. Some of the worst riverine flooding in Massachusetts' history occurred because of strong nor'easters and tropical storms in which snowmelt was not a factor. Tropical storms can produce very high rainfall rates and volumes of rain that can generate high runoff when soil infiltration rates are exceeded.

Floodplains are the low, flat, and periodically flooded lands adjacent to rivers, lakes, and oceans. These areas are subject to geomorphic and hydrologic processes. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined. These areas form a complex physical and biological system that supports a variety of natural resources and flood storage.

Drainage-Related Flooding: Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and adjacent properties. They make use of a conveyance system that channels water away from a developed area to surrounding streams, bypassing natural processes of water infiltration into the ground, groundwater storage, and evapotranspiration. Flooding from overwhelmed drainage entails floods caused by increased water runoff due to development and drainage systems that are not capable of conveying high flows. Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding can occur more quickly and reach greater depths than if there were no urban development at all. In almost any community with some degree of development, basement, roadway, and infrastructure flooding can result in significant damage due to poor or insufficient stormwater drainage.

The following types of flooding are not found in Marblehead but are described here because they may occur in adjacent communities:

- Dam Overtopping: Dam overtopping is caused by floods that exceed the capacity of the dam, and it can occur as a result of inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors. Overtopping accounts for one-third of all dam failures in the U.S. The two primary types of dam failure are catastrophic failure (characterized by the sudden, rapid, and uncontrolled release of impounded water) and design failure (which occurs as a result of minor overflow events). There are a number of ways in which climate change could alter the flow behavior of a river, causing conditions to deviate from what a dam was designed to handle. For example, more extreme precipitation events could increase the frequency of intentional discharges. Many other climate impacts, including shifts in seasonal and geographic rainfall patterns, could also cause the flow behavior of rivers to deviate from previous hydrographs. When flows are greater than expected, spillway overflow events (often referred to as "design failures") can occur. These overflows result in increased discharges downstream and increased flooding potential. Therefore, although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.
- Beaver Dams: Additional causes of flooding include beaver dams. Beaver dams obstruct the flow of water and cause water levels to rise. Significant downstream flooding can occur if beaver dams break.
- Ice Jam: An ice jam is an accumulation of ice that acts as a natural dam and restricts the flow of a body of water. A freeze-up jam usually occurs in early winter to midwinter during extremely cold weather when super-cooled water and ice formations extend to nearly the entire depth of the river channel. This type of jam can act as a dam and begin to back up the flowing water behind it. A breakup jam, forms as a result of the breakup of the ice cover at ice-out, causing large pieces of ice to move downstream, potentially piling up at culverts, around bridge abutments, and at curves in river channels. Breakup ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding upstream of the obstruction.

Secondary Hazards: The most problematic secondary hazards for flooding are fluvial erosion, riverbank erosion, and landslides affecting infrastructure and other assets located within floodplains. Without the space required along river corridors for natural physical adjustment, such changes in rivers after flood events can be more harmful than the actual flooding. The impacts from these secondary hazards are especially prevalent in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging buildings, and structures closer to the river channel or cause them to fall in. Landslides can occur following flood events when high flows oversaturate soils on steep slopes, causing them to fail. These secondary hazards also affect infrastructure.

Roadways and bridges are impacted when floods undermine or wash out supporting structures. Dams may fail or be damaged, compounding the flood hazard for downstream communities. Failure of wastewater treatment plants from overflow or overtopping of hazardous material tanks and the dislodging of hazardous waste containers can occur during floods as well, releasing untreated wastewater or hazardous materials directly into storm sewers, rivers, or the ocean. Flooding can also impact public water supplies and the power grid in similar ways, through inundation and/or erosion.

Location

Heavy rainfall events occur regularly in Massachusetts. As a result, inland flooding such as drainage-related flooding affect most of the communities in the Commonwealth, including Marblehead. In Marblehead, the 1% annual chance floodplain (100-year floodplain) covers only about 219 acres, or approximately 1.7 percent of the town, mainly along its fringes; this is primarily a coastal floodplain. Only one FEMA-delineated flood zone is located in the interior of the town, and it is a 0.2% flood zone (500-year) located along the stream that passes under West Shore Drive. Flooding from intense precipitation has the potential to cause localized flooding along West Shore Drive (in this 0.2% flood zone), Pleasant Street, in the Evans Road/Curtis Street area, at Abbot Library, and in other locations noted below under *Previous Occurrences*. Dams are not located in Marblehead, and ice jams cannot occur in Marblehead given the profiles of the small streams in the town.

Previous Occurrences

Flooding is a concern in Marblehead, and the previous edition of this plan includes narratives about previous flood events. These areas were listed; some have been subject to drainage improvements, but residual risks may remain:

- Along West Shore Drive
- Maverick Street/Pleasant Street
- The Abbot Library previously experienced stormwater flooding: storm events have caused flooding in the children's wing
- Bubier Road
- At the Sundance Day Care
- Thompson Road/Leo Road; several residential properties previously experienced stormwater related flooding approximately three times a year, causing considerable damage, including loss of utilities/services
- Evans Road/Curtis Street

The local planning team explained during the October 2022 meeting that the Commercial Street area appears to be emerging as a location of flood concerns.

As noted earlier, this plan update relies primarily on a roughly ten-year lookback (2012 through 2022). The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Essex County lists one flood event impacting Marblehead for the period 2012-2022.

Table 13. NCEI Severe Storm Database Entries Covering Inland Floods in Marblehead.

Date	Description	Losses Reported
8/12/18	*Flood:* A cold front stalled over Southern New England; low pressure from the Midwest then moved slowly east along the front. The weather system drew upon warm and very humid air to create showers with local downpours, resulting in rainfall amounts of two to five inches on August 11th and 12th. An exceptionally powerful downpour left 8.15 inches in the city of Lynn… **At 752 AM, West Shore Drive in Marblehead was flooded and impassable near the Tower School.**	---

In summary, inland flooding along small streams and from stormwater – both related to intense precipitation – appears to be a moderate concern in Marblehead.

Extent

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the "100-year discharge" has a 1 percent chance of being equaled or exceeded in any given year. The "annual flood" is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

The 1% annual chance flood is the standard used by most federal and state agencies. It is used by the National Flood Insurance Program (NFIP) to guide floodplain management and determine the need for flood insurance. The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is called the 100-year floodplain, which is used as the regulatory boundary by many agencies. Also referred to as the Special Flood Hazard Area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. The term "500-year flood" is the flood that has a 0.2% chance of being equaled or exceeded each year. Base flood elevations and the boundaries of the 1% annual chance (100-year) and the 0.2% annual chance (500-year) floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principal tools for identifying the extent and location of the flood hazard.

Both the 100-year and the 500-year floodplains are determined based on past events. As a result, the flood maps do not reflect projected changes in precipitation events.

Flooding in Massachusetts is forecast and classified by the National Weather Service (NWS) Northeast River Forecast Center as minor, moderate, or severe based upon the types of impacts that occur. Minor flooding is considered “disruptive” flooding that causes impacts such as road closures and flooding of recreational areas and farmland. Moderate flooding can involve land with structures becoming inundated. Major flooding is a widespread, life-threatening event. River forecasts are made at many locations in the state containing USGS river gauges with established flood elevations and levels that correspond to each of the degrees of flooding.

Due to the pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Flash flooding, which occurs when excessive water fills either normally dry creeks or riverbeds or dramatically increases the water surface elevation on currently flowing creeks and river, can be less predictable. However, potential hazard areas can be warned in advance of potential flash-flooding danger. Flooding is more likely to occur due to a rainstorm when the soil is already wet and/or streams are already running high from recent previous rains. NOAA’s Northeast River Forecast Center provides flood warnings for Massachusetts, relying on monitoring data from the USGS stream gauge network. Notice of potential flood conditions is generally available several days in advance. State agency staff also monitor river, weather, and forecast conditions throughout the year. Notification of potential flooding is shared among state agency staff, including the Massachusetts Emergency Management Agency (MEMA) and the Office of Dam Safety. The NWS provides briefings to state and local emergency managers and provides notifications to the public via traditional media and social networking platforms.

Probability of Future Events

The frequency of hazard events of disaster declaration proportions is defined by the number of federally declared disaster events for the Commonwealth over a specified period of time. The historical record indicates the Commonwealth has experienced 22 coastal and inland flood-related disaster declaration events from 1954 to 2017. In the northeast, precipitation has increased by 17% from the baseline level recorded in the period from 1901 to 1960 to present-day levels measured from 2011 to 2012. Therefore, based on these figures, the Commonwealth may experience a flood event of disaster declaration proportions approximately once every three years.

However, the frequency of flooding varies significantly based on watershed, riverine reach, and location along each reach. Additionally, it is important to note that floods of lesser magnitude occur at a much higher frequency. The SHMCAP notes that in the ten-year period 2007 to 2017, the NOAA Storm Events Database reports that there were 433 flood events in Massachusetts, which is an average of more than 43 floods per year. In addition, the Massachusetts Climate Change Assessment notes that flooding is likely to increase, with the historical 10% annual chance daily rainfall event (2.6 to 4 inches) four times more frequent by 2090. The Town of Marblehead should assume that the probability of future flood events is high, especially as precipitation intensities increase.

Vulnerability Assessment

Exposure

In Marblehead, the 1% annual chance floodplain (100-year floodplain) covers 218.9 acres, or approximately 1.7 percent of the town. In addition to the 100- year floodplain, stormwater has the potential to cause localized flooding at Abbot Library and other locations as noted above. The analysis below is based on the FEMA delineation of the 100- and 500-year floodplains, and does not distinguish between inland and coastal flooding. Coastal flooding will be subject to an additional level of analysis in a later section of this plan.

Pumping stations located in the 100- and 500-year floodplain are forced to close several times a year due to flooding. There are 264 buildings in the 100-year floodplain consisting of mostly single-family homes. For the 100-year floodplain, there are no structures in an environmental justice community. Table 14 shows the types of buildings exposed to the flood and their value. The number in parathesis shows the total number of buildings and building values for the town.

Table 14. Buildings in the Current 100-Year Floodplain

Building Type	Number of Buildings (Total in Town)	Building Value (Total in Town)
Single Family	230 (7,564)	$213,581,400 ($2,479,847,199)
Multi-Family	10 (949)	$4,260,900 ($621,712,100)
Commercial	15 (197)	$19,833,700 ($132,564,601)
Educational	0 (4)	$0 ($7,951,500)
Government	0 (70)	$0 ($159,407,800)
Religious/Non-Profit	0 (32)	$0 ($38,945,800)
Agriculture	0 (0)	$0 ($0)
Undeveloped	1 (24)	$0 ($0)
Garage/Outbuilding	8 (37)	$70,800 ($666,300)
Vacant	0 (79)	$0 ($22,612,500)
Total	**264 (8,901)**	**$237,746,800 ($3,463,707,800)**

The population exposed to the 100-year floodplain is shown in Table 15. The column in the left shows the population in and around the floodplain (wherever the Census Block overlapped with the floodplain boundary) while the column on the right shows the total population numbers for the town. There is a large older population in the floodplain.

Table 15. Population Exposed to Current 100-year Floodplain (2020 U.S. Census).

Demographics	**Population in and Adjacent to Floodplain**	**Total Population**
Population	4,796	20,441
Households	2,194	8,965
White	4,507 (94.0%)	18,702 (91.5%)
Black	26 (0.5%)	180 (0.9%)
American Indian	6 (0.1%)	31 (0.2%)
Asian	45 (0.9%)	273 (1.3%)
Pacific Islander	0 (0.0%)	1 (0.0%)
Other Race	23 (0.5%)	252 (1.2%)
Two or More Races	189 (4.0%)	1,002 (4.9%)
Hispanic or Latino:	100 (2.1%)	770 (3.8%)
Population under 18:	1,056 (22.0%)	4,509 (22.1%)
Population over 64:	1,134 (23.6%)	4,654 (22.8%)
Annual Income < $30K/year	199 (9.1%)	923 (10.3%)
Population in EJ Zone:	0 (0.0%)	1,358 (6.6%)

The 100-year Floodplain (FEMA) with the town's critical facilities is shown in Figure 9. Critical facilities are not located in the 100- and 500-year floodplain.

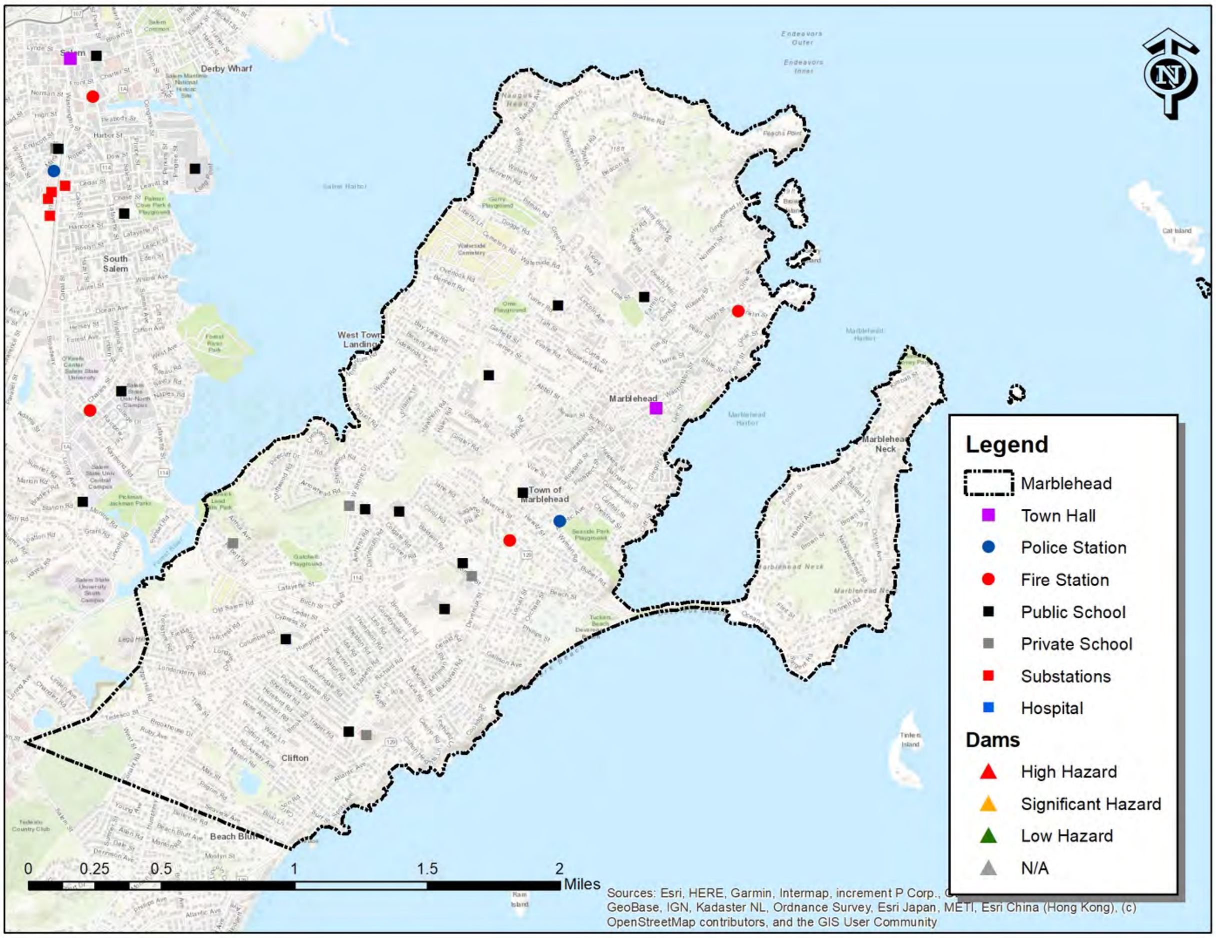


Figure 9. Marblehead Critical Facilities and 100-Year Floodplain.

Built Environment Impacts

To identify built environment impacts to the town, FEMA’s risk assessment software, Hazus, was implemented. Building footprint data and parcel data was used to update the model while the latest floodplain was also integrated into the software. The economic loss results of the current 100-year event are shown in Table 16. The town’s Average Annual Loss (AAL) is calculated to be $887,900.

Climate change will increase the probability and magnitude of flood impacts to the built environment. Future floodplains may be larger than the current FEMA modeled floodplain and new development should consider these projected conditions.

Table 16. Building Loss for the Current 100-Year Flood Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	23.03	4.08	0.68	**27.79**
Content Loss	19.05	10.08	1.99	**31.12**
Business Inventory Loss	0.00	0.05	0.09	**0.14**
Business Income Loss	0.08	10.86	0.47	**11.41**
Business Relocation Loss	3.86	1.68	0.17	**5.71**
Rental Income Loss	1.44	1.31	0.01	**2.76**
Wage Loss	0.20	8.53	1.09	**9.82**
Total	**47.66**	**36.59**	**4.50**	**88.75**

Population Impacts

The town should be aware that senior and low-income segments of Marblehead's population may be more vulnerable to hazard events due to a number of factors. Senior and low-income populations may be physically or financially unable to react and respond to a hazard event and require additional assistance. Access to information about the hazard event may be lacking, as well as access to transportation in the case of an evacuation. The location and construction quality of housing can also pose a significant risk. Table 15 shows the number of senior and low-income residents in Marblehead. The town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Using the Hazus software, the 100-year flood scenario results showed that there would be approximately 250 to 275 displaced households and 125 to 150 people seeking public shelter.

Climate change will increase the probability and magnitude of flood impacts to the population. Future floodplains may be larger than the current FEMA modeled floodplain and new development should consider these projected conditions. Vulnerable populations should be considered when development near the current floodplain is planned.

Environment Impacts

One of the major environmental impacts of a major flood would be the potential release of hazardous materials. There is sewer infrastructure at risk for damage which could cause waste materials to be released including 13 pump stations.

Climate change will increase the probability and magnitude of flood impacts to the environment. Future floodplains may be larger than the current FEMA modeled floodplain and new development should consider these projected conditions including whether hazardous materials are stored there.

Problem Statements for Flood.

Problem statements summarize risk and vulnerability and are included following each hazard profile. The problem statements were developed to bridge the gap between identified hazard and development of the mitigation actions. Problem statements are included in each hazard profile section.

Table 17. Problem Statements Related to Flooding.

Assets	Problems Associated with Flood
People (including underserved communities and socially vulnerable populations)	• Few people have been directly harmed by floods caused by intense precipitation, but the following areas are reportedly affected: ○ Along West Shore Drive ○ Maverick Street/Pleasant Street ○ Abbot Library ○ Bubier Road ○ Sundance Day Care ○ Thompson Road/Leo Road ○ Evans Road/Curtis Street ○ Commercial Street
Structures (including facilities, lifelines, and critical infrastructure)	• Floods have affected structures, roads, and lifeline systems located in the areas listed above.
Systems (including networks and capabilities)	• Floods have affected structures, roads, and lifeline systems located in the areas listed above. • The Town is currently precluded from adopting higher regulatory standards to protect against flooding (must comply with State Building Code).
Natural, historic, and cultural resources	• The library has been impacted by stormwater flooding, affecting this cultural resource.

Assets	Problems Associated with Flood
Activities that have value to the community	• The library has been impacted by stormwater flooding, affecting this community resource.

Droughts

Droughts are typically defined as periods of deficient precipitation. How this deficiency is experienced can depend on factors such as land use change, the existence of dams, and water supply withdrawals or diversions. Droughts can vary widely in duration, severity, and local impact.

Description

The National Drought Mitigation Center references five common, conceptual definitions of drought:

1. Meteorological drought is a measure of departure of precipitation from normal.
2. Hydrological drought is related to the effects of precipitation shortfalls on stream flows and on reservoir and groundwater levels.
3. Agricultural drought links various characteristics of meteorological and hydrological drought to agricultural impacts and occurs when there is not enough water available for a particular crop to grow at a particular time.
4. Socioeconomic drought is associated with the supply and demand of economic goods with elements of meteorological, hydrological, and agricultural drought.
5. Ecological drought is an episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability and impacts ecosystem services.

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. Public water suppliers may struggle to meet system demands while maintaining adequate pressure for fire suppression and meeting water quality standards. The Massachusetts DEP requires all PWSs to maintain an emergency preparedness plan.

Private well owners can be vulnerable to droughts. With declining groundwater levels, well owners may experience dry wells or sediment in their water due to the more intense pumping required to pull water from the bedrock or overburden aquifer. Wells may also develop a concentration of pollutants, which may include nitrates and heavy metals depending on local geology.

The loss of clean water for consumption and for sanitation may be a significant impact depending on the affected population's ability to quickly drill a deeper or a new well or to relocate to unaffected areas.

During a drought, dry soil and the increased prevalence of wildfires can increase the amount of irritants (such as pollen or smoke) in the air. Reduced air quality can have widespread deleterious health impacts but is particularly significant to the health of individuals with pre-existing respiratory health conditions like asthma (CDC).

Lowered water levels can result in direct environmental health impacts, as the concentration of contaminants in swimmable bodies of water will increase when less water is present. Harmful algal blooms may occur, closing recreational areas.

One primary hazard in this plan that is commonly associated with drought is wildfire. A prolonged lack of precipitation dries out soil and vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. A drought may increase the probability of a wildfire occurring.

Location

Parts of Massachusetts can experience significantly different weather patterns due to topography, distance from coastal influence, as well as a combination of regional, national, and global weather patterns. As a result, the Massachusetts Drought Management Plan (DMP) assesses drought conditions in six regions: Western, Connecticut River Valley, Central, Northeast, Southeast, and Cape and Islands. A regional approach allows customization of drought actions and conservation measures to address situations in each region; and allows for the determination of a drought on a watershed basis. Droughts have the potential to impact the entirety of Marblehead.

Previous Occurrences

The Commonwealth of Massachusetts has never received a Presidential Disaster Declaration for a drought-related disaster. However, several substantial droughts have occurred over the past 100 years. Massachusetts experienced its most significant drought on record in the 1960s. The severity and duration of the drought caused significant impacts on both water supplies and agriculture.

Although short or relatively minor droughts occurred over the 50 years following the drought of the 1960s, the next long-term event began in March 2015 when Massachusetts began experiencing widespread abnormally dry conditions. In July 2016, based on a recommendation from the Drought Management Task Force (DMTF), the Secretary of the Executive Office of Energy and Environmental Affairs (EOEEA) declared a Drought Watch for Central and Northeast Massachusetts and a Drought Advisory for Southeast Massachusetts and the Connecticut River Valley. Drought warnings were issued in five out of six drought regions of the state. Many experts stated that this drought was the worst in more than 50 years. DMTF declared an end to the drought in May 2017 with a return to wetter-than-normal conditions. *During the timeframe of this drought, the Massachusetts Water Resources Authority (MWRA) did not impose any restrictions in Marblehead.*

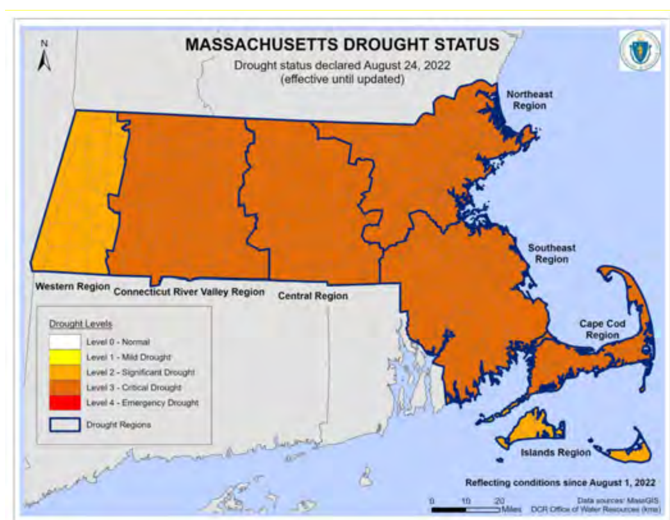
USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The line items related to droughts in Essex County are listed below, corresponding to 2015-2016 and 2020.

Table 18. USDA Disasters Events That Refer to Drought.

Year	Event	Event "Begin Dates"
2020	Drought	8/18/2020, 9/15/2020, 9/29/2020
2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016
2015	Drought	2/1/2015

The drought of 2020, a so-called "flashy drought" that impacted southern New England, was sufficiently impactful in Plymouth County to be included in the USDA data table. Flashy droughts are described below under *Extent*.

The drought of 2022 was ongoing when this plan development commenced, but its severity was alleviated by rainfall in September 2022. At the present time, the drought of 2022 appears to be typical of a flashy drought.



Applying the same ten-year lookback as the severe storms database review, USDA payments to Massachusetts agricultural sectors for drought impacts associated with events from 2012 through 2022 were reviewed. This timeframe includes the droughts of 2015-2017 and 2020. USDA reimbursements for droughts were not paid in Marblehead, reflecting the lack of agricultural land uses.

The severity of a drought depends on the degree of moisture deficiency, duration, spatial extent, and location relative to resources or assets. The drought of the 1960s is the drought of record because duration, spatial extent, moisture deficiency, and impact all contributed to historic levels. In contrast, the severity of the 2016-2017 drought was due to impacts on natural resources (record low stream flows and groundwater levels), many water supplies, farms, and agriculture and to the swift onset of the drought.

Extent

Drought is defined by a combined look at several indices as detailed in the Massachusetts DMP (EOEEA and MEMA, 2013). The indices are:

- Standard Precipitation Index for 3-, 6-, and 12-month time periods
- Precipitation as a percent of normal (or historic average) for 2-, 3-, 6-, and 12-month time periods
- Crop Moisture Index
- Keetch-Byram Drought Index
- Groundwater levels
- Stream flow
- Reservoir levels

These indices are analyzed monthly to generate a hydrological conditions report and used to determine the onset, severity, and end of droughts. Five levels of increasing drought severity are defined in the DMP: *Normal, Advisory, Watch, Warning,* and *Emergency*. The drought levels are associated with actions outlined in the DMP. Recommendations of drought levels are made by the DMTF to the Secretary of the EOEEA, who then declares the drought level for each region of the state.

Other entities may measure drought conditions by these or other criteria more relevant to their operations. For example, water utilities may calculate the days of supply remaining. Farmers may assess soil moisture and calculate the water deficit for specific plants to determine irrigation needs or decide to change their crop based on the deficit or harvest early for non-irrigated crops.

The five drought levels in the 2013 DMP provide a basic framework for taking actions to assess, communicate, and respond to drought conditions. Under the “Normal” condition, data are routinely collected, assessed, and distributed. When drought conditions are identified, the four drought levels escalate moving to heightened action, which may include increased data collection and assessment, interagency communication, public education and messaging, recommendations for water conservation measures, and a state of emergency issued by the Governor. At the “Emergency” level, mandatory water conservation measures may be enacted. These regionally declared drought levels and associated state actions are intended to communicate and provide guidance to the public and stakeholders across industries to enable them to respond early and effectively and to reduce impacts. Individual public water suppliers may have their own drought management plan, drought levels, and associated actions, which they may follow at all levels except at the Emergency level when mandatory actions may be required.

Droughts develop over long periods of time relative to other hazards. However, flashy droughts are changing these norms (AMS, 2017). Flashy droughts may develop quickly or quickly intensify a developing or existing drought. The 2016-2017 drought is an example. Dry conditions from late 2015 lingered through the winter, with scattered groundwater levels reporting below normal and less than normal snowpack heading into spring 2016. Impacts were first seen in March 2016 in stream flows, groundwater levels, and reservoirs showing the long-term deficit. Then, as precipitation dramatically dropped below normal from June through September 2016, the entire state experienced record low stream flows and groundwater levels.

NOAA and others are advancing the science of early warning for droughts like the early warnings for floods and earthquakes to better project flashy droughts. Based on projected climate change, the distributions of precipitation events will continue to become more extreme, with periods of minimal rain alternating with extreme rain events. Therefore, developing ways to project and adapt to flash droughts may be critical for sectors such as agriculture and water supply.

The Massachusetts Water Resources Commission publishes the hydrologic condition report monthly, which includes the seven drought indices and the National Climate Prediction Center's U.S. Monthly and Seasonal Drought Outlooks. The National Drought Mitigation Center produces a weekly Drought Monitor map. In accordance with the DMP, drought declarations are made monthly.

Probability of Future Events

Using data collected since 1850, the probability of the precipitation index of the DMP exceeding the threshold at each drought level was calculated. On a monthly basis over the 162-year period of record from 1850 to 2012, there is a 2% chance of being in a drought warning level.

Table 19. Frequency of Drought Events Exceeding the Precipitation Index of the DMP.

Level	Frequency Since 1850	Probability in Any Given Month
Emergency	5 occurrences	1% chance
Warning	5 occurrences	2% chance
Watch	46 occurrences	8% chance
Source: EOEEA and MEMA		

The likely range of consecutive dry days per year is projected to increase by up to nearly 20 days per year in 2090, compared to the annual statewide baseline of approximately 16 days per year from 1971 to 2001. Table 4-16 indicates the projected number of consecutive dry days according to the "high" and "low" limits of the Northeast Climate Adaptation Science Center (NE CASC) data.

Table 20. Projected Continuous Dry Days by Planning Year.

Planning Year	**2030**	**2050**	**2070**	**2100**
Projected Range of Consecutive Dry Days	16.44-17.94	16.34-18.64	15.94-18.94	16.34-19.64
Source: resilient MA, 2018				

These projections suggest that the average time between rain events is likely to remain fairly constant; however, individual drought events could still increase in frequency and severity. The incidence of droughts in 2015-2016, 2020, and 2022 certainly underscores that the probably of future droughts is high.

Vulnerability Assessment

Exposure

Drought is a gradual phenomenon, and its condition occurs naturally in a broad geographic area. The entire town would be exposed to drought conditions.

Built Environment Impacts

Major water users are more susceptible to drought, and these include water utilities and some commercial users.

With an increased probability of drought and drought magnitude, water utilities should consider reviewing or developing extreme drought scenarios.

Population Impacts

Populations considered most vulnerable to drought impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard. Table 15 summarizes the senior and low-income populations in Marblehead. It should be noted that there may be overlap within the two categories, so that the total number of persons exposed may be lower than what is shown in the table. However, the town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Socioeconomic impacts of the drought may also include anxiety and depression about economic impact, health problems associated with poor water quality, fewer recreational activities, higher incidents of heat stroke, and even loss of human life.

With an increased probability of drought and increased drought magnitude, and the potential of increased water costs, vulnerable populations may be more severely impacted in the future.

Environment Impacts

Although agriculture is limited in the town, there are some natural areas which may be adversely impacted by drought. Drought amplifies the risk of loss of biodiversity and affects animal and plant species. Economic impacts include higher food and lumber prices. Drought can shrink the food supplies of animals and plants dependent on water and damage their habitats. Sometimes the environmental damage caused by a drought is temporary, and other times it is irreversible.

Problem Statements for Drought

Table 21. Problem Statements for Drought.

Assets	Problems Associated with Drought
People (including underserved communities and socially vulnerable populations)	• None apparent
Structures (including facilities, lifelines, and critical infrastructure)	• None apparent
Systems (including networks and capabilities)	• None apparent
Natural, historic, and cultural resources	• None apparent
Activities that have value to the community	• None apparent

Primary Climate Change Interaction: Sea Level Rise

Coastal Flooding

As suggested earlier in the *Vulnerability Assessment* for flooding in Marblehead, the FEMA-delineated flood zones in Marblehead are primarily a reflection of coastal flood risk. Sea level rise will continue to increase the impacts of coastal flooding, increasing the depths of flooding during severe events and also increasing the frequency of nuisance flooding occurring during less severe events.

> The Town of Marblehead Community Resilience Building Workshop Summary of Findings (2018) lists "Coastal flooding" as one of the top four hazards of concern.

Description

The SHMCAP notes that coastal floods are defined by the submersion of land along the ocean coast and other inland waters caused by the movement of seawater over and above normal present-day tide action. Coastal flooding is often characterized as minor or major based on the magnitude (elevation), duration, and frequency of the flooding that is experienced.

Sea level rise driven by climate change will exacerbate existing coastal flooding and coastal hazards. The *2022 Massachusetts Climate Change Assessment* report issued in December 2022 includes an update to the coastal flood assessment for Massachusetts. In the section "Sea Level Rise and Coastal Flooding," the report notes that the "climate assessment followed the approach in the 2017 National Climate Assessment and the Global and Regional Sea Level Rise Scenarios (U.S. Global Change Research Program [USGCRP], 2017, 2018) by adopting a scenario for sea level rise that supports planning and decision-making, while taking into account uncertainty and future risks. For the purposes of this assessment, the Commonwealth of Massachusetts has selected from among several options the USGCRP's High scenario as the preferred scenario for assessment of vulnerability and flood risk."

The report proceeds to explain that "the relative sea level rise which Massachusetts residents may see in the future reflects both sea-level and land-level changes, as well as other regional factors which can affect the rate of sea level rise. In the northern part of Massachusetts, this scenario corresponds to approximately 21 inches (54 cm) between 2020 and 2050, and 43 inches (109 cm) between 2020 and 2070; estimates for the southern part of Massachusetts are slightly higher - 23 inches (59 cm) by 2050 and 45 inches (113 cm) by 2070."

The report also explains that the effect of sea level rise will be to cause more frequent inundation in areas in the future, compared to areas today. For example, the report notes that the area of Massachusetts inundated by the 1,000-year flood (0.1% chance per year) today will be inundated by the 20-year flood (5% chance per year) by 2050.

Location

The fringes of the Town of Marblehead are exposed to coastal flooding. Because the entire town is a coastal community, indirect impacts can be expected throughout Marblehead.

Previous Occurrences

The previous edition of this plan provided the following detailed narratives about coastal flooding in eight specific geographic areas with the highest risk of coastal flooding.

Beacon Street/Norman Street

The neighborhood located on the northeast corner of the mainland adjacent to Grace Oliver Beach has experienced significant flooding several times. There is also a larger portion of this area that experiences shallow flooding during a 100-year flood in accordance with FEMA FIRMs. Flooding of structures, yards, beaches and streets occur in several locations throughout this area especially at the intersection of Norman and Beacon Streets. The Norman Street Wastewater Pump Station is a critical facility that was previously susceptible to damage/becoming disabled from flooding inundation. Since the 2004 Plan, the

Sewer Department has installed new Bilco floodproof doors. In addition, the sea wall at Grace Oliver Beach is another critical facility which remains at risk if damaged or undermined and could cause more frequent problems in this area in the future. The following critical facilities and community assets are located within this flood hazard area:

- Sea wall at Grace Oliver's Beach
- Grace Oliver Beach
- Gas House Beach
- Old Burial Hill Cemetery (not directly within FEMA Floodplain)
- Norman Street Wastewater Pump Station (not directly within FEMA Floodplain)

Front Street/Doaks Lane

The area in the northeast coast of the mainland around Fort Sewall, including Gas House Beach and Fort Beach experiences flooding from velocity wave action, shallow flooding and/or sheet flow flooding approximately three times a year. Flooding of structures, yards, beaches and streets occur in various locations throughout this area on a yearly basis. The Fort Sewall Wastewater Pump Station is a critical facility that was previously susceptible to damage/becoming disabled from flooding inundation. After 2004, the Sewer Department installed new Bilco floodproof doors. Approximately 300 linear feet of coastline extending southward from the Fort Sewall peninsula experiences an estimated coastal erosion of 6 inches to 17 inches annually. The following critical facilities and community assets are located within this flood hazard area:

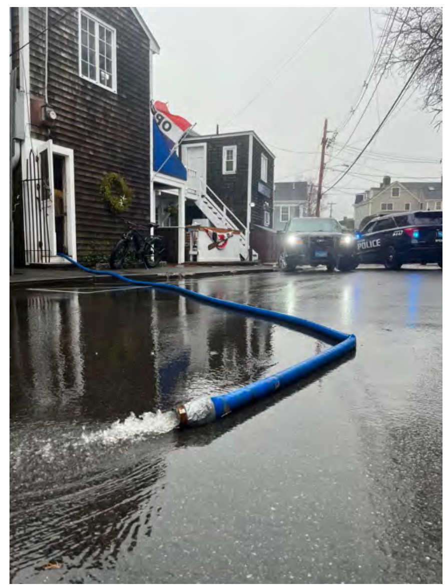


Figure 10. Front Street Floodwater.

- Old North Nursery School (not directly within FEMA Floodplain)
- Old North Congregation Church (not directly within FEMA Floodplain)
- Fort Beach
- Franklin Fire House (not directly within FEMA Floodplain)
- Fort Sewall Wastewater Pump Station

Devereux Beach/Tucker's Beach

Approximately 2,000 linear feet of beach, residences, and saltwater marshland extending south from the southwestern shore of the Causeway westerly to Goldthwait Road experiences flooding from velocity wave action, shallow flooding, and/or sheet flow. Flooding of structures, yards, beaches and streets of the surrounding neighborhood have occurred on many occasions. In the past, there have been some tidal surges here that destroyed homes that were rebuilt in accordance with FEMA regulations at the time. Devereux Beach is a community asset for families in the Marblehead community that frequent this location during the summer months. The Phillips Street Wastewater Pump Station is a critical facility that was previously susceptible to damage/becoming disabled from flooding inundation. Since 2004, the Sewer Department completed the full replacement of the Phillips Street pump station. Coastal erosion, estimated at 6 inches to 10 inches annually, remains a concern along the Devereux Beach area.

Faulty tide gates remain the recognized potential source for some of the flooding problems in this area. Past proposals for replacing the existing tide gates have been denied due to environmental concerns with the saltwater marsh and its ecosystem. It is also understood that flooding in Tucker's Beach area is exacerbated by water entering through the Marblehead Harbor side through Riverhead Beach. The following critical facilities and community assets are located within this flood hazard area:

- Heliport at Devereux Beach
- Devereux Beach
- Heliport at Tucker's Beach
- Tucker's Beach
- Heliport at Goldthwait Reservation
- Rivers Head Beach
- Phillips Street Wastewater Pump station (not directly within FEMA Floodplain)

Front Street/Ferry Lane

Various public boat landings, restaurants, and commercial properties characterize this area of Marblehead's eastern coastline located adjacent to Marblehead Harbor. The boundaries of the 100-year floodplain indicate the potential to experience significant flooding during periods of heavy storm surge and high velocity wave action. This hazard area contains public and municipal sites such as Clark Landing and Tucker's Wharf. Flooding of structures, parking lots, and streets has occurred on numerous occasions in this area. The following critical facilities and community assets are located within this flood hazard area:

- Elbridge Gerry Elementary School (not directly within FEMA Floodplain)
- St. Michael's Day Care (not directly within FEMA Floodplain)
- Marblehead Trading Company
- Crosby's Supermarket (not directly within FEMA Floodplain)
- Baptist Church (not directly within FEMA Floodplain)
- Unitarian-Universalist Church (not directly within FEMA Floodplain)
- St. Michael's Episcopal Church (not directly within FEMA Floodplain)
- Boston Yacht Club

- Tucker’s Wharf
- Tucker’s Wharf sea wall
- Clark Landing
- Sea wall at Clark Landing
- Unitarian Cemetery (not directly within FEMA Floodplain)

Boston Yacht Club

The Boston Yacht Club, surrounding commercial area, and portions of Crocker Park experience significant flooding roughly once every two years from coastal storm surges with velocity wave action. When floods occur, the Yacht Club experiences flooding of structures and the parking lot.

The Causeway

The Causeway is the primary source of access and egress for Marblehead neck residents. The Causeway frequently experiences significant storm surges with velocity wave action that overtops the existing seawall located at the southern shore of the roadway (ocean side), both engulfing the roadway and over-washing cobbles, requiring the roadway to be closed. The closing of the Causeway, required during most large storm events, strands the residents of Marblehead Neck until after the storm has subsided and the cobbles can be removed from the streets. The flood hazard on the Causeway is clearly the most significant natural hazard risk to Marblehead and frequently affects approximately 3,000 residents of the Neck. The Causeway routinely requires temporary closure in order to ensure the safety of the community. Marblehead personnel initiate a plan to ensure public safety during flooding episodes on the Causeway. Coastal erosion is also of concern on the ocean side of the Causeway in which 9 inches to 10 inches of shoreline is eroded annually, encroaching on the existing seawall.

Figure 11. Coastal Flooding.

Houses located on Marblehead Neck near the southeastern shore of the Causeway experience frequent flooding. These homes experience flooding from sheet flow as well as shallow flooding during large storm events. Flood waters have been known to flow over Ocean Avenue and into backyards of homes in this area. Coastal water also floods Flint Street and the yards of homes on Harbor Avenue.

Foster Street/Sean Way

This neighborhood located on the southwestern shore of the Neck experiences infrequent shallow flooding. Flooding of structures, yards, beaches and streets infrequently occurs in various locations throughout this area. The Harbor Avenue Wastewater Pump Station is a critical facility that was previously susceptible to damage/becoming disabled from flooding inundation. Since he 2004, the Sewer Department installed new Bilco floodproof doors. The following critical facility is located within this flood hazard area:

- Harbor Avenue Wastewater Pump Station

Sargent Road/Ocean Avenue

The southernmost tip of Marblehead Neck experiences flooding from velocity wave action and sheet flow flooding approximately once every ten years, and significant flooding in this area has occurred three to four times since 1972. Flooding of residential structures, yards and streets is experienced over a large area on Ocean Street and to the south of Ocean Street. Typically, water entering this area from the ocean surge collects in the low-lying area near Sargent Road. The Sargent Road Wastewater Pump Station is a critical facility that was previously susceptible to damage/becoming disabled from flooding inundation. Since 2004, the Sewer Department installed new Bilco floodproof doors. The following critical facility is located within this flood hazard area:

- Sargent Road Wastewater Pump Station

Coastal erosion, estimated at 10 inches of coastline annually, is also a concern.

As noted earlier, this plan update relies primarily on a roughly ten-year lookback (2012 through 2022). The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Essex County lists numerous coastal flood events impacting Marblehead for the period 2012-2022.

Table 22. NCEI Severe Storm Database Entries Covering Coastal Floods in Marblehead.

Date	Description	Losses Reported
6/4/12	High spring astronomical tides combined with low pressure off the east coast of Massachusetts to produce coastal flooding. A parking lot near Devereaux Beach was flooded with splashover reaching the Marblehead Causeway.	--
2/9/13	An historic winter storm deposited tremendous amounts of snow over all of southern New England, mainly from the mid-afternoon on Friday, February 8 and lasting into the daylight hours of Saturday, February 9. The Marblehead Causeway (Ocean Avenue) and Marblehead Neck were flooded and impassable.	$5.8M for all affected towns in Essex County [FEMA PA was available for this event]

Date	Description	Losses Reported
3/7/13	A low pressure system caused a winter storm coastal flood event. A parking lot at Devereux Beach was under a foot of fast-moving water and overwash. Atlantic Avenue was closed near the Swampscott line due to coastal flooding and large debris in the road. Marblehead Neck Causeway (Ocean Avenue) was flooded, closing the road. Rocks and other ocean debris blocked the roadway.	$1M for all affected towns in Essex County
1/3/14	A significant, rapidly developing coastal storm moved southeast of Southern New England bringing heavy snow, bitter cold temperatures, coastal flooding, and strong winds. The Marblehead Causeway and Devereaux Beach area in Marblehead were closed due to flooding.	--
1/27/15	An historic winter storm brought heavy snow to southern New England with blizzard conditions to much of Rhode Island and eastern Massachusetts, beginning during the day on Monday, January 26 and lasting into the early morning hours of Tuesday, January 27. Overwash debris covered the causeway to Marblehead Neck. Overwash debris damaged the Devereaux Beach parking lot and the Goldthwait Reservation.	-- [FEMA PA was available for this event]
3/2/18	Low pressure moving out of the Ohio Valley passed south of Southern New England bringing heavy snow to northwest Massachusetts, heavy rain and strong winds to central and eastern Massachusetts, and coastal flooding to the coastline. Moderate to major coastal flooding took place over three tide cycles due to astronomically high tides and a persistent northeast wind. Flooding closed Front Street, eroded the shoreline adjacent to the Lead Mill area which endangered the electrical supply line for the Town.	--
9/22/20	Hurricane Teddy passed well to the east of Massachusetts. Strong winds gusted to between 40 and 47 mph in eastern Massachusetts. Also, a storm surge of up to 2.5 feet, combined with relatively high astronomical tides, produced mainly minor coastal flooding in eastern and southeastern Massachusetts. Splashover was reported on Front Street near Fort Sewall.	--

Date	Description	Losses Reported
2/2/21	A storm produced strong winds and minor coastal flooding. Minor coastal flooding on Crowninshield Rd near Grace Oliver Beach.	--

Finally, the local planning team explained during the October 2022 meeting that the Front Street area appears to be emerging as a location of monthly nuisance flood challenges. As sea level rises, other areas may emerge. In summary, coastal flooding is a significant and worsening challenge in Marblehead.

Extent

As explained earlier in the section about inland flooding, the 1% annual chance flood is the standard used by most federal and state agencies. It is used by the NFIP to guide floodplain management and determine the need for flood insurance. The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is called the 100-year floodplain, which is used as the regulatory boundary by many agencies. Also referred to as the SFHA, this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. The term “500-year flood” is the flood that has a 0.2% chance of being equaled or exceeded each year. Base flood elevations and the boundaries of the 1% annual chance (100-year) and the 0.2% annual chance (500-year) floodplains are shown on FIRMs, which are the principal tools for identifying the extent and location of the flood hazard. Both the 100-year and the 500-year floodplains are determined based on past events. As a result, the flood maps do not reflect projected sea level rise.

FEMA defines the Coastal High Hazard Area (V Zone) as a SFHA that extends from offshore to the inland limit of a primary frontal dune along an open coast and any other portion of the SFHA that is subject to high-velocity wave action from storms or seismic sources. The boundary of a V Zone is generally based on wave heights (3 feet or greater) or wave run-up depths (3 feet or greater). V Zones can also be mapped based on the wave overtopping rate (when waves run up and over a dune or barrier).

In 2017, the Coastal A Zones and AE Zones were further divided in Massachusetts coastal areas with the limit of moderate wave action (LiMWA) line. The area between the LiMWA and the landward limit of the V Zone is often referred to as the Coastal A Zone in many building codes. This area is subject to wave heights between 1.5 and 3 feet during the base flood. The area between the LiMWA and the landward limit of the A Zone is known as the Minimal Wave Action area and is subject to wave heights less than 1.5 feet during the base flood.

In addition to providing the basis for flood insurance premiums, these flood zones are referenced in the Massachusetts State Building Code and used to ensure, among other things, that new and substantially improved structures are elevated based on the magnitude of the hazard. Under the Massachusetts State

Building Code, the top of the first floor in residential structures must be located 1 foot above the base flood elevation (BFE) in A and AE Zones and the lowest horizontal structural member must be 2 feet above the BFE in V Zones.

The NWS issues a variety of coastal flood warnings and watches that are effective in Marblehead when needed. The NWS issues storm surge watches and warnings to highlight coastal areas with significant risk of life-threatening inundation from an ongoing or potential tropical cyclone, subtropical cyclone, or a post-tropical cyclone during an event. A storm surge watch is issued, generally within 48 hours, for the possibility of life-threatening inundation from rising water moving inland from the shoreline. The watch is issued earlier if other conditions such as wind may limit the time to take protective actions for surge, such as evacuations. A storm warning is issued, generally within 36 hours, if there is a danger of life-threatening inundation.

Probability of Future Events

As sea level rises, the probability of both nuisance and damaging coastal flood events will increase. For example, the *2022 Massachusetts Climate Change Assessment* report notes that the area of Massachusetts inundated by the 1,000-year flood (0.1% chance per year) today will be inundated by the 20-year flood (5% chance per year) by 2050.

Vulnerability Assessment

Exposure

To help determine sea-level rise impacts, the water surface elevations developed by the Woods Hole Group for the future 100-year flood events were used with USGS 3DEP elevation data to develop flood depth grids. There are no critical facilities located in the 2050 100-year floodplain except for pumping stations. There are 382 buildings in the 2050 100-year floodplain. There are no buildings in an environmental justice community. Table 23 shows the types of buildings exposed to the flood and their value. The number in parathesis shows the total number of buildings and building values for the town.

Table 23. Buildings in the 2050 100-Year Floodplain.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	271 (7,564)	$251,154,606 ($2,479,847,199)
Multi-Family	63 (949)	$160,999,400 ($621,712,100)
Commercial	15 (197)	$19,833,700 ($132,564,601)
Educational	0 (4)	$0 ($7,951,500)
Government	0 (70)	$0 ($159,407,800)
Religious/Non-Profit	0 (32)	$0 ($38,945,800)
Agriculture	0 (0)	$0 ($0)
Undeveloped	1 (24)	$0 ($0)

Garage/Outbuilding	8 (37)	$70,800 ($666,300)
Vacant	24 (79)	$776,300 ($22,612,500)
Total	**382 (8,901)**	**$670,581,606 ($3,463,707,800)**

The 2070 100-year event developed by the Woods Hole Group was then evaluated. There are no critical facilities located in the 2050 100-year floodplain except for the pumping stations. There are 468 buildings in the 2070 100-year floodplain. There are no buildings in an environmental justice community. Table 23 shows the types of buildings exposed to the flood and their value. The number in parathesis shows the total number of buildings and building values for the town.

Table 24. Buildings in the 2070 100-Year Floodplain.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	339 (7,564)	$314,174,950 ($2,479,847,199)
Multi-Family	79 (949)	$ 178,606,600 ($621,712,100)
Commercial	15 (197)	$19,833,700 ($132,564,601)
Educational	0 (4)	$0 ($7,951,500)
Government	0 (70)	$0 ($159,407,800)
Religious/Non-Profit	0 (32)	$0 ($38,945,800)
Agriculture	0 (0)	$0 ($0)
Undeveloped	1 (24)	$0 ($0)
Garage/Outbuilding	8 (37)	$70,800 ($666,300)
Vacant	26 (79)	$ 1,184,700 ($7,600)
Total	**468 (8,901)**	**$513,870,750 ($3,441,102,900)**

Built Environment Impacts

The hurricane surge map for Marblehead (pictured below) provides a reasonable approximation of the potentially exposed sections of the Town under future coastal storm events.

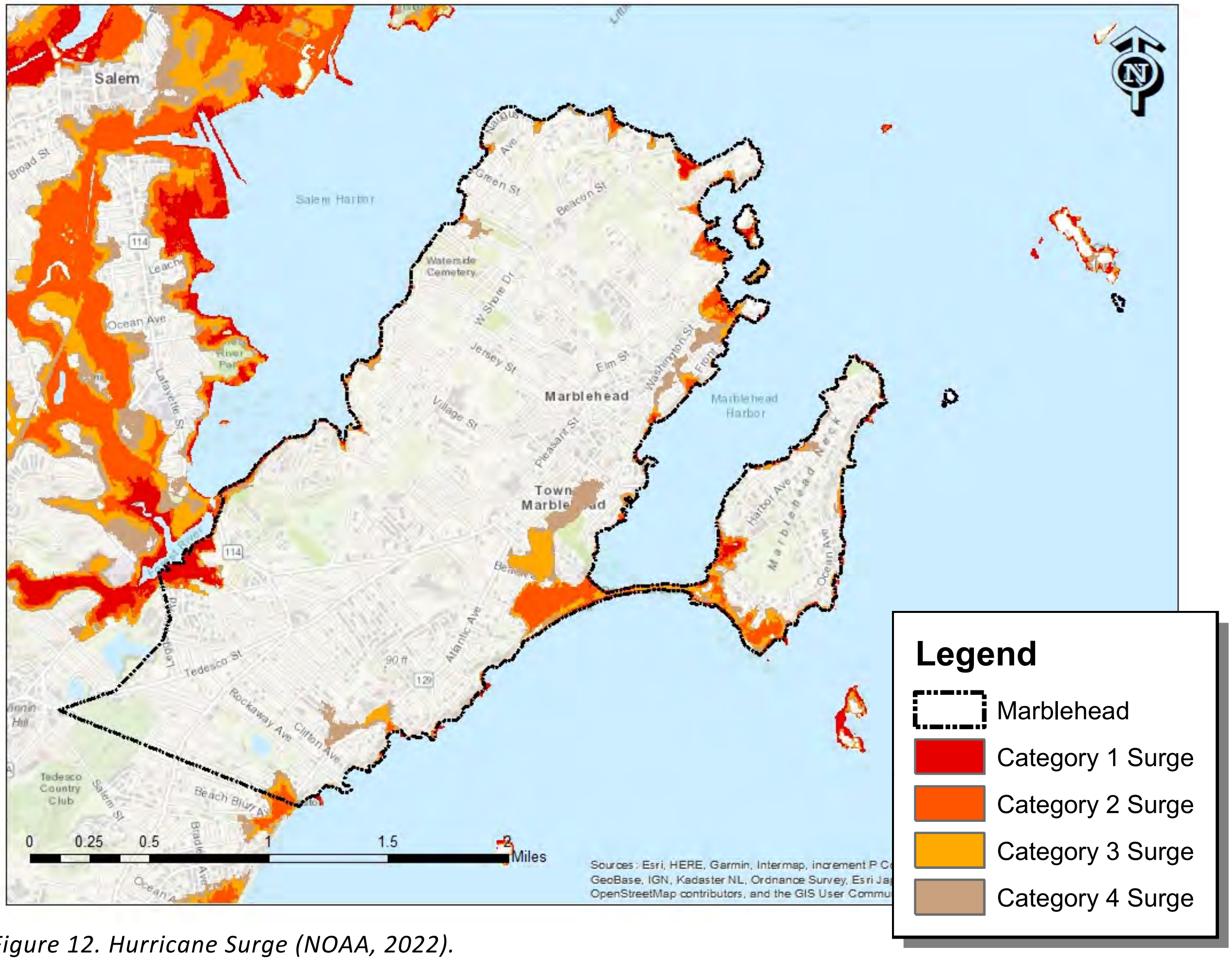


Figure 12. Hurricane Surge (NOAA, 2022).

Hurricane surge inundation areas were modeled in Hazus to identify the impacts of today's extreme events and events which may happen more often in the future with sea-level rise. Table 25 shows the impacts of a Category 1 storm surge while Table 26 shows the economic impacts of a Category 2 storm surge.

Table 25. Building Losses Due to Surge for a Current Hurricane Category 1 Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	2.8	0.3	0.1	**3.2**
Content Loss	1.9	0.9	0.2	**3.0**
Business Inventory Loss	0.0	0.0	0.0	**0.0**

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Business Income Loss	0.0	1.1	0.1	**1.2**
Business Relocation Loss	0.6	0.2	0.0	**0.8**
Rental Income Loss	0.2	0.1	0.0	**0.3**
Wage Loss	0.0	0.9	0.1	**1.0**
Total	**5.5**	**3.5**	**0.5**	**9.5**

Table 26. Building Losses Due to Surge for a Current Hurricane Category 2 Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	9.1	1.1	0.2	**10.4**
Content Loss	7.1	3.5	0.7	**11.3**
Business Inventory Loss	0.0	0.0	0.0	**0**
Business Income Loss	0.0	5.4	0.2	**5.6**
Business Relocation Loss	2.3	1.0	0.1	**3.4**
Rental Income Loss	0.8	0.8	0.0	**1.6**
Wage Loss	0.1	4.1	0.6	**4.8**
Total	**19.4**	**15.9**	**1.8**	**37.1**

Climate change will increase sea-levels which will create larger surge zones and other coastal flooding in the future. Future floodplains may be larger than the current FEMA modeled floodplains and new development in the coastal areas should consider these projected conditions.

Population Impacts

Population impacts from storm surge flooding will be similar to those described in the flood vulnerability assessment above. The town should be aware that senior and low-income segments of Marblehead's population may be more vulnerable to storm surges as compared to other segments of the population. Senior and low-income populations may be physically or financially unable to react and respond to a hazard event and require additional assistance. Access to information about the hazard event may be lacking, as well as access to transportation in the case of an evacuation. However, unlike a flood event accruing due to severe precipitation, the warning time may be longer for a storm surge.

Climate change will increase sea-levels which will create larger surge zones and other coastal flooding in the future. Future floodplains may be larger than the current FEMA modeled floodplains and new development in the coastal areas should consider these projected conditions. Vulnerable populations should be considered when development near the current floodplain is planned.

Environment Impacts

The environmental impacts would be similar to those caused by flooding. Specifically, the major environmental impacts would be the potential release of hazardous materials in the surge zone.

Climate change will increase sea-levels which will create larger surge zones and other coastal flooding in the future. Future floodplains may be larger than the current FEMA modeled floodplain and new development should consider these projected conditions including whether hazardous materials are stored there.

Problem Statements for Coastal Flooding

Table 27. Problem Statements Related to Coastal Flooding.

Assets	Problems Associated with Flood
People (including underserved communities and socially vulnerable populations)	• Numerous people live in areas of direct coastal flood risk. • Numerous people depend on the Causeway for access and egress, and routinely become isolated during coastal flood events.
Structures (including facilities, lifelines, and critical infrastructure)	• Numerous structures are within areas of direct coastal flood risk.
Systems (including networks and capabilities)	• Sewer pumping stations are in areas of coastal flood risk, and many have been flooded. • Critical roadway corridors such as the Causeway are in areas of coastal flood risk and have been inundated many times.
Natural, historic, and cultural resources	• Many beaches and coastal structures such as seawalls have historic and cultural value.
Activities that have value to the community	• Waterfront and shoreline coastal public access locations and recreational resources are impacted by coastal flooding.

Coastal Erosion

Coastal erosion is a significant challenge in Marblehead, though rates of erosion vary from point to point along the shoreline.

The Town of Marblehead Community Resilience Building Workshop Summary of Findings (2018) lists "Coastal erosion" as one of the top four hazards of concern.

Description

The SHMCAP notes that coastal shorelines change constantly in response to wind, waves, tides, sea level fluctuation, seasonal and climatic variations, human alteration, and other factors that influence the movement of sand and material within a shoreline system. Storms, including hurricanes and nor'easters, decrease sediment supplies; and sea-level rise contributes to these coastal hazards. Loss (erosion) and gain (accretion) of coastal land are visible results of the way these conditions reshape shorelines. Shorelines naturally change seasonally, accreting slowly during summer when sediments are deposited by relatively low energy waves and eroding dramatically during winter when sediments are moved offshore by high-energy storm waves, such as those generated by nor'easters.

Location

The fringes of the Town of Marblehead are exposed to coastal processes and therefore are the locations of coastal erosion. Because the entire town is a coastal community, indirect impacts of coastal erosion can be expected throughout Marblehead; for example, costs to re-nourish beaches may be borne by all residents.

Previous Occurrences

The Community Resilience Building (CRB) Summary Report (2018) provides narratives about coastal erosion. The report explained that "wind and wave action provide enormous energy that weathers, erodes, and changes unprotected intertidal zones: rocky outcrops, sandy beaches, sheltered coves, and salt marshes. Waterfront open spaces and parks areas, such as Beach Bluff Park, Seaside Park, Crocker Park, Chandler Hovey Park, and Fort Sewall and the two largest beaches in town, Preston Beach and Devereux Beach, receive the brunt of ocean storms and tidal action. Preston Beach, a sandy barrier beach, is armored by seawalls and spans the border between Marblehead and Swampscott. Devereux Beach, a sandy to cobble beach, is armored at one end by the wall supporting the Causeway. Forest River Conservation Area and the Goldthwait Reservation contain salt marshes. Within the town's boundary, there are two small islands, Brown's Island and Gerry Island, both under the jurisdiction of the Trustees of Reservations."

The CRB report further stated that "erosion rates per year of 6 to 17 inches have been documented at Fort Sewall, 9 to 10 inches at The Causeway, and 6 to 10 inches at Devereux Beach. [Workshop] participants recognized that with the rising sea level and increasing intensity and frequency of storms, greater rates of erosion will take place. Given the higher elevations landward of the salt marshes and beaches, landward retreat by these valued natural assets will be difficult or impossible. If there is nowhere to retreat, they will disappear with sea level rise."

The CRB report explained that the March 2018 winter storm was a significant erosion event in Marblehead. The CRB report noted that "Aerial photos taken on May 14, 2018 documented that the ocean-side (Salem Harbor) of the trail embankment had eroded approximately 45%, as measured from the trail center line to the base of the embankment, to within 12 feet of the underground supply high voltage lines. When compared to 2009-2017 aerial photography that showed no erosion, it became clear that the erosion was attributable to the March 2018 storms. This erosion is a serious threat to Marblehead's power supply and presents a severe town-wide safety and health hazard if further erosion is allowed to take place." The Town's local planning team explained during the October 2022 meeting that the Light Department had completed erosion mitigation projects to help stabilize previous-damaged areas.

Extent

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time. A number of factors determine whether a community exhibits greater long-term erosion or accretion, including the following:

- Exposure to high-energy storm waves
- Sediment size and composition of eroding coastal landforms feeding adjacent beaches
- Near-shore bathymetric variations, which direct wave approach
- Alongshore variations in wave energy and sediment transport rates
- Relative sea level rise
- Frequency and severity of storm events
- Human interference with the sediment supply (e.g., revetments, seawalls, and jetties)

Additional impacts from this hazard that may occur as a result of climate change (and municipal responses to climate change) include:

- Increased armoring of shorelines, resulting in decreases in the sediment supply to beaches and the prevented migration of coastal landforms
- A decrease in sediment, which contributes to flattening of the adjacent profile and increases wave effects
- More intense, longer-duration coastal storms
- Increases in erosion rates

NOAA's NWS monitors potential events and provides forecasts and information in advance of a storm through multiple means, which vary in system characteristics and time issued. The NWS provides early notification through its Hazardous Weather Outlook, which is a narrative statement produced and issued on a routine basis to provide information regarding the potential of significant weather expected during the next 1 to 5 days. Additionally, many of the standard warning products can help people prepare for erosional events:

- For nor'easters, the NWS issues Coastal Flood Advisories when minor flooding is possible; Coastal Flood Watches when flooding with significant impacts is possible; or Coastal Flood Warnings when flooding that will pose a serious threat to life and property is occurring, imminent, or highly likely.
- For tropical, subtropical, or post-tropical systems, the NWS will issue a Hurricane or Tropical Storm Warning 36 hours in advance of the anticipated onset of tropical-storm-force winds or a Hurricane or Tropical Storm Watch 48 hours in advance of the anticipated onset of tropical-storm-force winds.

Probability of Future Events

The *2022 Massachusetts Climate Change Assessment* report states that climate change is expected to increase coastal erosion, primarily driven by sea level rise, particularly in areas not protected by wetlands (e.g., dunes, banks, beaches). The probability of coastal erosion in Marblehead is therefore expected to increase.

Vulnerability Assessment

Exposure

The coastal erosion hazard occurs at different rates around Marblehead. In order to determine what is exposed to future erosion, the erosion estimates around the Town which have been recorded over time by the Massachusetts Office of Coastal Zone Management were used. An estimate of the erosion over the next fifty years was calculated and mapped to determine exposure.

There were no critical facilities found in the future erosion areas. The other building data was overlaid with the erodible areas to determine the exposure. Table 28 shows the result of this analysis. Twenty-three buildings were found in the erodible areas including single-family and multi-family homes.

Table 28. Buildings in Unstable and Moderately Unstable Area

Building Type	Number of Buildings (Total in Town)	Building Value (Total in Town)
Single Family	15 (7,564)	$10,182,500 ($2,479,847,199)
Multi-Family	8 (949)	$29,152,000 ($621,712,100)

Figure 13 shows the erosion susceptibility map for the town. The red areas are eroding while the blue areas are accreting.

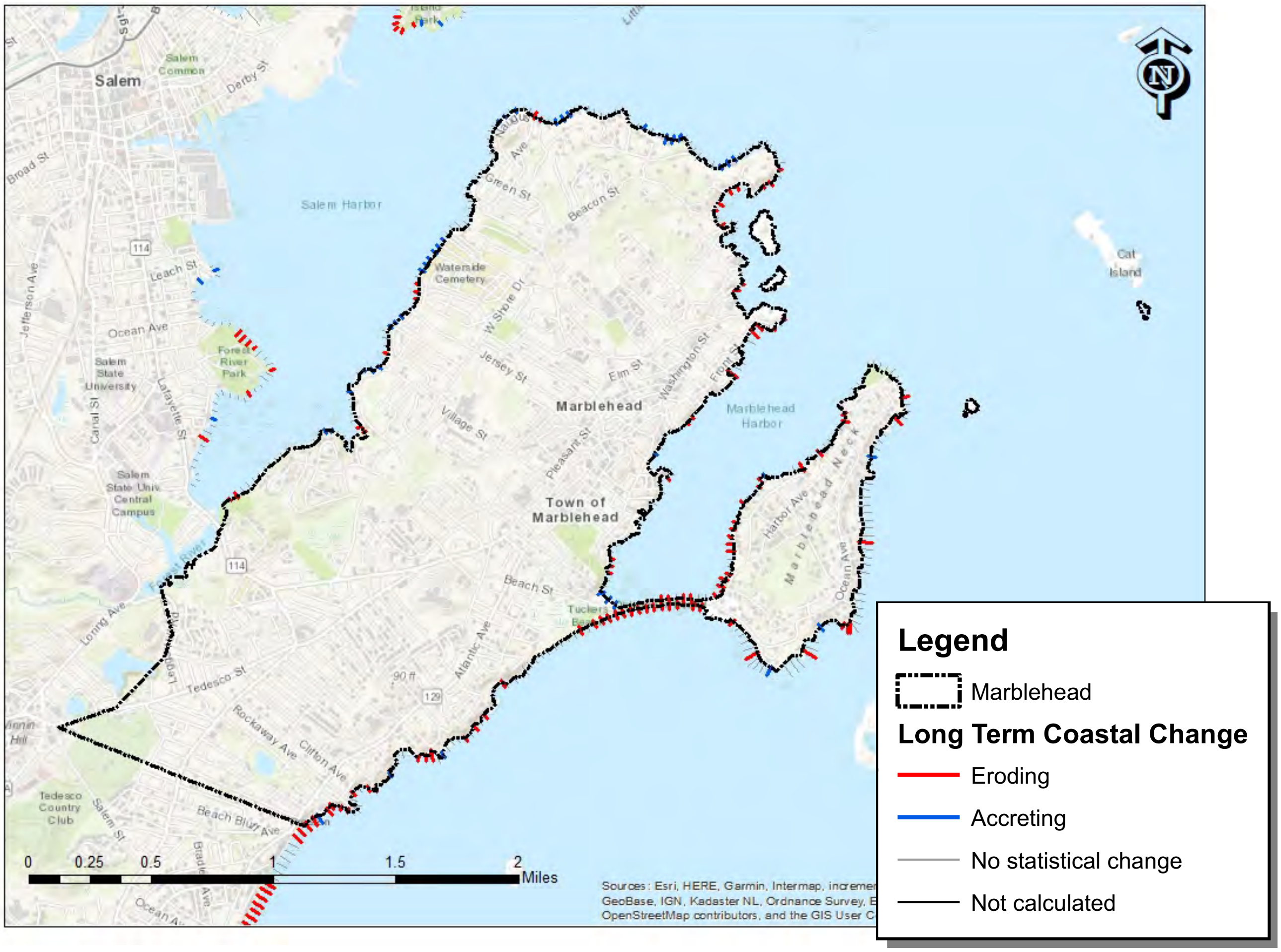


Figure 13. Erosion Susceptibility Map (MA Office of Coastal Zone Management, 2022).

Built Environment Impacts

Historic data for erosion provides an indication of how much land is going to be lost in the future. However, the data shows the average erosion rates and these may be accelerated with sea-level rise and major storm events. We'll assume a total loss for the buildings exposed the fifty years of erosion. The value of the buildings in the erosion zone is $39,334,500. This would result in an AAL of $786,690.

Climate change will increase sea-levels and coastal erosion rates which will increase the probability of damage and loss to the coastal built environment. New development in the coastal areas should consider these projected conditions.

Population Impacts

Populations considered most vulnerable to landslide impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Table 15 summarizes the senior and low-income populations in Marblehead. The town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Climate change will increase sea-levels and coastal erosion rates which will increase the probability of damage and loss to the coastal built environment. New development in the coastal areas should consider these projected conditions and vulnerable populations should be considered when development near the coastline is planned.

Environment Impacts

There are few unstable and moderately unstable areas around the transportation routes used to move hazardous materials.

Climate change will increase sea-levels and coastal erosion rates which will increase the probability of coastal property damage. New development should consider these projected conditions including whether hazardous materials are stored and/or transported there.

Problem Statements for Coastal Erosion

Table 29. Problem Statements Related to Coastal Erosion.

Assets	Problems Associated with Coastal Erosion
People (including underserved communities and socially vulnerable populations)	• Numerous people depend on the Causeway for access and egress, and routinely become isolated during coastal flood events. A severe erosion event could render the Causeway closed for a longer period of time.
Structures (including facilities, lifelines, and critical infrastructure)	• Numerous buildings are within areas of direct coastal erosion risk.
Systems (including networks and capabilities)	• Critical roadway corridors such as the Causeway are in areas of coastal erosion risk and have been inundated many times. • Marblehead Light Department infrastructure has been affected by coastal erosion.

Assets	Problems Associated with Coastal Erosion
Natural, historic, and cultural resources	• Many beaches and coastal structures such as seawalls have historic and cultural value.
Activities that have value to the community	• Waterfront and shoreline coastal public access locations and recreational resources are impacted by coastal erosion.

Primary Climate Change Interaction: Changing Temperatures

Extreme Temperatures

According to the SHMCAP, extreme heat for Massachusetts is usually defined as a period of three or more consecutive days above 90 degrees Fahrenheit (°F), but more generally as a prolonged period of excessively hot weather which may be accompanied by high humidity. Extreme cold is also considered relative to the normal climatic lows in a region. Extreme cold temperatures are characterized by the ambient air temperature dropping to approximately 0°F or below.

Description

Extreme cold is a dangerous situation that can result in health emergencies for susceptible or vulnerable people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without heat. Extreme cold events are events when temperatures drop well below normal in an area. When winter temperatures drop significantly below normal, staying warm and safe can become a challenge. Extremely cold temperatures often accompany a winter storm, which may also cause power failures and icy roads. During cold months, carbon monoxide may be high in some areas because the colder weather makes it difficult for car emission control systems to operate effectively, and temperature inversions can trap the resulting pollutants closer to the ground.

Likewise, extreme heat is a dangerous situation that can result in health emergencies for susceptible and vulnerable people, such as those without shelter or who are stranded or who live in homes that are poorly insulated or without adequate cooling.

A heat wave is defined as three or more days of temperatures of 90°F or above. A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle, and which may have adverse health consequences for the affected population. Heat waves cause more fatalities in the U.S. than the total of all other meteorological events combined. According to the SHMCAP, more than 9,000 Americans have died from heat-related ailments (EPA, 2016) since the 1970s.

Heat impacts can be particularly significant in urban areas. Buildings, roads, and other infrastructure replace open land and vegetation. Dark-colored asphalt and roofs also absorb more of the sun's energy. These changes cause urban areas to become warmer than the surrounding areas. This forms "islands" of higher temperatures, often referred to as "heat islands." Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and Green House Gas emissions, heat-related illness and death, and water quality degradation (EPA).

Many conditions associated with heat waves or more severe events (including high temperatures, low precipitation, strong sunlight, and low wind speeds) contribute to a worsening of air quality in several ways. High temperatures can increase the production of ozone from volatile organic compounds and other aerosols. Weather patterns that bring high temperatures can also transport particulate matter air pollutants from other areas of the continent. Additionally, atmospheric inversions and low wind speeds allow polluted air to remain in one location for a prolonged period of time.

Location

The Massachusetts Climate Assessment (2022) explains that recent efforts to characterize extreme heat have underscored that risks are present throughout the entire commonwealth. Therefore, the entire town of Marblehead is subject to extreme heat. As with the entire commonwealth, Marblehead is also exposure to extreme cold temperatures.

Previous Occurrences

Extreme Cold: The SHMCAP notes that since 1994, there have been 33 cold weather events within the Commonwealth, ranging from Cold/Wind Chill to Extreme Cold/Wind Chill events.

Extreme Heat: The SHMCAP notes that according to the NOAA's Storm Events Database (accessed in March 2018 for that planning process) there have been 43 warm weather events (ranging from Record Warmth/Heat to Excessive Heat events) since 1995. The most current event in the database occurred in July 2013. Excessive heat results from a combination of temperatures well above normal and high humidity. Whenever the heat index values meet or exceed locally or regionally established heat or excessive heat warning thresholds, an event is reported in the database.

In 2012, Massachusetts temperatures broke 27 heat records. Most of these records were broken between June 20 and June 22, 2012, during the first major heat wave of the summer to hit Massachusetts and the East Coast. In July 2013, a long period of hot and humid weather occurred throughout New England. One fatality occurred on July 6, when a postal worker collapsed as the Heat Index reached 100°F.

Notwithstanding the occurrences of heat waves in the Marblehead area, the NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Essex County does not list any extreme heat events for Marblehead in the timeframe 2012-2022. Evidence demonstrates that several extreme heat events occurred in Marblehead in July and August 2022. The Town noted that its cooling center was opened a few times in July and August 2022.

Cold events are typically reported with winter storms and will be described in the winter storm section of this chapter.

USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The events related to extreme temperatures in Essex County are listed below.

Table 30. USDA Disasters Events That Refer to Extreme Temperatures.

Year	Event	Event "Begin Dates"
2021	Excessive heat	6/1/2021
2020	Frost/freeze	5/6/2020
2019	Cool/cold, below normal temps	12/1/2018
2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016
2016	Frost/Freeze	5/4/2016 (event date)
2016	Heat, Excessive Heat, Frost, Freeze	4/30/2016 (event date)
2014	Hail, Frost, Freeze	5/22/2014
2014	Frost, Freeze, Below normal temps	12/1/2013

Extent

Extreme Cold: The extent (severity or magnitude) of extreme cold temperatures is generally measured through the Wind Chill Temperature Index. Wind Chill Temperature is the temperature that people and animals feel when they are outside, and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body loses heat at a faster rate, causing the skin's temperature to drop. The NWS issues a Wind Chill Advisory if the Wind Chill Index is forecast to dip to – 15°F to – 24°F for at least 3 hours, based on sustained winds (not gusts). The NWS issues a Wind Chill Warning if the Wind Chill Index is forecast to fall to –25°F or colder for at least 3 hours. On November 1, 2001, the NWS implemented a Wind Chill Temperature Index designed to more accurately calculate how cold air feels on human skin.

Extreme Heat: The NWS issues a Heat Advisory when the NWS Heat Index is forecast to reach 100 to 104°F for 2 or more hours. The NWS issues an Excessive Heat Warning if the Heat Index is forecast to reach 105°F or higher for 2 or more hours. The NWS Heat Index is based both on temperature and relative humidity and describes a temperature equivalent to what a person would feel at a baseline humidity level. It is scaled to the ability of a person to lose heat to their environment. Exposure to full sunshine can increase heat index values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can increase the risk of heat-related impacts.

Probability of Future Events

The SHMCAP notes that Massachusetts averaged 2.4 declared cold weather events and 0.8 extreme cold weather events annually between January 2013 and October 2017. The year 2015 was a particularly notable one, with seven cold weather events, including three extreme cold/wind chill events, as compared to no cold weather events in 2012 and one in 2013. The SHMCAP notes that an average of between four and five heat waves occur annually in Massachusetts.

There are a number of climatic phenomena that determine the number of extreme weather events in a specific year. However, there are significant long-term trends in the frequency of extreme hot and cold events. In the last decade, U.S. daily record high temperatures have occurred twice as often as record lows (as compared to a nearly 1:1 ratio in the 1950s). Models suggest that this ratio could climb to 20:1 by midcentury, if GHG emissions are not significantly reduced (C2ES, n.d.).

The NE CASC data support the trends of an increased frequency of extreme hot weather events and a decreased frequency of extreme cold weather events. High, low, and average temperatures in Massachusetts are all likely to increase significantly over the next century as a result of climate change. The graphics below (from resilient MA, 2018) show the projected annual days with maximum temperature above 90 degrees and projected annual days with minimum temperature below 32 degrees.

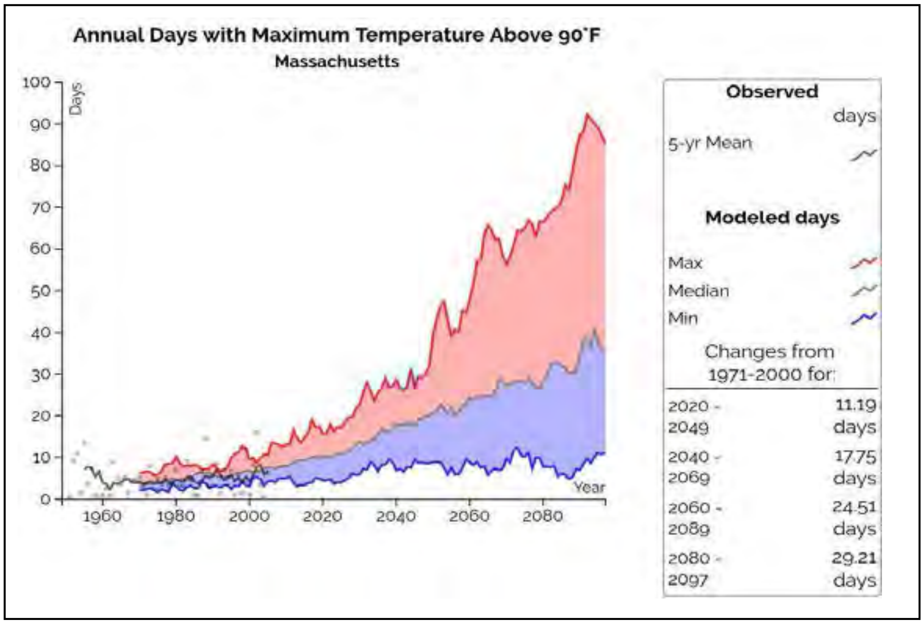


Figure 14. Annual Days with Maximum Temperature Above 90 F.

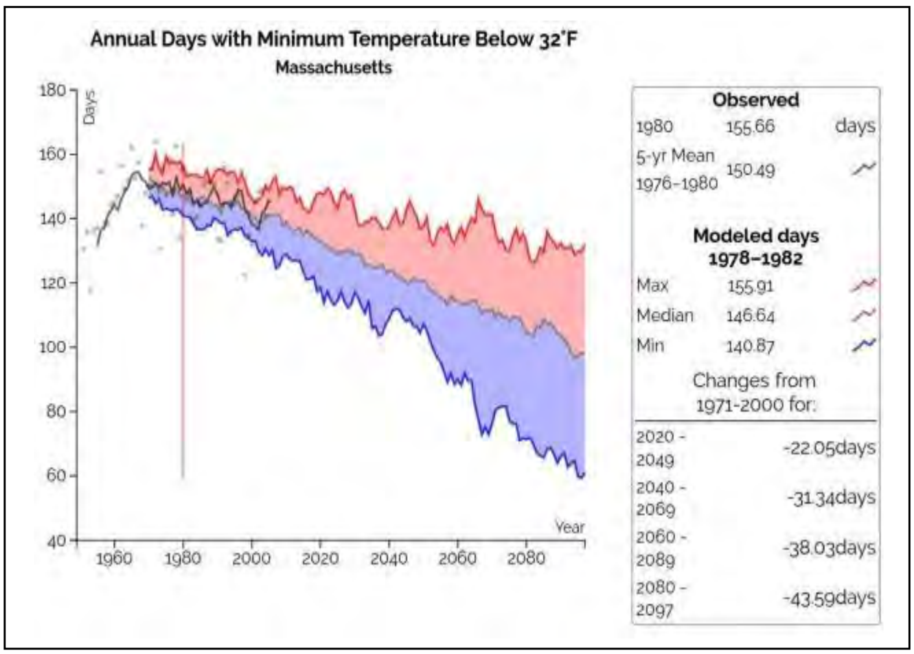


Figure 15. Annual Days with Minimum Temperature Below 32 F.

Vulnerability Assessment

Exposure

Extreme temperatures are not a hazard with a defined geographic boundary. The entire town should be considered exposed to the hazard. Excessive heat can occur at any time during the year, but is most dangerous during the summer between June and August when average temperatures are at their highest.

Built Environment Impacts

The impact of excessive heat is most prevalent in developed areas, where the town lacks a tree canopy. Secondary impacts of excessive heat are severe strain on the electrical power system and potential brownouts or blackouts. Extreme heat can have a negative impact on transportation. Highways and roads are damaged by excessive heat as asphalt roads soften and concrete roads expand and can buckle, crack, or shatter. Moreover, concrete has been known to "explode," lifting chunks of concrete and putting those nearby at serious risk. Stress is also placed on automobile cooling systems, diesel trucks, and railroad locomotives which lead to an increase in mechanical failures. Steel rails are at risk of overheating and warping which can lead to train derailments.

Extreme cold weather poses a significant threat to utility production, which in turn threatens facilities and operations that rely on utilities, specifically climate stabilization. As temperatures drop and stay low, increased demand for heating places a strain on the heating system, which can lead to temporary outages. These outages can impact operations throughout the campus, which can result in interruptions and delays in services. Broken pipes may cause flooding in buildings, causing property damage and loss of utility service. Some of the secondary effects presented by extreme/excessive cold include dangerous conditions to livestock and pets.

Climate change will increase the probability of extreme temperatures which may impact utilities, transportation, and especially older structures. Future development should consider keeping more mature trees, less dark asphalt areas, and more natural areas.

Population Impacts

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

The greatest danger from extreme cold is to people, as prolonged exposure can cause frostbite or hypothermia, and can become life threatening. Body temperatures that are too low affect the brain, making it difficult for the victim to think clearly or move well. This makes hypothermia particularly dangerous for those suffering from it, as they may not understand what is happening to them or what to do about it. Hypothermia is most likely at very cold temperatures but can occur at higher temperatures (above 40 degrees Fahrenheit) if the person exposed is also wet from rain, sweat, or submersion. Warning signs of hypothermia include shivering, exhaustion, confusion, fumbling hands, memory loss, slurred speech, or drowsiness. In infants, symptoms include bright red, cold skin, and very low energy. A person with hypothermia should receive medical attention as soon as possible, as delays in medical treatment may result in death.

Older adults are often at elevated risk due to a high prevalence of pre-existing and chronic conditions. In Marblehead, 22.8% of the population is over age 64. People who live in older housing stock and in housing without air conditioning have increased vulnerability to heat-related illnesses. Power failures are more likely to occur during heat waves, affecting the ability of residents to remain cool during extreme heat. Individuals with pre-existing conditions and those who require electric medical equipment may be at increased risk during a power outage. Heat impacts are more likely to be felt by residents without air conditioning, by those who work outdoors, and those with underlying health conditions.

Extreme heat can pose severe and life-threatening problems for people. According to the NWS, it is one of the leading weather-related killers in the United States, resulting in hundreds of fatalities each year and even more heat-related illnesses. Extreme heat has a special impact on the most vulnerable segments of the population - the elderly, young children and infants, impoverished individuals, and persons who are in poor health. The high-risk population groups with specific physical, social, and economic factors that make them vulnerable include:

- Older persons (age > 65)
- Infants (age < 1)
- Homeless population
- Very low- and low-income persons
- People who are socially isolated
- People with mobility restrictions or mental impairments
- People taking certain medications (e.g., for high blood pressure, depression, insomnia)
- People engaged in vigorous outdoor exercise or work or those under the influence of drugs or alcohol.

Climate change will increase the rate of heat illness and need for cool spaces. Outdoor workers and vulnerable populations will need to be considered during extreme heat events.

Environment Impacts

The water temperatures elevated over a longer period of time will increase the number of times the town will need to treat for algae blooms. More harmful blooms could result in more potential for injuries and death for swimmers and pets

Problem Statements for Extreme Temperatures.

Table 31. Problem Statements for Extreme Temperatures.

Assets	Problems Associated with Extreme Temperatures
People (including underserved communities and socially vulnerable populations)	• Extreme heat will be a significant public health threat to all residents, but especially for vulnerable populations living in older homes or homes without air conditioning. • The elderly and those with mobility issues may not be able to leave their homes and travel safely. • People working in businesses without air conditioning may be at risk of heat illness. • First responders may also be impacted by extreme temperatures. • Pets may be adversely impacted by extreme heat.
Structures (including facilities, lifelines, and critical infrastructure)	• Older homes without insulation and single-pane glass are difficult to heat and cool and may not provide safe living conditions. • Businesses that require refrigerated trucks or refrigeration units may see business losses and increased utility costs.
Systems (including networks and capabilities)	• The electric grid may become stressed and fail during extreme heat events, though the Marblehead Light Department has been successful in load management according to the local planning team.
Natural, historic, and cultural resources	• Extreme heat may lead to, or exacerbate, impacts to natural systems related to wildfires and invasive species (refer to the following sections). • Extreme heat may lead to additional algae blooms in ponds which would need to be treated.
Activities that have value to the community	• Recreational activities may be adversely impacted by extreme heat, despite the availability of water access.

Wildfires

A wildfire can be defined as any non-structure fire that occurs in vegetative wildland that contains grass, shrub, leaf litter, and forested tree fuels. Wildfires in Massachusetts are caused by natural events, human activity, or prescribed fire. Wildfires often begin unnoticed but spread quickly, igniting brush, trees, and potentially homes.

Description

The wildfire season in Massachusetts usually begins in late March and typically culminates in early June, corresponding with the driest live fuel moisture periods of the year. April is historically the month in which wildfire risk is the highest. Drought, snowpack level, and local weather conditions can impact the length of the fire season.

According to the National Fire Protection Agency, several elements (known as the fire tetrahedron) must be present in order to have any type of fire:

- Fuel: Without fuel, a fire will stop. Fuel can be removed naturally (when the fire has consumed all burnable fuel) or manually by mechanically or chemically removing fuel from the fire. In structure fires, removal of fuel is not typically a viable method of fire suppression. Fuel separation is important in wildfire suppression and is the basis for controlling prescribed burns and suppressing other wildfires. The type of fuel present in an area can help determine overall susceptibility to wildfires. According to the Forest Encyclopedia Network, four types of fuel are present in wildfires:
    - Ground Fuels: organic soils, forest floor duff, stumps, dead roots, buried fuels
    - Surface Fuels: the litter layer, downed woody materials, dead and live plants to 2 meters tall
    - Ladder Fuels: vine and draped foliage fuels
    - Canopy Fuels: tree crowns
- Heat: Without sufficient heat, a fire cannot begin or continue. Heat can be removed through the application of a substance, such as water, powder, or certain gases, that reduces the amount of heat available to the fire. Scraping embers from a burning structure also removes the heat source.
- Oxygen: Without oxygen, a fire cannot begin or continue. In most wildland fires, this is commonly the most abundant element of the fire triangle and is therefore not a major factor in suppressing wildfires.
- Uninhibited Chain Reaction: The chain reaction is the feedback of heat to the fuel to produce the gaseous fuel used in the flame. In other words, the chain reaction provides the sustained heat necessary to maintain the fire. Fire suppression techniques, such as dry chemical extinguishers, break up the uninhibited chain reaction of combustion to stop a fire.

Location

According to the SHMCAP, the ecosystems that are most susceptible to the wildfire hazard are pitch pine, scrub oak, and oak forests, as these areas contain the most flammable vegetative fuels. Other portions of the Commonwealth are also susceptible to wildfire, particularly at the urban-wildland interface.

Previous Occurrences

Several notable wildfires have occurred in Massachusetts history, although none has ever resulted in a FEMA disaster declaration. Smaller fires such as brush fires are somewhat easier to characterize. According to statewide data sets (https://www.mass.gov/service-details/fire-data-and-statistics), the number of brush fire events per year from 2012 through 2019 ranged from about 3,000 in 2019 to almost 8,000 in the drought year of 2016.

Table 32. Statewide Brush Fire Counts.

Year	Total # of Events	Injuries/deaths (civilians and fire service)	Losses
2019	2,974	12/0	$136,357
2018	3,253	1/5	$493,145
2017	4,206	20/0	$215,156
2016	7,834	40/0	$1,526,654
2015	6,962	35/0	$323,211
2014	4,627	25/0	$209,857
2013	4,968	31/3	$297,854
2012	5,857	38/0	$705,457

According to this statewide data set, fire event counts back to 2012 were as follows for Marblehead:

Table 33. Outdoor and Total Fire Event Figures for Marblehead.

Year	Total Outdoor Fires	Total Fire Events	Reported Losses for Outdoor Fires
2012	19	39	$104,794

Year	Total Outdoor Fires	Total Fire Events	Reported Losses for Outdoor Fires
2013	24	45	$207,588
2014	14	34	$1,281,022
2015	11	22	$204,118
2016	15	31	$248,414
2017	19	39	$131,110
2018	12	40	$302,841
2019	12	34	$72,674
2020	15	36	Not available
2021	11	33	Not available

Applying the fraction of outdoor fire incidents that are typically brush fires in Massachusetts (52%) and the fraction of fire losses that are typically from brush fires in Massachusetts (0.2%), an alternate set of figures for brush fires in Marblehead is shown in the table below.

Table 34. Estimated Brush Fire Event Figures for Marblehead.

Year	Estimated Brush Fires	Estimated Brush Fire Losses
2012	10	$409
2013	12	$740
2014	7	$5,911
2015	6	$776
2016	8	$975
2017	10	$511
2018	6	$1,918
2019	6	$391
2020	8	$741*

Year	Estimated Brush Fires	Estimated Brush Fire Losses
2021	6	$797*

*Estimated from Countywide figures

Finally, USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The single line item related to wildfires in Essex County is listed below; this line corresponds to the drought of 2016.

Table 35. USDA Disasters Events That Refer to Wildfires.

Year	Event	Event "Begin Dates"
2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016

Extent

Unfragmented and heavily forested areas of the state are vulnerable to wildfires, particularly during droughts. The greatest potential for significant damage to life and property from fire exists in areas designated as wildland-urban interface areas. A wildland-urban interface area defines the conditions where highly flammable vegetation is adjacent to developed areas.

Fires can be classified by physical parameters such as their fireline intensity, or Byram's intensity, which is the rate of energy per unit length of the fire front (BTU [British thermal unit] per foot of fireline per second) (NPS, n.d.). Wildfires are also measured by their behavior, including total heat release during burnout of fuels (BTU per square foot) and whether they are crown-, ground-, or surface-burning fires. Following a fire event, the severity of the fire can be measured by the extent of mortality and survival of plant and animal life aboveground and belowground and by the loss of organic matter (NPS, n.d.).

The National Wildfire Coordinating Group defines seven classes of wildfires:

- Class A: 0.25 acre or less
- Class B: more than 0.25 acre, but less than 10 acres
- Class C: 10 acres or more, but less than 100 acres
- Class D: 100 acres or more, but less than 300 acres
- Class E: 300 acres or more, but less than 1,000 acres
- Class F: 1,000 acres or more, but less than 5,000 acres

- Class G: 5,000 acres or more

Early detection of wildfires is a key part of the overall efforts of the Massachusetts Bureau of Fire Control. Early detection is achieved by trained Bureau observers who staff the statewide network of 42 operating fire towers. During periods of high fire danger, the Bureau conducts county-based fire patrols in forested areas. These patrols assist cities and towns in prevention efforts and allow for the quick deployment of mobile equipment for suppression of fires during their initial stage. If a fire breaks out and spreads rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

Probability of Future Events

It is difficult to predict the likelihood of wildfires in a probabilistic manner because a number of factors affect fire potential and because some conditions (e.g., ongoing land use development patterns, location, and fuel sources) exert changing pressure on the wildland-urban interface zone. The Massachusetts Climate Change Assessment report suggests that wildfire risk will increase over time in association with extreme heat events and changing precipitation and droughts. The following discussion helps characterize the risk further for Marblehead.

Vulnerability Assessment

Exposure

To help identify potential wildfire areas for Marblehead, the U.S. Forest Service's Wildfire Risk to Communities spatial data was downloaded. This data was developed in 2020 using the vegetation and wildland fuels from the LANDFIRE 2014 model with the burn probability coming from the Forest Service Fire Simulation System (FSim). To create a product with a finer resolution, the data was upsampled to the native 30m resolution of the LANDFIRE fuel and vegetation data spreading the values of the modeled burn probability into developed areas represented in LANDFIRE fuels as non-burnable. The areas with a 0.005% probability of burning were identified and overlaid with the critical facilities and other buildings. There were no critical facilities found in the 0.005% burn probability areas and 13 buildings including single-family and vacant buildings found there Table 36 shows the result of this analysis.

Table 36. Buildings in 0.005% Annual Chance Area.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	9 (7,564)	$2,608,100 ($2,479,847,199)
Multi-Family	0 (949)	$0 ($621,712,100)
Commercial	0 (197)	$0 ($132,564,601)
Educational	0 (4)	$0 ($7,951,500)

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Government	0 (70)	$0 ($159,407,800)
Religious/Non-Profit	0 (32)	$0 ($38,945,800)
Agriculture	0 (0)	$0 ($0)
Undeveloped	0 (24)	$0 ($0)
Garage/Outbuilding	0 (37)	$0 ($666,300)
Vacant	4 (79)	$62,800 ($22,612,500)
Total	**13 (8,901)**	**$2,670,900 ($3,463,707,800)**

The population exposed to the 0.005% probability area is shown in Table 37. The column in the left shows the population in and around the 0.01% probability wildfire area (wherever the Census Block overlapped with the wildfire area) while the column on the right shows the total population numbers for the town. There is an older and lower income population exposed to the wildfire hazard with a lower annual income than the town average.

Table 37. Population Exposed to 0.01% Annual Chance Wildfire (2020 U.S. Census)

Demographics	Population in and Adjacent to 0.005% Wildfire Area	Total Population
Population	513	20,441
Households	196	8,965
White	484 (94.3%)	18,702 (91.5%)
Black	2 (0.4%)	180 (0.9%)
American Indian	1 (0.2%)	31 (0.2%)
Asian	4 (0.8%)	273 (1.3%)
Pacific Islander	0 (0.0%)	1 (0.0%)
Other Race	9 (1.8%)	252 (1.2%)
Two or More Races	13 (2.5%)	1,002 (4.9%)
Hispanic or Latino:	22 (4.3%)	770 (3.8%)
Population under 18:	82 (16.0%)	4,509 (22.1%)
Population over 64:	193 (37.6%)	4,654 (22.8%)
Annual Income < $30K/year	0 (0.0%)	923 (10.3%)
Population in EJ Zone:	0 (0.0%)	1,358 (6.6%)

Figure 16 shows the burn probability map from the USFS overlaid on the town.

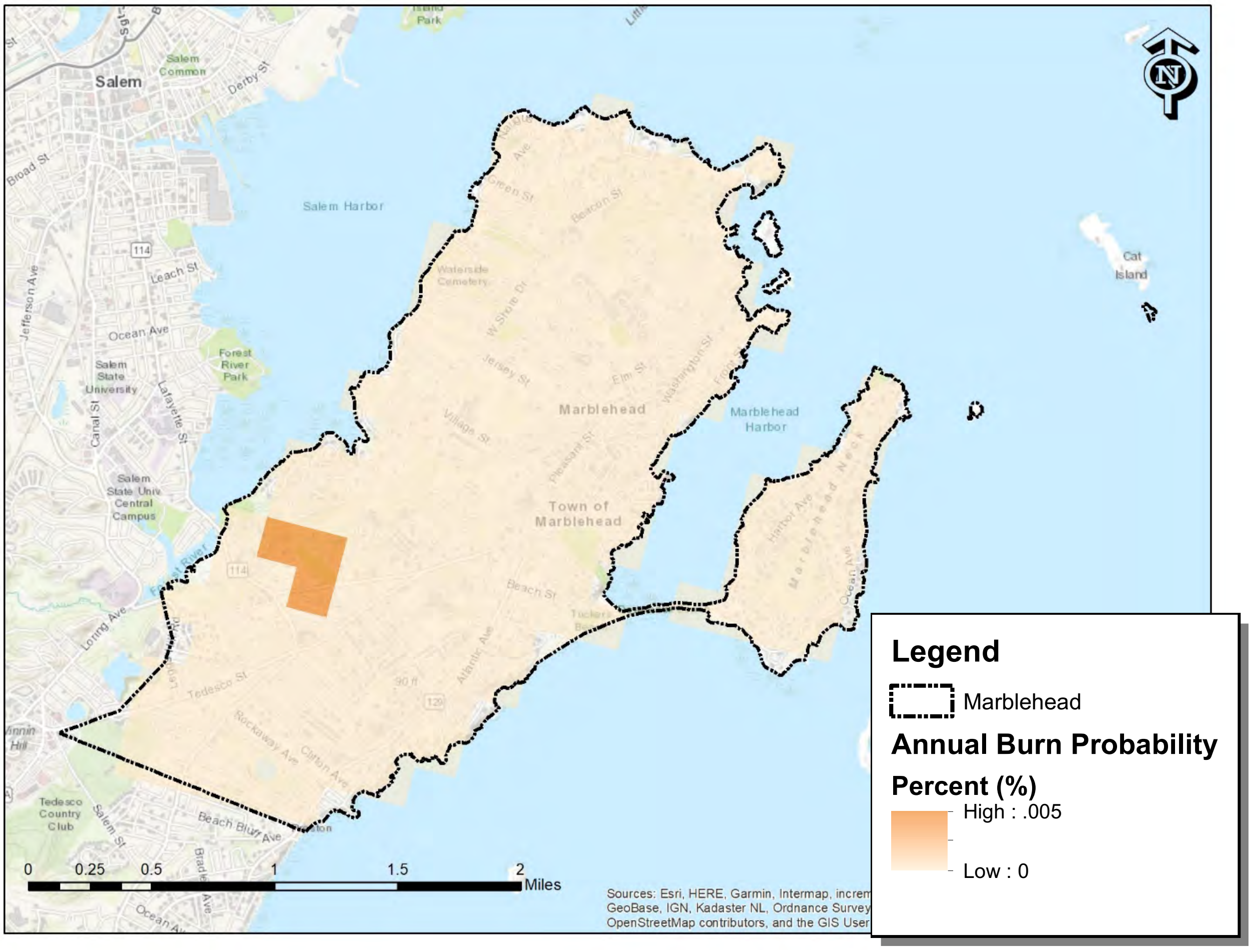


Figure 16. Wildfire Burn Probability Map.

Built Environment Impacts

A major out-of-control wildfire can damage property, utilities and forested land; create smoke that can cause breathing problems; and injure or kill people. Other associated concerns are debris management issues including debris removal and identification of disposal sites.

No property damage, injuries or deaths have been recorded for the reported brushfires in Marblehead between 2004 and 2022. Using the wildfire probabilities and building values, a loss estimate was produced for the 0.005% scenario. The losses are $2,670,900 for the .005% event and the AAL will be $134.

Climate change will increase the probability of brushfires which could lead to additional property damage. Future development in forested and other high-fuel areas also could lead to additional increases in the probability of brushfires.

Population Impacts

Populations considered most vulnerable to wildfire impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Table 15 summarizes the senior and low-income populations in Marblehead. The town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

With the increased probability of brushfires outside of the Town in the future due to climate change, populations may be impacted more often due to air quality issues.

Environment Impacts

Many of the natural features in the town are susceptible to wildfire including the trees and parks.

Problem Statements for Wildfires

Table 38. Problem Statements for Wildfires.

Assets	Problems Associated with Wildfires
People (including underserved communities and socially vulnerable populations)	• Populations with severe asthma may be adversely impacted by wildfires in the vicinity.
Structures (including facilities, lifelines, and critical infrastructure)	• Several residential structures are found in the higher probability burn areas. Structures without defensible zones are more susceptible to wildfires and brush fires.
Systems (including networks and capabilities)	• Wildfires often cause roads to be closed requiring detours.
Natural, historic, and cultural resources	• Wildfires may adversely impact forested and other vegetated areas of Marblehead.
Activities that have value to the community	• Recreational activities may be adversely impacted by wildfires, depending on location.

Infectious Diseases

The SHMCAP does not address infectious diseases as a profiled hazard. While major disease outbreaks are uncommon, public health emergencies can become standalone disasters that compound the threat of other natural hazards and exceed local and state capacity. Precedent for federal assistance due to public health emergencies has been set including West Nile Virus (2000), a mosquito-borne disease, for which a federal emergency declaration was made in New York and New Jersey; and the COVID-19 pandemic, which resulted in a major disaster declaration in all states, territories, and the District of Columbia as well as an emergency declaration in Massachusetts. Given that COVID-19 has resulted in excessive public expenditures and resulted in a disaster declaration, and in light of heightened concerns about tick and mosquito-borne illnesses, this plan addresses infectious diseases.

Description

Public health risks, such as those presented by infectious diseases and vector-borne illnesses, are present within every community. An infectious disease is one that is caused by micro-organisms, such as bacteria, viruses, and parasites. A vector-borne illness is an infectious disease that is transmitted to humans by blood-feeding arthropods, including ticks, mosquitoes, and fleas, or in some cases by mammals (e.g., rabies). Infectious diseases cause illness, suffering and even death, and place an enormous financial burden on society.

Most infectious diseases are caused by pathogens that can be spread, directly or indirectly, from person to person. Such diseases may be seasonal (seasonal influenza) or result, in the case of new diseases, result in a global pandemic. Infectious disease dynamics depend on a range of factors, including land use, human behavior, climate, efficacy of healthcare services, population dynamics of vectors, population dynamics of intermediate hosts and the evolution of the pathogens themselves. Many of these diseases require continuous monitoring, as they present seasonal threats to the general population.

In Massachusetts, state public health officials rely on local boards of health, healthcare providers, laboratories, and other public health personnel to report the occurrence of notifiable diseases as required by law. An epidemic emerges when an infectious disease occurs suddenly in numbers that are more than normal expectancy. Infectious disease outbreaks put a strain on the healthcare system and may cause continuity issues for local businesses. These outbreak incidents are a danger to emergency responders, healthcare providers, schools, and the public. This can include influenza (e.g., H1N1), pertussis, West Nile virus, and many other diseases. A pandemic is an epidemic that has spread over a large area, that is, it is prevalent throughout an entire country, continent, or the whole world.

On March 11, 2020, the World Health Organization (WHO) officially declared the Coronavirus disease 2019 (COVID-19) outbreak a pandemic due to the global spread and severity of the disease. COVID-19 is a respiratory illness that can spread from person to person. COVID-19 is a highly contagious, viral upper respiratory illness that was first detected in China in late 2019. The virus quickly spread throughout the world and has resulted in a global pandemic ongoing at the time of this plan. COVID-19 symptoms include cough, difficulty breathing, fever, muscle pain, and loss of taste or smell. Severe cases may result in death, especially in individuals over the age of 65 or with underlying medical conditions, such as diabetes, lung disease, asthma, obesity, or those who are immunocompromised. COVID-19 spreads from person to person through respiratory droplets in the air or on surfaces.

Location

The entire Commonwealth of Massachusetts and Town of Marblehead are considered at risk to the infectious diseases addressed in this chapter.

Previous Occurrences

Pandemic influenza episodes that were considered to be global outbreaks spread were observed in 1918, 1957, 1968, and in 2009 with the novel H1N1 strain. The 2009 H1N1 outbreak, though not considered a serious threat, still affected some residents in Massachusetts with nearly 2,000 confirmed cases and 33 deaths. The great influenza epidemic of 1918 killed millions worldwide and would likely cause hundreds to thousands of deaths in Massachusetts should a similar outbreak occur today. It is anticipated that a more serious strain of the usual flu will occur some year and that vaccines might not be ready in time to combat rapid spread.

The most significant recent occurrence of infectious disease for Marblehead is that of COVID-19. Approximately 2.2 million cases and 24,000 deaths have been reported in Massachusetts through June 2023. The federal designation for the Massachusetts COVID-19 Pandemic is DR-4496-MA, with incident period January 20, 2020 and continuing through May 2023. The Major Disaster Declaration was issued March 27, 2020.

Vector-borne diseases continue to pose a significant threat to communities across Massachusetts. Blacklegged (deer) ticks and dog ticks are found throughout Massachusetts and may spread different diseases. The most common tick-borne diseases in Massachusetts are Lyme Disease, Babesiosis, and Anaplasmosis. Other diseases that are rare, but still occur, are Tularemia, Rocky Mountain spotted fever, Borrelia miyamotoi, and Powassan virus. Tickborne figures for Plymouth County are available at https://www.mass.gov/lists/monthly-tick-borne-disease-reports; a summary for the last few calendar years is provided below.

Table 39. Tick-Borne Illness Figures for Essex County.

Year	Emergency Department Visits	Number of Tick-Borne Disease Visits	Rate (per 10,000) of Tick-borne Disease Visits
2022	240,031	101	4.21
2021	348,272	155	4.45
2020	307,994	98	3.18

Year	Emergency Department Visits	Number of Tick-Borne Disease Visits	Rate (per 10,000) of Tick-borne Disease Visits
2019	381,637	133	3.48

Mosquito-borne diseases are also a seasonal threat. West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE or "Triple E") are viruses that occur in Massachusetts and can cause illness ranging from a mild fever to more serious disease like encephalitis or meningitis. Other diseases spread by mosquitoes may affect people when traveling in other regions of the world such as Zika virus, Dengue fever, and Chikungunya.

Extent

Well-established scales for characterizing total impacts of infectious diseases are not present for applied uses such as a hazard mitigation plan. Nevertheless, commonly accepted methods are in place for characterizing active transmission, such as color scales (yellow, orange, red). Future editions of this plan will provide updates to measures of extent. Johns Hopkins continues to provide a very comprehensive dashboard of information for all regions of the U.S. including Massachusetts. County-level data can also be accessed (https://coronavirus.jhu.edu/region/us/massachusetts).

Probability of Future Events

Probability of infectious disease in the planning area is extremely variable. Many public health risks occur seasonally and are ongoing, such as the common cold and influenza. Major disease outbreaks such as the current COVID-19 pandemic are much less common but can last for long periods. Based on the information available regarding occurrences of greatest concern, the infectious disease hazard has been assigned a probability of likely for the foreseeable future.

The COVID-19 pandemic has the potential to continue to some degree over the next several years, even as vaccines continue to be developed are distributed. The Town is continually updating community mitigation measures and guidance in close consultation with Massachusetts Department of Public Health and based on new information from the CDC.

The effects of climate change will result in an increase in the probability and/or frequency of some infectious diseases. Those infectious diseases that are currently present in Massachusetts and which may be exacerbated by climate change are already exhibiting increased prevalence in New England. For example, with both temperature and precipitation expected to increase in Massachusetts, West Nile Virus mosquito vector activity will likely increase, as well as the vector's period of activity. Similarly, between 1964 and 2010, counts of Eastern Equine Encephalitis (EEE) have continued to rise in New England, though they remain constant in the southeastern states. The Massachusetts Climate Change Assessment predicts that increases in vector-borne disease incidence and bacterial infections will occur in the region, including West Nile Virus and Lyme disease, due to more favorable conditions for ticks and mosquitoes; and explains that 65 fewer days below freezing could occur by 2070, increasing the chance of ticks overwintering and reducing winter recreation opportunities.

The United States is already seeing a significant increase in vector-borne infectious diseases. According to the CDC, the number of reported disease cases from mosquito, tick, and flea bites tripled from 2004 to 2016, and mosquito-borne disease epidemics are happening more frequently. Annual cases of Lyme disease have increased over the last decade, and with shrinking winters, the potential for infection through tick bite continues to grow. Given increasing trends for global travel, several other diseases not typically observed in Massachusetts could continue to make their way back to the state through infected travelers. COVID-19 is the most recent and severe example of this threat. Another example is the Zika virus, transmitted from infected mosquitoes to humans, which received international attention during an outbreak in 2015 and persists today.

Vulnerability Assessment

Exposure

The risk associated with communicable disease in the region has not been formally quantified, due to the difficulty in predicting specific occurrences, and the lack of complete data on impacts. However, the potential risk and impact of communicable diseases is often presumed to be very high in the chaos that follows natural disasters (WHO, 2006).

Natural disasters, particularly meteorological and geological events such as hurricanes, floods and earthquakes, can bring about serious health consequences. These disasters can affect vector breeding sites and vector-borne disease transmission. In a flood hazard area, initial flooding may wash away existing mosquito breeding sites, but standing water caused by heavy rainfall or overflow of rivers can create new breeding sites. This can result (with typically some weeks delay) in an increase of the vector population and potential for disease transmission, depending on the local mosquito vector species and its preferred habitat. The crowding of infected and susceptible hosts, a weakened public health infrastructure and interruptions of ongoing control programs are all risk factors for vector-borne disease transmission.

The major causes of communicable disease from natural disasters can be categorized into four areas: Infections due to contaminated food and water, respiratory infections, vector and insect borne diseases, and infections due to wounds and injuries. The most common causes of morbidity and mortality in this situation are diarrheal disease and acute respiratory infections.

- Waterborne diseases: Diarrheal disease outbreaks can arise subsequent to drinking water contamination and have been reported after flooding and related movement. Hepatitis A and E have fecal-oral transmission in areas with poor water sanitation.

- Diseases associated with crowding: Acute respiratory infections are the main cause of morbidity and mortality among unsettled people and are seen predominantly in children less than 5 years old.
- Vector-borne diseases: The most common vector-borne diseases are carried by mosquitoes and ticks and include Lyme Disease, Rocky Mountain Spotted Fever, West Nile Virus, and Eastern equine encephalitis. Environmental changes after disaster could increase vector breeding sites and proliferation of disease vectors.
- Infections due to wounds and injuries: The potentially significant threats to persons suffering a wound are tetanus, staphylococci, and streptococci.

Built Environment Impacts

All human-occupied critical facilities are assumed to be at risk of contamination from a communicable disease. If facilities supporting emergency response lost their functionality because of contamination, delays in emergency services could result. Additionally, with a significant human disease outbreak, resources of health care systems such as ambulance services, hospitals, and medical clinics could quickly become overwhelmed. In most cases, critical infrastructure would not be affected by communicable disease. Scenarios that would affect infrastructure include the contamination of the water supplies and diseases that require special provisions in the treatment of wastewater. Should an epidemic necessitate quarantine or incapacitate a significant portion of the population, support of and physical repairs to infrastructure may be delayed, and services may be disrupted for a time due to limitations in getting affected employees to work.

Population Impacts

High death counts during a natural disaster (either human or animal) can indicate an increased risk of outbreaks associated with the size, health status, and living conditions of the population displaced by the natural disaster. Crowding, inadequate water and sanitation, and poor access to health services, often characteristic of sudden population displacement, increase the risk of communicable disease transmission.

Populations that are vulnerable to communicable diseases include the economically disadvantaged, racial and ethnic minorities, the uninsured, low-income children, the elderly, the homeless, and those with other chronic health conditions, including severe mental illness. It may also include rural residents, who often encounter barriers to accessing healthcare services, transportations, or the internet.

With climate change increasing the probability of infectious diseases with additional mosquito and tick activity occurring longer during the year, populations will be more at risk in the future.

Environment Impacts

Infectious diseases can also impact livestock and other animals. Some of the most common communicable diseases include Eastern Equine Encephalitis, Equine Herpes Virus, West Nile Virus, and

Avian Influenza. While Zoonotic diseases (those transmissible between humans and animals or via an animal vector) are also a concern for the region, those events are best addressed in a pandemic or contagious disease plan rather than this hazard mitigation plan

Problem Statements for Infectious Disease

Table 40. Problem Statements for Infectious Disease.

Assets	Problems Associated with Infectious Diseases
People (including underserved communities and socially vulnerable populations)	• Future flu pandemics may adversely impact all residents and present additional complications to the elderly and those with pre-existing conditions. • Tickborne and mosquito-borne infection rates are expected to increase as winter seasons become less severe and shorter in duration.
Structures (including facilities, lifelines, and critical infrastructure)	• Not applicable.
Systems (including networks and capabilities)	• May impact medical and response services. • Large scale closures/shutdowns due to pandemic response can negatively impact the Town's ability to deliver routine government operations and services.
Natural, historic, and cultural resources	• Not applicable.
Activities that have value to the community	• May impact in-person social events.

Invasive Species

According to the SHMCAP, invasive species are defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health (NISC 2006). The focus of this section is on invasive terrestrial plants, as this is the most studied and managed typed of invasive; information for invasive aquatic flora and fauna (including marine species) is also provided when relevant.

Description

The Massachusetts Invasive Plant Advisory Group (MIPAG), a collaborative representing organizations and professionals concerned with the conservation of the Massachusetts landscape, is charged by EOEEA to provide recommendations to the Commonwealth to manage invasive species. MIPAG defines invasive plants as "non-native species that have spread into native or minimally managed plant systems in Massachusetts, causing economic or environmental harm by developing self- sustaining populations and becoming dominant and/or disruptive to those systems." These species have biological traits that provide them with competitive advantages over native species, particularly because in a new habitat they are not restricted by the biological controls of their native habitat. As a result, these invasive species can monopolize natural communities, displacing many native species and causing widespread economic and environmental damage.

MIPAG recognized 69 plant species as "Invasive," "Likely Invasive," or "Potentially Invasive." The criteria for an “Invasive” species are listed below; the other assigned categories are associated with lower scores on the criteria checklist. The criteria for invasive animal species are less well-defined, but many of the same characteristics (including a non-Massachusetts origin and the ability to out-compete native species) are similar. In order to be considered “Invasive” by MIPAG, a plant species must meet the following criteria:

- Be nonindigenous to Massachusetts.
- Have the biologic potential for rapid and widespread dispersion and establishment in minimally managed habitats.
- Have the biologic potential for dispersing over spatial gaps away from the site of introduction.
- Have the biologic potential for existing in high numbers away from intensively managed artificial habitats.
- Be naturalized in Massachusetts (persists without cultivation in Massachusetts).
- Be widespread in Massachusetts or at least common in a region or habitat in the state.
- Have many occurrences of numerous individuals in Massachusetts that have high numbers of individuals forming dense stands in minimally managed habitats.
- Be able to outcompete other species in the same natural plant community.
- Have the potential for rapid growth, for high seed or propagule production and dissemination, and for establishment in natural plant communities.

Some examples of invasive insect species include:

- Nantucket Pine Tip Moth (native pest) is a moth with heads, bodies, and appendages covered with gray scales with mottled rusty-red markings. Larvae causes damage to young trees (up to five years old) by feeding inside growing shoots, buds, and conelets. The preferred host is the loblolly pine.

- Bark Beetles (native pest) include more than 600 species of beetles which serve in important ecological roles in small numbers where they live in dead, weakened, and dying host conifer trees.
- Forest Tent Caterpillar (native pest) has the biggest footprint of any indigenous tent caterpillar in North America (Furniss and Carolin 1977) and is a major defoliator of a variety of deciduous hardwood trees. The caterpillars spin silken mats on the trunks and large branches of trees where they molt and feed. Forest Tent Caterpillars can reach outbreak proportions causing massive defoliation of host trees and becoming a nuisance to people.
- Pine Reproduction Weevils (native pest) is a very dark, elongate, oval insect up to 1/2 inch long with indistinct to distinct gray or pale orange spots of scales on the wings and thorax. They feed at night on the conifer seedlings or near the tips of branches of larger plants. Females lay their eggs on the roots of these trees. The weevils breed in all species of pines, hemlocks, junipers, spruces, firs, and cedars.
- Hardwood Borers (native pest) usually attack hardwoods experiencing some kind of stress although the clear-wing moths attack healthy trees. These insects attack the tree year after year and may eventually weaken it enough that it is prone to wind breakage. Some borers develop in the root system damaging young trees.
- Hemlock Wooly and Balsam Wooly Adelgid (non-native pest) is a very small, invasive, aphid-like insect that attacks North American hemlocks (Hemlock Wooly) and firs (Balsam Wooly). They can be identified by the white woolly masses that form on the underside of branches at the base of the tree's needles. They stay at this location for the rest of their lives. Their feeding disrupts the flow of nutrients to the tree twigs and needles leading to a decline in tree health and mortality in 4 to 10 years.
- Gypsy Moth (non-native pest) is an insect which feeds on a large variety of tree leaves from oak, maple, apple, crabapple, hickory, basswood, aspen, willow, birch, pine, spruce, hemlock, and others. It does prefer oak tree leaves, however. Periodically, large populations can cause defoliation damaging and killing trees they are feeding on.
- Spotted Lanternfly (non-native pest) is an invasive insect first detected in the U.S. in 2014. It feeds on a variety of fruit, ornamental, and wood trees and could seriously impact the grape, orchard, and logging industries.

Location

The damage rendered by invasive species is significant. Experts estimate that about 3 million acres within the U.S. are lost each year to invasive plants (Pulling Together, 1997, from Mass.gov "Invasive Plant Facts"). The massive scope of this hazard means that the entire Commonwealth experiences impacts from these species. Furthermore, the ability of invasive species to travel distances (either via natural mechanisms or accidental human interference) allows these species to propagate rapidly over a large geographic area. Similarly, in open freshwater and marine ecosystems, invasive species can quickly spread once introduced, as there are generally no physical barriers to prevent establishment, outside of physiological tolerances, and multiple opportunities for transport to new locations (by boats, for example). The entire geographic area of Marblehead is believed at risk for invasive species propagation.

Previous Occurrences

Invasive species do not represent a singular event but rather an ongoing or emerging problem, so it is difficult to measure the frequency of occurrences. Invasives of current concern to forest health (https://www.mass.gov/service-details/current-forest-health-threats) in Essex County are reportedly:

- Gypsy Moth
- Winter Moth
- Hemlock Woolly Adelgid
- Southern Pine Beetle
- Emerald Ash Borer
- White Pine Needlecast

The annual budget to address invasive species in Massachusetts has fluctuated over time but, in general, appears to have decreased. This likely implies a lack of resources rather than a decrease in risk. The following figures are from https://budget.digital.mass.gov/summary/fy22/enacted/energy-and-environmental-affairs/environmental-affairs/20000100.

Table 41. Statewide Budgets for Addressing Invasive Species.

FY Year	Budget
2022	$277,838
2021	$146,348
2020	$4,150,000
2019	$3,831,135
2018	$4,347,000
2017	$6,046,870

Specific occurrences of invasive species in Marblehead have been documented in several reports and plans over the last 20 years, underscoring a trend of increasing concern.

According to the Open Space and Recreation Plan (2012), Goldthwait Reservation is a location of concern. The Open Space and Recreation Plan notes that “Historically, this area was the site of Devereux Pond, a large pond in the middle of a saltwater marsh. The pond no longer exists but was shown on maps up to about 1900. Whether it really was a pond or just a marsh is hard to tell. There also was a smaller pond located by Orchard Street, which was formed by a dam. After this time neither is shown. The dam was obviously removed, and the larger ‘pond’ probably filled in from eutrophication.”

The Open Space and Recreation Plan goes on to explain that “Today the area comprises 12 acres of salt marsh/salt meadow nestled behind Devereux Beach, a cobble barrier beach. The marsh is connected to Riverhead Beach by a series of 48-inch culverts. A small tidal creek meanders through the marsh, dividing several times. The creek is bordered by a small quantity of salt marsh cordgrass (*Spartina alternaflora*), while the majority of the marsh is vegetated by a dense stand of salt meadow grass (*Spartina patens*). The Reservation is bordered by a band of common reed (*Phragmites communis*), a common inhabitant of marsh edges and fresh- and saltwater transition zones. Along the northern and western borders, where runoff from the adjacent residential neighborhood enters through several stormwater pipes, the area is vegetated by invasive freshwater wetlands species. These include cattails (*Typha*), purple loosestrife (*Lythrum salicaria*), sensitive fern (*Onoclea sensibilis*), willows (*Salix sp.*), and red maple (*Acer rubrum*). The Trustees of Goldthwait Reservation have undertaken a restoration effort at the marsh, aimed at eradicating these invaders through mechanical removal and burning of vegetation, as well as channel dredging to enhance circulation of salt water within the marsh. Because the real culprit is likely fresh stormwater runoff, a rerouting of the town's stormwater drains will be necessary to restore the marsh. Efforts are being made now to rid the area of phragmites.”

The Open Space and Recreation Plan also explains the following:

- Invasive plants such as oriental bittersweet, Japanese knotweed, purple loosetrife, and phragmites threaten to convert some of these [conservation] lands into less valuable monocultures.
- The Trails Committee of the Marblehead Conservancy, a volunteer group, has contributed a great deal to controlling the spread of these invasives, including eradicating a large stand of kudzu, a vine that is capable of reaching lengths of more than 100 feet, growing at a rate of one foot per day. One of two stands was discovered at the end of the Path in Wyman Woods.
- Other invasive plants have been identified in town with some effort to control their spreading. Porcelain berry, pepperweed, garlic mustard, Norway maple are all examples.
- Watershield has covered some 75% of Black Joe’s Pond.

- Careless discarding of unwanted plants has also led to the spread of English ivy and other ground covers.

A member of the local planning team explained in October 2022 that poison ivy, while not typically addressed as an invasive species, is impacting power lines and utility poles.

Extent

The MIPAG has developed a list of Early Detection plant species according to an established set of criteria that includes MIPAG classification as an *invasive, likely invasive,* or *potentially invasive* ecological threat and one of these three criteria: *limited prevalence in Massachusetts, partial containment potential,* or *public health threat.* The Early Detection table includes the documented distribution of a species by county.

Once established, invasive species often escape notice for years or decades. Introduced species that initially escaped many decades ago are only now being recognized as invasives. Because these species can occur anywhere (on public or private property), new invasive species often escape notice until they are widespread, and eradication is impractical. As a result, early and coordinated action between public and private landholders is critical to preventing widespread damage from an invasive species.

Probability of Future Events

The USDA Animal and Plant Health Inspection Service (APHIS) manages the Plant Protection and Quarantine (PPQ) Program which safeguards U.S. agriculture and natural resources from the introduction, establishment, and spread of plant pests and noxious weeds. PPQ is the lead federal agency for plant health emergencies and works closely with federal, state, and local agencies; universities; industries; and private entities in developing and implementing science-based framework designed to protect against invasive pests and diseases.

Massachusetts has a variety of laws and regulations in place that attempt to mitigate the impacts of these species. The Department of Agricultural Resources (DAR) maintains a list of prohibited plants for the state, which includes federally noxious weeds as well as invasive plants recommended by MIPAG and approved for listing by DAR. Species on the DAR list are regulated with prohibitions on importation, propagation, purchase, and sale in the Commonwealth. Additionally, the Massachusetts Wetlands Protection Act (310 CMR 10.00) includes language requiring all activities covered by the Act to account for, and take steps to prevent, the introduction or propagation of invasive species.

In 2000, Massachusetts passed an Aquatic Invasive Species Management Plan, making the Commonwealth eligible for federal funds to support and implement the plan through the federal Aquatic Nuisance Prevention and Control Act. MassDEP and CZM are part of the Northeast Aquatic Nuisance Species Panel, which was established under the federal Aquatic Nuisance Species Task Force.

This panel allows managers and researchers to exchange information and coordinate efforts on the management of aquatic invasive species. The Commonwealth also has several resources pertaining to terrestrial invasive species, such as the Massachusetts Introduced Pest Outreach Project, although a strategic management plan has not yet been prepared for these species. All these efforts are aimed at reducing the probability of future occurrences.

Notwithstanding the above efforts, the presence of invasive species is ongoing, and it is difficult to quantify the future frequency of these occurrences. Increased rates of global trade and travel have created many new pathways for the dispersion of exotic species. As a result, the frequency with which these threats have been introduced has increased significantly. Increased international trade in ornamental plants is particularly concerning because many of the invasive plants species in the U.S. were originally imported as ornamentals. Furthermore, they are expected to be an increasing problem due to a changing climate and projected increases in non-native plant and animal infestations. For this reason and based on the fact invasive species are already an ongoing issue for the region, this hazard has been assigned a probability of highly likely.

Vulnerability Assessment

Exposure

The entire Town of Marblehead has the potential to be exposed to invasive pests. Climate change will make the area more attractive to pests who have not been found there traditionally.

Built Environment Impacts

Although the built environment is not as susceptible to pests as the natural environment, it can help spread the invasive species. This includes trains and vehicles that could move the species from one location to another. Trees, which are damaged or killed by invasive pests, can become hazards to people, property, utility lines, and roadways when they fall. Many dead trees in one area can also become fuel for wildfires interconnecting the two hazards.

Population Impacts

The direct population impacts are minimal. However, the indirect impacts could destroy livelihoods.

Environment Impacts

Most of the natural features in the town have some susceptible pests including the parks and other forested areas. Trees that have been damaged by other events such as fire, wind, flooding, and animal browsing are more susceptible to diseases and pests. Certain species of trees are more susceptible based on the need of the damaging species.

Climate change will increase the probability of invasive pests which will pose increased environmental impacts in the future.

Problem Statements for Invasive Species

Table 42. Problem Statements for Invasive Species.

Assets	Problems Associated with Invasive Species
People (including underserved communities and socially vulnerable populations)	• None apparent or projected.
Structures (including facilities, lifelines, and critical infrastructure)	• None apparent or projected.
Systems (including networks and capabilities)	• Town capabilities are overtaxed to deal with aquatic and riverbank invasive vegetation and algae.
Natural, historic, and cultural resources	• Invasive species are problematic in Goldthwait Reservation, Wyman Woods, and Black Joe's Pond.
Activities that have value to the community	• Recreational activities may be adversely impacted, depending on location, and especially in Goldthwait Reservation, Wyman Woods, and Black Joe's Pond.

Primary Climate Change Interaction: Extreme Weather Events

Hurricanes and Tropical Storms

Flooding in Massachusetts is often the direct result of tropical storms and hurricanes. These powerful storms can also cause significant widespread damage due to high winds. The impacts from high winds are the primary concern of this section.

> The Town of Marblehead Community Resilience Building Workshop Summary of Findings (2018) lists "High winds" as one of the top four hazards of concern.

Description

Tropical cyclones (tropical depressions, tropical storms, and hurricanes) that affect New England form over the warm, moist waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. Tropical systems customarily come from a southerly direction and when they accelerate up the East Coast of the U.S., most take on a distinct appearance that is different from a typical hurricane. Although rain is often limited in the areas south and east of the track of the storm, these areas can incur the worst winds and storm surge. Dangerous flooding occurs most often to the north and west of the track of the storm. An additional threat associated with a tropical system making landfall is the possibility of tornado generation.

Tornadoes would generally occur in the outer bands to the north and east of the storm, a few hours to as much as 15 hours prior to landfall.

Hurricane season runs from June 1 to November 30. In New England, these storms are most likely to occur in August, September, and the first half of October. The SHMCAP notes that this is due in large part to the fact that it takes a considerable amount of time for the waters south of Long Island to warm to the temperature necessary to sustain the storms this far north. Also, as the region progresses into the fall months, the upper-level jet stream steering winds might flow from the Great Lakes southward to the Gulf States and then back northward up the eastern seaboard. This pattern is conducive for capturing a tropical system over the Bahamas and accelerating it northward.

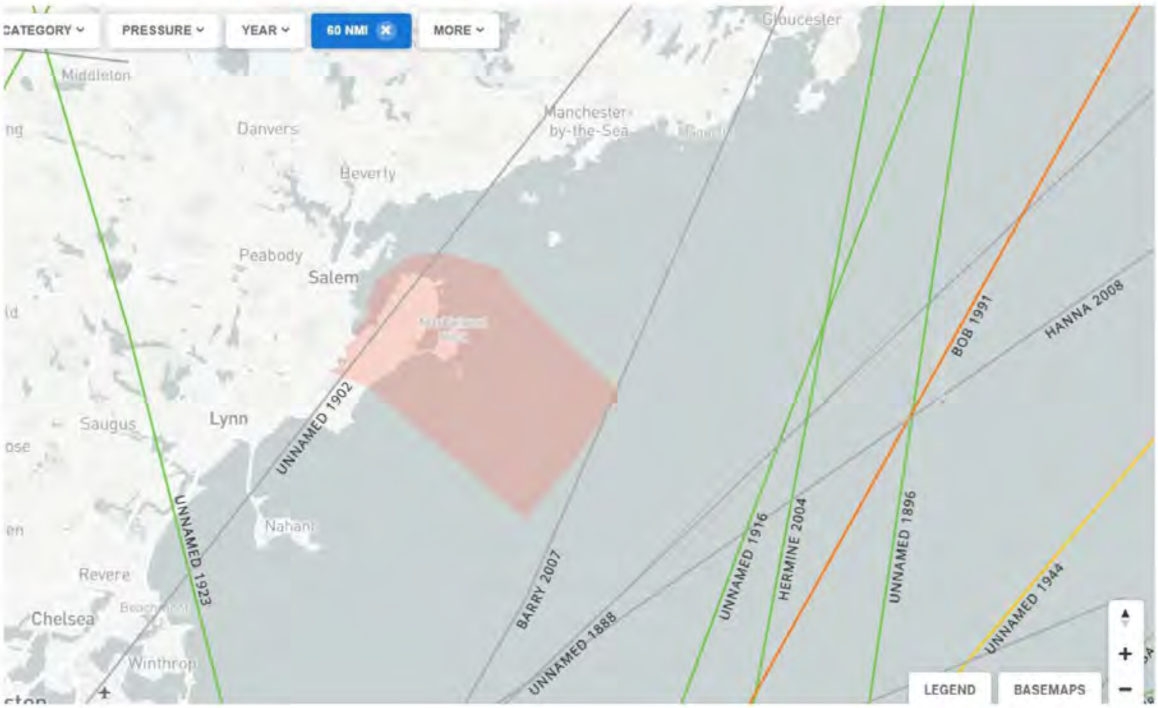
Location

Tropical storms and hurricanes can affect the entirety of Massachusetts, including the geographic extent of Marblehead.

Previous Occurrences

The SHMCAP notes that hurricanes and tropical storms occur somewhat regularly in Massachusetts. Historical tropical system tracks near and through Marblehead are depicted on the following page. This mapping is available from NOAA and updated continuously.

Historical Tropical Storm Tracks in the Town of Marblehead



Graphic courtesy of NOAA

Numerous tropical storms and hurricanes have passed through and near Marblehead since recordkeeping began, although most passed offshore given the geography of Massachusetts relative to typical storm tracks. An unnamed storm of 1902 passed through the town whereas storms such as Bob (1991), Hermine (2004), Barry (2007), and Hanna (2008) all passed to the east. Many of these storms caused high surf conditions that contributed to wave impacts and erosion in Marblehead.

Figure 17. Historical Tropical Storm Tracks In Marblehead.

As noted elsewhere, this plan update relies primarily on a ten-year lookback (2012 through 2022) ending with the date of plan development. During that ten-year period, only one declared disaster in

Massachusetts (SuperStorm Sandy of October 2012) was associated with a tropical system, and the impacts to the Marblehead region were significant. The Town's previous edition of this plan provided the following description of impacts in Marblehead: "a total of 600 people were without power over the course of the evening, but almost all were back on by midnight. In addition to power outages, the Light Department had to deal with downed live wires all over town, of which there were quite a few. Winds blew at 50-60 mph with falling trees perhaps the biggest issue for Marblehead municipal departments, accounting for most of the damage and lost power. High tides under a full Hunter's moon Monday night created rough waters that caused several boats and docks to come loose. But the tides did not cause as much damage as originally predicted. Besides branch and leaf cleanup, the municipal departments had to fix some minor fence damage over by Fort Sewall Beach and remove rocks from the causeway and Grace Oliver's Beach area."

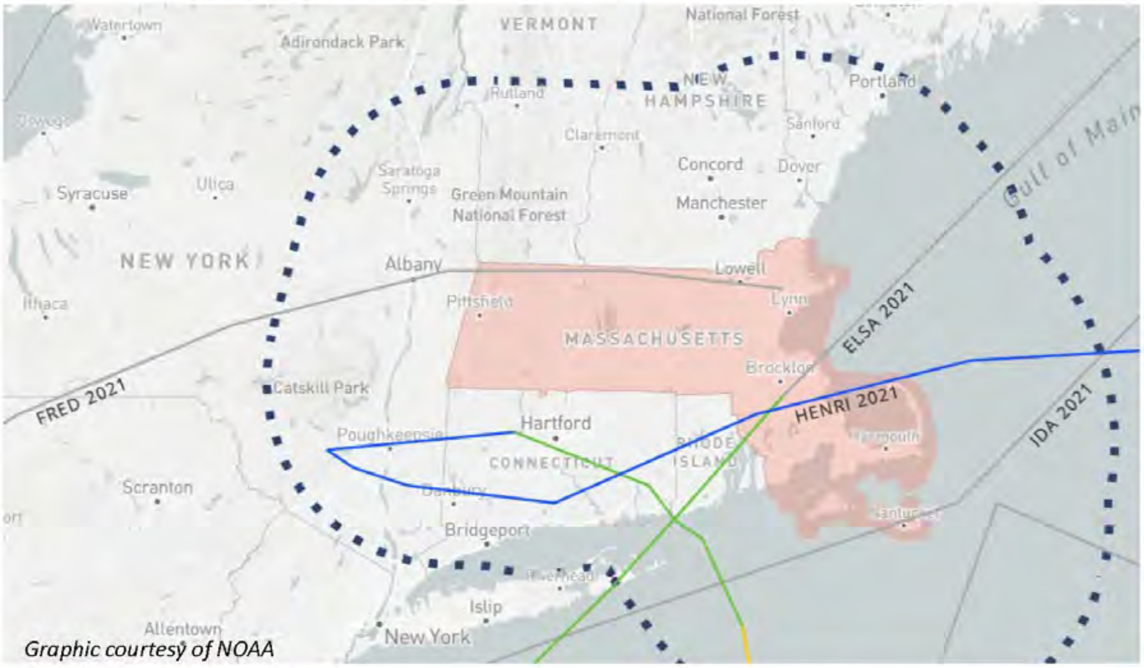
The NCEI Storm Events database described the impacts Tropical Storm Jose on September 20, 2017 in Marblehead: "As he moved north, Jose diminished to a Tropical Storm during Tuesday the 19th and then stalled about 150 miles southeast of Nantucket. The storm then slowly drifted south by Friday the 22nd and started to dissipate…. a tree was down on the back of a house on Winthrop Avenue in Marblehead."

Marblehead was minimally impacted by the series of tropical and post-tropical storm systems that impacted Massachusetts in 2021. These storms occurred in July, August, and September 2021 as follows:

- T.S. Elsa - July 9, 2021
- T.S. Fred - August 19, 2021
- T.S. Henri - August 22-23, 2021
- T.D. Ida - September 1, 2021

Marblehead experienced heavy precipitation impacts from these events, and the track for Storm Fred ended near the town. Nevertheless, the local planning team noted that flooding did not result from any of the four named storms in 2021.

Impacts of the 2021 Hurricane Season on Massachusetts



T.S. Elsa crossed eastern Massachusetts on July 9, delivering wind and flooding rains while transitioning to an extratropical storm later that day. Approximately 2 to 4 inches of rain were recorded in many towns. MBTA commuter rail trains were delayed on the Worcester line due to flooding, and Route 146 was flooded. About 11,000 Eversource customers in Massachusetts lost power.

Extratropical Storm Fred crossed northern Massachusetts lengthwise on August 19 and 20, delivering flooding rains to parts of southern New England. Flooding in Massachusetts was worst in the Worcester area. Approximately 2 to 4 inches of rain were recorded in many towns.

T.D. Henri crossed eastern Massachusetts on August 24, delivering flooding rains to parts of southern New England. Prior to crossing Massachusetts, the storm looped through Connecticut and New York on August 22-24. The path and slow movement of the storm contributed to widespread flooding in all three states, made worse due to the conditions caused by storm Fred only a few days before. Approximately 1 to 4.5 inches of rain were recorded in many towns. About 12,000 Eversource customers in Massachusetts lost power.

Extratropical Storm Ida passed south of New England and crossed Nantucket on September 2, delivering flooding rains to parts of southern New England. The precipitation from Ida was more intense than expected, and it caused widespread flooding. Approximately 2 to 6 inches of rain were recorded in many towns. About 4,000 people in Massachusetts lost power.

Figure 18. Tracks for Tropical Storms that Impacted Massachusetts 2021.

Even without the presence of a catastrophic hurricane striking Marblehead in the last few decades, less severe tropical storms and remnants such as SuperStorm Sandy and Tropical Storm Jose have created significant disruptions and necessitated public expenditures to deal with outages and debris.

Extent

Hurricanes are measured according to the Saffir-Simpson scale, which categorizes or rates hurricanes from 1 (minimal) to 5 (catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, inherently leaving out any measure of precipitation and flooding.

Table 43. Saffir-Simpson Scale.

Saffir-Simpson Hurricane Wind Scale

	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt 119-153 km/h	**Damaging winds will produce some damage:** Well-constructed framed homes could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap, and shallow-rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 83-95 kt 154-177 km/h	**Very strong, damaging winds will cause widespread damage:** Well-constructed framed homes could sustain major roof and siding damage. Many shallow-rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph 96-112 kt 178-208 km/h	**Dangerous winds will cause extensive damage:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph 113-136 kt 209-251 km/h	**Extremely dangerous winds will cause devastating damage:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher 137 kt or higher 252 km/h or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: National Hurricane Center, NOAA

Tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Nevertheless, serious power outages can also be associated with these types of events.

The NWS issues a hurricane warning when sustained winds of 74 mph or higher are expected in a specified area in association with a tropical, subtropical, or post-tropical cyclone. A warning is issued 36 hours in advance of the anticipated onset of tropical-storm-force winds. A hurricane watch is announced when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. A watch is issued 48 hours in advance of the anticipated onset of tropical-storm-force winds (NWS, 2013).

Probability of Future Events

The SHMCAP notes that Massachusetts experiences an average of one storm every other year or 0.5 storms per year. Storms severe enough to receive FEMA disaster declarations are far rarer, occurring every 9 years on average. According to NOAA, a Category 1 hurricane can be expected to make landfall in/near southern New England once every 17 years. A Category 2 hurricane could be expected to make landfall once every 39 years, and a Category 3 hurricane has a calculated return period of 68 to 70 years.

Some researchers have suggested that the intensity of tropical cyclones has increased over the last 40 years, with some believing that there is a connection between this increase in intensity and climate change. While most climate simulations agree that greenhouse warming enhances the frequency and intensity of tropical storms, models of the climate system are still limited by resolution and computational ability. However, given the history of major storms and the possibility of increased frequency and intensity of tropical storms due to climate change, it is prudent to expect that there will be hurricanes impacting Marblehead in the future that may be of greater frequency and intensity than in the past.

Vulnerability Assessment

Exposure

High winds and heavy rain and/or hail associated with hurricanes and tropical storms can cause damage to utilities, structures, roads, trees (potentially causing vehicle accidents) and injuries and death. Other associated concerns are debris management issues including debris removal and identification of disposal sites. All assets in Marblehead should be considered exposed to high winds while specific areas are exposed to hurricane surge. Figure 19 shows the 100-year windspeeds identified in the ASCE 7-98 publication and Figure 20 shows the hurricane surge by category.

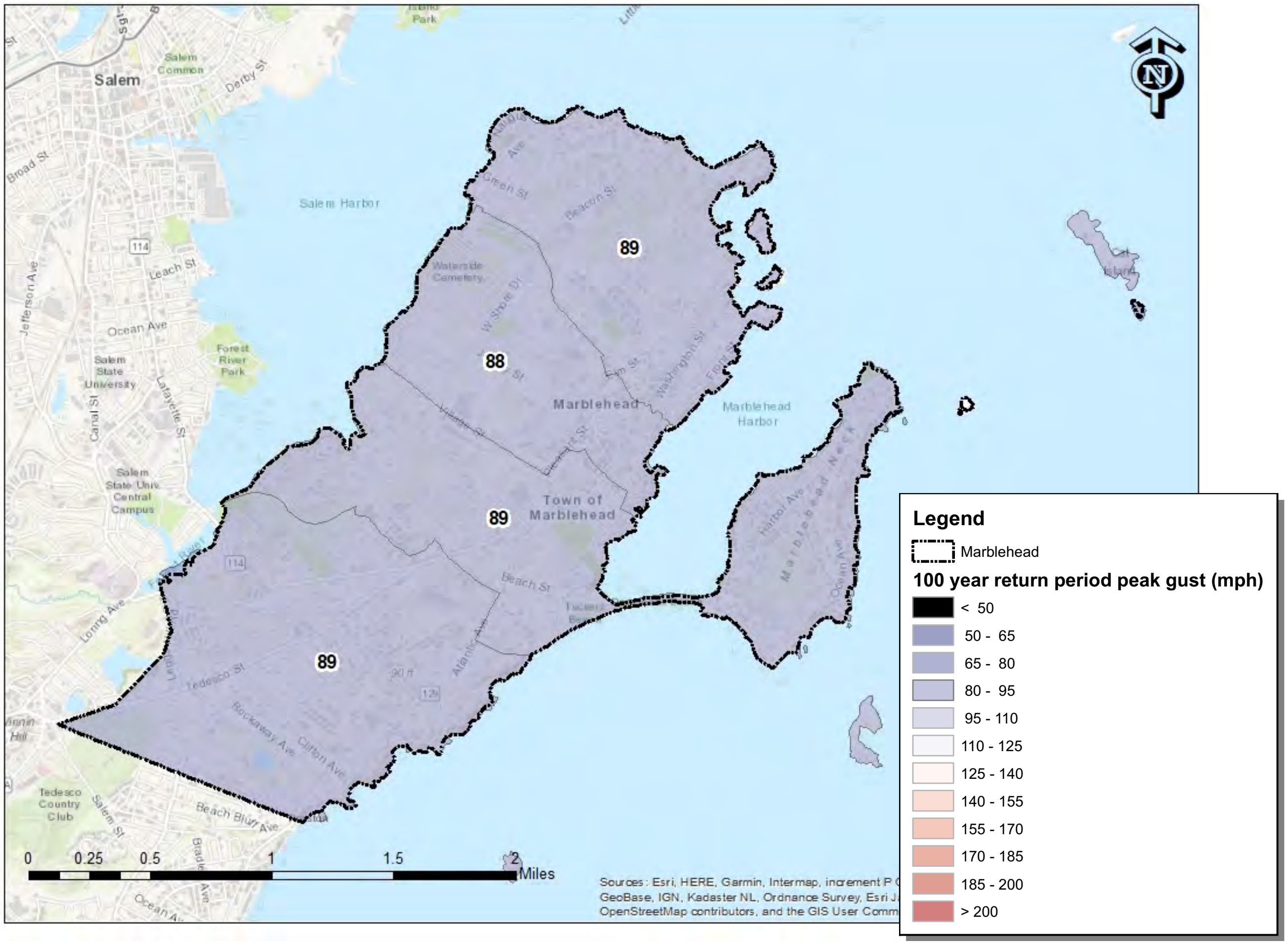


Figure 19. 100-Year Windspeeds (ASCE 7-98).

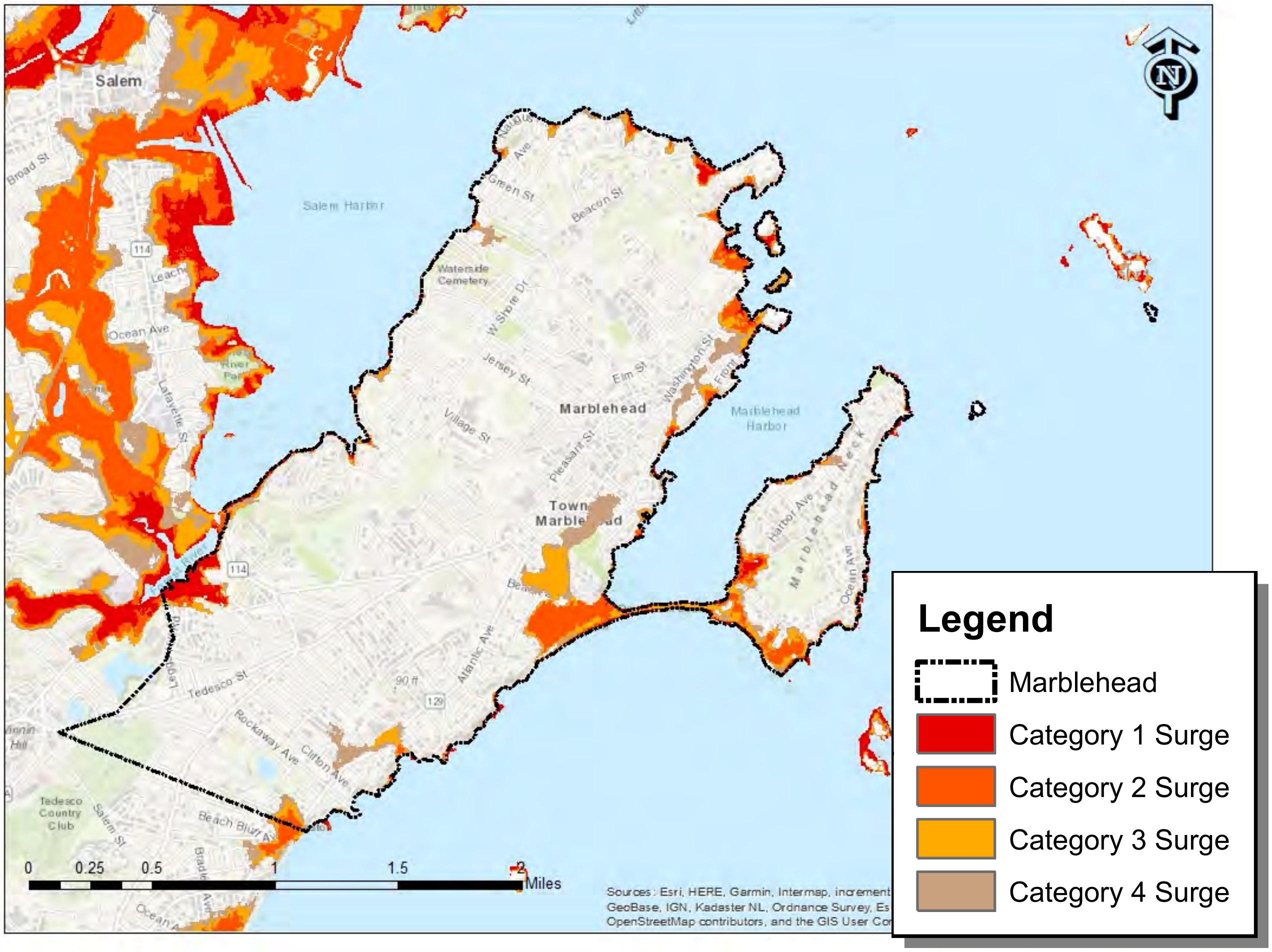


Figure 20. Hurricane Surge (NOAA, 2022).

There are no critical facilities in the category 1 or category 2 surge zones. There are 121 buildings in the category 2 surge zone. Table 44 shows the types of buildings exposed to the flood and their value. The number in parathesis shows the total number of buildings and building values for the town.

Table 44. Buildings in 500-Year Surge Zone.

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Single Family	68 (7,564)	$26,004,700 ($2,479,847,199)
Multi-Family	18 (949)	$46,765,000 ($621,712,100)
Commercial	11 (197)	$8,804,800 ($132,564,601)
Educational	0 (4)	$0 ($7,951,500)
Government	0 (70)	$0 ($159,407,800)
Religious/Non-Profit	0 (32)	$0 ($38,945,800)
Agriculture	0 (0)	$0 ($0)
Undeveloped	0 (24)	$0 ($0)

Building Type	Number of Buildings (Total in City)	Building Value (Total in City)
Garage/Outbuilding	6 (37)	$60,000 ($666,300)
Vacant	18 (79)	$324,700 ($22,612,500)
Total	**121 (8,901)**	**$81,959,200 ($3,463,707,800)**

Built Environment Impacts

To identify built environment impacts to the town resulting from wind damage, FEMA's risk assessment software, Hazus, was implemented. The economic loss results of the 500-year event are shown in Table 45 while the results for the 1000-year event are shown in Table 46. The town's Average Annual Loss (AAL) is calculated to be $1,586,921.

Table 45. Building Losses Due to Wind for a 500-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	86.4	4.8	2.2	**93.4**
Content Loss	31.8	1.6	1.2	**34.6**
Business Inventory Loss	0.0	0.0	0.1	**0.1**
Business Income Loss	0.0	0.6	0.1	**0.7**
Business Relocation Loss	4.5	0.8	0.2	**5.5**
Rental Income Loss	2.0	0.5	0.0	**2.5**
Wage Loss	0.0	0.6	0.4	**1.0**
Total	**124.7**	**8.9**	**4.2**	**137.8**

Table 46. Building Losses Due to Wind for a 1000-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	142.2	8.5	4.0	**154.7**
Content Loss	56.0	3.4	2.4	**61.8**
Business Inventory Loss	0.0	0.0	0.2	**0.2**
Business Income Loss	0.0	0.5	0.1	**0.6**
Business Relocation Loss	10.1	1.4	0.4	**11.9**

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Rental Income Loss	4.0	0.8	0.0	**4.8**
Wage Loss	0.0	0.5	0.4	**0.9**
Total	**212.3**	**15.1**	**7.5**	**234.9**

Hurricane surge inundation areas were modeled in Hazus to identify the impacts of today's extreme events and events which may happen more often in the future with sea-level rise. Table 47 shows the impacts of a Category 1 storm surge while Table 48 shows the economic impacts of a Category 2 storm surge.

Table 47. Building Losses Due to Surge for a Current Hurricane Category 1 Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	2.8	0.3	0.1	**3.2**
Content Loss	1.9	0.9	0.2	**3.0**
Business Inventory Loss	0.0	0.0	0.0	**0.0**
Business Income Loss	0.0	1.1	0.1	**1.2**
Business Relocation Loss	0.6	0.2	0.0	**0.8**
Rental Income Loss	0.2	0.1	0.0	**0.3**
Wage Loss	0.0	0.9	0.1	**1.0**
Total	**5.5**	**3.5**	**0.5**	**9.5**

Table 48. Building Losses Due to Surge for a Current Hurricane Category 2 Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	9.1	1.1	0.2	**10.4**
Content Loss	7.1	3.5	0.7	**11.3**

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Business Inventory Loss	0.0	0.0	0.0	**0**
Business Income Loss	0.0	5.4	0.2	**5.6**
Business Relocation Loss	2.3	1.0	0.1	**3.4**
Rental Income Loss	0.8	0.8	0.0	**1.6**
Wage Loss	0.1	4.1	0.6	**4.8**
Total	**19.4**	**15.9**	**1.8**	**37.1**

Population Impacts

Populations considered most vulnerable to hurricane and tropical storm impacts in Marblehead are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. For high windspeeds, it's important to maintain the building envelope during the event. If a window or door fails, damage to the structure will be much greater. Table 15 summarizes the senior and low-income populations in Marblehead. It should be noted that there may be overlap within the two categories, so that the total number of persons exposed may be lower than what is shown in the table. However, the town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

For the 500-year event, Hazus predicts that there will be up to 75 to 125 displaced households with 40 to 50 people seeking public shelter from the high windspeeds alone. However, if the rainfall leads to flooding, families may be displaced (see flood section). For the 1000-year event, Hazus predicts nearly up to 160 to 200 displaced households with 75 to 100 people seeking public shelter.

Environment Impacts

Hurricanes can cause damage to parks, and other, natural areas. Some areas of the town may be out of service until trees are removed.

Problem Statements for Hurricanes/Tropical Storms

Table 49. Problem Statements for Hurricanes/Tropical Storms.

Assets	Problems Associated with Hurricanes and Tropical Storms
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations may need to be evacuated and could be displaced from their homes.
Structures (including facilities, lifelines, and critical infrastructure)	• Coastal flood and erosion events have affected Marblehead as noted in the problem statements for coastal flooding and erosion. • Wind may cause trees to fall into structures and infrastructure, and roadways. • Wind damage to wind-susceptible buildings such as carports, greenhouses, and open-walled recreational buildings. Additional damage to commercial buildings with HVAC located on roofs.
Systems (including networks and capabilities)	• The emergency preparedness and response capabilities of DPW and the Light Department may be stretched thin immediately before and after a major hurricane impacting the region. • Electric grid may go down during high wind events.
Natural, historic, and cultural resources	• Historic buildings may experience damage during high wind events, especially the roofing and windows. Water entering these buildings could impact important historic and cultural artifacts.
Activities that have value to the community	• A severe hurricane wind and rain event could negatively impact outdoor activities in the Town, causing beach closures for several days or weeks.

Severe Winter Storms

Severe winter storms include ice storms, nor'easters, heavy snow, blowing snow, and other extreme forms of winter precipitation. These are often accompanied by very low temperatures which were previously addressed.

Description

Blizzard: A blizzard is a winter snowstorm with sustained or frequent wind gusts to 35 mph or more, accompanied by blowing snow that reduces visibility to or below a quarter of a mile (NWS, 2018). These conditions must be the predominant condition over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions but are not a formal part of the definition. However, the hazard created by the combination of snow, wind, and low visibility increases significantly with temperatures below 20ºF. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero.

Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions due to the blowing snow. Blowing snow is wind-driven snow that reduces visibility to 6 miles or less, causing significant drifting. Blowing snow may be snow that is falling and/or loose snow on the ground picked up by the wind.

Ice Storms: Ice storm conditions are defined by liquid rain falling and freezing on contact with cold objects, creating ice buildups of one-fourth of an inch or more. These can cause severe damage to vegetation, utilities, and structures. An ice storm warning, which is now included in the criteria for a winter storm warning, is issued when a half inch or more of accretion of freezing rain is expected. This may lead to dangerous walking or driving conditions and the pulling down of power lines and trees. Ice pellets are another form of freezing precipitation, formed when snowflakes melt into raindrops as they pass through a thin layer of warmer air. The raindrops then refreeze into particles of ice when they fall into a layer of subfreezing air near the surface of the earth. Finally, sleet occurs when raindrops fall into subfreezing air thick enough that the raindrops refreeze into ice before hitting the ground. The difference between sleet and hail is that sleet is a wintertime phenomenon whereas hail falls from convective clouds (usually thunderstorms), often during the warm spring and summer months.

Nor'easters: A nor'easter is a storm that occurs along the East Coast of North America. A nor'easter is characterized by a large counterclockwise wind circulation around a low-pressure center that often results in heavy snow, high winds, and rain. A nor'easter gets its name from its continuously strong northeasterly winds blowing in from the ocean ahead of the storm and over the coastal areas.

Nor'easters are among winter's most ferocious storms. These winter weather events are notorious for producing heavy snow, rain, and oversized waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. These storms occur most often in late fall and early winter. The storm radius is often as much as 100 miles, and nor'easters often sit stationary for several days, affecting multiple tide cycles and causing extended heavy precipitation. Sustained wind speeds of 20 to 40 mph are common during a nor'easter, with short-term wind speeds gusting up to 50 to 60 mph.

Location

Although the entire Commonwealth may be considered at risk to the hazard of severe winter storms, higher snow accumulations appear to be prevalent at higher elevations in Western and Central Massachusetts, and along the coast where snowfall can be enhanced by additional ocean moisture. Ice storms occur most frequently in the higher-elevation portions of Western and Central Massachusetts. Overall, winter storms can affect the entirely of Massachusetts, including the geographic extent of Marblehead.

Previous Occurrences

Winter storms occur somewhat regularly in Massachusetts. Four of the disasters declared in Massachusetts from 2012 through 2022 were associated with winter storms, and all four covered Essex County and therefore the Town of Marblehead:

- Massachusetts Severe Winter Storm, Snowstorm, and Flooding (DR-4110-MA)
  Incident Period: February 8, 2013 – February 9, 2013
  Public Assistance (PA) reimbursements eligible for entire state

- Massachusetts Severe Winter Storm, Snowstorm, and Flooding (DR-4214-MA)
  Incident Period: January 26, 2015 – January 28, 2015
  PA reimbursements eligible for Worcester County and eastward

- Massachusetts Severe Winter Storm and Flooding (DR-4372-MA)
  Incident Period: March 2, 2018 – March 3, 2018
  PA reimbursements eligible for Norfolk, Essex, Bristol, Plymouth, Cape and Islands

- Massachusetts Severe Winter Storm and Flooding (DR-4379-MA)
  Incident Period: March 13, 2018 – March 14, 2018
  PA reimbursements eligible for Norfolk, Essex, Bristol, Plymouth, Cape and Islands

The 2013, 2015, and 2018 storm events were subject to emergency declarations in Massachusetts, as well. The PA assistance reimbursements associated with the winter storms of 2013, 2015, and 2018 for the Town totaled $1,315,197. This indicates that severe winter storms comprised a substantial expenditure for Marblehead over the course of a decade.

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Essex County lists several severe winter storm events impacting Marblehead for the period 2012-2022.

Table 50. NCEI Severe Storm Database Entries Covering Winter Storms in Marblehead.

Date	Description	Losses Reported
3/14/17	*Blizzard:* A major winter storm moved up the east coast, hugging the southern NJ coast then moving rapidly northeast across southern Rhode Island and interior southeast Massachusetts. The storm dropped 12 to nearly 20 inches of snow across much of western, central, and northeastern Massachusetts, with lesser amounts in the southeast, where a changeover to rain occurred in the late morning and early afternoon. Snowfall totals ranged from as little as 4 to 5 inches in Marblehead	--
3/2/18	*High Wind:* Low pressure moving out of the Ohio Valley passed south of Southern New England on the 2nd and moved out to sea on the 3rd. This storm brought heavy snow to northwest Massachusetts, heavy rain and strong winds to central and eastern Massachusetts, and coastal flooding to the coastline. Moderate to major coastal flooding took place over three tide cycles due to astronomically high tides and a persistent northeast wind. This built a storm surge of two to four feet along the Massachusetts East Coast. A mesonet station at Childrens Island in Marblehead reported a wind gust of 60 mph.	Damage of $40,000 for all affected towns [FEMA PA was available for this event]
3/13/18	*Winter Storm:* Low pressure along the Carolina coast March 12 moved up the coast and passed offshore of Southern New England on March 13, moving off through the Maritimes on March 14. The storm brought snow accumulations of one to two feet across Eastern Massachusetts and wind gusts of 70 to 80 miles per hour to Cape Cod and the Islands. Blizzard conditions were observed at Boston's Logan International Airport, Marshfield, Plymouth, Hyannis, and Martha's Vineyard. A tree was down on Old Ridge Terrace in Marblehead.	Damage of $45,000 for all affected towns [FEMA PA was available for this event]
2/8/19	*Wind:* A weather system from the Midwest initially brought snow and ice to the region. The system swung a cold front through New England, followed by strong west to northwest winds from the afternoon of the 8th to the afternoon of the 9th. A tree and wires down on Harbor Avenue.	Damage of $1,500.

Date	Description	Losses Reported
1/17/22	*Wind:* A strong low pressure system moved up the eastern seaboard Sunday night into Monday bringing heavy snow to western and central Massachusetts and snow changing to rain elsewhere. Strong winds caused some damage and there were some coastal flooding issues as well. Snow overspread the region before changing to rain. A tree and wires were down on Edgewood Rd.	Damage of $3,000 from all affected towns.

Extent

Snowfall is a component of multiple hazards, including nor'easters and severe winter storms. Two scores, the *Regional Snowfall Index (RSI) and the NESIS*, are described in this section.

Since 2005, the RSI has become the descriptor of choice for measuring winter events that impact the eastern two-thirds of the U.S. The RSI ranks snowstorm impacts on a scale system from 1 to 5. The RSI is like the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes, except that it includes an additional variable: population. The RSI is based on the spatial extent of the storm, the amount of snowfall, and population (NOAA, n.d.).

The RSI is a regional index. Each of the six climate regions (identified by the NOAA National Centers for Environmental Information) in the eastern two-thirds of the nation has a separate index. The RSI incorporated region-specific parameters and thresholds for calculating the index. The RSI is important because, with it, a storm event and its societal impacts can be assessed within the context of a region's historical events. Snowfall thresholds in Massachusetts (in the Northeast region) are 4, 10, 20, and 30 inches of snowfall, while thresholds in the Southeast U.S. are 2, 5, 10, and 15 inches.

Table 51. RSI Scale.

Category	RSI Value	Event Description
1	1 to 3	Notable
2	3 to 6	Significant
3	6 to 10	Major
4	10 to 18	Crippling
5	18+	Extreme

Source: NOAA

Prior to the use of the RSI, the Northeast Snowfall Impact Scale, developed by Paul Kocin of The Weather Channel and Louis Uccellini of the NWS, was used to characterize, and rank high- impact northeast snowstorms with large areas of 10-inch snowfall accumulations and greater. In contrast to the RSI, which is a regional index, NESIS is a quasi-national index that is calibrated to Northeast snowstorms. NESIS has five categories. The RSI and NESIS approaches do not include separate scales for ice storms; in general, ice storm extent is expressed on a case-by-case basis, and forecasts will provide the information needed to determine how to prepare and respond.

Meteorologists can often predict the likelihood of a severe storm or nor'easter. This can give several days of warning time. The NOAA's NWS monitors potential events and provides extensive forecasts and information several days in advance of a winter storm to help the state to prepare for the incident.

Probability of Future Events

The SHMCAP notes that Massachusetts experiences high-impact snowstorms at approximately the rate of one per year, although there is significant interannual variability in the frequency and severity of winter storms. The Town of Marblehead should assume that winter storms are likely, even if the impacts of climate change will shift the timing to a shorter winter season. Heavy wet snowfall may be more common in the future. The overall probability of winter storms of all kinds, including blizzards and ice storms, is believed high.

Vulnerability Assessment

Exposure

Heavy snowfall coupled with low temperatures often results in increases in traffic accidents; disruptions in transportation, commerce, government, and education; utility outages due to falling trees, branches, and other objects; personal injuries associated with slippery surfaces and freezing temperatures; and numerous other problems. Specific damages associated with severe winter storm (snow) events include:

- Injuries and fatalities associated with accidents, low temperatures, power loss, falling objects and accidents associated with frozen and slippery surfaces and snow accumulation
- Increases in the frequency and impact of traffic accidents, resulting in personal injuries
- Ice-related damage to trees, building and infrastructure inventory, and utilities (power lines, bridges, substations, etc.)
- Roads damaged through freeze and thaw processes
- Stress on the local shelters and emergency response infrastructure
- Lost productivity that occurs when people cannot go to work, school, or stores due to inclement conditions

The entire town should be considered exposed to the severe winter storm hazard.

Built Environment Impacts

The entire built environment of Marblehead is vulnerable to a severe winter storm. New England's climate offers no immunity to the potential damaging effects of severe winter storms. Some minimum damage is anticipated annually, with potential extensive damage occurring about once every 10 years.

Since Hazus doesn't support severe winter storms and there aren't other readily available severe winter storm models, historical data was used to determine potential losses and probabilities. From 2013 until 2022, there was $1,315,197 in storm damage to Marblehead. This equates to an AAL of $131,520.

Population Impacts

As discussed above, some traffic accidents associated with storm events include injuries and in limited cases, deaths. However, the number of injuries and deaths reported for accidents is generally low. Populations considered most vulnerable to severe winter storm impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Table 15 summarizes the senior and low-income populations in Marblehead. It should be noted that there may be overlap within the two categories, so that the total number of persons exposed may be lower than what is shown in the table. However, the town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

Severe winter storms can cause damage to parks and other, natural areas. Some areas of the town may be out of service until roads are cleared and trees are removed

Problem Statements for Severe Winter Storms

Table 52. Problem Statements for Severe Winter Storms.

Assets	Problems Associated with Severe Winter Storms
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations may be stranded during a winter storm event and may not be able to travel to emergency services.
Structures (including facilities, lifelines, and critical infrastructure)	• Ice dams may cause damage to structures.

Assets	Problems Associated with Severe Winter Storms
Systems (including networks and capabilities)	• Severe winter storms comprised a substantial expenditure for Marblehead over the course of the last decade, some of which was reimbursed through FEMA PA available after disaster declarations. • Electrical grid and roadways are susceptible to failure during storms.
Natural, historic, and cultural resources	• Severe storms may damage trees in natural areas, and historical and cultural sites.
Activities that have value to the community	• Outdoor activities may be adversely impacted by severe winter storms.

Tornadoes

Tornadoes are a relatively infrequent occurrence but can be very destructive when they occur. While small tornadoes in outlying areas cause little to no damage, larger tornadoes in populated sections of Massachusetts have historically caused significant damage, injury, and death through the destruction of trees, buildings, vehicles, and power lines.

The Town of Marblehead Community Resilience Building Workshop Summary of Findings (2018) lists "High winds" as one of the top four hazards of concern.

Description

A tornado is a narrow rotating column of air that extends from the base of a cumulonimbus cloud to the ground. The observable aspect of a tornado is the rotating column of water droplets, dust, and debris caught in the column. Tornadoes are the most violent of all atmospheric storms.

Tornadoes can form from individual cells within severe thunderstorm squall lines. They can also form from an isolated supercell thunderstorm. They can be spawned by tropical cyclones or the remnants thereof, and weak tornadoes can even occur from little more than a rain shower if air is converging and spinning upward.

Most tornadoes occur in the late afternoon and evening hours when the heating is the greatest. The most common months for tornadoes to occur are June, July, and August, although the Great Barrington tornado (1995) occurred in May.

A waterspout is a rapidly rotating column of air extending from the cloud base (typically a cumulonimbus thunderstorm) to a water surface, such as a bay or the ocean. They can be formed in the same way as regular tornadoes or can form on a clear day with the right amount of instability and wind shear. Tornadic waterspouts can have wind speeds of 60 to 100 mph, but since they do not move very far, they can often be navigated around. They can become a threat to land if they drift onshore.

Location

The U.S. experiences an average of 1,253 tornadoes per year, more than any other country (NOAA, n.d.). Because Massachusetts experiences fewer tornadoes than other parts of the country, residents may be less prepared to react to a tornado. The SHMCAP notes that the area at greatest risk for a tornado touchdown runs from central to northeastern Massachusetts. Marblehead is outside this area.

Previous Occurrences

The most devastating tornado to occur in New England was the Worcester Tornado of July 9, 1953, a category F4 tornado. The tornado passed through Barre, Rutland, Holden, Worcester, Shrewsbury, Westborough, and Southborough causing 90 deaths and over 1,300 injured. Damage estimates were placed more than $52 million. The National Storm Prediction Center has ranked this as one of the deadliest tornados in the nation's history. The most recent severe tornado to impact Massachusetts occurred June 1, 2011, affecting communities in Hampden and Worcester Counties. The EF3 tornado touched down in Westfield and traveled through West Springfield, Springfield, Wilbraham, Monson, Brimfield, and Sturbridge. The tornado caused extensive property damage and resulted in a FEMA disaster declaration.

Notwithstanding previous occurrences in Massachusetts, no known tornados have touched down in Marblehead. The NOAA Storm Events database for Essex County lists a variety of severe storms in Marblehead from 2012 through 2021, but none were caused by or associated with tornadoes.

Extent

The NWS rates tornadoes using the Enhanced Fujita scale (EF scale), which does not directly measure wind speed but rather the amount of damage created. This scale derives 3-second gusts estimated at the point of damage based on the assignment of 1 out of 8 degrees of damage to a range of different structure types. These estimates vary with height and exposure. This method is considerably more sophisticated than the original Fujita scale, and it allows surveyors to create more precise assessments of tornado severity.

Table 53. Enhanced Fujita Scale.

EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.		

Source: National Weather Service

Tornado watches and warnings are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly that little, if any, advance warning is possible.

Probability of Future Events

According to the SHMCAP, the Commonwealth experienced 171 tornadoes from 1950 to 2017, or an average annual occurrence of 2.6 tornado events per year. In the last 20 years, the average frequency of these events has been 1.7 events per year (NOAA, 2018). Massachusetts experienced an average of 1.4 tornadoes per 10,000 square feet annually between 1991 and 2010, less than half of the national average of 3.5 tornadoes per 10,000 square feet per year (NOAA, n.d.). As highlighted in the National Climate Assessment, tornado activity in the U.S. has become more variable, and increasingly so in the last two decades. While the number of days per year that tornadoes occur has decreased, the number of tornadoes on these days has increased. Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase (USGCRP, 2017).

Vulnerability Assessment

Exposure

High winds, heavy rain, lightning and/or hail associated with tornados, thunderstorms and microbursts can cause damage to utilities, structures, roads, trees (potentially causing vehicle accidents) and injuries and death. The entire town should be considered exposed to the tornado hazard.

Built Environment Impacts

Since Hazus doesn't support tornadoes and there aren't other readily available tornado models, historical data will be used to determine potential losses and probabilities. From 2012 until 2021, there was no property damage to Marblehead due to tornadoes. According to the NOAA NCDC database, there were 11 events in the county from 1951 to 2022 resulting in $562.78K in damage. This equates to an AAL of $7,816 for the county.

Population Impacts

Populations considered most vulnerable to tornado impacts in Marblehead are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Table 15 summarizes the senior and low-income populations in Marblehead. It should be noted that there may be overlap within the two categories, so that the total number of persons exposed may be lower than what is shown in the table. However, the town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

Tornadoes can cause damage to parks, and other, natural areas. Some areas of the town may be out of service until trees are removed.

Problem Statements for Tornadoes

Table 54. Problem Statements for Tornadoes.

Assets	Problems Associated with Tornadoes
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations may need support seeking protected shelter. Those without cell phones may not get weather alerts. • People without basements are susceptible to tornado impacts.
Structures (including facilities, lifelines, and critical infrastructure)	• Structures and critical infrastructure can all be impacted by tornadoes.

Assets	Problems Associated with Tornadoes
	• Roadways may be blocked due to downed trees and other debris.
Systems (including networks and capabilities)	• Electric grid may be impacted by winds and downed trees.
Natural, historic, and cultural resources	• Historic and cultural resources may be impacted by tornado winds. • Winds may damage trees and cause natural areas to close for cleanup.
Activities that have value to the community	• Outdoor events could be impacted by potential tornado activity.

Other Severe Weather

Several frequent natural hazards in Massachusetts – particularly strong winds and extreme precipitation events – occur outside of notable storm events. This section discusses the nature and impacts of these hazards, as well as ways in which they are likely to respond to climate change.

The Town of Marblehead Community Resilience Building Workshop Summary of Findings (2018) lists "High winds" as one of the top four hazards of concern.

Description

Thunderstorms: A thunderstorm is a storm originating in a cumulonimbus cloud. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave known as thunder. Frequently during thunderstorm events, heavy rain and gusty winds are present. Less frequently, hail is present, which can become very large in size. Tornadoes can also be generated during these events. An average thunderstorm is 15 miles across and lasts 30 minutes, but severe thunderstorms can be much larger and longer.

Three basic components are required for a thunderstorm to form: moisture, rising unstable air, and a lifting mechanism. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise, it will continue to rise as long as it weighs less and stays warmer than the air around it. As the warm surface air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool, releasing the heat, and the vapor condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both have electrical charges. When a sufficient charge builds up, the energy is discharged in a bolt of lightning, which causes the sound waves we hear as thunder.

Downbursts: A downburst is a severe localized wind blasting down from a thunderstorm. They are more common than tornadoes. Depending on the size and location of downburst events, the destruction to property may be significant. Downbursts fall into two categories:

1. Microbursts affect an area less than 2.5 miles in diameter, last 5 to 15 minutes, and can cause damaging winds up to 168 mph.
2. Macrobursts affect an area at least 2.5 miles in diameter, last 5 to 30 minutes, and can cause damaging winds up to 134 mph.

An organized, fast-moving line of microbursts traveling across large areas is known as a "derecho." These occasionally occur in Massachusetts. Downburst activity is, on occasion, mistaken for tornado activity. Both storms have very damaging winds (downburst wind speeds can exceed 165 mph) and are very loud. These "straight line" winds are distinguishable from tornadic activity by the pattern of destruction and debris such that the best way to determine the damage source is to fly over the area.

Hail: Hailstones are chunks of ice that grow as updrafts in thunderstorms keep them in the atmosphere. Most hailstones are smaller in diameter than a dime, but stones weighing more than 1.5 pounds have been recorded. NOAA has estimates of the velocity of falling hail ranging from 9 meters per second (m/s) (20 mph) for a 1-centimeter (cm)-diameter hailstone to 48 m/s (107 mph) for an 8 cm, 0.7 kilogram stone.

Lightning: Lightning is a discharge of electricity that occurs between the positive and negative charges within the atmosphere or between the atmosphere and the ground. According to NOAA, the creation of lightning during a storm is a complicated process that is not fully understood. In the initial stages of development, air acts as an insulator between the positive and negative charges. However, when the potential between the positive and negative charges becomes too great, a discharge of electricity (lightning) occurs. In-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom. Cloud-to-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom of a second cloud. Cloud-to-ground lightning is the most dangerous. In summertime, most cloud-to-ground lightning occurs between the negative charges near the bottom of the cloud and positive charges on the ground.

Location

High wind events, thunderstorms, lightning, and hail can affect the entirely of Massachusetts, including the geographic extent of Marblehead.

Previous Occurrences

The NOAA Storm Events database (https://www.ncdc.noaa.gov/stormevents/) for Essex County lists numerous severe storms affecting Marblehead from 2012 through 2022. The individual damage figures for these events appear nominal but given the frequency of events, the overall losses from severe storms are striking. Some of these events were truly associated with winter storms, but the lack of snowfall contributed to them being classified as high wind events by NOAA.

Table 55. NCEI Severe Storm Database Entries Covering Other Severe Storms in Marblehead.

Date	Description	Losses Reported
7/3/14	*Thunderstorm Wind:* Trees and wires were downed in Peabody, Salem, Danvers, Beverly, and Marblehead.	Damage of $25,000 from all affected towns.
10/22/14	*High Wind:* Low pressure moving up the east coast brought a soaking rain and strong winds to much of southern New England. The strongest winds were along the east coast of Massachusetts where many trees were still fully leaved. In Marblehead, trees were downed on Ruby Avenue, Bubier Road, and Auburndale Road at Humphrey Street. A tree was downed onto a house on Dodge Road. A boat broke loose from moorings near Crestwood Road. A tree was downed blocking the intersection of Harbor Avenue and Nanepashemet Street.	Damage of $150,000 from all affected towns.
6/29/16	*Thunderstorm Wind:* A cold front moved through southern New England, producing a few showers and thunderstorms. Trees and wires were downed throughout Marblehead, including on Roosevelt Avenue, Fairview Avenue, Jersey Street, and Mugford Street.	Damage of $25,000.
5/4/18	*Strong Wind:* A large tree and wires were down on Euclid Avenue in Marblehead	Damage of $5,000 from all affected towns.
10/15/18	*Strong Wind:* A large tree was down along Maple Street.	Damage of $2,000 from all affected towns.
4/3/19	*Strong Wind:* A tree was down on a car on Tedesco Street.	Damage of $16,000 from all affected towns.
10/17/19	*High Wind:* A powerful coastal storm developed along the NJ coast then moved northeast across southern New England. In	--

Date	Description	Losses Reported
	Marblehead there was a wind gust of 69 mph. Also in Marblehead, there was a sustained wind of 65 mph.	
9/30/20	*High Wind:* A cold front produced a fine line of low-topped convection that moved across the region from west to east during the morning. A southerly low level jet of 80 knots at 850 mb, combined with fully leafed trees, helped cause damaging winds. A mesonet site at Children's Island in Marblehead measured a gust to 61 mph.	--

The Town's planning committee explained during its meeting of October 2022 that fall storms are becoming a significant challenge for Marblehead. They stated that at least three of the last four years (approximately 2018-2021) were characterized by strong wind events in the autumn. Some of these are listed above in the table of events reported to NCEI. The committee explained that power was shut down for eight hours to address wind damage after a storm in October 2021. This October 2021 storm was not listed in the NCEI database.

The Town's planning committee also described a microburst of 2019 that was extremely damaging in Marblehead. This microburst reportedly took down many trees and damaged boats at a yacht club. The event was not reported to the NCEI database. According to wickedlocal.com, about 10% of the town was without power after the storm, all due to tree damage.

USDA declares agricultural disasters as needed for a variety of hazards. Information can be found at https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index. The line items for events related to severe winds and hail in Essex County are listed below.

Table 56. USDA Disasters Events That Refer to Severe Storms.

Year	Event	Event "Begin Dates"
2016	Drought, high winds, wildfire, excessive heat, insects	8/24/2016, 9/21/2016
2014	Hail, Frost, Freeze	5/22/2014

Extent

The strength of thunderstorms is typically measured in terms of its effects, namely the speed of the wind, the presence of significant lightning, and the size of hail. High winds are defined by the NWS as sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of

50 knots (58 mph) or greater for any duration (NCDC, 2018). A thunderstorm is classified 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).

Probability of Future Events

According to the NWS, an average of 100,000 thunderstorms per year occur in the United States. The SHMCAP notes that over the ten-year period between January 1, 2008, and December 31, 2017, a total of 435 high wind events occurred in Massachusetts on 124 days, and an annual average of 43.5 events occurred per year. This is consistent with the figure from the SHMCAP that thunderstorms typically occur on 20 to 30 days each year in Massachusetts, which is a subset of the 43.5 high wind event days.

NOAA reports that there are ten downburst reports for every tornado report in the United States. This implies that there are approximately 10,000 downbursts reported in the United States each year and further implies that downbursts occur in approximately 10% of all thunderstorms in the United States annually. This figure suggests that downbursts are a relatively uncommon yet persistent hazard.

An average of 33 people per year died from lightning strikes in the United States from 2004 to 2013. Most lightning deaths and injuries occur outdoors, with 45% of lightning casualties occurring in open fields and ballparks, 23% under trees, and 14% involving water activities. The SHMCAP notes that 8 fatalities and 145 injuries have occurred in Massachusetts as a result of lightning events between 1993 and 2017 (NCDC, 2017).

According to NOAA's National Weather Service, hail caused two deaths and an average of 27 injuries per year in the United States from 2004 to 2013.

Climate models show projections that the frequency and intensity of severe thunderstorms (which include tornadoes, hail, and winds) will increase (USGCRP, 2017).

Vulnerability Assessment

Exposure

The entire built environment of Marblehead is vulnerable to the high winds and/or flooding from a severe weather event.

Built Environment Impacts

Severe thunderstorms, and their associated hail and lightning events, brought about property damage in Marblehead in previous years. From 2014 until 2022, there was $223,000 in property damage to Marblehead. This equates to an AAL of $24,778.

Population Impacts

Some traffic accidents associated with storm events include injuries and deaths. However, the number of injuries and deaths reported for accidents is generally low. Populations considered most vulnerable to tornado, microburst and thunderstorm impacts in Marblehead are identified based on a number of factors including their physical and financial ability to react or respond during a hazard. Table 15 summarizes the senior and low-income populations in Marblehead. It should be noted that there may be overlap within the two categories, so that the total number of persons exposed may be lower than what is shown in the table. However, the town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Environment Impacts

Thunderstorms and microbursts can cause damage to parks and other, natural areas. Some areas of the town may be out of service until trees are removed.

Problem Statements for Other Severe Weather

Table 57. Problem Statements for Other Severe Weather.

Assets	Problems Associated with Other Severe Weather
People (including underserved communities and socially vulnerable populations)	• People in Marblehead are disrupted by severe weather events such as the frequent autumn wind and thunderstorm events and the summer microburst of 2019.
Structures (including facilities, lifelines, and critical infrastructure)	• The individual damages for frequent severe weather events appear nominal, but given the frequency of events in Marblehead, the total damage to structures and property from severe storms is striking.
Systems (including networks and capabilities)	• The individual damage figures for frequent severe weather events appear nominal, but given the frequency of events in Marblehead, the total financial losses, and costs to recover from severe storms is significant. This includes costs to the Municipal Light Department. • Redundant transmission lines running into Marblehead, and below-grade lines in specific areas, are needed to help reduce outages.
Natural, historic, and cultural resources	• These can be adversely impacted depending on the specific locations of damage.
Activities that have value to the community	• These can be adversely impacted depending on the specific locations of damage.

Non Climate-Induced Hazards

Earthquakes

An earthquake is the vibration of the Earth's surface that follows a release of energy in the Earth's crust. New England experiences intraplate earthquakes because it is located within the interior of the North American plate. Although damaging earthquakes are rare in Massachusetts, low-magnitude earthquakes occur regularly in the state.

Description

An earthquake is a sudden rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. Earthquakes can cause buildings and bridges to collapse; disrupt gas, electric, and telephone lines; and often cause landslides, flash floods, fires, avalanches, and tsunamis. Earthquakes can occur at any time without warning.

The underground point of origin of an earthquake is called its focus; the point on the surface directly above the focus is the epicenter. Earthquakes are described based on their magnitude and intensity as explained below under *Extent*.

New England's earthquakes appear to be the result of the cracking of the crustal rocks due to compression as the North American Plate is being very slowly squeezed by the global plate movements. As a result, New England epicenters do not follow the major mapped faults of the region, nor are they confined to particular geologic structures or terrains. Because earthquakes have been detected all over New England, seismologists suspect that a strong earthquake could be centered anywhere in the region. Furthermore, the mapped geologic faults of New England currently do not provide any indications detailing specific locations where strong earthquakes are most likely to be centered.

In addition to earthquakes occurring within the Commonwealth, earthquakes in other parts of New England can impact widespread areas. Large earthquakes in Canada, which is more seismically active than New England, can affect buildings Massachusetts. This is due in part to the fact that earthquakes in the eastern U.S. are felt over a larger area than those in the western U.S. The difference between seismic shaking in the East versus the West is primarily due to the geologic structure and rock properties that allow seismic waves to travel farther without weakening (USGS, 2012).

In some places in New England, including locations in Massachusetts, small earthquakes seem to occur with some regularity. For example, since 1985 there has been a small earthquake approximately every 2.5 years within a few miles of Littleton. It is not clear why some localities experience such clustering of earthquakes, but clusters may indicate locations where there is an increased likelihood of future earthquake activity.

Location

Given the above discussion, the potential exists for earthquakes to occur within Marblehead or to occur elsewhere and be felt anywhere in Marblehead.

Previous Occurrences

According to the previous edition of this plan, no documented earthquakes have been centered in the Town of Marblehead. To determine whether earthquakes have occurred more recently near or in Marblehead, all events listed by Weston Observatory were reviewed for all towns in Massachusetts for a five-year lookback. Listed earthquakes above magnitude 2.0 include:

- 12/21/18 – 3 km WSW of Gardner, 2.1/2.1 [Mn*/Mc**]
- 8/21/19 – 2 km SSE of Wareham, 1.7/2.4
- 12/3/19 – 4 km SSE of Plymouth, 1.6/2.2
- 11/8/20 – 11 km SW of New Bedford, 3.8/3.4
- 11/22/20 – 12 km WSW of New Bedford, 1.7/2.6

*Mn is the Nuttli Magnitude (see *Extent* below)
**Mc is the Coda Duration Magnitude (see *Extent* below)

These are very minor earthquakes.

Extent

Magnitude is an estimate of the relative size or strength of an earthquake and is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of earthquake waves recorded on instruments that have a common calibration. The magnitude of an earthquake is thus represented by a single instrumentally determined value recorded by a seismograph, which records the varying amplitude of ground oscillations.

The Richter scale was developed in 1935 and was used exclusively until the 1970s. The scale set the magnitude of an earthquake based on the logarithm of the amplitude of recorded waves. Being logarithmic, each whole number increase in magnitude represents a tenfold increase in measured strength. Earthquakes with a magnitude of about 2.0 or less are usually called "microearthquakes" and are generally only recorded locally. Earthquakes with magnitudes of 4.5 or greater are strong enough to be recorded by seismographs all over the world.

As more seismograph stations were installed around the world following the 1930s, it became apparent that the method developed by Richter was valid only for certain frequency and distance ranges, particularly in the southwestern United States. New magnitude scales that are an extension of Richter's original idea were developed for other areas. In particular, the Moment magnitude scale (Mw) was developed in the 1970s to replace the Richter scale and has been in official use by the USGS since 2002.

According to USGS, these multiple methods are used to estimate the magnitude of an earthquake because no single method is capable of accurately estimating the size of all earthquakes. Some magnitude types are calculated to provide a consistent comparison to past earthquakes, and these scales are calibrated to the original Richter scale. However, differences in magnitude of up to 0.5 can be calculated for the same earthquake through different techniques. In general, Moment magnitude provides an estimate of earthquake size that is valid over the complete range of magnitudes and so is commonly used today.

Although Moment magnitude is the most common measure of earthquake size for medium and larger earthquakes, the USGS does not calculate Mw for earthquakes with a magnitude of less than 3.5 which is the more common situation for Massachusetts. Localized Richter scales or other scales are used to calculate magnitudes for smaller earthquakes.

Regionally, the Weston Observatory utilizes two scales to track the magnitude of earthquakes. These include the Nuttli magnitude (Mn) for North America east of the Rocky Mountains and is more appropriate for the relatively harder continental crust in Connecticut compared to California. Weston Observatory also utilizes the Coda Duration magnitude (Mc), which is based on the duration of shaking at a particular station. The advantages of the Coda Duration magnitude are that this method can quickly estimate the magnitude before the exact location of the earthquake is known.

The effect of an earthquake on the earth's surface is called the intensity. The Modified Mercalli Intensity Scale consists of a series of key responses such as people awakening, movement of furniture, damage to chimneys, and total destruction. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It is an arbitrary ranking based on observed effects.

Table 58. Modified Mercalli Intensity.

Modified Mercalli Intensity	Description
I	Not felt except by a very few under especially favorable conditions
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

Modified Mercalli Intensity	Description
V	Felt by nearly everyone; many awakened. Some dishes and windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry), structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown in the air.

Source: USGS

A comparison of Richter magnitude to typical Modified Mercalli intensity is presented below.

Table 59. Modified Mercalli Intensity and Moment Magnitude.

Moment Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 to 3.0	I
3.0 to 3.9	II to III
4.0 to 4.9	IV to V
5.0 to 5.9	VI to VII
6.0 to 6.9	VII to IX
7.0 and above	VIII or higher

Source: USGS

Probability of Future Events

Earthquake location and magnitude probabilities are exceptionally difficult to predict in Massachusetts. Minor earthquakes are relatively common in New England, but damaging earthquakes are not. Therefore, USGS instead characterizes the probability of ground acceleration rather than estimating a probability of magnitude. The Seismic Hazard Map for the state of Massachusetts (USGS) shows a peak ground acceleration of 14% to 20% of gravity in Marblehead having a 2% probability of being exceeded in 50 years.

Vulnerability Assessment

Exposure

A major earthquake could cause severe damage to Marblehead buildings, including older structures that were built before a 1975 law requiring new buildings to withstand earthquakes. Other associated concerns are debris management issues including debris removal and identification of disposal sites.

Built Environment Impacts

Historic data for earthquake events indicate that between 1991 and 2022, no major (>5.0 magnitude) earthquakes were recorded in Essex County during this period, causing no damage to property. The entire built environment of Marblehead is vulnerable to earthquakes. Older, unreinforced masonry buildings are very susceptible to earthquakes.

To identify built environment impacts to the town, FEMA's risk assessment software, Hazus, was implemented. The economic loss results of the 1500-year event are shown in Table 60 while the results for the 2500-year event are shown in Table 61. The town's Average Annual Loss (AAL) is modeled to be $329,282.

Table 60. Building Loss for a 1500-Year Scenario.

Loss Type	**Residential ($Million)**	**Commercial ($Million)**	**Other Occupancy ($Million)**	**Total ($Million)**
Building Loss	22.4	5.5	2.1	**30.0**
Content Loss	7.9	2.7	1.7	**12.3**
Business Inventory Loss	0.0	0.0	0.1	**0.1**
Business Income Loss	0.0	1.1	0.0	**1.1**
Business Relocation Loss	1.1	0.9	0.2	**2.2**
Rental Income Loss	0.6	0.6	0.0	**1.2**
Wage Loss	0.1	1.2	0.1	**1.4**
Total	**32.1**	**12**	**4.2**	**48.3**

Table 61. Building Loss for a 2500-Year Scenario.

Loss Type	Residential ($Million)	Commercial ($Million)	Other Occupancy ($Million)	Total ($Million)
Building Loss	44.1	10.0	3.9	**58.0**
Content Loss	16.7	5.1	2.3	**24.1**
Business Inventory Loss	0.0	0.1	0.2	**0.3**
Business Income Loss	0.1	2.0	0.1	**2.2**
Business Relocation Loss	2.2	1.5	0.4	**4.1**
Rental Income Loss	1.1	1.1	0.1	**2.3**
Wage Loss	0.2	2.1	0.2	**2.5**
Total	**64.4**	**21.9**	**7.2**	**93.5**

Population Impacts

Populations considered most vulnerable to earthquake impacts are identified based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Table 15 summarizes the senior and low-income populations in Marblehead. It should be noted that there may be overlap within the two categories, so that the total number of persons exposed may be lower than what is shown in the table. However, the town should be aware of the potential needs of residents within these population segments in the event of a hazard occurrence.

Hazus was used to model injuries and fatalities for the 1500- and 2500-year events. For the 1500-year event, there are up to 7 minor injuries not requiring medical attention with up to 1 injury requiring medical attention. For the 2500-year event there are 5 to 15 minor injuries not requiring medical attention with up to 2 injuries requiring medical attention.

Environment Impacts

The environment may be impacted by cascading impacts from the earthquake, such as a truck accident or train derailment caused by track or road damage, landslide, or dam breach. This could result in a hazardous material release.

Problem Statements for Earthquakes

Table 62. Problem Statements for Earthquakes.

Assets	Problems Associated with Earthquakes
People (including underserved communities and socially vulnerable populations)	• Vulnerable populations located in unreinforced masonry structures may sustain injuries. • Elderly population falls during event.
Structures (including facilities, lifelines, and critical infrastructure)	• Unreinforced masonry and utility lifelines impacted.
Systems (including networks and capabilities)	• Utility systems impacted.
Natural, historic, and cultural resources	• Historical buildings constructed out of unreinforced masonry are susceptible and may be impacted.
Activities that have value to the community	• None apparent or projected.

National Flood Insurance Repetitive Loss Properties

B2. Does the plan include a summary of the jurisdiction's vulnerability and the impacts on the community from the identified hazards? Does this summary also address NFIP-insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))

According to FEMA, repetitive loss properties are those for which two or more losses of at least $1,000 each have been paid under the National Flood Insurance Program (NFIP) within any 10-year period since 1978. Severe repetitive loss properties are residential properties that have at least four NFIP payments over $5,000 each and the cumulative amount of such claims exceeds $20,000, or at least two separate claims payments with the cumulative amount exceeding the market value of the building.

***REPETITIVE LOSS STRUCTURE** means a structure covered under an NFIP flood insurance policy that (1) has incurred flood-related damage on two occasions, in which the cost of repair, on average, equaled or exceeded 25% of the value of the structure at the time of each such flood event; and (2) at the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage.*

- According to data provided by MEMA, 21 repetitive loss facilities collectively have experienced 77 loss events, with $2,134,840.75 total building payments and $166,474.55 total content payments. The types are nine single-family, one two-family, two other residential properties, and nine non-residential properties.

- Six severe repetitive loss properties have sustained 36 loss events, with 1,496,794.13 total building payments and $82,030.52 of content payments. The types are three single-family and three non-residential properties.

A summary of the Town's participation and compliance with the NFIP, including current policy and historical claims statistics, is provided in Table 7 of Chapter 5 (Capability Assessment).

***SEVERE REPETITIVE LOSS** structure means a structure that is covered under an NFIP flood insurance policy and has incurred flood-related damage (1) for which four or more separate claims have been made under flood insurance coverage, with the amount of each claim (including building and contents payments) exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or (2) for which at least two separate flood insurance claims payments (building payments only) have been made, with cumulative amount of such claims exceeding the value of the insured structure.*

Hazard Ranking

Ranking hazards helps the Town set goals and mitigation priorities. To compare the risk of different hazards, and prioritize which are more significant, requires a scoring system for equalizing the units of analysis. As not all hazards assessed in this plan have precisely quantifiable probability or impact data, a scoring system based on multi-criteria decision analysis (MCDA) methodology was developed to rank all the hazards. This multi-criteria ranking analysis approach prioritizes hazard risk based on a blend of quantitative factors from the available data, such as historical data, local knowledge, public survey, and Hazus assessment. This hazard ranking analysis assigns varying degrees of risk to five categories for each of the hazards, including: probability (how often it can occur), impact (economic, social, and environmental loss), spatial extent (the size of the area affected), warning time (how long does a community have to prepare for the event), and duration. Each degree of risk was assigned a value ranging from 1 to 4. The weighting factor derived from a review of best practice plans. Some of these hazard characteristics, like probability and impact, are more important than others and are weighted more heavily.

To calculate a rank score value for a given hazard, the assigned risk value for each category was multiplied by the weighting factor. The sum of all five categories represents the final rank score, as demonstrated in the following equation:

Hazard Score Value = [(Probability x 30%) + (Impact x 30%) + (Spatial Extent x 20%) + (Warning Time x 10%) + (Duration x 10%)]

Table 63 provides the hazard characteristic, level description, level criteria, level index value, and weighting value.

Table 63. Hazard Ranking Criteria.

Hazard Characteristic	**Degree of Risk**			**Assigned Weighting Factor**
	Level	**Criteria**	**Index Value**	
Probability	Unlikely	Less than 1% annual probability	1	30%
	Possible	Between 1 and 10% annual probability	2	
	Likely	Between 10 and 100% annual probability	3	
	Highly Likely	100% annual probability	4	
Impact	Minor	Very few injuries, in any. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of critical facilities.	1	30%
	Limited	Minor injuries only. More than 10% of property in affected area damaged or destroyed. Complete shudown of critical facilities for more than one day.	2	
	Critical	Mulitiple deaths/injuires possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of critical faicliteis for more than one week.	3	
	Catastrophic	High number of deaths/injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for 30 days or more.	4	
Spatial Extent	Negligible	Less than 1% of area affected	1	20%
	Small	Between 1 and 10% of area affected	2	
	Moderate	Between 10 and 50% of area affected	3	
	Large	Between 50 and 100% of area affected	4	
Warning Time	Long	More than 24 hours	1	10%
	Moderate	12 to 24 hours	2	
	Short	6 to 12 hours	3	
	Very short or no warning	less than 6 hours	4	
Duration	Very short	Less than 6 hours	1	10%
	Short	Less than 24 hours	2	
	Moderate	Less than one week	3	
	Long	More than one week	4	

Table 64 provides the final hazard ranking for Marblehead. Each hazard characteristic is assigned a value between 1 (lowest value) and 4 (highest value). When the risk values were calculated, if the value was greater than 3, it was assigned as a high risk hazard. If the value was greater than 2 and less than or equal to 3, it was assigned as a moderate risk. If the value was less than or equal to 2, it was assigned as a low risk hazard. The hurricane/wind, coastal flooding, and severe winter storms hazards were ranked highest. The extreme temperatures, other severe weather, drought, infectious disease, invasive species, coastal erosion, and earthquakes are all ranked as moderate. The landslide, wildfires, and tornado hazards are ranked as low.

Table 64. Final Hazard Ranking of Hazards for Marblehead.

Hazards	Probability	Impact	Spatial Extent	Warning Time	Duration	Value	Rank
Hurricanes/Tropical Storm	3	4	4	1	2	3.2	High
Coastal Flood	4	3	2	4	2	3.1	High
Severe Winter Storm/Nor'easter	4	2	4	1	3	3.0	High
Extreme Temperatures	4	2	4	1	2	2.9	Mod.
Infectious Disease	4	2	4	1	2	2.9	Mod.
Drought	2	3	4	1	4	2.8	Mod.
Flood	4	2	2	4	2	2.8	Mod.
Invasive Species	3	2	4	1	3	2.7	Mod.
Other Severe Weather	4	1	4	2	1	2.6	Mod.
Coastal Erosion	4	1	2	1	4	2.4	Mod.
Earthquake	1	2	4	4	1	2.2	Mod.
Wildfire/Brushfire	2	1	1	3	2	1.6	Low
Tornado	1	2	1	3	1	1.5	Low

The following table summarizes changes in population patterns, land use, and development and how those impact hazards.

Table 65. Impacts from Population and Land Use.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
Flooding Including Dam Failures and Ice Jams	There is a growing elderly population exposed to the floodplain: • Along Beacon St.	Existing codes and regulations in the SFHA will help to keep flood impacts low.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
	• Along Fort Beach Ln. and Doaks Ln.	New development areas may produce additional flooding due to the addition of impervious surfaces.
Droughts	The town's elderly population has increased from 15.6% in 2010 to 21.4% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	All new developments will create more demand for limited water resources.
Coastal Erosion	There is a growing elderly population exposed to coastal erosion south of Gerry Island and Browns Island, east of Gregory St., and Fort Beach.	Limiting development along areas of eroding shoreline will help reduce risks.
Coastal Flooding	There is a growing elderly population exposed to the floodplain: • East of Norman St. along coast • North of Franklin St. along coast	Existing codes and regulations in the SFHA will help to keep flood impacts low.
Extreme Temperatures	The town's elderly population has increased from 15.6% in 2010 to 21.4% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	All new developments will exacerbate heat island effect if the development includes tree removal and adding black surfaces such as asphalt and roofs.
Wildfires	There is a growing elderly population in the Lead Mills Conservation Area and Wyman Woods with a moderate wildfire susceptibility.	Development in or adjacent to a forested or brushland area can lead to a higher risk of wildfire.
Infectious Diseases	The town's elderly population has increased from 15.6% in 2010 to 21.4% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.

Hazards	Changes in Population Patterns	Changes in Land Use and Development
Invasive Species	Shouldn't be impacted by population changes.	Shouldn't be impacted by changes in land use and development.
Hurricanes and Tropical Storms	The town's elderly population has increased from 15.6% in 2010 to 21.4% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Severe Winter Storms	The town's elderly population has increased from 15.6% in 2010 to 21.4% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Tornadoes	The town's elderly population has increased from 15.6% in 2010 to 21.4% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Other Severe Weather	The town's elderly population has increased from 15.6% in 2010 to 21.4% in 2020. The number of people living below the poverty line has decreased from 2010 to 2020.	Shouldn't be impacted by changes in land use and development.
Earthquakes	Not considered.	Not considered.

Problem Statements Summary

The following problem statements reflect a summary of the problem statements included at the end of each hazard profile. They were designed to briefly summarize the key hazard risks and vulnerabilities to the community based on potential impacts and losses from future events. They are among the issues of greatest concern and were used to assist in the identification and analysis of potential mitigation actions for Chapter 6 (Mitigation Strategy). These problem statements will be reviewed and revised as needed during plan updates to reflect the most current information resulting from the risk assessment.

Table 66. Problem Statements Summary.

Hazard	Problem Summary
Hurricanes/Tropical Storms	• Wind damage to wind-susceptible buildings such as carports, greenhouses, and open-walled recreational buildings. Additional damage to commercial buildings with HVAC located on roofs.
Coastal Flood	• Numerous people live in areas of direct coastal flood risk. • Numerous people depend on the Causeway for access and egress, and routinely become isolated during coastal flood events.
Severe Winter Storm/Nor'easter	• Severe winter storms comprised a substantial expenditure for Marblehead over the course of the last decade, some of which was reimbursed through FEMA PA available after disaster declarations.
Extreme Temperatures	• Extreme heat may lead to, or exacerbate, impacts to natural systems related to wildfires and invasive species (refer to the following sections). • Extreme heat may lead to additional algae blooms in ponds which would need to be treated.
Infectious Disease	• Future flu pandemics may adversely impact all residents and present additional complications to the elderly and those with pre-existing conditions. • Tickborne and mosquito-borne infection rates are expected to increase as winter seasons become less severe and shorter in duration.
Drought	• None Apparent
Flood	• Floods have affected structures, roads, and lifeline systems located in the areas listed above. • The Town is currently precluded from adopting higher regulatory standards to protect against flooding (must comply with State Building Code).

Hazard	Problem Summary
Invasive Species	• Town capabilities are overtaxed to deal with aquatic and riverbank invasive vegetation and algae.
Other Severe Weather	• Redundant transmission lines running into Marblehead, and below-grade lines in specific areas, are needed to help reduce outages.
Coastal Erosion	• Critical roadway corridors such as the Causeway are in areas of coastal erosion risk and have been inundated many times. • Marblehead Light Department infrastructure has been affected by coastal erosion.
Earthquakes	• Vulnerable populations located in unreinforced masonry structures may sustain injuries.
Wildfire/Brushfire	• Wildfires may adversely impact forested and other vegetated areas of Marblehead.
Tornado	• Roadways may be blocked due to downed trees and other debris.

Chapter 5: Capability Assessment

Capability Assessment Purpose

The purpose of conducting a capability assessment is to determine the ability of a community to mitigate hazard risks and to identify potential opportunities for establishing or enhancing specific mitigation policies, programs, projects, or other activities. Coupled with the risk assessment, the capability assessment serves as the foundation for designing an actionable and effective hazard mitigation strategy.

As in any planning process, it is important to establish which goals or actions are feasible based on the organizational capacity of those agencies or departments tasked with their implementation. A capability assessment helps to determine which types of mitigation actions are practical and likely to be implemented over time based on a community's existing authorities, policies, programs, and resources available to support such implementation. This analysis will identify any critical capability gaps or limitations to address through corrective actions, as well the key strengths or positive measures in place that should continue to be supported and/or expanded upon to improve local mitigation capabilities.

This capability assessment was completed to not only help establish the goals and actions for the Town of Marblehead's hazard mitigation plan, but to also help ensure that those goals and actions are realistically achievable under current local conditions. As highlighted in FEMA's 2022 Local Mitigation Planning Policy Guide, *"describing the current capabilities provides a rationale for which mitigation projects can be undertaken to address the vulnerabilities identified in the Risk Assessment."*[58]

The capability assessment for the Town of Marblehead includes a comprehensive examination of several components as summarized in Table 67.

Table 67. Capability Assessment Components.

Components	Description
Planning and Regulatory Capabilities	Local plans, policies, codes, and ordinances that are relevant to reducing the potential impacts of hazards.
Administrative and Technical Capabilities	Local human resources and their skills/tools that can be used to support mitigation activities.
Financial Capabilities	Fiscal resources the community has access to for helping to fund hazard mitigation projects.

[58] Local Mitigation Planning Policy Guide. FEMA. April 2022. P. 25.

Components	Description
Education and Outreach Capabilities	Local programs and methods already in place that can be used to support mitigation activities.
NFIP Participation and Compliance	Summary of information relevant to the community's participation in the NFIP and continued compliance with NFIP requirements.

Review and Incorporation of Existing Plans, Studies, and Reports

A4. Does the Plan describe the review and incorporation of existing plans, studies, reports, and technical information? (Requirement §201.6(b)(3))

The first step in completing the updated capability assessment was to gather and review any relevant local plans, studies, or reports completed or updated since the previous hazard mitigation plan was prepared in 2015. This information was used to help gain a current understanding of the Town's current ability to mitigate risk, and how local capabilities may have changed over the past seven years. The 2018 Massachusetts State Hazard Mitigation and Climate Adaptation Plan, as well as other plans adopted by the Town of Marblehead in the recent past, were reviewed for consistency as well as opportunities for plan integration. The goal of this review was to support updates to this plan that easily align with and possibly incorporate key aspects of relevant plans at the state and local level.

Table 68 provides a summary of the most relevant plans, studies, reports, or sources of other technical information consulted as part of this process and how they were incorporated into this plan update.

Table 68. Relevant Plans, Studies, and Reports for Incorporation.

Plan / Study / Report	Summary Description / Incorporation
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (2019)	The SHMCAP is an innovative, first-of-its-kind statewide plan that fully integrates a traditional hazard mitigation plan with a climate change adaptation plan. The SHMCAP fulfills two important requirements, including (1) updating the 2013 State Hazard Mitigation Plan as required by Federal regulations (44 CFR Part 201.4); and (2) fulfilling requirements for a state climate adaptation plan per Massachusetts Executive Order 569. The SHMCAP has five goals as shown below:

Plan / Study / Report	Summary Description / Incorporation
	• Enhance the Commonwealth's resiliency to natural hazards and climate change by integrating programs and building institutional capacity. • Reduce the impacts of natural hazards and climate change with forward-looking policies, plans, and regulations. • Understand our vulnerabilities and risks and develop immediate and long-term risk reduction strategies for current and future conditions using the best available science. • Increase the resilience of State and local government, people, natural systems, the built environment, and the economy by investing in performance-based solutions. • Support implementation of this plan through increased education, awareness, and incentives for action for state agencies, local governments, private industry, non-profits, and the public. The SHMCAP was incorporated as a key source of information for this plan update. The Town of Marblehead's Hazard Mitigation Plan was also updated to be consistent and aligned with the SHMCAP. For example, the goals and actions identified in Chapter 6 address several of the key themes identified in the SHMCAP, including the integration of hazard mitigation and climate adaptation strategies in local policies, plans, and regulations; improving public education and awareness; building local capacity; and reducing risk to people, property, and infrastructure to natural hazards and climate change. In addition, as seen in Chapter 4, the risk assessment has been updated to be organized using the same hazard classification scheme as used for the SHMCAP.
Town of Marblehead Municipal Vulnerability Preparedness (MVP) / Community Resilience Building (CRB) Summary of Findings Report (2019)	The Commonwealth's Municipal Vulnerability Preparedness (MVP) program provides support for cities and towns in Massachusetts to plan for resiliency and implement key climate change adaptation actions for resiliency. In 2017, Marblehead was awarded an MVP Planning Grant to assess its vulnerability to and prepare for climate change impacts, build community resilience, and receive designation from the Executive Office of Energy and Environmental Affairs (EEA) as an MVP Community. Communities with this designation become eligible for MVP Action Grant funding and other opportunities to support the implementation of priority climate adaptation actions.

Plan / Study / Report	Summary Description / Incorporation
	In completing the MVP planning process, the Town of Marblehead followed the Community Resilience Building (CRB) framework with technical assistance provided by a state-certified MVP Provider, Salem Sound Coastwatch. The CRB methodology is an “anywhere at any scale” format that draws on stakeholders’ wealth of information and experience to foster dialogue about a community’s strengths and vulnerabilities. A day long CRB Workshop was held on May 16, 2018, with the following central objectives: • Define top local natural and climate-related hazards of concern. • Identify existing and future strengthen and vulnerabilities. • Develop prioritized actions for the community. • Identify immediate opportunities to collaboratively advance actions to increase resilience. The resulting Summary of Findings Report and supporting materials served as a primary source of information and community-based inputs for incorporation into the update of this plan. These inputs include the identification of top climate-influenced hazards (coastal flooding from storm surge and sea level rise, inland flooding due to intense precipitation, high winds, and coastal erosion) and vulnerable areas or community assets (infrastructural, societal, and environmental), current community concerns and challenges presented by these hazards, current strengths and assets, and specific, prioritized recommendations to improve resilience in Marblehead.
Marblehead Harbor Municipal Structures Visual Assessment Report (2020)	This report includes an assessment of existing municipal waterfront structures along Marblehead Harbor. A total of 24 individual structures of varying construction at 18 different locations all around the harbor were included in the evaluation. Many of these municipal structures provide critical protection to upland infrastructure and/or enhance the public’s interaction with the shoreline around the harbor. The goal of these updated evaluations was to provide a current assessment of the general condition of the structures and potential changes that could be considered to improve their resiliency to projected climate change impacts. The information provided in this report was reviewed and considered as part of updating the risk assessment and mitigation strategy chapter of this plan. Some of the potential resiliency options discussed in the report were incorporated into the discussion of new mitigation actions as well. These options represented

Plan / Study / Report	Summary Description / Incorporation
	initial considerations for potential interventions to improve the resiliency of each structure that can be considered in future planning efforts, including but not limited to this hazard mitigation plan.
Marblehead Housing Production Plan (2020)	The Town's Housing Production Plan (HPP) identifies Marblehead's unmet housing need and outlines the steps that can be taken to address this need in the next five years. It also helps the Town meet state targets for affordable housing stock, have greater control over comprehensive permits for affordable housing, shape the overall development of housing over time, and improve coordination in working toward these efforts. The HPP includes information on flood hazards and the long-term threat of future flood conditions caused by sea level rise, identified by the Town as key concerns for future housing development. This information, including current problem areas, projected future conditions, local map figures, and how the Town anticipates rising sea levels to impact existing flood hazards was reviewed and incorporated into this plan as part of the risk assessment and mitigation strategy update process. The HPP also represents an excellent example of how the Town of Marblehead continues to integrate hazard mitigation into other local planning mechanisms beyond this plan.
Marblehead Open Space and Recreation Plan (2012)	The Marblehead Open Space and Recreation Plan represents Marblehead's strategy to enhance and expand the existing open and recreational space and programs within the town. The plan identifies additional land that the town could acquire for open space and recreational purposes. Recognizing that Marblehead's centuries of development have left little open land subject to traditional open space planning, the plan looks for ways to increase the recreational and conservation value of existing town lands and for other means of protecting the natural resources of the community. Although somewhat dated, this plan provided helpful information for incorporation into the updated hazard mitigation plan. This includes information on community setting (i.e., landscape, natural features, growth and development patterns, etc.) as well as the town's flood hazard areas, previous flood and storm occurrences, and problems areas that have experienced chronic or repetitive flooding. It also provided relevant information for other hazards covered in the risk assessment, such as shoreline erosion and the nature and presence of invasive species. Such information has been incorporated into this plan update when applicable and confirmed to still be current and accurate enough for such purposes.

Plan / Study / Report	Summary Description / Incorporation
FEMA Flood Insurance Study for Essex County (2023)	Last revised by FEMA on May 26, 2023, this report constitutes the revised preliminary Flood Insurance Study (FIS) report for Essex County. This latest FIS revises and updates information from the currently effective (2018) FIS report on the existence and severity of flood hazards for the study area, which includes the Town of Marblehead. The studies described in this report provide flood hazard data that will, once formally adopted as final/effective, be used to establish actuarial flood insurance rates and to assist communities in efforts to implement sound floodplain management. The FIS and accompanying Flood Insurance Rate Maps (FIRMs) include relevant data and information on flood hazards for Marblehead, including but not limited to descriptions of principal flood problems, flooding sources, FEMA flood zone designations, base flood elevations, and discharge rates of flooding sources. This data and information were reviewed and incorporated into the plan update process by informing the risk assessment, especially as it relates to the hazard profile and GIS-based vulnerability assessment that was prepared for the flood hazard.

In addition to the above plans and reports which were determined to be most relevant for incorporation into the hazard mitigation plan update, the following plans, studies, reports, and other technical documents were reviewed to gain a clearer understanding of local capabilities and their existing or potential effects on hazard risk reduction. More information on some of these documents is provided in Table 69 in the next section.

- ***Harbor Management Plan (MAY 2023)*** – The Harbor Management Plan presents the community's goals, objectives and recommendations for guiding public and private use of the land and water of its harbor areas and establishes an implementation program to achieve the desired outcomes. The plan is designed to be useful to the Town in determining their priorities for the management of the harbor, matching their goals with the vision of the harbor, and for obtaining funding for harbor programs and infrastructure improvements. This most recent draft version of the plan builds off the Municipal Structures Visual Assessment Report described above in Table 68, including updated costs or additional recommendations for the maintenance and investment in the structures and Town-owned properties that protect and support the harbor. (https://www.marblehead.org/sites/g/files/vyhlif4661/f/uploads/20230322_-_draft_harbor_plan_-_public_l-r.pdf)
- ***Stormwater Management Plan (2021)*** – The Town's SWMP is maintained in compliance with MS4 permit requirements as administered by the U.S. Environmental Protection Agency and Massachusetts Department of Environmental Protection (MassDEP). It is focused on reducing pollutants in stormwater runoff versus mitigating flood hazards. The goal of the MS4 Permit is to

improve water quality through more robust stormwater management activities, such as public education, maintaining and repairing drainage infrastructure, and installing Best Management Practices (BMPs).

- ***Flood Insurance Study for Essex County, MA (2018)*** – FEMA's FIS Report provides information and maps for the study region's special flood hazard areas, including detailed flood elevation data in flood profiles and data tables, as well as information on the region's principal flood problems and flood protection measures. The report was reviewed as part of the risk assessment process and the latest flood risk map products were incorporated into the analysis as described in Chapter 4.
- ***Marblehead Community-Wide Historic Preservation Survey Master Plan (2014)*** – The plan lays out a phased and prioritized plan to inventory the entire town for historical resources. It includes information on the town's existing inventory and National Register documentation for historic resources, current threats and priorities, neighborhood overviews and recommendations, and a survey action plan. The plan was prepared to allow the Marblehead Historical Commission to begin expanding its role in preservation planning and managing Marblehead's many historic resources through a more systematic approach.

Lastly, in addition to the above documents, a series of reports, presentations, and videos resulting from the Town's ongoing, multi-phased **Coastal Resilience Projects** were reviewed and incorporated as appropriate into the plan update process. For many years Marblehead has demonstrated a strong commitment to implement proactive strategies to address coastal flooding and sea level rise, and much of its recent work began with the MVP planning process in 2018 as described earlier in this section in Table 68. These efforts led to the development of detailed coastal flood studies and assessments of adaptation options for public infrastructure (funded in 2020 through a CZM Coastal Resiliency Grant award), and then even more detailed analysis and design studies for four town-owned properties. This second phase of the project, funded through another CZM Coastal Resilience Grant in 2022, focuses on the Marblehead Municipal Light Department property and adjoining parcels along Marblehead Harbor. In addition to structural retrofits of the MMLD and improved designs for seawalls, non-structural measures to address coastal flooding and increase community resilience along the harbor and at flood pathways are being explored.

Planning and Regulatory Capabilities

C1. Does the plan document each jurisdiction's existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3))

Table 69 is based off Worksheet 4.1 from FEMA's *Local Mitigation Planning Handbook*.[59] It was used by the HMPC to document and review the current planning and regulatory capabilities of the Town including local plans, policies, codes, and ordinances that are relevant to reducing the potential impacts of hazards.

Table 69. Planning and Regulatory Findings.

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
Plans		
Comprehensive/Master Plan	N/A	The Town hasn't created or updated a comprehensive/master plan in decades as it is no longer determined necessary by Town officials. The community is already at 100% build-out and not seeing or projecting any future redevelopment or applicable land use changes that would be guided through such a plan. Long-term planning and hazard risk reduction are routinely guided through other more-specific community plans (HMP, MVP, Coastal Resilience, etc.) as described in this chapter.
Open Space & Recreation Plan	Conservation Commission	As more fully described above, the Open Space and Recreation Plan represents Marblehead's strategy to enhance and expand the existing open and recreational space and programs within the town. It is considered a highly effective tool in terms of promoting hazard risk reduction through the preservation and management of areas at high risk to natural hazards (flooding, erosion, wind, etc.). The plan could include more detailed mitigation actions as part of its next scheduled update in 2023.
Housing Production Plan	Housing Production Plan (HPP) Implementation Committee	As more fully described above, the Town's Housing Production Plan (HPP) identifies Marblehead's unmet housing need and outlines the steps that can be taken to address this need in the next five years. It clearly identifies existing flood hazards and rising sea levels as a key constraint to future housing development, making this plan an effective tool for hazard risk reduction in terms of long-term planning and implementation of housing strategies.

[59] Local Mitigation Planning Handbook. FEMA. March 2013.

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
Capital Improvements Plan	Town Administrator	The Town's five-year capital improvement plan (CIP) for FY2022-FY2026 addresses significant infrastructure, building and facility needs for this fiscal year and develops strategies to make regular investments in the maintenance and improvement of the Town's capital assets in future years. The CIP includes a multi-year schedule to address capital needs allowing Town departments to assess needs and plan for investments over multiple years. Can be very effective in terms of securing funds in support of hazard risk reduction projects, including but not limited to building retrofits, flood control and stormwater drainage improvements.
Emergency Operations Plan	Emergency Management Agency	Every community in Massachusetts is required to have a Comprehensive Emergency Management Plan (CEMP). These plans address mitigation, preparedness, response, and recovery from a variety of natural and man-made emergencies. The Town has developed a CEMP to properly respond to emergency situations such as recurrent flooding on the causeway.
Harbor Plan	Town Planner	The Harbor Plan is meant as a document which presents the community's goals, objectives and recommendations for guiding public and private use of the land and water of its harbor areas and establishes an implementation program. The plan is currently being updated and will include strategies for increasing the coastal resilience as well as economic development of harbor areas.
Stormwater Management Plan	Department of Public Works	As more fully described above, the Town's Stormwater Management Plan is more focused on reducing pollutants in stormwater runoff versus hazard risk reduction.
Historic Preservation Plan	Historical Commission	As noted above, the plan lays out a phased and prioritized plan to inventory the entire town for historical resources. It is not currently considered an effective tool for hazard risk reduction though future integration opportunities with this hazard mitigation plan may be explored, particularly with regard to

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
		those historical resources identified to be at the greatest risk to damage caused by natural hazards.
Building Code, Permitting, and Inspections		
Building Code	Building Inspection Department	Version/Year: MA State Building Code (780 CMR), Ninth Edition, 2017 The Town enforces the most current version of the Massachusetts State Building Code (MSBC), which includes numerous provisions for reducing risks posed by natural hazards (e.g., flood-resistant construction, seismic design standards, wind and snow load requirements, etc.). This includes a requirement for the design and construction of structures located in flood hazard areas to be in accordance with American Society of Civil Engineers (ASCE) standards, which are consistent with, and in some cases, exceed minimum NFIP requirements. * *More detailed information on the MSBC is provided below this table.*
Building Code Effectiveness Grading Schedule (BCEGS)	Building Inspection Department	BCEGS Commercial Score: Unknown / Not Reported BCEGS Residential Score: Unknown / Not Reported
ISO Fire Protection Rating	Fire Department	Public Protection Classification: 03 *Represents a very strong fire suppression system that includes a FSRS creditable dispatch center, fire department, and water supply.*
Site Plan Review Requirements	Planning Board	Threshold for a site plan review special permit is very low (any new construction or addition over 500 square feet within a shoreline district).
Land Use, Zoning, and Development Regulations		
Zoning Bylaws/Ordinances	Planning Board / Building Inspections Department	Considered very effective in terms of regulating development in ways that support hazard risk reduction, especially through the adopted floodplain, wetland, and stormwater regulations as further described below. Rules and regulations for the conservation/protection of natural resources are also very effective in terms if hazard risk reduction.
Subdivision Regulations	Planning Board	Addressed through Chapter 258 (Subdivision of Land) of the Town Rules and Regulations. No new

Planning/Regulatory Tool	Responsible Authority	General Description and Effectiveness for Hazard Risk Reduction
		subdivisions are expected for the town, but the rules and regulations do help govern new roadways.
Floodplain Regulations	Planning Board / Conservation Commission	Very effective and addressed through Article XII (Floodplain District) of the Town's Zoning Bylaw. The Floodplain District is an overlay district to all other districts. All development in the district, including structural and nonstructural activities, whether permitted by right or by special permit must be in compliance with all state regulations and minimum standards of the NFIP. This includes sections of the State Building Code (780 CMR) which address floodplain and coastal high hazard areas which exceed minimum NFIP standards as described on other areas of this chapter.
Stormwater Management Regulations	Department of Public Works	The Town's bylaw for stormwater management (Chapter 195, Stormwater Management and Erosion Control of its General Bylaws) was first enacted in 2007 and was most recently updated in 2021. The regulations include detailed requirements for the submission of a stormwater management plan for land disturbance of 40,000 square feet or more, in addition to requiring techniques for Low Impact Development (LID) to the maximum extent feasible. They also require that new development sites meet Massachusetts Stormwater Handbook Standards using Best Management Practices for the permanent management and treatment of stormwater. Considered very effective in terms of managing the quantity and quality of stormwater runoff caused by any new site development or redevelopment.
Wetlands Protection	Conservation Commission	Through Chapter 194 (Wetlands Protection) of its General Bylaws, the Town of Marblehead has adopted wetland regulations that provide additional restrictions to those stipulated in the State Wetlands Protection Act. Land within the 100-year floodplain is designated as a resource area. Proposed construction within this area and/or within a 100 foot buffer zone beyond the floodplain requires approval from the local Conservation Commission.

Massachusetts State Building Code

All municipalities in the state must adopt and enforce the current Massachusetts State Building Code (MSBC). The MSBC consists of a series of international model codes and any state-specific amendments adopted by the Board of Building Regulations and Standards (BBRS). The BBRS regularly updates the state building codes as new information and technology becomes available and change is warranted.

The MSBC is separated into two distinct volumes: The Residential volume regulates all one- and two-family structures and townhouses that are three stories or less, as well as their accessory structures. The Base volume regulates all structures that are not covered by the Residential regulations.

The current version of the MSBC is the Ninth Edition, which became effective on October 20, 2017. The Town of Marblehead began enforcing the Ninth Edition for all applicable projects as required by January 1, 2018. The Ninth Edition code is based on modified versions of the following 2015 codes as published by the International Code Council (ICC).*

- The International Building Code (IBC)
- International Residential Code (IRC)
- International Existing Building Code (IEBC)
- International Mechanical Code (IMC)
- International Energy Conservation Code (IECC)
- International Swimming Pool and Spa Code (ISPSC)
- Portions of the International Fire Code (IFC)

** Although the Ninth Edition of the code is still in effect, members of the BBRS have voted that the next edition of the MSBC will be based on modified versions of the 2021 International Codes. The content of these codes is still under review by the BBRS, but it is anticipated that the Tenth Edition of the code will be available for use in 2023.*

The Commonwealth of Massachusetts requires mandatory enforcement of the MSBC and does not allow local amendments to the residential code. In addition, the Commonwealth adopts a plumbing and electrical code. The Commonwealth also has a program in place for code official certification, which includes taking code classes prior to examination and certification, requires continuing education, and allows consumers to file complaints against inspectors. Massachusetts also requires licensing of general, plumbing, electrical, and roofing contractors; requires licensing candidates to pass an examination prior to licensing; and requires continuing education.

Massachusetts continues to perform well in terms of objective assessments of the MSBC. For example, in its most recent “Rating the States” report, the Insurance Institute for Business and Home Safety (IBHS) ranked Massachusetts 9th (scoring 78 out of a possible 100 points on the IBHS scale). Now in its fourth edition, IBHS's 2021 report evaluates the 18 states along the Atlantic and Gulf coasts, all vulnerable to catastrophic hurricanes, based on building code adoption, enforcement, and contractor licensing.

Lastly, as noted in the table above, the MSBC contains a series of requirements for flood-resistant design and construction that are in accordance with the ASCE 24 standard, which incorporates—and in certain areas exceeds—FEMA's NFIP construction standards. Highlights of ASCE 24 that complement the NFIP minimum requirements include requirements for building performance; flood-damage-resistant materials, utilities and service equipment, and siting considerations. Specific requirements for design flood elevations and the use of flood-resistant materials may be found in the ASCE Tables included in 780 CMR Section 1612.4.

Higher regulatory standards that affect development and redevelopment in flood hazard areas include: (1) new or substantially improved buildings in A Zones have to be elevated so that the lowest floor surface is at least 1 foot above the FEMA base flood elevation; and new or substantially improved buildings in V Zones must be elevated so that the lowest floor is at least 2 feet above the FEMA base flood elevation; and (2) for new or substantially improved buildings in V Zones, utilities can no longer be located below the FEMA base flood elevation.

Additional state-specific higher standards for flood-resistant construction in coastal dunes may be found in Appendix G of the MSBC. For example, the State requires the use of pilings in coastal dune areas, even if the areas are not in a mapped Velocity flood zone (V Zone) and has higher elevation requirements than the NFIP (the lowest floor must be built to at least 2 feet above a dune).

Administrative and Technical Capabilities

Table 70 is based off Worksheet 4.1 from FEMA's *Local Mitigation Planning Handbook*. It was used by the HMPC to document and review the current administrative and technical capabilities of the Town. These include staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions.

Table 70. Administrative and Technical Findings.

Administrative/Technical Resource	Full-time (FT) / Part-time (PT) / Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
Administration		
Planning Board	FT / V	The Planning Board is a five member elected board. The Town Planner oversees the Board's administrative process and provides technical assistance to prospective applicants. Very effective in terms of overseeing the regulatory

Administrative/Technical Resource	Full-time (FT) / Part-time (PT) / Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
		review and approval process for different types of development throughout the community. In addition to the site plan approval special permits and subdivision control approvals, the Board issues smart growth special permits, wireless communication special permits and incentive zoning special permits.
Conservation Commission	FT / V	The Town Engineer serves as the Town's Conservation Agent, and there are seven members who are appointed by the Select Board for three-year, staggered terms. Very effective in terms of administering and enforcing floodplain, wetlands, and stormwater regulations within the jurisdictional areas of the Commission. These areas include coastal beaches, coastal banks, salt marshes, ponds, streams, and wetlands such as bogs and swamps.
Hazard Mitigation Planning Committee	FT / V	The HMPC is made up of a combination of Town staff and volunteers as appointed by the Select Board. Very effective in terms of providing input and overseeing the update and implementation of this plan.
Maintenance Programs to Reduce Risk (e.g., tree trimming, drainage clearance)	FT	The Town implements numerous routine maintenance programs to reduce risk, including hazard tree management/trimming and drainage clearance. The Tree Department oversees the planting, care, and maintenance of approximately 9,000 shade trees on 72 miles of public ways as well as additional trees and shrubs in parks and on other public grounds. This includes pruning, removing fallen limbs and trees on public roads, and clearing branches for overhead wires in collaboration with the Marblehead Municipal Light Department (MMLD). MMLD works very closely with the Tree Warden and Town Engineer as it relates to tree pruning/maintenance and post-storm recovery and clean up. DPW's Drain Department oversees best management practices

Administrative/Technical Resource	Full-time (FT) / Part-time (PT) / Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
		of catch basin cleaning that is completed annually. Catch basin reconstruction is also part of the Town's 5-year capital plan. The Town maintains a Memorandum of Understanding (MOU) with a local company for rental equipment to assist with this process. The Water & Sewer Department conducts additional maintenance of the Town's water and wastewater infrastructure as required.
Staff		
Chief Building Official	FT	Building Commissioner, very effective.
Floodplain Administrator	FT	Town Engineer/Conservation Administrator, very effective.
Emergency Manager	FT	Fire Department, very effective. Under the direction of the Select Board, the Emergency Management Director plans, organizes, and directs the emergency management programs for the Town; acts as the community's representative on all emergency management matters; and coordinates activities of the local Office of Emergency Management Agency with other local agencies having emergency management responsibilities.
Community Planner	FT	Town Planner, very effective and acts in a much-needed coordination capacity.
Civil Engineer	FT	Town Engineer and Conservation Administrator, very effective. DPW created the engineering position in addition to head of water and sewer departments.
GIS Coordinator	FT	GIS Field Tech in Water & Sewer Department
Resource Development Staff or Grant Writers	PT	The Town Planner takes the lead on this and performs much of the grant writing and administration for the Town; other departments prepare/administer some grants as needed.
Technical		
Staff with knowledge of land development and land management practices	FT	Town Planner and Town Engineer/Conservation Administrator

Administrative/Technical Resource	Full-time (FT) / Part-time (PT) / Volunteer (V)	General Description and Effectiveness for Hazard Risk Reduction
Staff trained in construction practices related to buildings and/or infrastructure	FT	Building Commissioner; Water and Sewer staff are also trained in operations, maintenance, emergency / Incident Command Training.
Staff with an understanding of natural hazards and risk mitigation	FT	Emergency Management Director, Town Planner, Town Engineer/Conservation Administrator. Water and Sewer staff are also trained in operations, maintenance, emergency / Incident Command Training.
Hazards data and information	Yes	DPW and Water & Sewer Department maintain material data sheets and information.
Warning systems/services (e.g., Reverse 911, outdoor warning signals, etc.)	Yes	Code Red

Financial Capabilities

Table 71 is based off Worksheet 4.1 from FEMA's *Local Mitigation Planning Handbook*. It was used by the HMPC to identify the Town's eligibility and access to funding sources that can be used to support the implementation of hazard mitigation projects.

Table 71. Financial Findings.

Financial Tool/Source	Accessible for Hazard Mitigation (Yes/No)	General Description and Effectiveness for Hazard Risk Reduction
General funds	No	N/A
Capital Improvement Program (CIP) funding	Yes	Has been used in the past to support hazard mitigation measures such as pump station upgrades, stormwater drainage improvements, etc.
Special purpose taxes	No	N/A
Fees for water, sewer, gas, or electric services	Yes	W&S – Construction Articles SESD – Retained Earnings MWRA – Community Assistance Program
Stormwater utility fee	No	N/A
Development impact fees	No	N/A

Financial Tool/Source	Accessible for Hazard Mitigation (Yes/No)	General Description and Effectiveness for Hazard Risk Reduction
Incur debt through general obligation bonds and/or special tax bonds	Yes	The Town has used general obligation bonds for past infrastructure repair and improvement projects, including for hazard mitigation (flood control, stormwater management, etc.). A recent example of this is the Pleasant Street Drainage Project approved at Town Meeting in 2012.
Incur debt through private activities	No	N/A
FEMA Hazard Mitigation Assistance (HMA)	Yes	The Town has applied for HMGP grants in the past with some success. For example, the Pleasant Street Drainage Project was funded through an HMGP grant from MEMA in combination with local funds. FEMA's current HMA grant programs (BRIC, FMA, HMGP) remain a good source of external funding for the implementation of eligible and cost-effective mitigation projects through coordination with MEMA.
HUD Community Development Block Grant (CDBG)	Yes	The Town has utilized HUD CDBG Disaster Recovery Assistance for low-income areas.
Other federal funding programs	Yes	EPA, USACE, NOAA, NRCS, and other federal agencies do make grant funding available for a variety of resilience-themed projects and initiatives that the Town may be eligible to pursue in the future.
State funding programs	Yes	The Commonwealth makes a variety of funding programs available on a routine basis to support local risk reduction projects. Some of the most applicable opportunities for the Town include EEA's MVP Action Grants and CZM's Coastal Resilience Grants which have funded multiple coastal resilience projects for Marblehead as described earlier in this section.

Education and Outreach Capabilities

Table 72 is based off Worksheet 4.1 from FEMA's *Local Mitigation Planning Handbook*. It was used by the HMPC to identify education and outreach programs that can be used to support mitigation activities.

Table 72. Education and Outreach Findings.

Program/Method	Yes/No	Description and Effectiveness for Hazard Risk Reduction
Local citizen groups or non-profit organizations focused on environmental protection, emergency preparedness, access, and functional needs populations, etc.	Yes	Sustainable Marblehead (SM) engages in many activities to protect the Town's beaches and harbor from pollution, plant trees to prevent heat-islands, and promote clean energy to reduce pollution and protect the population from global warming.
Ongoing public education or information program (e.g., responsible water use, fire safety, household preparedness, environmental education)	Yes	The Water and Sewer Commission publishes a quarterly newsletter that is mailed with customers' bills four times each year. 'The Flow N' Go' has current news and information pertaining to Marblehead's water and sewer systems and helpful tips on water conservation, money-saving ideas and protecting your property from water freeze-ups.
Natural disaster or safety-related school programs	No	N/A
StormReady certification	No	N/A
Firewise USA® certification	No	N/A
Public-private partnership initiatives addressing disaster-related issues	No	N/A
Other programs/methods?	Yes	Town website, social media, cable access television, etc.

National Flood Insurance Program (NFIP) Participation and Compliance

C2. Does the Plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))

The National Flood Insurance Program (NFIP) is a program created by the United States Congress in 1968. The NFIP has two purposes: to share the risk of flood losses through flood insurance and to reduce flood damages by restricting floodplain development. The program enables property owners and renters in participating communities to purchase insurance protection, administered by the government, against losses from flooding, and requires flood insurance for all federally backed loans or lines of credit that are secured by existing buildings, manufactured homes, or buildings under construction that are in special flood hazard areas as identified and mapped by FEMA.

Participation in the NFIP is voluntary for communities and is based on an agreement between each participating community and FEMA. The availability of NFIP policy coverage is limited to communities that enter such agreements and adopt adequate land use and regulatory control measures with effective enforcement provisions to reduce flood damages by restricting development in areas exposed to flooding. These measures include the adoption of the latest effective Flood Insurance Rate Maps (FIRMs) prepared by FEMA along with local regulations that meet or exceed minimum federal standards for regulating development in identified special flood hazard areas. There are now more than 20,000 participating communities across the United States and its territories.

In Massachusetts, many of floodplain management regulations required by the NFIP are covered under state laws which are enforced locally. These regulations include the following:

- Massachusetts State Building Code: 780 CMR 3107.0, "Flood Resistant Construction")
- Wetlands Protection Regulations: 310 CMR 10.00
- Inland Wetlands Restriction: 302 CMR 6.00
- Coastal Wetlands Restriction:302 CMR 4.00 (only applies to certain communities)
- Minimum Requirements for Subsurface Disposal of Sanitary Sewage 310 CMR 15, Title 5

The Town of Marblehead has participated in the NFIP since 1985. As summarized in Table 73, the HMPC used Worksheet 4.3 from FEMA's *Local Mitigation Planning Handbook* to collect information regarding the Town's participation in and compliance with the NFIP. This worksheet, in addition to a separate *NFIP Survey* for the Town's designated Community Floodplain Administrator, helped the HMPC to identify areas for improvement and other ideas that could be potential mitigation actions. These actions, including those related to continued compliance with NFIP requirements, are identified and further discussed in Chapter 6 (Mitigation Strategy).

Table 73. NFIP Participation and Compliance Findings.

NFIP Topic	Source of Information	Comments
Insurance Summary		
How many NFIP policies are in the community? What is the total premium and coverage?	FEMA NFIP Services, Flood Insurance Data and Analytics; State NFIP Coordinator	As of August 31, 2022, a total of 261 NFIP policies are in force. The total premium is $401,809 for a total of $84,856,500 in coverage.
How many claims have been paid in the community? What is the total amount of paid claims? How many of the claims were for substantial damage?	FEMA NFIP Services, Flood Insurance Data and Analytics (HUDEX report)	There has been a total of 241 claims paid since 1985, totaling $3,116,686 in losses. There have been nine reported paid claims for substantial damage.
How many structures are exposed to flood risk within the community?	GIS analysis (FEMA FIRMs + building footprint data)	It has been estimated that 386 structures are at risk to the 1-percent annual chance flood, and 392 are at risk to the 0.2 percent annual chance flood for a combined total of 778 structures exposed to flood risk.
Describe any areas of flood risk with limited NFIP policy coverage.	HMPC	No address-specific data has been made available by FEMA, but it is generally assumed that owners of property located in special flood hazard areas are underinsured when it comes to flood insurance coverage (based on only 261 current policies under the NFIP in comparison to nearly 800 structures estimated to be exposed to moderate to high flood risk).
Staff Resources		
Is the Community FPA or NFIP Coordinator certified?	Community FPA	No
Is floodplain management an auxiliary function?	Community FPA	Yes, for the Town Engineer/Conservation Administrator position.
Provide an explanation of NFIP administration services (e.g., permit review, GIS, education or outreach, inspections, engineering capability)	Community FPA	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. The Engineering Department offers FIRMs and other

NFIP Topic	Source of Information	Comments
		relevant information for those considering the purchase of flood insurance.
What are the barriers to running an effective NFIP program in the community, if any?	Community FPA	Armoring coastal slopes is contrary to the policy of the Massachusetts Coastal Zone Management [CZM] Department and the Massachusetts DEP.
Compliance History		
Is the community in good standing with the NFIP?	Community FPA, State NFIP Coordinator, FEMA	Yes
Are there any outstanding compliance issues (i.e., current violations)?	Community FPA	No
When was the most recent Community Assistance Visit (CAV) or Community Assistance Contact (CAC)?	State NFIP Coordinator, FEMA (CIS)	Last CAC was 9/26/1995 Last CAV was 12/6/2017
Is a CAV or CAC scheduled or needed?	Community FPA	No
Regulation		
When did the community enter the NFIP?	FEMA NFIP Community Status Book	7/3/1985 (Regular Entry) 1/16/1974 (Emergency Entry)
Are the FIRMs digital or paper?	Community FPA	Digital (updated as of July 16, 2014)
Do floodplain development regulations meet or exceed FEMA or State minimum requirements? If so, in what ways?	Community FPA	Floodplain regulations are administered through the enforcement of the Town's Zoning Bylaw (Article XII, Floodplain District), which exceed current FEMA/NFIP minimum requirements. These regulations will be routinely updated as necessary to maintain compliance with existing NFIP and State minimum standards for floodplain management. As described earlier in this chapter, higher regulatory standards are met through the Town's enforcement of the Massachusetts State Building Code. The Town of Marblehead's Wetland Protection bylaw (Chapter 194) also contains 25-foot no touch and 50-foot no build

NFIP Topic	Source of Information	Comments
		buffer zones adjacent to the limits of resource areas. Although they don't address freeboard, they limit development in those specific areas.
Provide an explanation of the permitting process.	Community FPA, community records	FEMA flood and velocity zones are identified in 310 CMR 10.00 as resource areas coming under the jurisdiction of the local Conservation Commission. Alterations in those areas require the filing of a Notice of Intent with the local Conservation Commission.
Community Rating System (CRS)		
Does the community participate in CRS?	Community FPA	No, however the Town is interested in exploring the benefits of CRS participation as Risk Rating 2.0 goes into effect and as updates to the CRS program are made by FEMA. This will continue to be considered as part of the mitigation strategy and action development process as part of this and future updates to this plan.
What is the community's CRS Class Ranking?	N/A	N/A
What categories and activities provide CRS points and how can the class be improved?	N/A	N/A
Does the plan include CRS planning requirements	Yes	Yes, many of the planning requirements under CRS Activity 510 are included in the plan but will not be evaluated or scored for credit until if/when the Town decides to apply for CRS participation.

Table 74 provides some additional information in response to the updated requirements included in FEMA's 2022 Local Mitigation Planning Policy Guide:[60]

[60] Local Mitigation Planning Policy Guide. FEMA. April 2022. P. 26.

Table 74. Additional NFIP Participation and Compliance Information.

Required Information	Response
Adoption of NFIP minimum floodplain management criteria via local regulation.	Zoning Bylaws, Article XII (Floodplain District), added 5/7/2012 ATM by Article 33.
Adoption of the latest effective Flood Insurance Rate Map (FIRM), if applicable.	Yes, the Town administers the above local regulation based on the latest effective FIRM (dated 07/16/2014).
Implementation and enforcement of local floodplain management regulations to regulate and permit development in SFHAs.	See explanation of the Town's permitting process provided in Table 73.
Appointment of a designee or agency to implement the addressed commitments and requirements of the NFIP.	The Town Engineer/Conservation Administrator has been designated as the Community's Floodplain Administrator.
Description of how participants implement the substantial improvement/substantial damage provisions of their floodplain management regulations after an event.	The Town implements the SI/SD provisions of its floodplain management regulations as required per the NFIP (CFR Title 44, Parts 59 thru 65) and Massachusetts State Building Code (780 CMR). The Town will also coordinate with State Flood Hazard Management Program staff to assure that proper practices are followed and that a post-disaster plan will be in place to implement all SI/SD provisions.

Conclusions

The Town of Marblehead is a densely populated coastal community with relatively moderate municipal capabilities and resources to support the implementation of hazard mitigation actions. This chapter provides documentation on the existing local authorities, policies, programs, and resources to support hazard mitigation.

The primary hazard mitigation capabilities for the Town of Marblehead are found through the local administration and enforcement of codes and regulations in combination with the maintenance and preservation of protective natural features and coastal infrastructure. The Town employs skilled and committed staff across numerous departments to administer existing local programs, regulations, and other activities, who are supported by an active citizenry and volunteers that serve on numerous local boards and committees. As stated in the previous plan, the Marblehead Select Board, members of local boards and committees, and Town staff all work well together to develop, implement, and update policies and plans to promote the safety of its residents and minimize risk to the community. Specifically, the Emergency Management Director, Town Planner, Town Engineer, Water/Sewer Superintendent, GIS Coordinator, Building Commissioner, and Harbor Master all have roles and responsibilities in implementing/enforcing activities identified in Town plans and other municipal documents. In addition, all participate on the Hazard Mitigation Planning Committee and contribute to grant writing efforts. Coordination across various departments and staff is considered very effective and provides the town with strong capabilities for emergency preparedness and response as well as pre-disaster mitigation activities.

The Town's pre-disaster mitigation, emergency preparedness, and storm recovery capabilities are also greatly enhanced through the operation of its own electric utility, the Marblehead Municipal Light Department (MMLD), which helps tremendously with tree maintenance and power restoration following major storm events. The Town has been successful in funding and implementing past hazard mitigation projects, such as the Pleasant Street Drainage Project, and continues to pursue and successfully capture external sources of funding to support its coastal resilience and harbor management planning efforts. The Town also coordinates with neighboring communities along the North Shore and advocacy organizations (such as Salem Sound Coastwatch) on potential regional climate adaptation and risk reduction initiatives. The Town is also considering joining FEMA's Community Rating System (CRS) in partnership with other nearby jurisdictions.

While the Town of Marblehead has a moderate degree of capabilities and resources to support hazard mitigation activities, it can expand and improve on the capabilities described in this chapter. Some general and specific opportunities to address existing gaps or limitations in local capabilities to reduce risk have been identified for each capability type and are further described below. Each of these opportunities were then considered by the HMPC during the plan update process as potential new mitigation actions to be included in the Mitigation Strategy.

Opportunities to Expand and Improve on Capabilities to Reduce Risk

Planning and Regulatory Capabilities

- Incorporate hazard mitigation, climate adaptation and other resilience building actions into the next update of the Town's Open Space and Recreation Plan. This includes promoting risk reduction as an important co-benefit of open space preservation, natural resource protection, and other community goals as expressed in the OSRP.
- Increase the integration of hazard mitigation and climate resiliency into the Town's existing CIP planning and project lists. Examples include (1) making resilience a key objective for the Town's strategic, operational, and fiscal policies for municipal infrastructure and asset management; and (2) developing methods to help ensure the Town limit expenditures on projects or infrastructure improvements that would encourage development and/or redevelopment in areas vulnerable to natural hazards.
- Consider using the Plan Integration for Resilience Scorecard (PIRS) to better understand and discuss any inconsistencies or gaps across the Town's local planning framework by spatially evaluating the network of local plan documents and existing vulnerabilities. PIRS is a tool

developed to assist local practitioners to assess the degree to which networks of local plans target geographic areas most prone to hazards and evaluate the coordination of local plans.

Administrative and Technical Capabilities

- Provide more training and professional development opportunities for Town staff who are engaged in community resilience planning and the implementation of hazard mitigation and/or climate adaptation projects.
- Develop a central tracking system to facilitate improved coordination between departments on pre-disaster mitigation/resiliency-themed projects or routine maintenance activities, as well as improved information sharing and access for Town department heads and staff.

Financial Capabilities

- Maximize opportunities through the Town's budgeting and CIP process to help fund priority hazard mitigation and climate adaptation projects, especially when a local cost-share increases the Town's chances for a grant award.
- Continue to build and support the capacity of Town staff to identify and pursue funding made available through external funding programs, particularly those routinely made available through recurring state-level grant programs.
- Continue to coordinate with neighboring North Shore communities as it relates to positioning the Town to pursue and capture future grant funding for regional hazard risk reduction projects. This is particularly true for federal mitigation grants available through FEMA's HMA grant programs (BRIC, HMGP, FMA) and state funding available CZM's Coastal Resilience Grants and EEA's MVP Action Grants.
- Provide additional funding to DPW and the MMLD for more extensive tree trimming in the public right-of-way and other public lands as needed.

Education and Outreach Capabilities

- Increase use of the Town's website, social media platforms, and other readily available outreach mechanisms to support low-cost public education initiatives on building community resilience to hazards as well as individual mitigation actions for homeowners, business owners, etc.
- Explore and expand opportunities for public/private partnerships to support public education and community outreach initiatives related to hazard awareness and risk reduction efforts. These should build off any potential approaches the Town may pursue based on its previous stakeholder conversations for "Partners for Adaptation & Resilience" to help move resiliency planning and adaptations forward.
- Identify and seek to address any unmet needs related to targeted outreach and education for the community's more vulnerable populations (i.e., residents with special needs, property owners in high risk hazard areas, those who are homebound, etc.).

- Continue coordinating with MMLD to expand public outreach and education efforts on disaster preparedness and hazard mitigation (newsletters, bill stuffers, etc.).

Possible New Actions Related to NFIP Participation and Compliance

- Apply for participation in FEMA's Community Rating System (CRS).
- Maintain digital FEMA elevation certificates for all construction in the floodplain.
- Adopt the 2020 MA State Model Floodplain Bylaw to assure that the Town's current regulations (Section 5.7 of the Zoning By-laws: Floodplain Overlay District) contain the necessary and proper language for compliance with the NFIP and state requirements.
- Evaluate permit application forms to determine possible modifications focused on flood hazard prevention.
- To assist with implementing substantial damage provisions of the NFIP, develop a local post-disaster substantial damage plan in coordination with the State Flood Hazard Management Program and the Massachusetts Local Guidance for NFIP Substantial Damage Planning.
- Promote the availability of flood insurance to property owners and renters across the community, but especially those with structures located in moderate to high risk flood zones.

Chapter 6. Mitigation Strategy

The hazard mitigation strategy is the culmination of work presented in the planning area profile, risk assessment and capability assessment. It is also the result of multiple meetings and thorough public outreach. The work of the Hazard Mitigation Planning Committee (HMPC) was essential in developing the mitigation goals and actions included in this chapter. As described in Chapter 3 Planning Process, the HMPC worked in a consistent, coordinated manner to identify and prioritize the goals and mitigation actions for this Plan.

Mitigation Goals

C3. Does the Plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))

***GOALS** are broad, long-term policy and vision statements that explain what is to be achieved by implementing the mitigation strategy.*

Mitigation goals represent broad statements that are achieved through the implementation of more specific mitigation actions. These actions include both hazard mitigation policies (such as land use regulations) and hazard mitigation projects (such as structure or infrastructure projects). To develop goals for this Town of Marblehead, MA Hazard Mitigation Plan the HMPC reviewed the 2013 Town of Marblehead Natural Hazards Mitigation Plan, the Municipal Vulnerability Preparedness (MVP) plan goal statements, and the goals of the State's Hazard Mitigation and Climate Adaptation Plan (SHMCAP).

The HMPC developed the goal statements in the figure below to represent their vision and priorities for the Town of Marblehead in terms of hazard mitigation. All the hazards identified in this plan, while not named specifically in the goals, are implied and many are named specifically in the mitigation actions. When achieved by way of implementing the mitigation actions identified in this plan, the Town will mitigate risk posed by all identified hazards.

Save Lives	• Reduce risk to people, property, infrastructure, and natural resources from natural hazards and climate change.
Infrastructure	• Mitigate risk to critical facilities and infrastructure from natural hazards and climate change.
Capacity	• Increase the Town's capacity to mitigate risk through regulations, planning, and regional collaboration.
Education	• Educate all stakeholders about the value of hazard mitigation and how to implement it in their work, businesses, and homes.

Figure 21. Goal Statements.

The 2013 Town of Marblehead Hazard Mitigation Plan included forty-four mitigation actions. For the purposes of this plan, all the actions were reviewed for their status and relevance. The following table shows the previous plan's seventeen actions and the status of each. In addition to their status, if an action was moved forward to this plan the final column indicates the title of the new action.

E2-b. Was the plan revised to reflect changes in priorities and progress in local mitigation efforts? (Requirement §201.6(d)(3))

Table 75. Action Status from the 2013 Plan.

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
1	Volunteer Disaster Assistance Program	Partially Completed / In Progress	This mitigation has changed and now includes the creation of a CERT Team.	YES - updated/revised description provided at right, if applicable	Create a CERT Team.
2	Volunteer Disaster Assistance Officer	Cancelled	This is now going to be the creation of a CERT Team.	NO - explanation provided at left	
3	Continuity of Operations Plan	Completed		NO - explanation provided at left	
4	Public Information, Outreach and Incentive Program	Delayed		YES - updated/revised description provided at right, if applicable	Public Information, Outreach and Incentive Program.
5	GIS Integration Town-wide	Partially Completed / In Progress	The Town plans to purchase a new server that will have a capacity to include additional layers and centralize data.	YES - updated/revised description provided at right, if applicable	GIS Integration Town-wide.

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
6	GIS Software/Program Upgrades	Partially Completed / In Progress	In Process.	YES - updated/revised description provided at right, if applicable	GIS Integration Town-wide.
7	Recovery and Reconstruction Bylaw	Delayed	No progress was made. This never became a top priority for the Town.	YES - updated/revised description provided at right, if applicable	Recovery and Reconstruction Bylaw.
8	Low-Impact Development	Completed	The Town has integrated these into a MS4 update and stormwater bylaw.	NO - explanation provided at left	
9	Debris Management Plan	Completed	The Town has a contract in place for debris management.	NO - explanation provided at left	
10	Develop Shoreline Management Plan	Partially Completed / In Progress	The Town has worked with the CZM's Coastal Resilience Program to have modeling done for 2030, 2050 and 2070 sea level rise projections and explored short and long term measures to mitigate risk.	YES - updated/revised description provided at right, if applicable	Develop a sea level rise impact study.

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
11	Develop Overwash/Sand/Rubble Removal Plan	Completed		NO - explanation provided at left	
12	Enroll in the Community Rating System	Delayed	Progress has yet to be made because of the time it takes to determine eligibility and an application.	YES - updated/revised description provided at right, if applicable	Enroll in the Community Rating System.
13	Open Space Acquisition	Cancelled	The Town has not had any eligible parcels.	NO - explanation provided at left	
14	Non-Residential Structures in the Floodplain	Completed	The Town does this when 50% of the structure is considered a new building and must comply with all codes.	NO - explanation provided at left	
15	Develop Retrofit (Dry/Wet Floodproof, Elevation) Program	Completed + To Be Continued	The Town through a pilot Coastal Resilience Project is demonstrating to residents what can be done to retrofit buildings.	YES - updated/revised description provided at right, if applicable	Transfer the pilot project to private home owners.
16	Building Code Compliance Enforcement	Completed		NO - explanation provided at left	

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
17	Business Continuation	Cancelled	The Police Department has not assumed this responsibility.	NO - explanation provided at left	
18	Historic Structures	Delayed	The Town intends to implement the GIS portion of this project when the GIS system is fully operational.	YES - updated/revised description provided at right, if applicable	GIS Integration Town-wide.
19	School Vulnerability	Completed		NO - explanation provided at left	
20	Ensuring the Safety of Elderly Housing and Public Housing	Completed + To Be Continued	The Town does this on an as needed basis.	YES - updated/revised description provided at right, if applicable	Ensuring the Safety of Elderly Housing and Public Housing.
21	Elderly and Special Needs Residents	Completed		NO - explanation provided at left	
22	Contain Hazardous Materials	Cancelled	The HMPC decided not to include this in the hazard mitigation plan.	NO - explanation provided at left	
23	Preservation of Water Supply Reservoirs and their Watersheds	Cancelled	The HMPC decided not to include this in the hazard mitigation plan.	NO - explanation provided at left	

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
24	Uninterrupted Municipal Water Supply	Completed	The Town has put the following items in place to achieve uninterrupted service, one million gallon storage tank, increased pumping ability with upgraded pumps, and new generators to run pumps at both water booster stations.	NO - explanation provided at left	
25	Uninterrupted Wastewater Collection	Delayed	This action has not been addressed yet due to competing priorities.	YES - updated/revised description provided at right, if applicable	Uninterrupted Wastewater Collection.
26	Install Warning Lights at the Causeway	Delayed	This action has not been addressed yet due to competing priorities.	YES - updated/revised description provided at right, if applicable	Install Warning Lights at the Causeway.
27	Investigate breakwater	Cancelled	This is being promoted and studied in the harbor plan and is more appropriately addressed there.	NO - explanation provided at left	
28	Investigate Shoreline Protection Measures at Devereux Beach	Cancelled	This is being promoted and studied in the harbor plan and is more appropriately addressed there.	NO - explanation provided at left	

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
29	Pleasant Street Area Drainage Improvements	Completed	This project is complete.	NO - explanation provided at left	
30	Localized Flooding of Roadways	Completed	This project is complete.	NO - explanation provided at left	
31	Barnegat Landing	Delayed	The Town is working on a Chapter 91 license investigation.	YES - updated/revised description provided at right, if applicable	Incorporate coastal resiliency best practices.
32	Philip Clark Wharf (State Street South)	Delayed	The Town is working on a Chapter 91 license investigation.	YES - updated/revised description provided at right, if applicable	Incorporate coastal resiliency best practices.
33	Commercial Street landing	Partially Completed / In Progress	This project is part of the Coastal Zone Management project, phases 2 & 3.	YES - updated/revised description provided at right, if applicable	Incorporate coastal resiliency best practices.
34	Cliff Street Boatyard	Partially Completed / In Progress	This project is part of the Coastal Zone Management project, phases 2 & 3.	YES - updated/revised description	Incorporate coastal resiliency best practices.

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
				provided at right, if applicable	
35	Parkers Boatyard	Partially Completed / In Progress	This project is part of the Coastal Zone Management project, phases 2 & 3.	YES - updated/revised description provided at right, if applicable	Incorporate coastal resiliency best practices.
36	Fort Beach	Completed	The guard rail was repealed, and work done on the seawall.	NO - explanation provided at left	
37	Grace Oliver's Beach	Completed	This work was completed.	NO - explanation provided at left	
38	Complete the Community Hurricane Preparedness Course	Partially Completed / In Progress	Several people have taken the course.	YES - updated/revised description provided at right, if applicable	Complete the Community Hurricane Preparedness Course.
39	Maintain Viable Evacuation Routes	Completed	The utility company has contracted with tree company.	NO - explanation provided at left	
40	Publish Evacuation Routes	Partially Completed / In Progress	There is always work to be done here. Phone books are nearly obsolete so seek alternative methods of outreach.	YES - updated/revised description	Develop a public outreach and education campaign.

Action #	Action Title	Current Status	Current Status Description/Explanation	Keep for Updated Plan?	Updated Action Title/Description (if applicable)
				provided at right, if applicable	
41	Coordinate Evacuation Plans with Neighboring Municipalities	Completed		NO - explanation provided at left	
42	Tourist Evacuation and Shelter	Delayed	This action has not been addressed yet due to competing priorities.	YES - updated/revised description provided at right, if applicable	Develop a public outreach and education campaign.
43	Advise Homeowners in Floodplain	Cancelled	Code red has taken over as a better tool. The Town can use code red to identify those properties and send out information to those that are signed up on the alert system.	NO - explanation provided at left	
44	Official Town of Marblehead website	Completed	The Town website has expanded to include FEMA maps and the Hazard Mitigation Plan.	NO - explanation provided at left	

The Municipal Vulnerability Preparedness (MVP) plan, called the Town of Marblehead Community Resilience Building Workshops Summary of Findings was developed in 2018 and includes twenty-five recommendations. The MVP is part of a Massachusetts state-wide initiative through the Executive Office of Energy and Environmental Affairs (EEA) to provide support to cities and towns to plan for resiliency and implement climate change adaptation actions. The recommendations identified in Marblehead's MVP were reviewed and considered when developing mitigation actions for this plan update.

Comprehensive Range of Mitigation Actions

C4. Does the Plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))

A MITIGATION ACTION *is a measure, project, plan or activity proposed to reduce current and future vulnerabilities described in the risk assessment.*

Identifying a range of mitigation actions was a process that included identifying and analyzing a potential list of natural hazards (described in Chapter 4), then a list of problem statements was developed describing the impacts of each hazard and specific areas of high hazard and specific vulnerable assets. Following, the work done in the Risk Assessment, the HMPC considered possible solutions or actions for each problem identified.

These actions included recommendations from the Capability Assessment (described in Chapter 5), and review of potential actions in each of FEMA's mitigation action categories (plans and regulations, structure and infrastructure, natural resources protection, and education and awareness). This process is illustrated in the figure below. The first column Hazards, indicates four areas of climate change interaction which is how the hazards were reviewed in the Risk Assessment (Chapter 4). The second column, Problems, indicates that the hazards caused problems in the categories of risk, geographic area, and vulnerable asset. The third column, Actions, shows the four categories of mitigation action.

Figure 22. Process of Identifying a Range of Mitigation Actions.

The identified problems were detailed in the Risk Assessment (Chapter 4). The HMPC considered a variety of mitigation actions to address each identified problem. These ranged within the four mitigation action categories defined in Figure 23 below.

Local Plans and Regulations

- Government authorities, policies, or codes that shape how land and buildings are developed and maintained.

Structure and Infrastructure

- Projects modifying existing infrastructure to remove it from a hazard area, or building new structures in ways that reduce the impacts of hazards.

Natural Systems Protection

- Actions that reduce damage and losses, and that preserve or restore the functions of natural systems.

Education and Awareness Programs

- Sustained programs to teach the public and decision makers about hazard risks and community mitigation programs.

Figure 23. Four Types of Mitigation Actions.

Examples of actions in each of the above categories are shown in the table below.

Table 76. Examples of Mitigation Actions.

Mitigation Action Category	Examples of Mitigation Actions
Local Plans and Regulations	• Comprehensive plans • Land use ordinances • Subdivision regulations

Mitigation Action Category	Examples of Mitigation Actions
	• Development review • Building codes and enforcement • NFIP Community Rating System • Capital improvement programs • Open space preservation • Stormwater management regulations and master plans
Structure and Infrastructure Projects	• Acquisitions and elevations of structures in flood-prone areas • Utility undergrounding • Structural retrofits • Floodwalls and retaining walls • Detention and retention structures • Culverts
Natural Systems Protection	• Sediment and erosion control • Stream corridor restoration • Forest management • Conservation easements • Wetland restoration and preservation
Education and Awareness Programs	• Radio or television spots • Websites with maps and information • Real estate disclosure • Presentations to school groups or neighborhood organizations • Mailings to residents in hazard-prone areas

Potential mitigation actions for each identified hazard and problem identified in the Risk Assessment are shown Table 77 below. Hazards are listed in order of risk. Some of these mitigation actions are included in the Action Plan; some were not included because of cost-benefit-analysis outcomes or inconsistency with Town priorities.

Table 77. Possible Mitigation Actions.

Hazard	**Possible Mitigation Actions**
Hurricanes/Wind	• Put utility lines underground.

Hazard	Possible Mitigation Actions
	• Add a second utility line entering Town from a different direction. Currently one substation feeds entire Town. • Add Anemometers to know current wind speeds in real time.
Coastal Flood	• Establish a Community Rating System (CRS) users' group to manage a CRS outreach program. • Survey capacity of sea walls. • Develop an outreach and education program for privately owned sea walls which are threatening ground water, sewer, and power. • Add a breakwater at the harbor to prevent flooding. • Develop a Master Plan to protect the Causeway and Ocean Avenue from inundation.
Severe Winter Storms	• Add generators to critical facilities and infrastructure.
Extreme Temperatures	• Educate residents about the location of heating and cooling centers.
Infectious Disease	• Increase internal staff capacity to seek grant funding.
Drought	• Educate residents about water conservancy best practices.
Invasive Species	• Inventory trees and assess for health.
Other Severe Weather Events	• Provide additional funding to the Town's Department of Public Works and Marblehead Municipal Light District for more extensive tree trimming in the public right-of-way.
Coastal Erosion	• Create a Community Emergency Response Team (CERT) Team.
Earthquakes	• Revise the online permitting system to link builders to educational information regarding unreinforced masonry structures.
Wildfires/Brushfires	• Create defensible space around buildings and infrastructure.

Hazard	Possible Mitigation Actions
Landslides	• Identify steep slope areas and prevent building through zoning regulations.
Tornadoes	• Create a feasibility assessment for implementing microgrids for critical facilities and infrastructure.

Mitigation Action Plan

C5. Does the Plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? (Requirement §201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii))

The HMPC then had the job to identify cost-effective mitigation actions; projects to address the identified hazards, areas of risk and vulnerable assets. An online Mitigation Action Tracker was developed for the Town to track the implementation of each mitigation action. The Mitigation Action Tracker was an online spreadsheet with separate cells showing each action's essential details. These column labels listed below are included to facilitate the Town's ability to sort through the actions as well as to apply for grant funding.

- Action Title
- Action Description
- Action Lead
- Supporting Organizations
- Potential Funding Source
- Implementation Schedule
- Estimated Cost
- Hazard(s) Addressed
- Critical Facility Protection
- Type of Mitigation Action
- Priority

The HMPC considered each of the types of mitigation actions for each of the identified problems. Mitigation actions supporting underserved communities and environmental justice communities were specifically considered by the HMPC. They also focused on actions to the built environment both buildings and infrastructure as well as future development or redevelopment. The resulting list of mitigation actions includes at a minimum one action for hazard identified. In several instances multiple actions address an identified hazard and problem. For instance, flooding is addressed through multiple actions as shown in the table below.

The priority order was chosen based on weighing costs versus benefits. It was imperative for the Town to determine if the costs associated with an action were reasonable compared to the corresponding benefits. To do this, the HMPC developed a prioritization table that included eight categories of criteria; these are detailed in the able below. Each category was assigned points with priority criteria given the highest points. The most points an action could earn was 19. The actions were divided into categories of High, Medium, or Low in the following order:

- High = Actions that scored 16-18 points
- Medium = Actions that scored 14-15 points
- Low = Actions that scored 9-13 points

Table 78. Priority Ranking System.

	Criteria Category	Description	Detailed Ranking and Associated Points
1	Hazards Addressed	What level of hazards does the measure provide protection against?	High (Flood, Severe Winter Storms, Hurricanes/Wind) = 3 Medium (Wildfires/Brush Fires, Extreme Temperatures, Thunderstorms, Earthquakes, Drought, Infectious Disease, Invasive Species, Hazardous Materials) = 2 Low (Landslide, Tornadoes) = 1
2	Approximate Cost	How much will the measure cost to implement?	Low (Under $510k) = 3 Medium ($10k - $50k) = 2 High over $50k) = 1
3	Equity Focus	Does the measure provide support to Environmental Justice (EJ) and other Vulnerable Populations?	Direct Support = 3 Indirect Support = 2 No Support = 0

	Criteria Category	Description	Detailed Ranking and Associated Points
4	Protection of Lives	How effective is the measure in protecting lives and mitigating injuries resulting from the targeted hazard(s)?	Direct Support = 3 Moderate Indirect Support = 2 Minor Indirect Support = 1 None = 0
5	Protection of Critical Facilities or Infrastructure	Does the measure provide protection of critical facilities and infrastructure?	Yes = 3 No = 0
6	Natural Resource Protection	Does the measure provide protection of natural resources?	Yes = 2 No = 0
7	Alignment with Objectives	Does the measure align with the HMP objectives?	Yes =2 No =0

All the actions are listed in Table 79 in order of priority with the actions corresponding details. Additional tables are included in Appendix B. The breakdown of priority ranking points for each action is included in Appendix B. Readers of this plan must understand that the mitigation action list is aspirational, it does not mean that the HMPC is confident that all actions may be implemented in the span of five years.

Table 79. Marblehead Hazard Mitigation Actions.

1	**Purchase portable generators.**	
High	**Action Description**	Purchase portable generators for sewer stations and a generator dedicated for the new salt shed and the monopole town communications.
	Lead Position	Fire Chief
	Supporting Agencies	Department of Public Works, Police Department, Fire Department
	Cost	Medium
	Potential Funding Sources	MA Interlocal Insurance Association (MIIA) Grant, Emergency Management Performance Grant

	Hazards	Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe Weather, Earthquake, Tornado
	Implementation Schedule	2024

2	**Ensuring the Safety of Elderly Housing and Public Housing.**	
High	**Action Description**	Natural hazards occurring on a town-wide basis are a threat to all elderly housing and public housing facilities in the Town. The Building Commissioner will provide assistance towards self- assessment of these structures as to their vulnerability to hazards affecting the community. Retrofitting will be recommended and/or conducted as necessary.
	Lead Position	Building Commissioner
	Supporting Agencies	Council on Aging
	Cost	Low
	Potential Funding Sources	Building Commission Budget
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor’easter, Extreme Temperatures, Flood, Other Severe Weather, Earthquake, Wildfire/Brushfire, Tornado
	Implementation Schedule	2024-2026

3	**Incorporate coastal resiliency best practices.**	
High	**Action Description**	Incorporate findings from current Coastal Resiliency process for the area from Parker’s Boatyard to the Cliff Street Boatyard, including the Marblehead Electric Light building.
	Lead Position	Town Planner
	Supporting Agencies	Planning Department, Engineering Department
	Cost	High
	Potential Funding Sources	Coastal Zone Management Coastal Resilience Port Security Grant
	Hazards	Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather, Tornado
	Implementation Schedule	2023-2024

4	Transfer the pilot project to private home owners.	
High	Action Description	Through the pilot Coastal Resilience Project, demonstrate to homeowners retrofitting techniques.
	Lead Position	Town Planner
	Supporting Agencies	Building Commissioner
	Cost	Low
	Potential Funding Sources	Planning Department Budget
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather
	Implementation Schedule	2024-2028

5	Install Warning Lights at the Causeway.	
High	Action Description	Install warning lights and/or signs on the Causeway to alert citizens of an impending storm, the need for evacuation of the Neck, or the closing of the Causeway.
	Lead Position	Fire Chief
	Supporting Agencies	Department of Public Works
	Cost	Low
	Potential Funding Sources	Fire Department Budget
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather, Tornado
	Implementation Schedule	2025-2026

6	Develop a sea level rise impact study.	
High	Action Description	Conduct impact study of sea level rise on entire coastline for 2030, 2050, and 2070.
	Lead Position	Town Planner
	Supporting Agencies	Engineering Department, Department of Public Works
	Cost	High
	Potential Funding Sources	Coastal Zone Management Coastal Resilience, MVP Program

	Hazards	Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather, Coastal Erosion
	Implementation Schedule	2024

7	**Install battery storage.**	
Medium	**Action Description**	Installing a battery electric storage system, that will be discharged specifically to peak shave (reducing our load during the hours that ISO-NE defines as the capacity peak (one annually) or transmission peak (once monthly) that directly translates into lower costs. Installing batteries strategically around town to provide power during outages, or to back up strategically important loads, as sewer pumps, or schools, or traffic lights, would improve the resiliency of our distribution system.
	Lead Position	General Manager of Marblehead Municipal Light Department
	Supporting Agencies	Marblehead Municipal Electric Light Department, and Water and Sewer Commission
	Cost	High
	Potential Funding Sources	Rate payer IRA Funding, MA Department of Environmental Protection, MA Department of Energy Resources.
	Hazards	Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe Weather, Earthquake, Wildfire/Brushfire, Tornado
	Implementation Schedule	2023-2024

8	**Improve infiltration system.**	
Medium	**Action Description**	Infiltration and inflow projects so sewer main lining which alleviates the sewer system by not accepting ground water. Lowering the chance of sanitary sewer overflows and lessening burden on pp station and treatment plant.
	Lead Position	Water and Sewer commission
	Supporting Agencies	South Essex Sewage District
	Cost	High
	Potential Funding Sources	State Revolving Fund Grant Program, CDS Funding
	Hazards	Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Infectious Disease, Flood, Invasive Species, Other Severe Weather, Earthquake

	Implementation Schedule	2023-2024

9	**Develop a wave attenuating strategies study.**	
Medium	**Action Description**	Investigate the feasibility of wave attenuation strategies in the harbor.
	Lead Position	Harbor Master
	Supporting Agencies	Harbor
	Cost	Medium
	Potential Funding Sources	Coastal Zone Management Coastal Resilience, MVP Program
	Hazards	Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather, Coastal Erosion
	Implementation Schedule	2023-2024

10	**Recovery and Reconstruction Bylaw.**	
Medium	**Action Description**	The Town should utilize the opportunity of a disaster to improve its' disaster resilience. Once critical life and safety issues and vital public services have been addressed and re-established, emphasis should be placed on the long-term recovery of the community, balancing the need to rebuild rapidly and return to normal against the objective of building back better and stronger. Collaboration on a Regional Recovery and Reconstruction Bylaw could identify/facilitate resource and cost-sharing opportunities, as well as higher utilization of municipal services to those areas within the region most in need.
	Lead Position	Town Planner
	Supporting Agencies	Fire Department
	Cost	Medium
	Potential Funding Sources	FEMA BRIC
	Hazards	All Hazards
	Implementation Schedule	2025-2026

11	**Develop a Master Plan to protect the Causeway.**

Medium	Action Description	Develop a Master Plan to protect the Causeway/Ocean Avenue from inundation and overtopping.
	Lead Position	Town Engineer
	Supporting Agencies	Engineering Department, Department of Public Works
	Cost	Medium
	Potential Funding Sources	MVP Program, FEMA BRIC
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather, Coastal Erosion
	Implementation Schedule	2024-2025

12	Develop a public outreach and education campaign.	
Medium	Action Description	This campaign will include an updated website and material development educating the public about hazard risk, evacuation routes and shelters. Information distribution specifically to visitor. Information specific for contractors and homeowners on risks of building in hazard- prone areas and inform builders and homeowners of the benefits of building and renovating structures to current standards. The Town will use FEMA’s Home Builder’s Guide to Coastal Construction (Publication #499), FEMA’s Coastal Construction Manual (Publication #55CD Third Edition), No Adverse Impact (NAI) Coastal Land Management Guidelines developed by the Association of State Floodplain Managers, and other FEMA publications, as applicable.
	Lead Position	Town Planner
	Supporting Agencies	Council on Aging, Sustainable Marblehead
	Cost	Low
	Potential Funding Sources	FEMA BRIC
	Hazards	All Hazards
	Implementation Schedule	2024-2028

13	Develop a second feeder line.

Low	Action Description	If we were to design and install a second set of feeder lines that did not include the Lead Mills area, the Town's electric supply resiliency would be improved. There were earlier feeder lines that came into the Town from Swampscott along the Swampscott-line railroad right of way. The National Grid easements are still in place as are the likely National Grid substations we would tie to. A second set of feeder lines could be: (1) limited to emergency use only or (2) a regular-use second set of feeder lines.
	Lead Position	General Manager of Marblehead Municipal Light Department
	Supporting Agencies	Marblehead Municipal Electric Light Department
	Cost	High
	Potential Funding Sources	Rate payer IRA Funding
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe Weather, Wildfire/Brushfire, Tornado
	Implementation Schedule	2024-2024

14	Improve distribution system.	
Low	Action Description	Technically evaluating the options and engaging in discussions with National Grid on distribution system designs, capital and ongoing costs, permitting and timing would definitely improve our electric distribution system resiliency.
	Lead Position	General Manager of Marblehead Municipal Light Department
	Supporting Agencies	Marblehead Municipal Electric Light Department
	Cost	High
	Potential Funding Sources	Rate payer IRA Funding
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe Weather, Wildfire/Brushfire, Tornado
	Implementation Schedule	2025

15	Create a CERT Team.	
Low	Action Description	Create a formal Community Emergency Response Team (CERT). This would give us an additional pool of volunteers who would be trained for disaster preparedness for all types of hazards. A CERT would be a great asset to our community.

	Lead Position	Fire Chief
	Supporting Agencies	Fire Department
	Cost	Low
	Potential Funding Sources	Free training through MEMA
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Infectious Disease, Drought, Flood, Invasive Species, Other Severe Weather, Coastal Erosion, Earthquake, Wildfire/Brushfire, Tornado
	Implementation Schedule	2023-2024

16	**Enroll in the Community Rating System.**	
Low	**Action Description**	Fulfill the requirements of the National Flood Insurance Program (NFIP) to join the CRS. In addition to assisting in developing future mitigation activities, this could allow the Town and residents to qualify for discounts on flood insurance rate premiums.
	Lead Position	Town Engineer
	Supporting Agencies	Town Planner
	Cost	Medium
	Potential Funding Sources	FEMA BRIC
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather
	Implementation Schedule	2024-2027

17	**GIS Integration Town-wide.**	
Low	**Action Description**	Update and integrate GIS capabilities throughout Town departments for use in emergency situations, as well as for daily use by municipal personnel. Accurate GIS data can assist various Town departments with response actions such as street closings, re-routing of traffic, water main breaks, sewer system backups, flooding, etc.
	Lead Position	Water and Sewer Commission
	Supporting Agencies	
	Cost	Medium
	Potential Funding Sources	Water and Sewer Commission Budget

	Hazards	All Hazards
	Implementation Schedule	2024-2026

18	Complete the Community Hurricane Preparedness Course.	
Low	Action Description	Have the Marblehead Emergency Response Team and other associated personnel complete the web-based version of FEMA's Community Hurricane Preparedness Course.
	Lead Position	Fire Chief
	Supporting Agencies	
	Cost	Low
	Potential Funding Sources	Fire Department Budget
	Hazards	Hurricanes/Tropical Storm
	Implementation Schedule	2025-2028

19	Barnegat Landing.	
Low	Action Description	Recommended repairs and improvements include the rehabilitation of the granite curb sea wall and reconstruction and possible widening of the concrete ramp.
	Lead Position	Harbor Master
	Supporting Agencies	Department of Public Works
	Cost	High
	Potential Funding Sources	Permit fees, excise tax on private vessels
	Hazards	Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather, Coastal Erosion
	Implementation Schedule	2024-2025

Table 80 shows the mitigation actions that specifically target vulnerable populations and Table 81 shows the mitigation actions that specifically target buildings and infrastructure. Each table lists the actions in order of priority.

Table 80. Actions that Target Vulnerable Populations.

Action #	Action Title

1	Purchase portable generators.
2	Ensuring the Safety of Elderly Housing and Public Housing.
3	Incorporate coastal resiliency best practices.
6	Develop a sea level rise impact study.
9	Develop a wave attenuating strategies study.
10	Recovery and Reconstruction Bylaw.
12	Develop a public outreach and education campaign.

Table 81. Actions that Target Buildings and Infrastructure.

Action #	Action Title
1	Purchase portable generators.
2	Ensuring the Safety of Elderly Housing and Public Housing.
4	Transfer the pilot project to private home owners.
5	Install Warning Lights at the Causeway.
7	Install battery storage.
8	Improve infiltration system.
13	Develop a second feeder line.
14	Improve distribution system.

Possible Funding Sources

All the mitigation actions included in this plan have identified one or more potential funding sources. The HMWG focused on projects eligible for MVP Grant funding and FEMA BRIC funding. Below is a list of some of the federal and state funding mechanisms that may assist in implementing mitigation actions.

Federal Emergency Management Agency (FEMA) Mitigation Grants

The Federal Emergency Management Agency (FEMA) makes grant funding available for a range of mitigation activities via several Hazard Mitigation Assistance (HMA) programs. These grant programs provide funding for eligible mitigation activities that reduce disaster losses and protect life and property from future disaster damages. They are not intended to fund repair, replacement, or deferred maintenance activities but are rather designed to assist in developing long-term, cost-effective improvements that will reduce risk to natural hazards.

- **Building Resilient Infrastructure and Communities (BRIC)**
  BRIC is a new FEMA hazard mitigation program designed to replace the agency's former HMA Pre-Disaster Mitigation (PDM) grant program, aiming to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. It is a result of recent amendments made to Section 203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) by Section 1234 of the Disaster Recovery Reform Act of 2018 (DRRA). BRIC will support states, local communities, tribes, and territories as they undertake hazard mitigation projects reducing the risks they face from natural hazards. The BRIC program's guiding principles are supporting communities through capability- and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency.
- **Hazard Mitigation Grant Program (HMGP)**
  The HMGP is authorized under Section 404 of the Stafford Act. The HMGP provides grants to states, tribes, and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not lost during the recovery and reconstruction process following a disaster. HMGP is typically available only in the months after a federal disaster declaration, as funding amounts are determined based on a percentage of the funds spent on FEMA's Public and Individual Assistance programs.
- **Flood Mitigation Assistance (FMA) Program**
  The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities. One limitation of the FMA program is that it is generally used to provide mitigation for structures that are insured or located in Special Flood Hazard Areas (SFHAs) as mapped by FEMA. Federal funding for this nationally competitive grant program is generally an annual allocation (subject to Congressional appropriation) and eligibility is linked to a community's good standing in the NFIP.

<u>Municipal Vulnerability Preparedness Action Grants</u>[61]

[61] State of Massachusetts. *MVP Action Grant.* https://www.mass.gov/service-details/mvp-action-grant.

The MVP Action Grant offers financial resources to municipalities seeking to advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, inland and coastal flooding, severe heat, and other climate impacts.

Responses to the RFR may be submitted by municipalities who have received designation from the Executive Office of Energy and Environmental Affairs (EEA) as a Climate Change Municipal Vulnerability Preparedness (MVP) Community, or “MVP Community.” All projects are required to provide monthly updates, project deliverables, a final project report, and a brief project summary communicating lessons learned. The municipality is also required to match 25% of total project cost using cash or in-kind contributions. All proposals must include the following:

- Completed application template
- Project budget and deliverables
- MVP yearly progress report describing any relevant work toward advancing community priorities since earning MVP designation
- Statement of match
- Letters of support from landowner (if applicable), partners, and the public

Project types include:

- ***Detailed Vulnerability and Risk Assessment*** – In-depth vulnerability or risk assessment of a particular sector, location, or other aspect of the municipality.
- ***Public Education and Communication*** – Projects that increase public understanding of climate change impacts within and beyond the community and foster effective partnerships to develop support.
- ***Local Bylaws, Ordinances, Plans, and other Management Measures*** – Projects to develop, amend, and implement local ordinances, bylaws, standards, plans, and other management measures to reduce risk and damages from extreme weather, heat, flooding, and other climate change impacts.
- ***Redesigns and Retrofits*** – Engineering and construction projects to redesign, plan, or retrofit vulnerable community facilities and infrastructure (e.g., wastewater treatment plants, culverts, and critical municipal roadways/evacuation routes) to function over the life of the infrastructure given projected climate change impacts.
- ***Energy Resilience Strategies*** — Projects that incorporate clean energy generation and that are paired with resilience enabling technology to maintain electrical and/or heating and cooling services at critical facilities.
- ***Chemical Safety and Climate Vulnerabilities*** — Projects that seek to engage the business and manufacturing community through assistance or training on identifying vulnerabilities to chemical releases due to severe weather events, reducing use of toxic or hazardous chemicals, outreach to improve operations and maintenance procedures to prevent chemical releases and

accidents, outreach to improve emergency and contingency planning, and/or identifying existing contaminated sites that pose chemical dispersion risks during flood events.

- ***Nature-Based Storm-Damage Protection, Drought Mitigation, Water Quality, and Water Infiltration Techniques*** – Projects that utilize natural resources and pervious surfaces to manage coastal and inland flooding, erosion, and other storm damage, such as stormwater wetlands and bio-retention systems, and other Smart Growth and Low Impact Development techniques.
- ***Nature-Based, Infrastructure and Technology Solutions to Reduce Vulnerability to Extreme Heat and Poor Air Quality*** – Projects that utilize natural resources, vegetation, and increasing pervious surface to reduce ambient temperatures, provide shade, increase evapotranspiration, improve local air quality, and otherwise provide cooling services within the municipality.
- ***Nature-Based Solutions to Reduce Vulnerability to other Climate Change Impacts*** – Nature-based projects that address other impacts of climate change such as extreme weather, damaging wind and power outages, and increased incidence of pests and vector-borne illnesses and other public health issues.
- ***Acquisition of Land to Achieve a Resiliency Objective*** — Land purchases are eligible for grant funding if the parcel has been identified through a climate vulnerability assessment as an appropriate location for a specific eligible adaptation activity to occur, such as accommodating an infrastructure or facility redesign or retrofit project, providing natural flood storage to reduce downstream flooding, or removal of pavement and planting of trees to reduce flooding and heat island effects.
- ***Ecological Restoration and Habitat Management to Increase Resiliency*** — Projects that repair or improve natural systems for community and ecosystem adaptation, such as right-sizing culverts, dam removal, restoration of coastal wetlands, etc.
- ***Subsidized Low Income Housing Resilience Strategies*** — Investments in resiliency measures for affordable housing to protect vulnerable populations that may not have the resources to recover from an extreme climate event.
- ***Mosquito Control Districts*** — Projects to reduce the risk to public health from mosquito-borne illness and to increase mosquito surveillance and control capacity by incentivizing municipalities not in an organized mosquito control project or district to form a new mosquito control district or join an existing mosquito control district. Also funding for municipalities currently in a mosquito control district for new or proactive mosquito control measures.

Chapter 7. Plan Integration and Maintenance

The Hazard Mitigation Planning Committee (HMPC) will implement the mitigation strategy and specific mitigation actions outlined in this plan, and update and maintain the plan according to the guidelines below. The HMPC includes key stakeholders in the Town, who will use the plan's goals, as well as continued analysis of hazard risks and capabilities, to weigh the available resources against the costs and benefits for each mitigation action. The Town understands the value of this plan and its positive mitigation impact and intend to continue updating this plan and implementing the plan's strategies.

Continued Public Participation

D1. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii))

Public participation is an integral component of the mitigation planning process and will continue to be essential as this plan is implemented and updated over time. Based on the high level of interest in the mitigation planning process and in the Municipal Vulnerability Preparedness project, Town residents and stakeholders are interested in mitigation. The HMPC included several education and outreach mitigation actions designed to engage the public. The Town intends to involve the public throughout the five-year implementation of this plan, as well as in the reviewing and updating processes. The Town Planner will take the lead in soliciting participation from the public. This participation will take multiple forms, including all of those outlined in the Chapter 3: Planning Process of this plan. Efforts to involve the public include:

- Advertising on the Town's website and posting news and announcements on the Town's social media pages.
- The Town will record with closed captioning all meetings to air on the public television station.
- Copies of this plan will remain on the Town's website; and a hard copy will be kept in the Selectboard Office and the Planning Office for public review. Updates to the plan will also be posted on the Town's website.
- The Town of Marblehead will continue to work with private industry, regional agencies, and adjacent communities as this plan is implemented.

Method and Schedule for Keeping the Plan Current

D2. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))

The HMPC and the Town of Marblehead recognize the importance of keeping the mitigation plan up to date. Keeping the plan current includes monitoring, evaluating, and updating the plan over a five-year period. The overall responsibility for monitoring the implementation of the plan rests with the HMPC members, led by the Town Planner.

Process to Track Actions

> ***MONITORING** means tracking the implementation of the plan over time.*

Together the Town Planner and the HMPC will maintain the Mitigation Action Tracker (a tool to record the status of each mitigation action). They will send a reminder email with a link to the web-based Mitigation Action Tracker on a semi-annual basis (January and July) to all Department Heads responsible for a mitigation action and to relevant Town committees. They may also distribute the Mitigation Action Progress Worksheet (shown in Appendix C) for Department Heads who prefer a form over a digital spreadsheet.

If the Town experiences a large-scale disaster, the Town Planner will assemble a HMPC meeting to update the list of mitigation actions and review their order based on current priorities.

Process to Evaluate Effectiveness of the Plan

> ***EVALUATING** means assessing the effectiveness of the plan at achieving its stated purpose and goals.*

The HMPC has agreed to meet on a semi-annual basis to review the implementation of the mitigation plan. The first meeting will take place in June; the second, in January.

At the first meeting (June 2023), the HMPC will review the effectiveness of the planning process, public and stakeholder engagement, risk analysis, and the mitigation strategy, including its implementation. It is recommended that the HMPC use the worksheet provided in Appendix C. Beyond considering the planning process, the HMPC will seek to answer the following questions to determine if the plan is effective at mitigating risk to Town residents, the built environment, and the natural environment.

- Can the HMPC identify success stories of losses avoided because of hazard mitigation measures implemented? Can the HMPC identify political, social, and economic successes?
- Have the mitigation actions implemented achieved benefits beyond the cost of mitigation?
- Have the implemented mitigation actions saved lives or protected property?
- Does the list of mitigation actions coincide with the Town’s priorities? Do additional actions need to be added?

Process to Update the Plan

***UPDATING** means reviewing and revising the plan at least once every five years.*

At each semi-annual meeting, the HMPC will review the plan's goal statements and mitigation action status. If necessary, the goal statements and mitigation actions may be revised to reflect current Town priorities. In addition, the HMPC will discuss methods for continuing to integrate the mitigation plan with other plans, processes, and projects in the Town.

They will prepare a one-page brief regarding each semi-annual HMPC meeting to share with the Select Board and to post on the Town website. The HMPC recognizes the value in keeping the public and key stakeholders informed about the implementation and status of the mitigation plan.

HMPC members will continue to participate in regional and state-based meetings to stay current with best risk-mitigation practices. Such meetings may include the Massachusetts Emergency Management Agency (MEMA), the Metropolitan Area Planning Council (MAPC), and the 3D North Shore/Cape Ann Emergency Preparedness Coalition (a Massachusetts Regional Preparedness Coalition). The HMPC will also participate in land use planning and mitigation planning meetings with their neighbors, Salem, Clifton, and Swampscott.

The Town of Marblehead agrees to update and adopt this mitigation plan on a five-year basis. The update will include a comprehensive review and planning process like the one used to develop this mitigation plan update. It will update the mitigation action list, current land use practices, collect and review best available data, review the capability assessment, and engage the public and stakeholders. This process will occur according to FEMA guidelines. The HMPC will seek funding for the development of the plan update **two years** before the plan expires. The plan update process gives the Town the chance to add and/or re-prioritize mitigation actions based on current risk, capabilities, and public/stakeholder suggestions. The Town Planner will serve as the Project Manager for the update process. The figure below illustrates the update timeline.

Year 1	Year 2	Year 3	Year 4	Year 5
• Seek grant funding for mitigation actions • Gather the HMPC in January and June	• Seek grant funding for mitigation actions • Gather the HMPC in January and June	• Seek FEMA BRIC funding for plan update • Seek grant funding for mitigation actions • Gather the HMPC in January and June	• Begin the plan update process • Seek grant funding for mitigation actions • Gather the HMPC in January and June	• Complete the plan update process - adopt the new plan • Seek grant funding for mitigation actions • Gather the HMPC in January and June

Figure 24. Plan Update and Implementation Schedule.

Responsible Parties for Plan Implementation and Maintenance

Marblehead, MA:

Rebecca Curran, Town Planner

Abbot Hall

188 Washington Street

Marblehead, MA 01945

Phone: 781-631-1529

For State resources:

Massachusetts Emergency Management Agency:

Address: 400 Worcester Road, Framingham, MA 01702-5399

Phone: 508-820-2000 (MEMA Headquarters and Communications Center)

or 978-328-1500 (MEMA Region 1 Office)

Website: https://www.mass.gov/orgs/massachusetts-emergency-management-agency

For Federal resources:

Federal Emergency Management Agency:

Address: 220 Binney Street, Cambridge, MA 02142

Phone: 877-336-2734

Email: fema-r1-info@fema.dhs.gov

Website: https://www.fema.gov/region-i-ct-me-ma-nh-ri-vt

System to Integrate this Plan with Existing Planning Mechanisms

D3. Does the Plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate? (Requirement §201.6(c)(4)(ii))

***PLANNING MECHANISMS** refers to the governance structures used to manage local land use development and community decision-making, such as budgets, comprehensive plans, capital improvement plans, economic development strategies, climate action plans or other long-range plans.*

For the Town of Marblehead to succeed in reducing hazard risks over the long term, the information, conclusions, and recommendations of this hazard mitigation plan should be integrated throughout government operations. Many other local plans and processes will present opportunities to address hazard mitigation in a way that can support multiple community objectives, so an important part of maintaining and implementing this hazard mitigation plan will be to identify and capitalize on these opportunities to leverage activities that have co-benefits (including but not limited to risk reduction).

The HMPC will remain tasked with helping to ensure that all new or updated local plan documents are informed by and consistent with the goals and actions of this hazard mitigation plan and will not contribute to increased hazard vulnerability in Marblehead. Specifically, this includes but is not limited to the implementation or future updates to the following local plans as identified and further described in Chapter 5 (Capability Assessment):

- Municipal Vulnerability Preparedness / Community Resilience Building Summary of Findings Report (2019)
- Harbor Management Plan (2023)
- Marblehead Housing Production Plan (2020)
- Marblehead Open Space and Recreation Plan (2012)

Additional opportunities to integrate the requirements of this plan into other local planning mechanisms shall continue to be identified through future meetings of the HMPC and through the five-year review process described in this chapter. Other planning mechanisms include local regulations and existing code enforcement procedures (i.e., zoning bylaws, site plan review, etc.), internal municipal policies, special projects or initiatives, and other routine government or community decision-making activities such as capital improvement planning and the Town's annual budget process. Emphasis for identifying these integration opportunities will be placed on those governance structures used to manage local land use and community development in both the pre-disaster and post-disaster environment. Also, as it relates to implementing specific mitigation actions identified in this plan, it will be the responsibility of each assigned lead department to determine additional measures that can support action completion or

> ***INTEGRATE** means to include hazard mitigation principles, vulnerability information and mitigation actions into other existing community planning to leverage activities that have co-benefits, reduce risk and increase resilience.*

enhancement. This includes integrating mitigation actions from this plan into other local planning documents, processes, or mechanisms as deemed appropriate and most effective.

While it is recognized that there are many possible benefits to integrating components of this plan into other local planning mechanisms, the routine maintenance of this stand-alone plan is considered by the Town to be the most effective and appropriate method to identify, prioritize, and implement local hazard mitigation actions. In moving forward however the Town will consider the incorporation of some other plan documents into the hazard mitigation plan, such as any future iterations of the Town's MVP Plan, Coastal Resilience Plan, or related climate adaptation efforts.

Appendix A. Planning Process Supporting Materials

Hazard Mitigation Planning Committee Meetings

HMPC Meeting Participants

First Name	Last Name	Title	Affiliation	Phone	Email	#1 9/21/2022	#2 10/26/2022	#3 1/12/2023	#4 3/30/2023
John	Albright	Building Commissioner	Town of Marblehead	781-631-2220	albrightj@marblehead.org	☑	☑	☑	☑
Todd	Bloodgood	Facilities Director	Town of Marblehead	781-639-3140	bloodgood.todd@marbleheadschools.org	☐	☑	☐	☐
Charles	Cerrutti	Emergency Management Director	Town of Marblehead	781-631-0421	cerruttic@marblehead.org	☑	☐	☐	☑
Rebecca	Curran	Town Planner	Town of Marblehead	781-631-1529	rebeccac@marblehead.org	☑	☑	☑	☑
Jonathan	Fobert	Tree Warden	Town of Marblehead	781 631-2721	jfobert@marblehead.org				
Jason	Gilliland	Fire CChief/EMD	Town of Marblehead	781-631-0421	gillilandj@marblehead.org	☑	☐	☑	☑
Jimmy	Johnson	DPW Utilities Coordinator	Town of Marblehead	781-631-1750	johnsonj@marblehead.org	☑	☐	☑	☐
Thatcher	Kezer	Town Administrator	Town of Marblehead	781-631-0000	kezert@marblehead.org	☑	☐	☐	
Dennis	King	Police Chief	Town of Marblehead	781-631-1212	kingd@marblehead.org	☐	☐	☐	☐
Joe	Kowalik	Manager, Marblehead Municipal Light Department	Town of Marblehead	781-631-5600	jkowalik@marblehead.org	☐	☑	☑	☐
Amy	McHugh	DPW Director & Water and Sewer Supt	Town of Marblehead	781-631-1750	mchugha@marblehead.org	☐	☑	☐	☑
Andrew	Petty	Director of Public Health	Town of Marblehead	781-631-0212	pettya@marblehead.org	☑	☐	☑	☑
Charlie	Quigley	Town Engineer, Conservation Administrator	Town of Marblehead	781-631-1529	quigleyc@marblehead.org	☐	☑	☑	☑
Mark	Souza	Harbormaster	Town of Marblehead	781-631-2386	souzam@marblehead.org	☑	☑	☐	☐
Bethany	Spangler	Water and Sewer Assistant Superintent	Town of Marblehead	781-631-0102	spanglerb@marblehead.org	☑	☑	☑	☑
Maggie	Wheeler	DPW Engineer	Town of Marblehead	781-631-1750	wheelerm@marblehead.org	☐	☐	☐	☑
Jeffrey	Zukowski	Hazard Mitigation Planner	MA Emergency Management Agency	508-820-1422	jeffrey.zukowski@state.mas.us	☑	☑	☐	☐

Figure 25. HMPC Meeting Participants.

Public Outreach Materials

Disaster Mitigation Public Meeting

November 21, 2022

4:00pm - 5:00pm

Zoom Link on Town Website
https://www.marblehead.org

Share your ideas to make Town more resilient to natural hazards such as floods, drought, high winds, and winter storms.

NOVEMBER 21, 2022

PUBLIC MEETING ON ZOOM

The Town of Marblehead is updating the Town's Hazard Mitigation Plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. The public as well as regional and local stakeholders are invited to learn about the Hazard Mitigation Plan and share their ideas for reducing impacts associated with natural hazards. Approved by FEMA, the plan allows the Town to apply for pre-disaster mitigation grant funding.



FOR MORE INFORMATION CONTACT

Rebecca Curran Cutting
Town Planner

Town of Marblehead

781-631-1529

rebeccac@marblehead.org

PRESS RELEASE
For Immediate Release
March 9, 2023

Contact: Rebecca Curran Cutting
Town Planner
Town of Marblehead
781-631-1529

Town of Marblehead Invites the Public to a Meeting to Learn About the Hazard Mitigation Plan Update

The Town of Hudson is developing a Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change. Citizen participation is essential.

A virtual public meeting will be held on:

- Tuesday, March 21, 2023
- 6:00 pm – 7:00 pm

You can join the meeting on Zoom.

- https://us02web.zoom.us/meeting/register/tZElceGvqzgqEtHadCu17VwwxHI5HWPAa3aL
- Meeting ID: 858 6875 3085
- Passcode: 027292

At the meeting, you will have an opportunity to contribute your ideas for making the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures. This plan is being developed by a Hazard Mitigation Planning Committee comprised of Town leaders and local stakeholders. Jamie Caplan Consulting LLC, a Northampton, MA based firm, is leading this effort on behalf of the Town and the Massachusetts Emergency Management Agency. Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

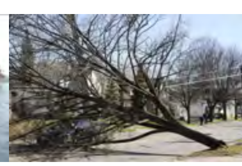
Marblehead developed a Municipal Vulnerability Preparedness (MVP) plan in 2018 that also identified possible actions to mitigate risks to natural hazards and climate change. The Hazard Mitigation Plan will include all of those identified actions still relevant today.

For questions regarding this project, please contact Rebecca Curran Cutting, Town Planner, Town of Marblehead, 781-631-1529, rebeccac@marblehead.org.

MARCH 21, 2023

PUBLIC MEETING ON ZOOM

Marblehead's Hazard Mitigation Planning Committee needs the Public's help completing the Town's Hazard Mitigation Plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. The public is invited to share their ideas for reducing impacts associated with natural hazards and to learn about the updated plan. Approved by FEMA, the plan allows the Town to apply for pre-disaster mitigation grant funding.


Disaster Mitigation Public Meeting

March 21, 2023

6:00pm - 7:00pm

Zoom Link on Town Website
https://www.marblehead.org

Share your ideas to make Town more resilient to natural hazards such as floods, drought, high winds, and winter storms.

FOR MORE INFORMATION CONTACT

Rebecca Curran Cutting
Town Planner

Town of Marblehead

781-631-1529

rebeccac@marblehead.org

PRESS RELEASE
For Immediate Release
March 9, 2023

Contact: Rebecca Curran Cutting
Town Planner
Town of Marblehead
781-631-1529

Town of Marblehead Invites the Public to a Meeting to Learn About the Hazard Mitigation Plan Update

Marblehead's Hazard Mitigation Planning Committee needs the public's help completing the Town's Hazard Mitigation Plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. The public is invited to share their ideas for reducing impacts associated with natural hazards and to learn about the updated plan.

A virtual public meeting will be held on:

- Tuesday, March 21, 2023
- 6:00 pm – 7:00 pm

You can join the meeting on Zoom.

- https://us02web.zoom.us/meeting/register/tZElceGvqzgqEtHadCu17VwwxHI5HWPAa3aL
- Meeting ID: 858 6875 3085
- Passcode: 027292

At the meeting, you will have an opportunity to contribute your ideas for making the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures. This plan is being developed by a Hazard Mitigation Planning Committee comprised of Town leaders and local stakeholders. Jamie Caplan Consulting LLC, a Northampton, MA based firm, is leading this effort on behalf of the Town and the Massachusetts Emergency Management Agency. Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

Marblehead developed a Municipal Vulnerability Preparedness (MVP) plan in 2018 that also identified possible actions to mitigate risks to natural hazards and climate change. The Hazard Mitigation Plan will include all of those identified actions still relevant today.

For questions regarding this project, please contact Rebecca Curran Cutting, Town Planner, Town of Marblehead, 781-631-1529, rebeccac@marblehead.org.

PUBLIC REVIEW NEEDED

Access the plan on the Town's Website:
https://www.marblehead.org/hazard-mitigation-plan-committee
or View a Hard Copy at Town Hall

COMMENT PERIOD

NOVEMBER 15, 2023 – DECEMBER 6, 2023

Marblehead's Hazard Mitigation Planning Committee has updated the Town's Hazard Mitigation Plan. This plan serves as a strategy for reducing current and future risks of natural hazards and climate change. Approved by FEMA, the plan allows the Town to apply for pre-disaster mitigation grant funding.

FOR MORE INFORMATION OR TO SHARE YOUR COMMENTS

Rebecca Curran Cutting, Town Planner
Email: rebeccac@marblehead.org

PRESS RELEASE
For Immediate Release
November 13, 2023

Contact: Rebecca Curran Cutting
Town Planner
Town of Marblehead
781-631-1529

Town of Marblehead Invites the Public to Review the Hazard Mitigation Plan Update

Marblehead's Hazard Mitigation Planning Committee has developed a Hazard Mitigation Plan that identifies and prioritizes actions the Town can take to mitigate the impacts of natural hazards and climate change.

The public is invited to review and comment on the draft plan.

- Read the plan here: https://www.marblehead.org/hazard-mitigation-plan-committee
- View a hard copy: 188 Washington St, Marblehead, MA 01945
- Comment period: November 15, 2023 – December 6, 2023

To provide comments.

- Send an email: rebeccac@marblehead.org

Marblehead's Hazard Mitigation Planning Committee has developed this plan as a strategy for reducing current and future natural hazards risks and impacts from climate change. When implemented, the Hazard Mitigation Plan makes the Town more resilient to natural hazards such as flooding, snowstorms, high winds, and extreme temperatures. Town officials and local stakeholders developed this plan with support from the Massachusetts Emergency Management Agency. Federal Emergency Management Agency (FEMA) approval, and Town adoption, of the Hazard Mitigation Plan Update allows the Town to apply for pre- and post-disaster hazard mitigation grant funds.

For questions regarding this project, please contact Rebecca Curran Cutting, Town Planner, Town of Marblehead, 781-631-1529, rebeccac@marblehead.org.

Appendix B. Mitigation Actions.

Priority Ranking Points

Table 82. Priority Ranking Points.

Action #	Action Title	Hazards Addressed	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total	Priority
1	Purchase portable generators.	3	2	3	3	3	2	2	18	High
2	Ensuring the Safety of Elderly Housing and Public Housing.	3	3	3	3	3	0	2	17	High
3	Incorporate coastal resiliency best practices.	3	1	3	2	3	2	2	16	High
4	Transfer the pilot project to private home owners.	3	3	2	3	3	0	2	16	High

Action #	Action Title	Hazards Addressed	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total	Priority
5	Install Warning Lights at the Causeway.	3	3	2	3	3	0	2	16	High
6	Develop a sea level rise impact study.	3	1	3	2	3	2	2	16	High
7	Install battery storage.	3	1	2	2	3	2	2	15	Medium
8	Improve infiltration system.	3	1	2	2	3	2	2	15	Medium
9	Develop a wave attenuating strategies study.	2	2	3	1	3	2	2	15	Medium
10	Recovery and Reconstruction Bylaw.	3	2	3	2	3	0	2	15	Medium
11	Develop a Master Plan to protect	3	2	0	2	3	2	2	14	Medium

Action #	Action Title	Hazards Addressed	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total	Priority
	the Causeway.									
12	Develop a public outreach and education campaign.	3	3	3	3	0	0	2	14	Medium
13	Develop a second feeder line.	3	1	1	3	3	0	2	13	Low
14	Improve distribution system.	3	1	1	3	3	0	2	13	Low
15	Create a CERT Team.	3	3	2	3	0	0	2	13	Low
16	Enroll in the Community Rating System.	3	2	2	2	0	0	2	11	Low
17	GIS Integration Town-wide.	3	2	2	1	0	0	2	10	Low
18	Complete the Community Hurricane Preparedness Course.	3	3	0	2	0	0	2	10	Low

Action #	Action Title	Hazards Addressed	Approximate Cost	Equity Focus	Protection of Lives	Protection of Critical Facilities or Infrastructure	Protection of Natural Resources	Alignment with Objectives	Total	Priority
19	Barnegat Landing.	3	1	0	1	0	2	2	9	Low

Types of Mitigation Actions

Table 83. Mitigation Actions Sorted by Type.

Mitigation Category	Priority	Action #	Action Title
Education and Awareness Programs	**Medium**	12	Develop a public outreach and education campaign.
	Low	15	Create a CERT Team.
		18	Complete the Community Hurricane Preparedness Course.
Local Plans and Regulations	**High**	6	Develop a sea level rise impact study.
	Medium	9	Develop a wave attenuating strategies study.
		10	Recovery and Reconstruction Bylaw.
		11	Develop a Master Plan to protect the Causeway.
	Low	16	Enroll in the Community Rating System.
		17	GIS Integration Town-wide.
Natural Systems Protection	**High**	3	Incorporate coastal resiliency best practices.
	Low	19	Barnegat Landing.
Structure and Infrastructure	**High**	1	Purchase portable generators.
		2	Ensuring the Safety of Elderly Housing and Public Housing.
		4	Transfer the pilot project to private home owners.
		5	Install Warning Lights at the Causeway.
	Medium	7	Install battery storage.
		8	Improve infiltration system.
	Low	13	Develop a second feeder line.
		14	Improve distribution system.

Actions Sorted by Goal Statement

Table 84. Mitigation Actions Sorted by Goal Statement.

Mitigation Goal	Priority	Action Title
Infrastructure	**High**	Purchase portable generators.
		Transfer the pilot project to private home owners.
		Install Warning Lights at the Causeway.
	Medium	Improve infiltration system.
		Install battery storage.
	Low	Barnegat Landing.
Save Lives	**High**	Incorporate coastal resiliency best practices.
		Ensuring the Safety of Elderly Housing and Public Housing.
	Medium	Develop a Master Plan to protect the Causeway.
	Low	Enroll in the Community Rating System.
Capacity	**High**	Develop a sea level rise impact study.
	Medium	Develop a wave attenuating strategies study.
		Recovery and Reconstruction Bylaw.
	Low	Develop a second feeder line.
		Improve distribution system.
		GIS Integration Town-wide.
Education	**Medium**	Develop a public outreach and education campaign.
	Low	Create a CERT Team.
		Complete the Community Hurricane Preparedness Course.

Actions Sorted by Hazard

Table 85. Mitigation Actions Sorted by Hazard.

Specific Hazards Addressed	Priority	Action #	Action Title
All Hazards	Medium	10	Recovery and Reconstruction Bylaw.
		12	Develop a public outreach and education campaign.
	Low	17	GIS Integration Town-wide.
Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather, Tornado	High	3	Incorporate coastal resiliency best practices.
Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather, Coastal Erosion	High	6	Develop a sea level rise impact study.
Hurricanes/Tropical Storms, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe Weather, Earthquake, Wildfire/Brushfire, Tornado	Medium	7	Install battery storage.
Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather, Coastal Erosion	Medium	9	Develop a wave attenuating strategies study.
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather, Coastal Erosion	Medium	11	Develop a Master Plan to protect the Causeway.
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe Weather, Wildfire/Brushfire, Tornado	Low	13	Develop a second feeder line.
		14	Improve distribution system.
Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe Weather, Earthquake, Tornado	High	1	Purchase portable generators.
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Flood, Other Severe	High	2	Ensuring the Safety of Elderly Housing and Public Housing.

Specific Hazards Addressed	Priority	Action #	Action Title
Weather, Earthquake, Wildfire/Brushfire, Tornado			
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather	High	4	Transfer the pilot project to private home owners.
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather, Tornado	High	5	Install Warning Lights at the Causeway.
Hurricanes/Tropical Storms, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Infectious Disease, Flood, Invasive Species, Other Severe Weather, Earthquake	Medium	8	Improve infiltration system.
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Extreme Temperatures, Infectious Disease, Drought, Flood, Invasive Species, Other Severe Weather, Coastal Erosion, Earthquake, Wildfire/Brushfire, Tornado	Low	15	Create a CERT Team.
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Flood, Other Severe Weather	Low	16	Enroll in the Community Rating System.
Hurricanes/Tropical Storm	Low	18	Complete the Community Hurricane Preparedness Course.
Hurricanes/Tropical Storm, Coastal Flood, Severe Winter Storm/Nor'easter, Other Severe Weather, Coastal Erosion	Low	19	Barnegat Landing.

Actions Sorted by Lead Position

Table 86. Mitigation Actions Sorted by Action Lead.

Action Lead	Priority	Action #	Action Title
Fire Chief	**High**	1	Purchase portable generators.
		5	Install Warning Lights at the Causeway.
	Low	15	Create a CERT Team.
		18	Complete the Community Hurricane Preparedness Course.
General Manager of Marblehead Municipal Light Department	**Medium**	7	Install battery storage.
	Low	13	Develop a second feeder line.
		14	Improve distribution system.
Harbor Master	**Medium**	9	Develop a wave attenuating strategies study.
	Low	19	Barnegat Landing.
Town Engineer	**Medium**	11	Develop a Master Plan to protect the Causeway.
	Low	16	Enroll in the Community Rating System.
Town Planner	**High**	3	Incorporate coastal resiliency best practices.
		4	Transfer the pilot project to private home owners.
		6	Develop a sea level rise impact study.
	Medium	10	Recovery and Reconstruction Bylaw.
		12	Develop a public outreach and education campaign.
Water and Sewer Commission	**Medium**	8	Improve infiltration system.
	Low	17	GIS Integration Town-wide.
Building Commissioner	**High**	2	Ensuring the Safety of Elderly Housing and Public Housing.

Actions Sorted by Implementation Schedule

Table 87. Mitigation Actions Sorted by Implementation Schedule.

Implementation Schedule	Action #	Action Title	Action Lead
2024	**1**	Purchase portable generators.	Fire Chief
	6	Develop a sea level rise impact study.	Town Planner
2025	**14**	Improve distribution system.	General Manager of Marblehead Municipal Light Department
2023-2024	**3**	Incorporate coastal resiliency best practices.	Town Planner
	7	Install battery storage.	General Manager of Marblehead Municipal Light Department
	8	Improve infiltration system.	Water and Sewer commission
	9	Develop a wave attenuating strategies study.	Harbor Master
	15	Create a CERT Team.	Fire Chief
2024-2026	**2**	Ensuring the Safety of Elderly Housing and Public Housing.	Building Commissioner
	13	Develop a second feeder line.	General Manager of Marblehead Municipal Light Department
	17	GIS Integration Town-wide.	Water and Sewer commission
2024-2028	**4**	Transfer the pilot project to private home owners.	Town Planner
	12	Develop a public outreach and education campaign.	Town Planner
2025-2026	**5**	Install Warning Lights at the Causeway.	Fire Chief

Implementation Schedule	Action #	Action Title	Action Lead
	10	Recovery and Reconstruction Bylaw.	Town Planner
2024-2025	**11**	Develop a Master Plan to protect the Causeway.	Town Engineer
	19	Barnegat Landing.	Harbor Master
2024-2027	**16**	Enroll in the Community Rating System.	Town Engineer
2025-2028	**18**	Complete the Community Hurricane Preparedness Course.	Fire Chief

Appendix C. Plan Implementation and Review Supporting Materials.

Plan Update Evaluation Worksheet

Plan Section	Considerations	Explanation
Planning Process	Should the town invite any additional stakeholders to participate in the planning process? What public outreach activities have occurred? How can public involvement be improved?	
Risk Assessment	What disasters has the town, or the region experienced? Should the list of hazards be modified? Are new data sources, maps or studies available? If so, what have they revealed, and should the information be incorporated into the plan update? Has development in the region occurred and could it create or reduce risk?	
Capability Assessment	Has the town adopted new policies, plans, regulations, or reports that could be incorporated into this plan? Are there different or additional administrative, human, technical, and financial resources available for mitigation planning? Are there different or new education and outreach programs and resources available for mitigation activities?	
Mitigation Strategy	Is the mitigation strategy being implemented as anticipated? Were the cost and timeline estimate accurate? Should new mitigation actions be added to the Action Plan? Should existing mitigation actions be revised or removed from the plan? Are there new obstacles that were not anticipated in the plan that will need to be considered in the next plan update? Are there new funding sources to consider? Have elements of the plan been incorporated into other planning mechanisms?	
Implementation Plan	Was the plan monitored and evaluated as anticipated? What are needed improvements to the plan implementation procedures?	

Mitigation Action Progress Worksheet

<table>
<tr><th colspan="5">Mitigation Action Progress Worksheet</th></tr>
<tr><td>Progress Report Period</td><td colspan="2">From Date</td><td colspan="2">To Date</td></tr>
<tr><td>Action/Project Title</td><td colspan="4"></td></tr>
<tr><td>Responsible Department</td><td colspan="4"></td></tr>
<tr><td>Contact Name</td><td colspan="4"></td></tr>
<tr><td>Contact Phone/Email</td><td colspan="4"></td></tr>
<tr><td>Project Description</td><td colspan="4"></td></tr>
<tr><td>Project Goal</td><td colspan="4"></td></tr>
<tr><td>Project Objective</td><td colspan="4"></td></tr>
<tr><td>Project Cost</td><td colspan="4"></td></tr>
<tr><td colspan="5">Project Status</td></tr>
<tr><td>Date of Project Approval</td><td>Date of Project Start</td><td>Anticipated Date of Completion</td><td>Project Canceled</td><td>Project Delayed</td></tr>
<tr><td colspan="5">Explanation of Delay or Cost Overruns</td></tr>
<tr><td colspan="5">Project Report Summary</td></tr>
<tr><td colspan="5">What was accomplished for this project during this reporting period?</td></tr>
<tr><td colspan="5">What obstacles, problems, or delays did the project encounter?</td></tr>
<tr><td colspan="5">Plans for next reporting period.</td></tr>
</table>

Appendix D. Hazus Reports

Hazus: Flood Global Risk Report

Region Name: MarbleheadFL

Flood Scenario: 100year

Print Date: Wednesday, November 23, 2022

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is approximately 4 square miles and contains 441 census blocks. The region contains over 8 thousand households and has a total population of 19,808 people (2010 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 8,149 buildings in the region with a total building replacement value (excluding contents) of 3,549 million dollars. Approximately 89.74% of the buildings (and 82.73% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 8,149 buildings in the region which have an aggregate total replacement value of 3,549 million dollars. Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	2,936,187	82.7%
Commercial	443,448	12.5%
Industrial	85,318	2.4%
Agricultural	8,975	0.3%
Religion	31,828	0.9%
Government	10,244	0.3%
Education	33,088	0.9%
Total	**3,549,088**	**100%**

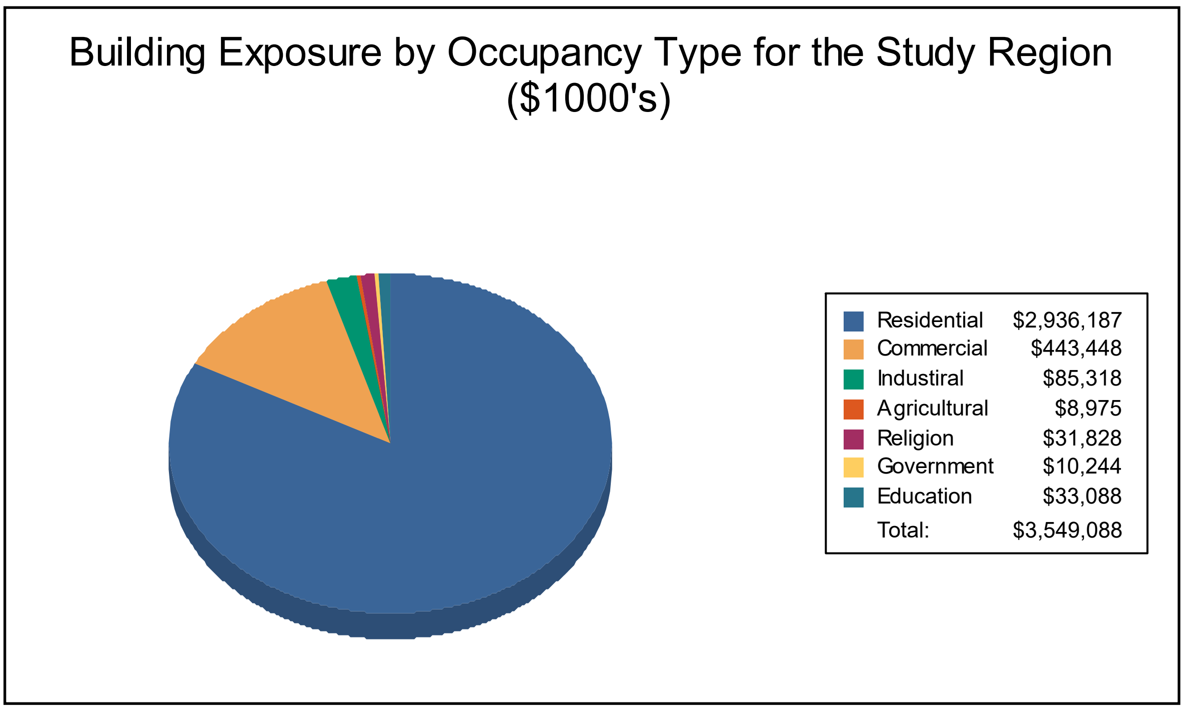
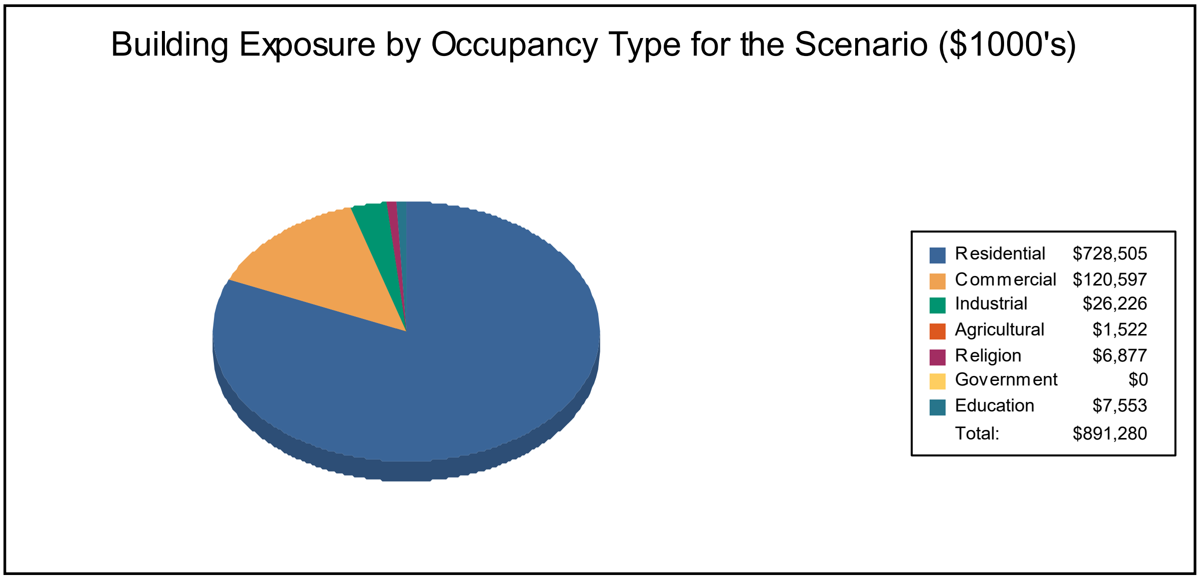


Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	728,505	81.7%
Commercial	120,597	13.5%
Industrial	26,226	2.9%
Agricultural	1,522	0.2%
Religion	6,877	0.8%
Government	0	0.0%
Education	7,553	0.8%
Total	**891,280**	**100%**



Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 12 schools, 2 fire stations, 1 police station and 2 emergency operation centers.

Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	MarbleheadFL
Scenario Name:	100year
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Study Region Overview Map

Illustrating scenario flood extent, as well as exposed essential facilities and total exposure

Building Damage

General Building Stock Damage

Hazus estimates that about 54 buildings will be at least moderately damaged. This is over 36% of the total number of buildings in the scenario. There are an estimated 8 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Flood Technical Manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Total Economic Loss (1 dot = $300K) Overview Map

Table 3: Expected Building Damage by Occupancy

Occupancy	1-10 Count	1-10 (%)	11-20 Count	11-20 (%)	21-30 Count	21-30 (%)	31-40 Count	31-40 (%)	41-50 Count	41-50 (%)	>50 Count	>50 (%)
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	0	0	2	100	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0
Government	0	0	0	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Religion	0	0	0	0	0	0	0	0	0	0	0	0
Residential	4	7	18	32	15	27	10	18	1	2	8	14
Total	**4**		**20**		**15**		**10**		**1**		**8**	

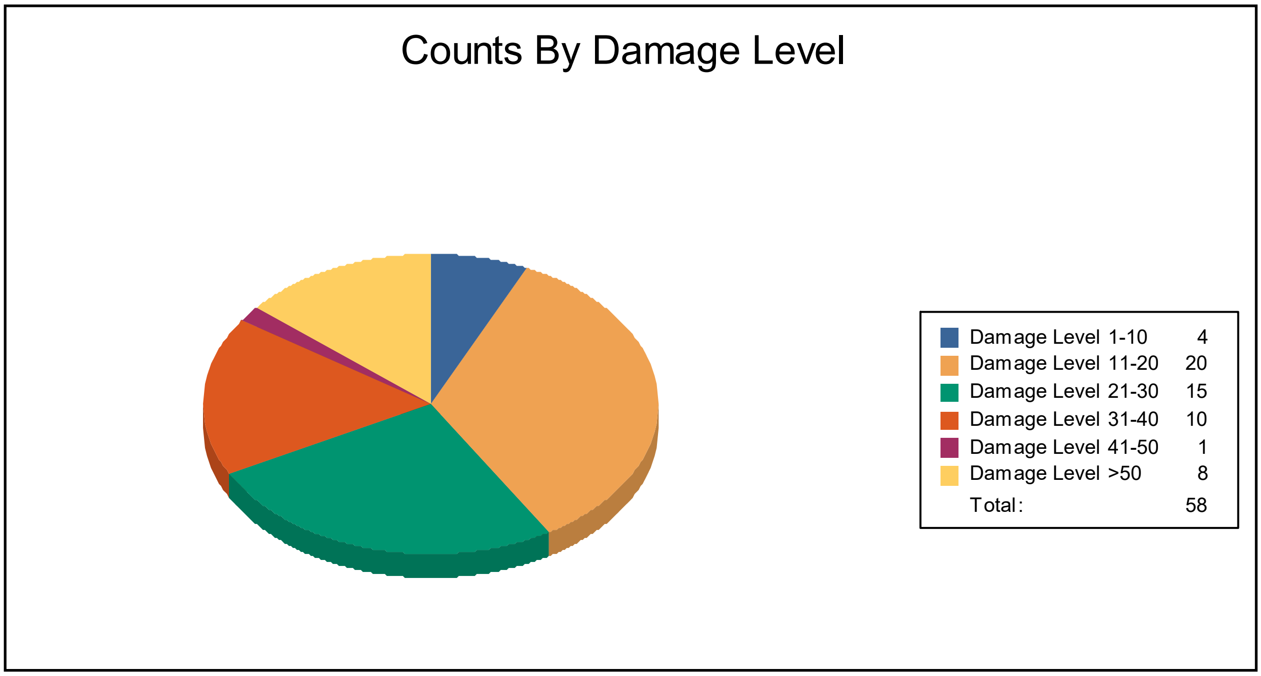


Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		>50	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	0	0	0	0	0	0	0	0	0	0	0	0
ManufHousing	0	0	0	0	0	0	0	0	0	0	0	0
Masonry	0	0	0	0	0	0	0	0	0	0	0	0
Steel	0	0	1	100	0	0	0	0	0	0	0	0
Wood	4	7	18	32	15	27	10	18	1	2	8	14

Essential Facility Damage

Before the flood analyzed in this scenario, the region had 0 hospital beds available for use. On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Emergency Operation Centers	2	0	0	0
Fire Stations	2	0	0	0
Hospitals	0	0	0	0
Police Stations	1	0	0	0
Schools	12	0	0	0

If this report displays all zeros or is blank, two possibilities can explain this.

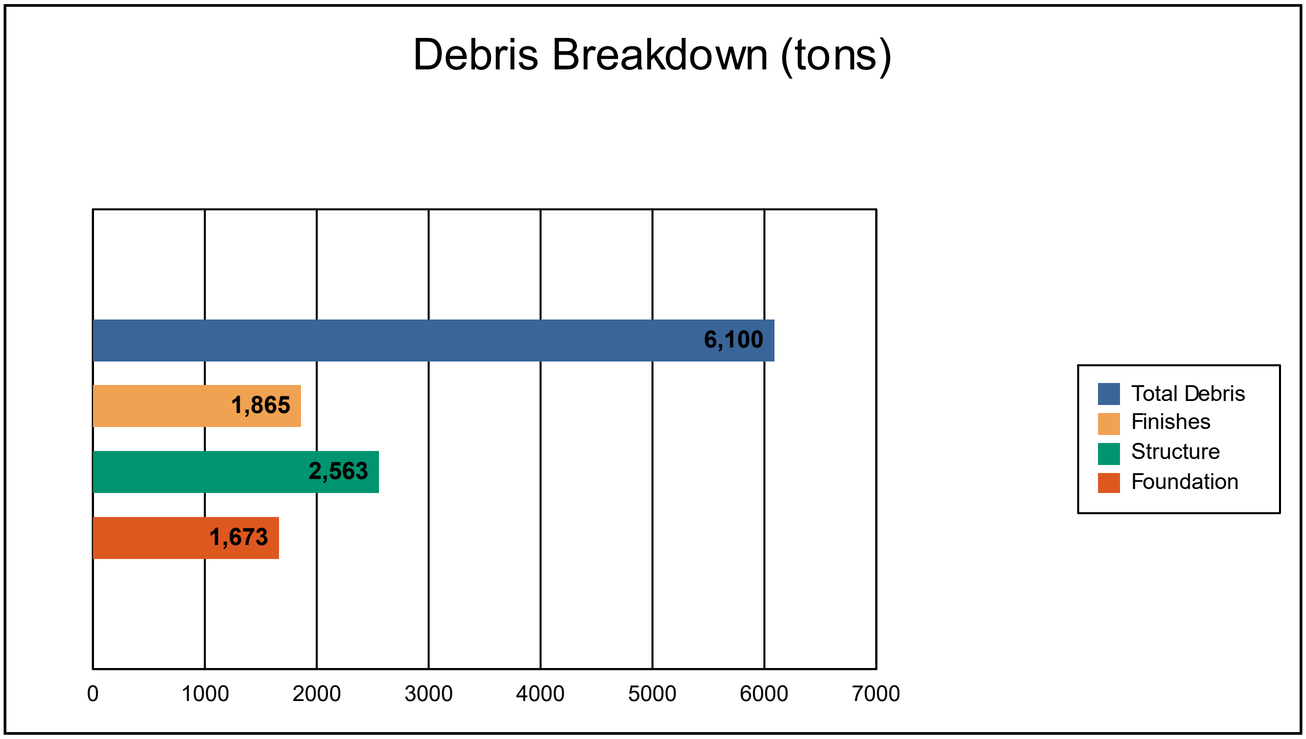
(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

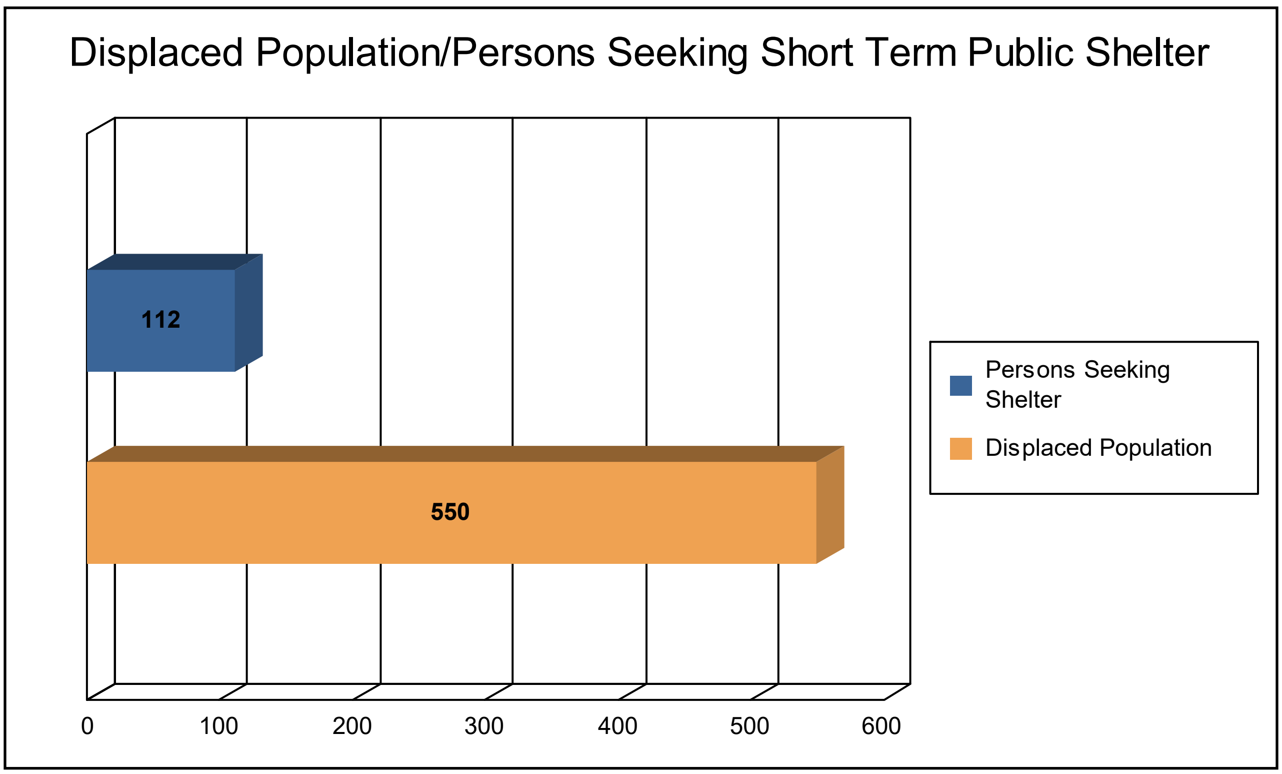


The model estimates that a total of 6,100 tons of debris will be generated. Of the total amount, Finishes comprises 31% of the total, Structure comprises 42% of the total, and Foundation comprises 27%. If the debris tonnage is converted into an estimated number of truckloads, it will require 245 truckloads (@25 tons/truck) to remove the debris generated by the flood.

Social Impact

Shelter Requirements

Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 183 households (or 550 of people) will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 112 people (out of a total population of 19,808) will seek temporary shelter in public shelters.



Economic Loss

The total economic loss estimated for the flood is 88.79 million dollars, which represents 9.96 % of the total replacement value of the scenario buildings.

Building-Related Losses

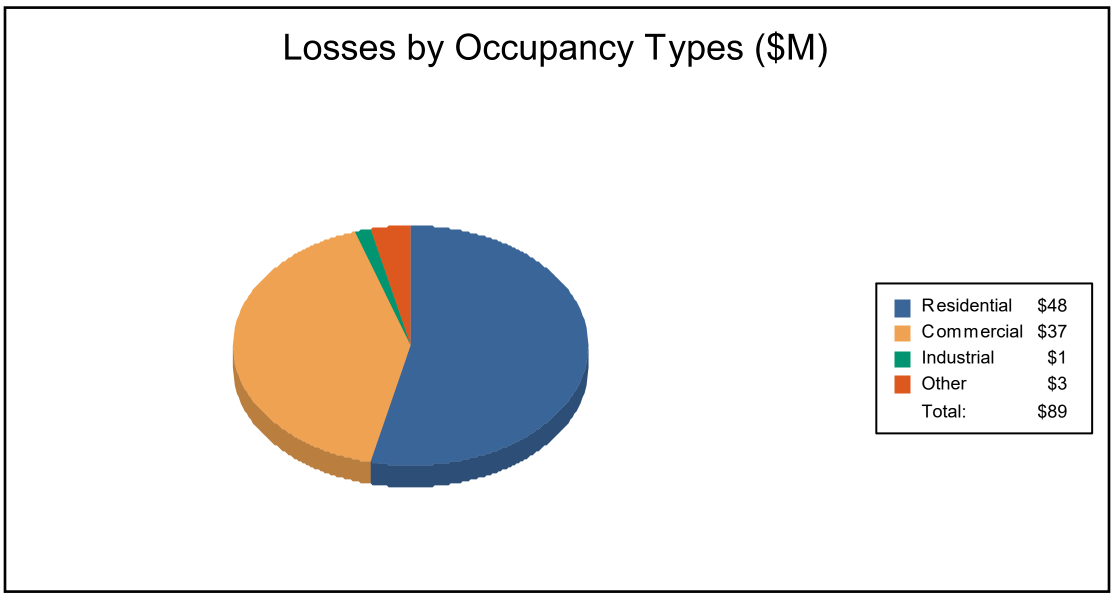
The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 59.08 million dollars. 33% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 53.68% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	23.03	4.08	0.40	0.28	27.79
	Content	19.05	10.08	0.73	1.29	31.15
	Inventory	0.00	0.05	0.09	0.00	0.14
	Subtotal	**42.08**	**14.21**	**1.22**	**1.58**	**59.08**
Business Interruption						
	Income	0.08	10.86	0.02	0.45	11.41
	Relocation	3.86	1.68	0.02	0.15	5.71
	Rental Income	1.44	1.31	0.00	0.01	2.76
	Wage	0.20	8.53	0.03	1.06	9.82
	Subtotal	**5.58**	**22.38**	**0.08**	**1.66**	**29.71**
ALL	**Total**	**47.66**	**36.59**	**1.29**	**3.24**	**88.79**



Appendix A: County Listing for the Region

Massachusetts

- Essex

Appendix B: Regional Population and Building Value Data

	Population	Building Value (thousands of dollars)		
		Residential	Non-Residential	Total
Massachusetts				
Essex	19,808	2,936,187	612,901	3,549,088
Total	**19,808**	**2,936,187**	**612,901**	**3,549,088**
Total Study Region	**19,808**	**2,936,187**	**612,901**	**3,549,088**

Hazus: Hurricane Global Risk Report

Region Name:	Marblehead_HU
Hurricane Scenario:	Probabilistic 500-year Return Period
Print Date:	Friday, October 21, 2022

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Hurricane. These results can be improved by using enhanced inventory data.

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General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 4.44 square miles and contains 4 census tracts. There are over 8 thousand households in the region and a total population of 19,808 people (2010 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 8 thousand buildings in the region with a total building replacement value (excluding contents) of 3,549 million dollars (2014 dollars). Approximately 90% of the buildings (and 83% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 8,149 buildings in the region which have an aggregate total replacement value of 3,549 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

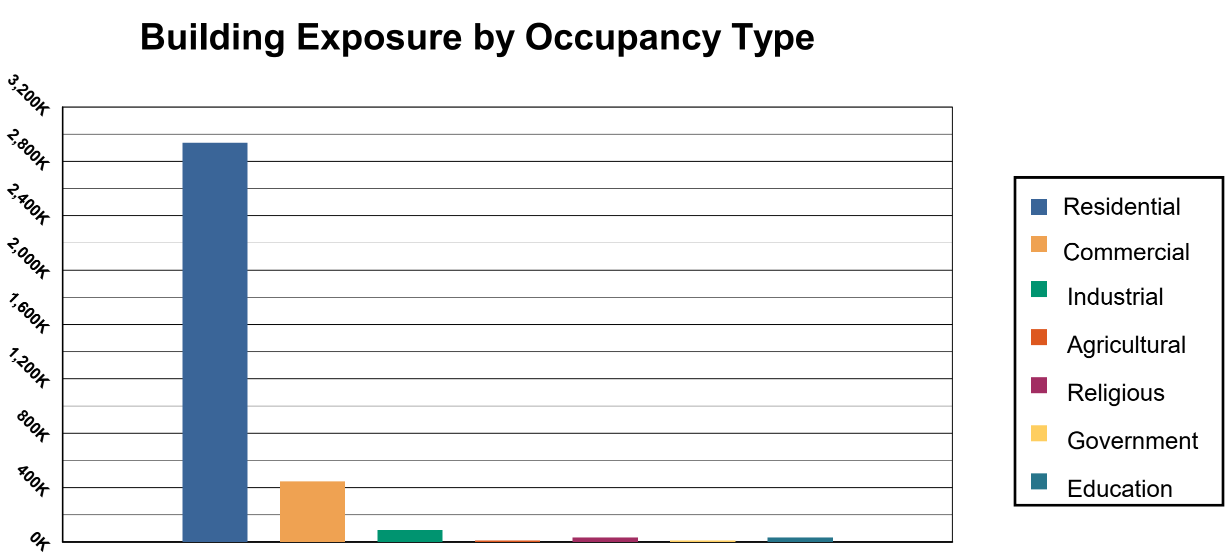


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	2,936,187	82.73%
Commercial	443,448	12.49%
Industrial	85,318	2.40%
Agricultural	8,975	0.25%
Religious	31,828	0.90%
Government	10,244	0.29%
Education	33,088	0.93%
Total	**3,549,088**	**100.00%**

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 12 schools, 2 fire stations, 1 police stations and 2 emergency operation facilities.

Hurricane Scenario

Hazus used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Scenario Name:	Probabilistic
Type:	Probabilistic

Building Damage

General Building Stock Damage

Hazus estimates that about 513 buildings will be at least moderately damaged. This is over 6% of the total number of buildings in the region. There are an estimated 24 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

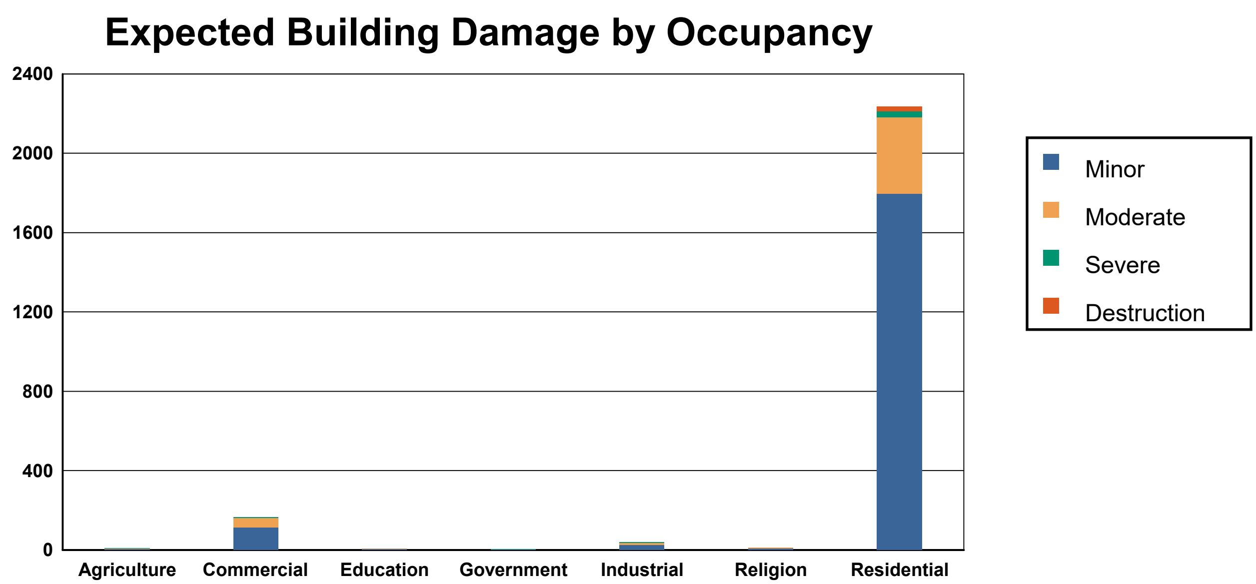


Table 2: Expected Building Damage by Occupancy : 500 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	17.66	67.93	5.43	20.88	1.88	7.24	0.90	3.47	0.12	0.47
Commercial	425.43	71.98	114.31	19.34	45.57	7.71	5.66	0.96	0.03	0.00
Education	19.70	72.96	5.11	18.94	1.99	7.37	0.20	0.72	0.00	0.00
Government	9.50	73.08	2.40	18.50	0.99	7.64	0.10	0.78	0.00	0.00
Industrial	99.76	71.26	25.12	17.95	11.86	8.47	3.00	2.14	0.26	0.19
Religion	28.32	72.61	8.00	20.52	2.45	6.28	0.23	0.58	0.00	0.00
Residential	5,077.20	69.43	1,797.59	24.58	383.58	5.25	30.69	0.42	23.94	0.33
Total	**5,677.57**		**1,957.98**		**448.33**		**40.77**		**24.36**	

Table 3: Expected Building Damage by Building Type : 500 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	70	70.51	19	19.30	9	9.45	1	0.73	0	0.00
Masonry	465	67.58	139	20.18	76	11.01	8	1.09	1	0.15
MH	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	275	72.52	66	17.52	33	8.60	5	1.36	0	0.01
Wood	4,885	69.97	1,741	24.94	305	4.37	27	0.39	23	0.33

Essential Facility Damage

Before the hurricane, the region had no hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (0%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, none of the beds will be in service. By 30 days, none will be operational.

Thematic Map of Essential Facilities with greater than 50% moderate

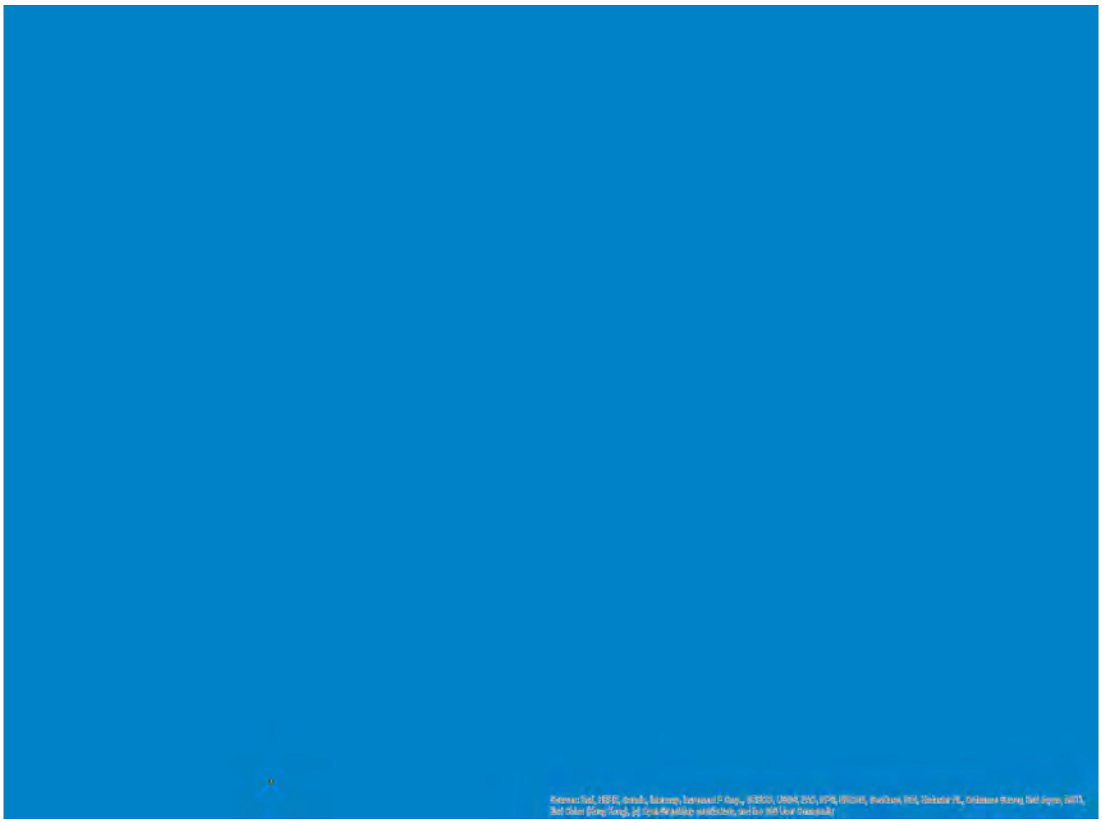
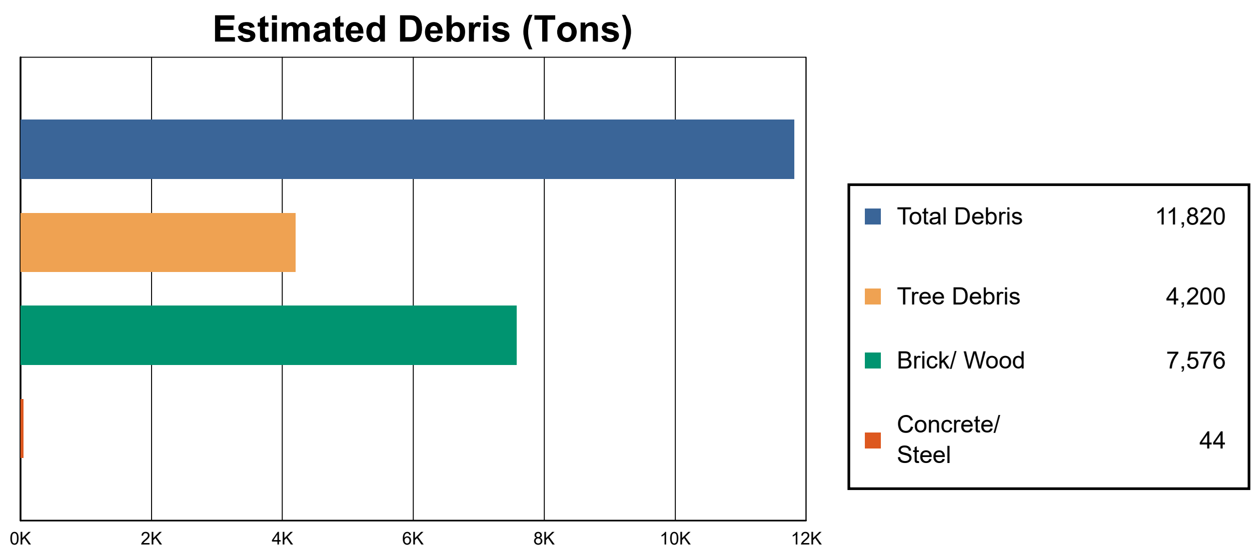


Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**Probability of at Least Moderate Damage > 50%**	**Probability of Complete Damage > 50%**	**Expected Loss of Use < 1 day**
EOCs	2	0	0	2
Fire Stations	2	0	0	2
Police Stations	1	0	0	1
Schools	12	0	0	0

Induced Hurricane Damage

Debris Generation

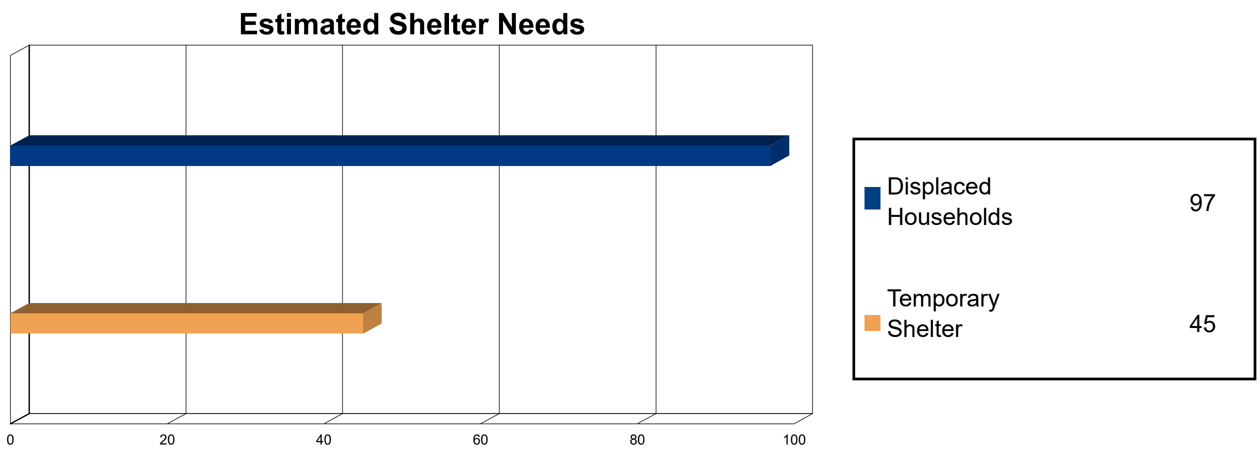


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 11,820 tons of debris will be generated. Of the total amount, 328 tons (3%) is Other Tree Debris. Of the remaining 11,492 tons, Brick/Wood comprises 66% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 305 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 3,872 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 97 households to be displaced due to the hurricane. Of these, 45 people (out of a total population of 19,808) will seek temporary shelter in public shelters.

Economic Loss

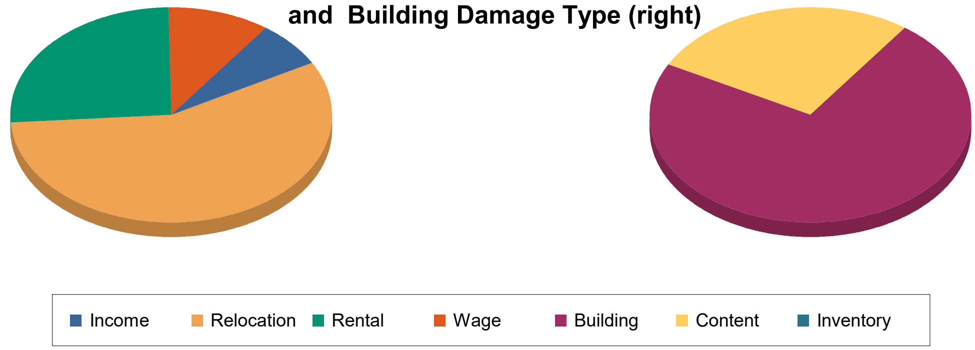
The total economic loss estimated for the hurricane is 137.9 million dollars, which represents 3.89 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 138 million dollars. 7% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 90% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.

Loss by Business Interruption Type (left) and Building Damage Type (right)



Loss Type by General Occupancy

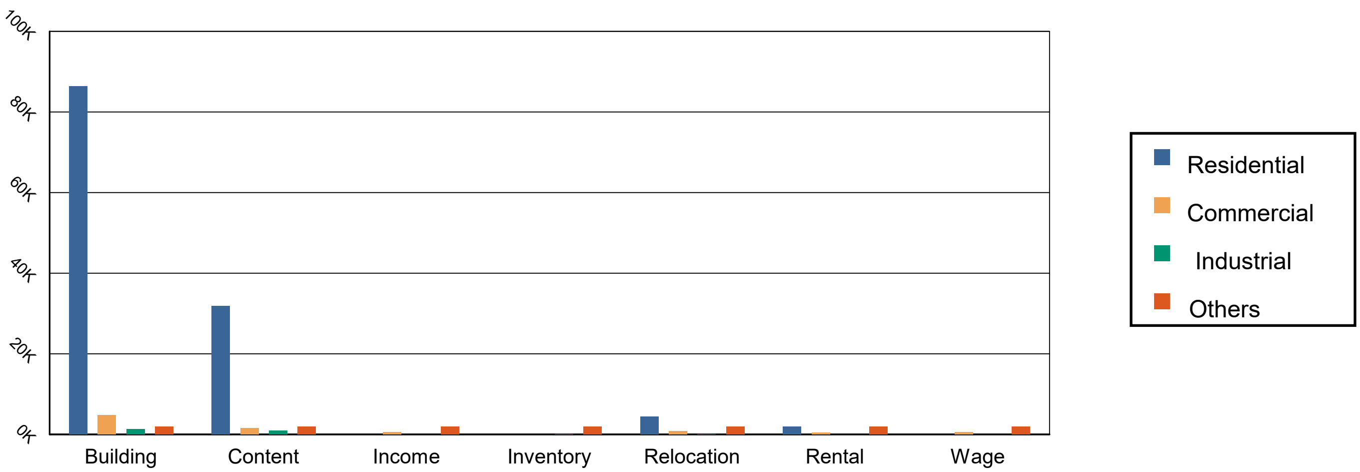


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	86,363.94	4,794.10	1,295.40	923.82	93,377.25
	Content	31,815.61	1,609.73	914.19	321.21	34,660.74
	Inventory	0.00	19.29	123.70	8.55	151.53
	Subtotal	**118,179.55**	**6,423.11**	**2,333.29**	**1,253.58**	**128,189.53**
Business Interruption Loss						
	Income	0.00	599.22	13.83	66.86	679.91
	Relocation	4,481.56	804.59	82.79	149.93	5,518.87
	Rental	2,027.39	464.75	12.48	11.06	2,515.68
	Wage	0.00	567.89	22.71	408.91	999.51
	Subtotal	**6,508.95**	**2,436.45**	**131.81**	**636.76**	**9,713.97**

Total

Total	**124,688.50**	**8,859.56**	**2,465.10**	**1,890.34**	**137,903.50**

Appendix A: County Listing for the Region

Massachusetts
- Essex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Essex	19,808	2,936,187	612,901	3,549,088
Total	**19,808**	**2,936,187**	**612,901**	**3,549,088**
Study Region Total	**19,808**	**2,936,187**	**612,901**	**3,549,088**

Hazus: Hurricane Global Risk Report

Region Name: Marblehead_HU

Hurricane Scenario: Probabilistic 1000-year Return Period

Print Date: Friday, October 21, 2022

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

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The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 4.44 square miles and contains 4 census tracts. There are over 8 thousand households in the region and a total population of 19,808 people (2010 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 8 thousand buildings in the region with a total building replacement value (excluding contents) of 3,549 million dollars (2014 dollars). Approximately 90% of the buildings (and 83% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 8,149 buildings in the region which have an aggregate total replacement value of 3,549 million (2014 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

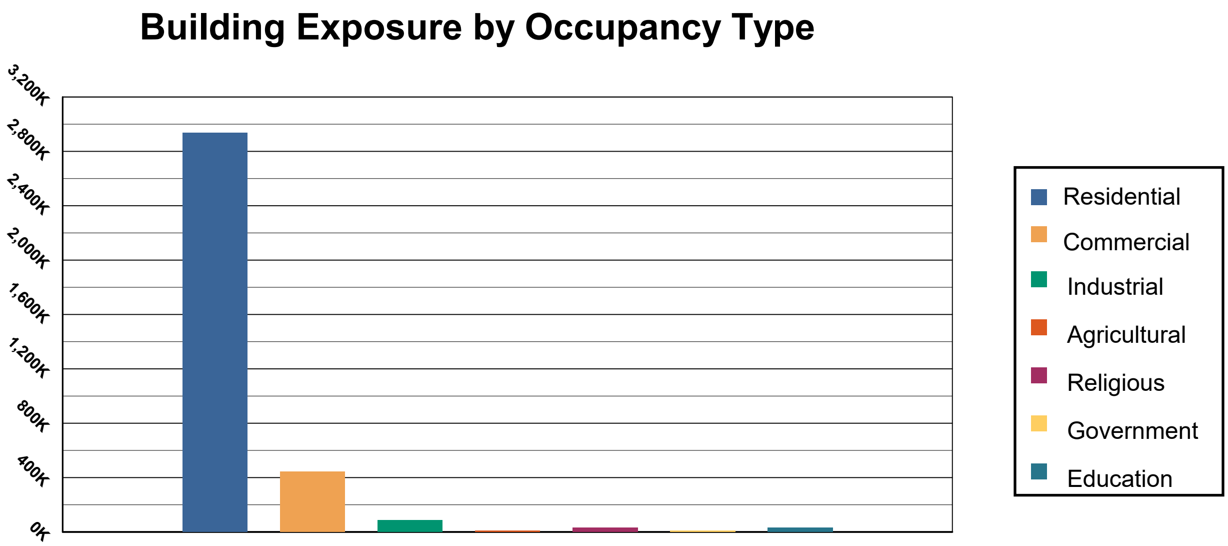


Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Tot
Residential	2,936,187	82.73%
Commercial	443,448	12.49%
Industrial	85,318	2.40%
Agricultural	8,975	0.25%
Religious	31,828	0.90%
Government	10,244	0.29%
Education	33,088	0.93%
Total	**3,549,088**	**100.00%**

Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 12 schools, 2 fire stations, 1 police stations and 2 emergency operation facilities.

Hurricane Scenario

Hazus used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Scenario Name:	Probabilistic
Type:	Probabilistic

Building Damage

General Building Stock Damage

Hazus estimates that about 932 buildings will be at least moderately damaged. This is over 11% of the total number of buildings in the region. There are an estimated 65 buildings that will be completely destroyed. The definition of the 'damage states' is provided in the Hazus Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

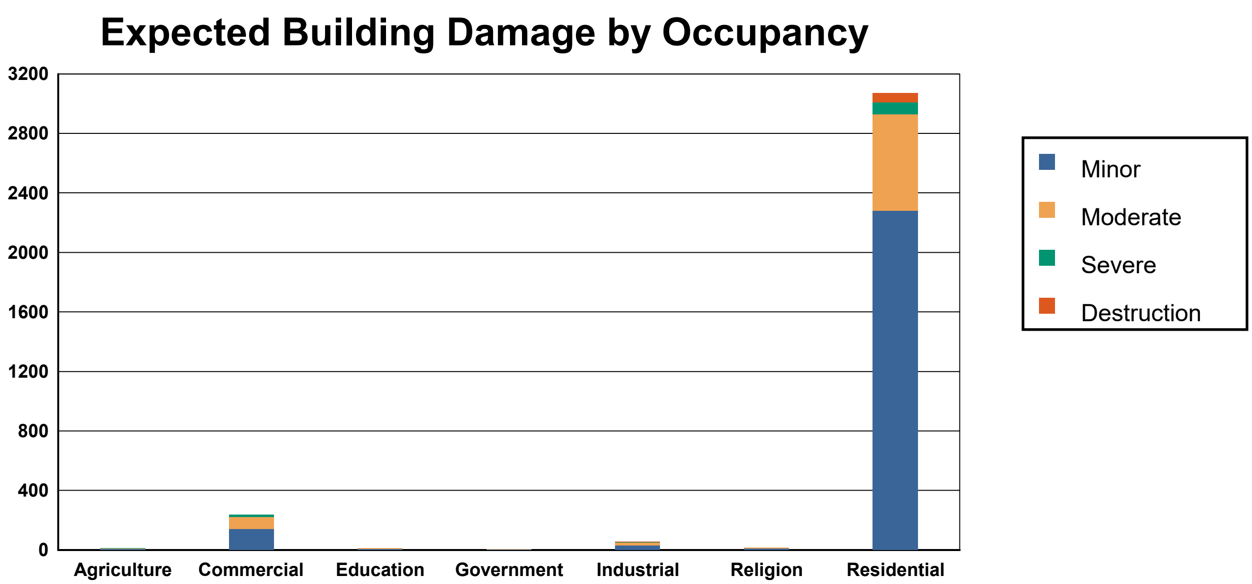


Table 2: Expected Building Damage by Occupancy : 1000 - year Event

	None		Minor		Moderate		Severe		Destruction	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	14.80	56.93	6.71	25.80	2.84	10.91	1.42	5.48	0.23	0.88
Commercial	355.83	60.21	140.98	23.85	78.99	13.37	15.11	2.56	0.09	0.01
Education	16.46	60.96	6.28	23.28	3.61	13.37	0.65	2.39	0.00	0.00
Government	7.64	58.80	3.01	23.14	1.95	14.98	0.40	3.08	0.00	0.00
Industrial	83.88	59.91	30.00	21.43	19.54	13.96	6.04	4.32	0.53	0.38
Religion	24.01	61.56	10.01	25.66	4.32	11.07	0.67	1.71	0.00	0.00
Residential	4,239.48	57.97	2,277.46	31.14	651.61	8.91	80.73	1.10	63.71	0.87
Total	**4,742.10**		**2,474.45**		**762.86**		**105.03**		**64.56**	

Table 3: Expected Building Damage by Building Type : 1000 - year Event

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	58	58.88	22	22.46	16	16.42	2	2.24	0	0.00
Masonry	390	56.62	165	24.01	115	16.66	16	2.35	2	0.36
MH	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Steel	231	60.93	79	20.91	56	14.74	13	3.40	0	0.03
Wood	4,079	58.43	2,224	31.86	543	7.77	74	1.05	62	0.88

Essential Facility Damage

Before the hurricane, the region had no hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (0%) are available for use by patients already in the hospital and those injured by the hurricane. After one week, none of the beds will be in service. By 30 days, none will be operational.

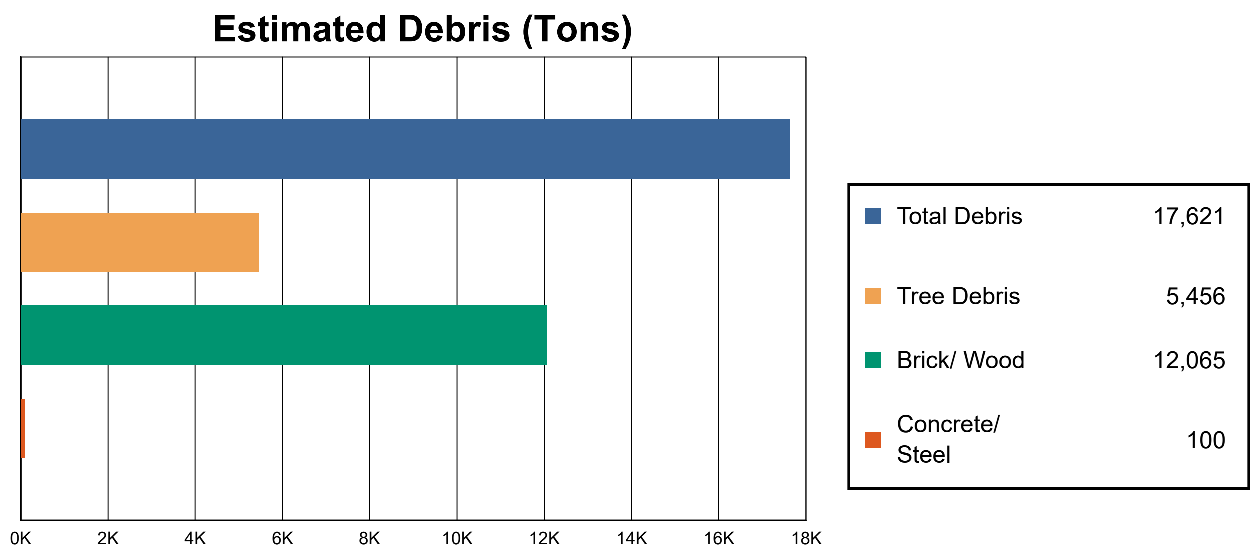
Thematic Map of Essential Facilities with greater than 50% moderate

Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	Probability of at Least Moderate Damage > 50%	Probability of Complete Damage > 50%	Expected Loss of Use < 1 day
EOCs	2	0	0	2
Fire Stations	2	0	0	2
Police Stations	1	0	0	1
Schools	12	1	0	0

Induced Hurricane Damage

Debris Generation

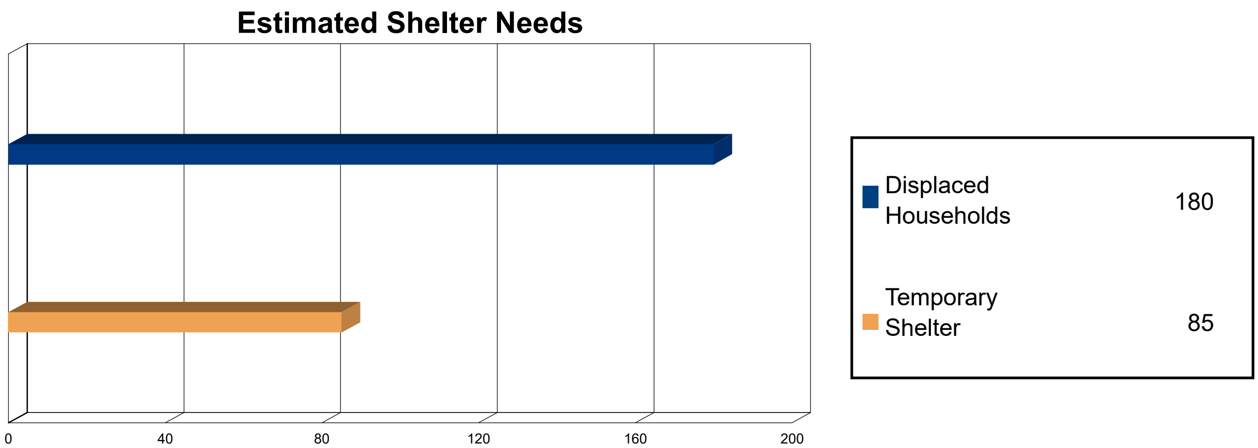


Hazus estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into four general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, c) Eligible Tree Debris, and d) Other Tree Debris. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 17,621 tons of debris will be generated. Of the total amount, 421 tons (2%) is Other Tree Debris. Of the remaining 17,200 tons, Brick/Wood comprises 70% of the total, Reinforced Concrete/Steel comprises of 1% of the total, with the remainder being Eligible Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 487 truckloads (@25 tons/truck) to remove the building debris generated by the hurricane. The number of Eligible Tree Debris truckloads will depend on how the 5,035 tons of Eligible Tree Debris are collected and processed. The volume of tree debris generally ranges from about 4 cubic yards per ton for chipped or compacted tree debris to about 10 cubic yards per ton for bulkier, uncompacted debris.

Social Impact

Shelter Requirement



Hazus estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 180 households to be displaced due to the hurricane. Of these, 85 people (out of a total population of 19,808) will seek temporary shelter in public shelters.

Economic Loss

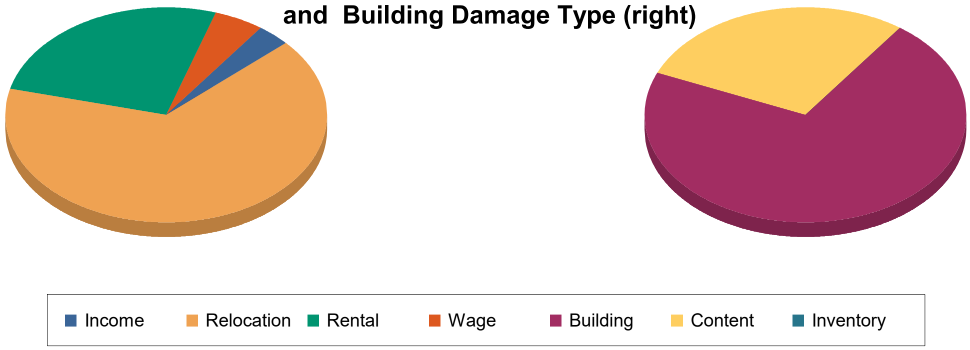
The total economic loss estimated for the hurricane is 235.3 million dollars, which represents 6.63 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 235 million dollars. 8% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 90% of the total loss. Table 5 below provides a summary of the losses associated with the building damage.

Loss by Business Interruption Type (left)
and Building Damage Type (right)



Loss Type by General Occupancy

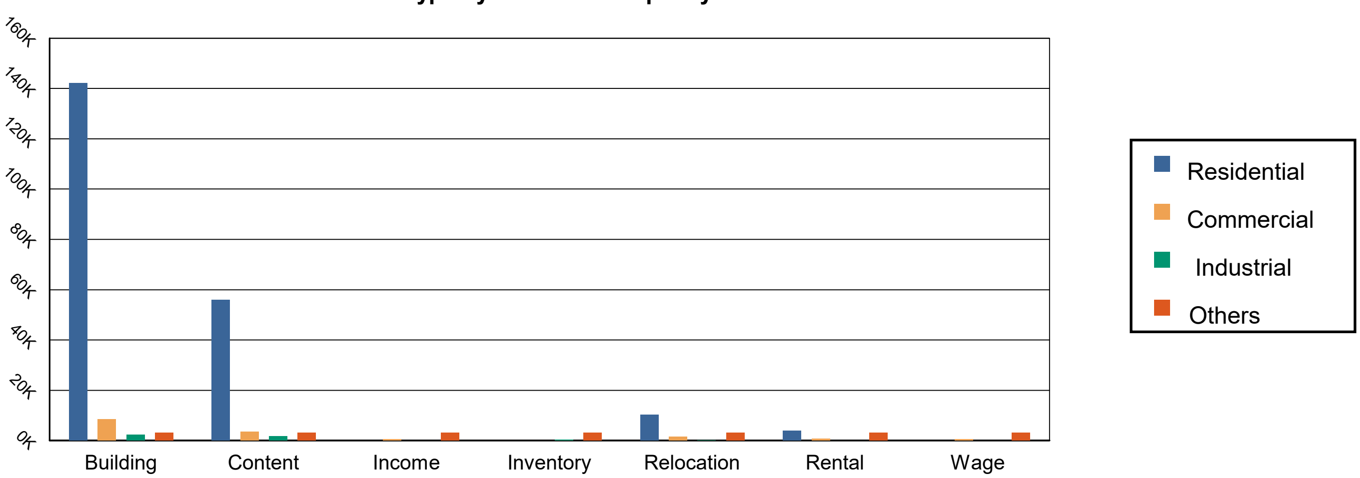


Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	142,227.68	8,514.01	2,307.73	1,701.31	154,750.73
	Content	55,986.71	3,443.06	1,736.19	712.52	61,878.48
	Inventory	0.00	41.34	232.10	14.70	288.14
	Subtotal	**198,214.38**	**11,998.41**	**4,276.02**	**2,428.53**	**216,917.34**
Business Interruption Loss						
	Income	1.86	539.91	23.91	59.12	624.81
	Relocation	10,149.13	1,416.69	149.06	284.33	11,999.22
	Rental	3,979.83	809.83	22.56	21.67	4,833.89
	Wage	4.36	525.07	39.27	326.72	895.42
	Subtotal	**14,135.18**	**3,291.51**	**234.81**	**691.84**	**18,353.33**

<u>Total</u>

Total	**212,349.56**	**15,289.92**	**4,510.82**	**3,120.37**	**235,270.67**

Appendix A: County Listing for the Region

Massachusetts

- Essex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Essex	19,808	2,936,187	612,901	3,549,088
Total	**19,808**	**2,936,187**	**612,901**	**3,549,088**
Study Region Total	**19,808**	**2,936,187**	**612,901**	**3,549,088**

Hazus: Earthquake Global Risk Report

Region Name: MarbleheadEQ

Earthquake Scenario: 1500year

Print Date: November 23, 2022

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

Hazus-MH is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 4.44 square miles and contains 4 census tracts. There are over 8 thousand households in the region which has a total population of 19,808 people (2010 Census Bureau data). The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 8 thousand buildings in the region with a total building replacement value (excluding contents) of 3,549 (millions of dollars). Approximately 90.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 296 and 33 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 8 thousand buildings in the region which have an aggregate total replacement value of 3,549 (millions of dollars) . Appendix B provides a general distribution of the building value by Total Region and County.

In terms of building construction types found in the region, wood frame construction makes up 86% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 0 hospitals in the region with a total bed capacity of beds. There are 12 schools, 2 fire stations, 1 police stations and 2 emergency operation facilities. With respect to high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations and no nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 329.00 (millions of dollars). This inventory includes over 23.61 miles of highways, 1 bridges, 238.61 miles of pipes.

Table 1: Transportation System Lifeline Inventory

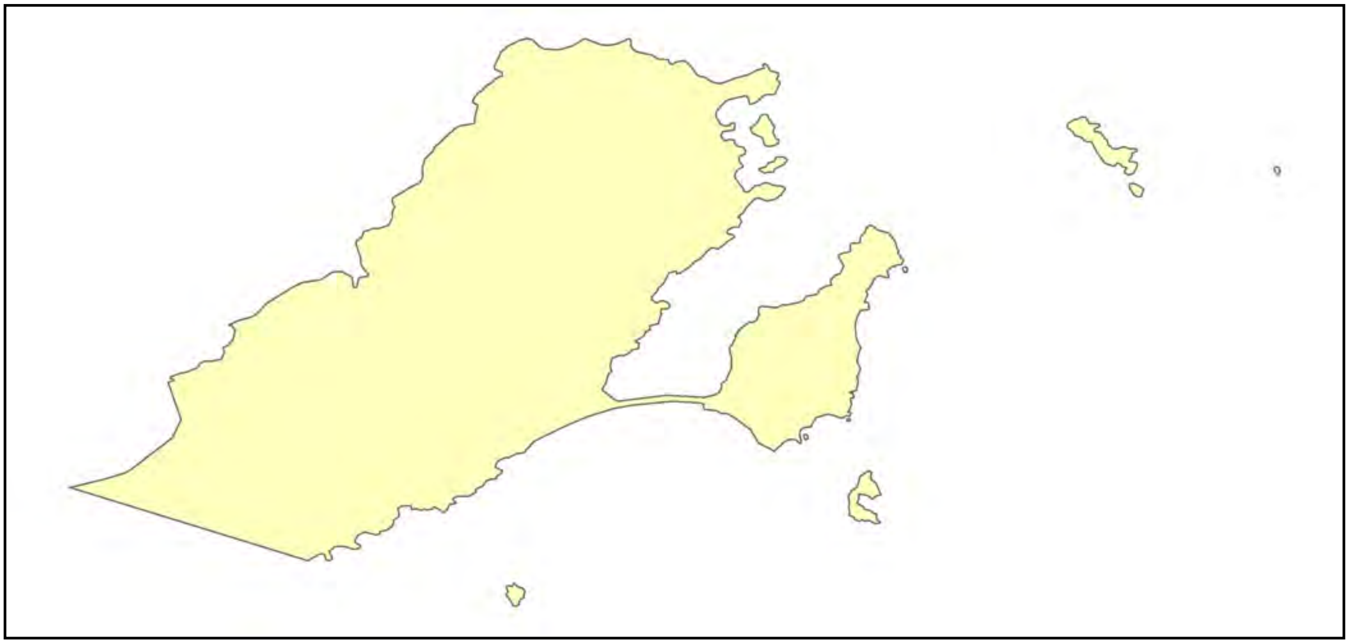
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	1	0.8917
	Segments	32	240.3597
	Tunnels	0	0.0000
		Subtotal	**241.2514**
Railways	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	17	37.0610
	Tunnels	0	0.0000
		Subtotal	**37.0610**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	3	17.9630
	Tunnels	0	0.0000
		Subtotal	**17.9630**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	0	0.0000
	Runways	0	0.0000
		Subtotal	**0.0000**
		Total	**296.30**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	4.3838
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**4.3838**
Waste Water	Distribution Lines	NA	2.6303
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**2.6303**
Natural Gas	Distribution Lines	NA	1.7535
	Facilities	0	0.0000
	Pipelines	3	24.6218
		Subtotal	**26.3753**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	0	0.0000
		Subtotal	**0.0000**
Communication	Facilities	1	0.1160
		Subtotal	**0.1160**
		Total	**33.50**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.



Scenario Name	1500year
Type of Earthquake	Probabilistic
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	1,500.00
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	5.00
Depth (km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Hazus estimates that about 206 buildings will be at least moderately damaged. This is over 3.00 % of the buildings in the region. There are an estimated 2 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

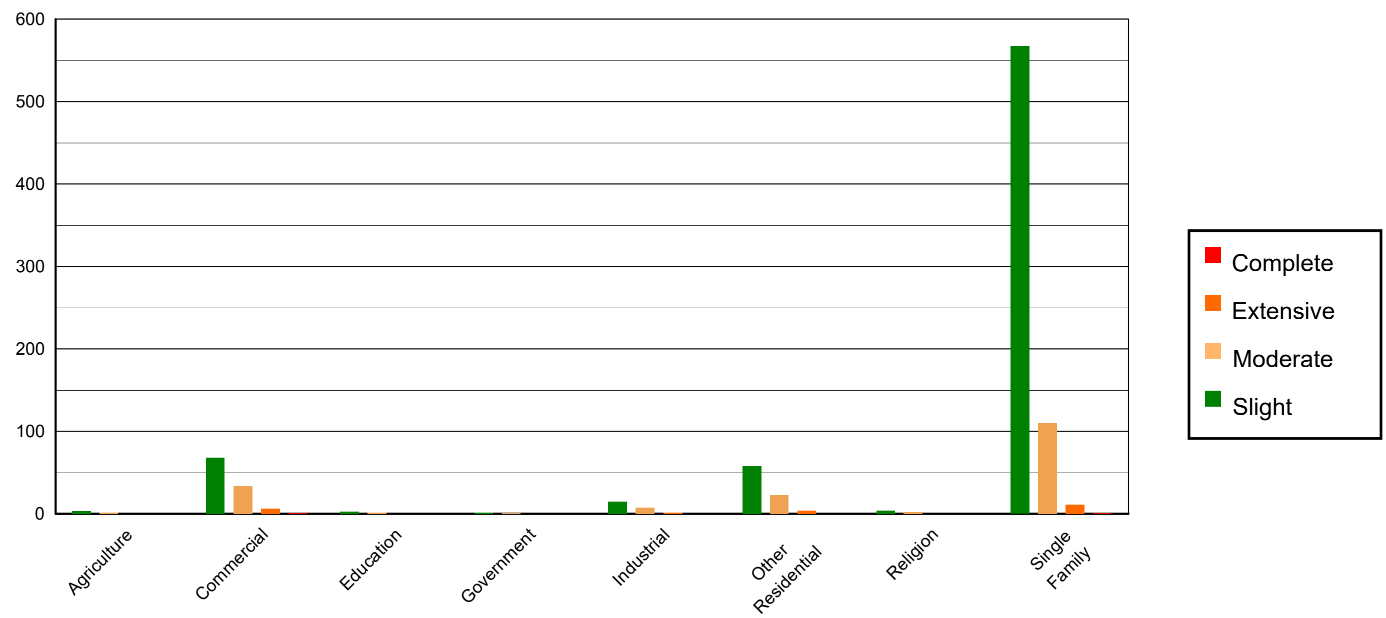


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	21.42	0.30	3.10	0.43	1.24	0.69	0.23	0.93	0.01	0.65
Commercial	481.32	6.67	68.51	9.50	34.06	18.92	6.55	26.92	0.57	25.29
Education	22.33	0.31	2.93	0.41	1.45	0.81	0.26	1.05	0.03	1.15
Government	10.66	0.15	1.43	0.20	0.76	0.42	0.13	0.55	0.01	0.45
Industrial	114.87	1.59	15.27	2.12	8.24	4.58	1.51	6.20	0.10	4.64
Other Residential	508.66	7.04	58.23	8.08	22.47	12.49	4.16	17.09	0.47	20.91
Religion	32.06	0.44	4.30	0.60	2.13	1.18	0.45	1.87	0.05	2.34
Single Family	6030.15	83.50	567.19	78.67	109.62	60.91	11.04	45.39	1.00	44.56
Total	**7,221**		**721**		**180**		**24**		**2**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Wood	6310.08	87.38	573.95	79.61	91.98	51.11	5.04	20.70	0.00	0.00
Steel	318.71	4.41	37.09	5.14	19.91	11.06	2.95	12.14	0.08	3.74
Concrete	61.48	0.85	8.25	1.14	4.53	2.52	0.45	1.83	0.02	0.71
Precast	18.86	0.26	2.92	0.40	2.75	1.53	0.81	3.34	0.02	0.77
RM	100.83	1.40	9.98	1.38	7.73	4.30	1.71	7.03	0.00	0.18
URM	411.52	5.70	88.78	12.31	53.06	29.48	13.37	54.96	2.12	94.59
MH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**7,221**		**721**		**180**		**24**		**2**	

*Note:

RM	Reinforced Masonry
URM	Unreinforced Masonry
MH	Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had hospital beds available for use. On the day of the earthquake, the model estimates that only hospital beds (%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, % of the beds will be back in service. By 30 days, % will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	0	0	0	0
Schools	12	0	0	12
EOCs	2	0	0	2
PoliceStations	1	0	0	1
FireStations	2	0	0	2

Transportation Lifeline Damage

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations_				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	32	0	0	22	22
	Bridges	1	0	0	1	1
	Tunnels	0	0	0	0	0
Railways	Segments	17	0	0	9	9
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	3	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Table 6 provides damage estimates for the transportation system.

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	1	0	0	1	1

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	136	1	0
Waste Water	82	1	0
Natural Gas	21	0	0
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	8,144	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

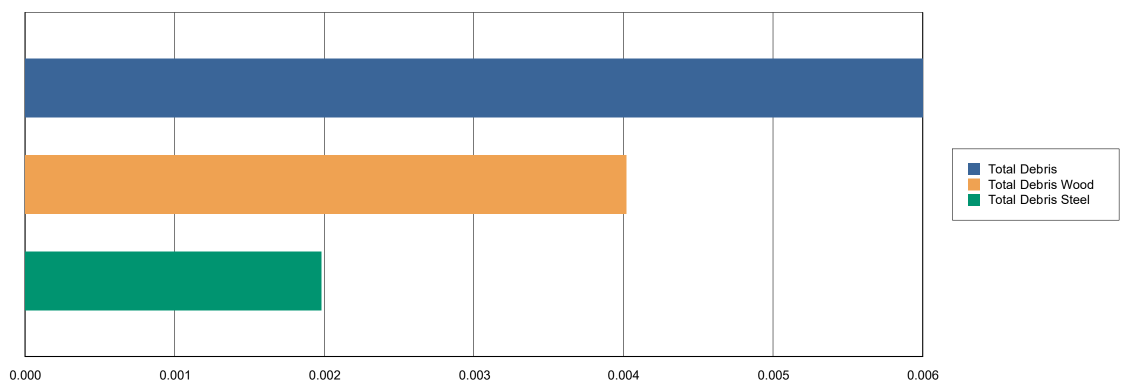
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 6,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 67.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 240 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



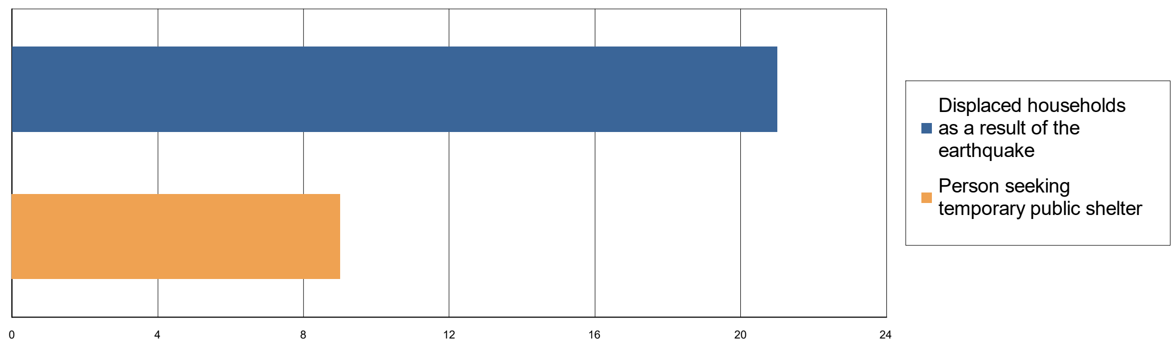
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.00	0.00	0.01	240 (@25 tons/truck)

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 21 households to be displaced due to the earthquake. Of these, 9 people (out of a total population of 19,808) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
21	9

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0.08	0.01	0.00	0.00
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.05	0.01	0.00	0.00
	Other-Residential	1.38	0.22	0.02	0.04
	Single Family	2.13	0.24	0.02	0.04
	Total	**4**	**0**	**0**	**0**
2 PM	Commercial	4.69	0.72	0.07	0.13
	Commuting	0.00	0.00	0.00	0.00
	Educational	1.50	0.24	0.02	0.04
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.40	0.06	0.01	0.01
	Other-Residential	0.27	0.04	0.00	0.01
	Single Family	0.41	0.05	0.00	0.01
	Total	**7**	**1**	**0**	**0**
5 PM	Commercial	3.26	0.51	0.05	0.09
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.10	0.02	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.25	0.04	0.00	0.01
	Other-Residential	0.55	0.09	0.01	0.02
	Single Family	0.82	0.10	0.01	0.02
	Total	**5**	**1**	**0**	**0**

Economic Loss

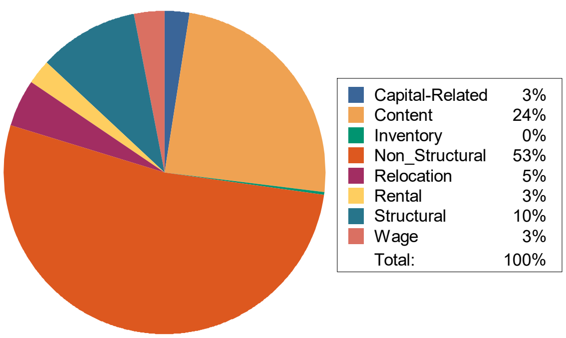
The total economic loss estimated for the earthquake is 48.19 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 48.18 (millions of dollars); 13 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 67 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Earthquake Losses by Loss Type ($ millions)



Earthquake Losses by Occupancy Type ($ millions)

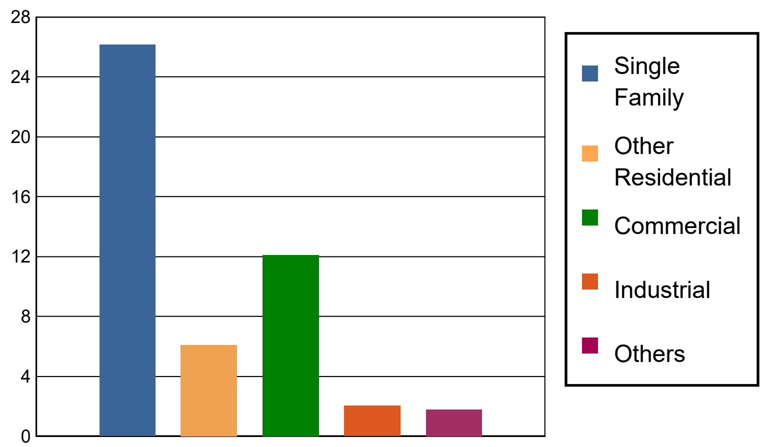


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.1037	1.2157	0.0289	0.0633	1.4116
	Capital-Related	0.0000	0.0441	1.1379	0.0173	0.0117	1.2110
	Rental	0.2514	0.3728	0.6484	0.0116	0.0171	1.3013
	Relocation	0.8460	0.2490	0.8568	0.0668	0.1736	2.1922
	Subtotal	**1.0974**	**0.7696**	**3.8588**	**0.1246**	**0.2657**	**6.1161**
Capital Stock Losses							
	Structural	2.6121	0.5930	1.1633	0.1984	0.2472	4.8140
	Non_Structural	15.6785	3.6114	4.3240	0.9392	0.7674	25.3205
	Content	6.7633	1.1266	2.7062	0.6695	0.5157	11.7813
	Inventory	0.0000	0.0000	0.0329	0.1044	0.0063	0.1436
	Subtotal	**25.0539**	**5.3310**	**8.2264**	**1.9115**	**1.5366**	**42.0594**
	Total	**26.15**	**6.10**	**12.09**	**2.04**	**1.80**	**48.18**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	240.3597	0.0000	0.00
	Bridges	0.8917	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**241.2514**	**0.0000**	
Railways	Segments	37.0610	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**37.0610**	**0.0000**	
Light Rail	Segments	17.9630	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**17.9630**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	0.0000	0.0000	0.00
	Runways	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**296.28**	**0.00**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	4.3838	0.0050	0.11
	Subtotal	**4.3838**	**0.0050**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	2.6303	0.0025	0.10
	Subtotal	**2.6303**	**0.0025**	
Natural Gas	Pipelines	24.6218	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	1.7535	0.0009	0.05
	Subtotal	**26.3753**	**0.0009**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Communication	Facilities	0.1160	0.0060	5.17
	Subtotal	**0.1160**	**0.0060**	
	Total	**33.51**	**0.01**	

Appendix A: County Listing for the Region

Essex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Essex	19,808	2,936	612	3,549
Total Region		**19,808**	**2,936**	**612**	**3,549**

Hazus: Earthquake Global Risk Report

Region Name: MarbleheadEQ

Earthquake Scenario: 2500year

Print Date: November 23, 2022

Disclaimer:
This version of Hazus utilizes 2010 Census Data.
Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

Hazus-MH is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 4.44 square miles and contains 4 census tracts. There are over 8 thousand households in the region which has a total population of 19,808 people (2010 Census Bureau data). The distribution of population by Total Region and County is provided in Appendix B.

There are an estimated 8 thousand buildings in the region with a total building replacement value (excluding contents) of 3,549 (millions of dollars). Approximately 90.00 % of the buildings (and 83.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 296 and 33 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 8 thousand buildings in the region which have an aggregate total replacement value of 3,549 (millions of dollars) . Appendix B provides a general distribution of the building value by Total Region and County.

In terms of building construction types found in the region, wood frame construction makes up 86% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 0 hospitals in the region with a total bed capacity of beds. There are 12 schools, 2 fire stations, 1 police stations and 2 emergency operation facilities. With respect to high potential loss facilities (HPL), there are no dams identified within the inventory. The inventory also includes no hazardous material sites, no military installations and no nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 329.00 (millions of dollars). This inventory includes over 23.61 miles of highways, 1 bridges, 238.61 miles of pipes.

Table 1: Transportation System Lifeline Inventory

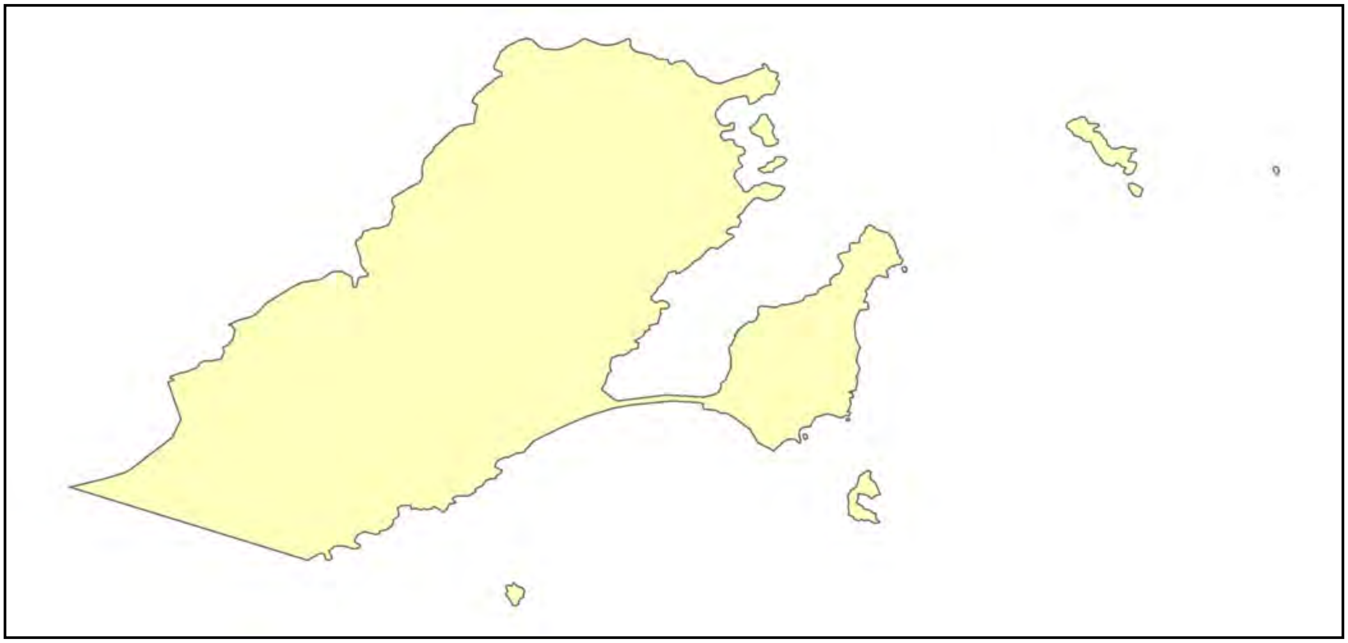
System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	1	0.8917
	Segments	32	240.3597
	Tunnels	0	0.0000
		Subtotal	**241.2514**
Railways	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	17	37.0610
	Tunnels	0	0.0000
		Subtotal	**37.0610**
Light Rail	Bridges	0	0.0000
	Facilities	0	0.0000
	Segments	3	17.9630
	Tunnels	0	0.0000
		Subtotal	**17.9630**
Bus	Facilities	0	0.0000
		Subtotal	**0.0000**
Ferry	Facilities	0	0.0000
		Subtotal	**0.0000**
Port	Facilities	0	0.0000
		Subtotal	**0.0000**
Airport	Facilities	0	0.0000
	Runways	0	0.0000
		Subtotal	**0.0000**
		Total	**296.30**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	4.3838
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**4.3838**
Waste Water	Distribution Lines	NA	2.6303
	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**2.6303**
Natural Gas	Distribution Lines	NA	1.7535
	Facilities	0	0.0000
	Pipelines	3	24.6218
		Subtotal	**26.3753**
Oil Systems	Facilities	0	0.0000
	Pipelines	0	0.0000
		Subtotal	**0.0000**
Electrical Power	Facilities	0	0.0000
		Subtotal	**0.0000**
Communication	Facilities	1	0.1160
		Subtotal	**0.1160**
		Total	**33.50**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.



Scenario Name	2500year
Type of Earthquake	Probabilistic
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	2,500.00
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	6.00
Depth (km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Direct Earthquake Damage

Building Damage

Hazus estimates that about 390 buildings will be at least moderately damaged. This is over 5.00 % of the buildings in the region. There are an estimated 5 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Damage Categories by General Occupancy Type

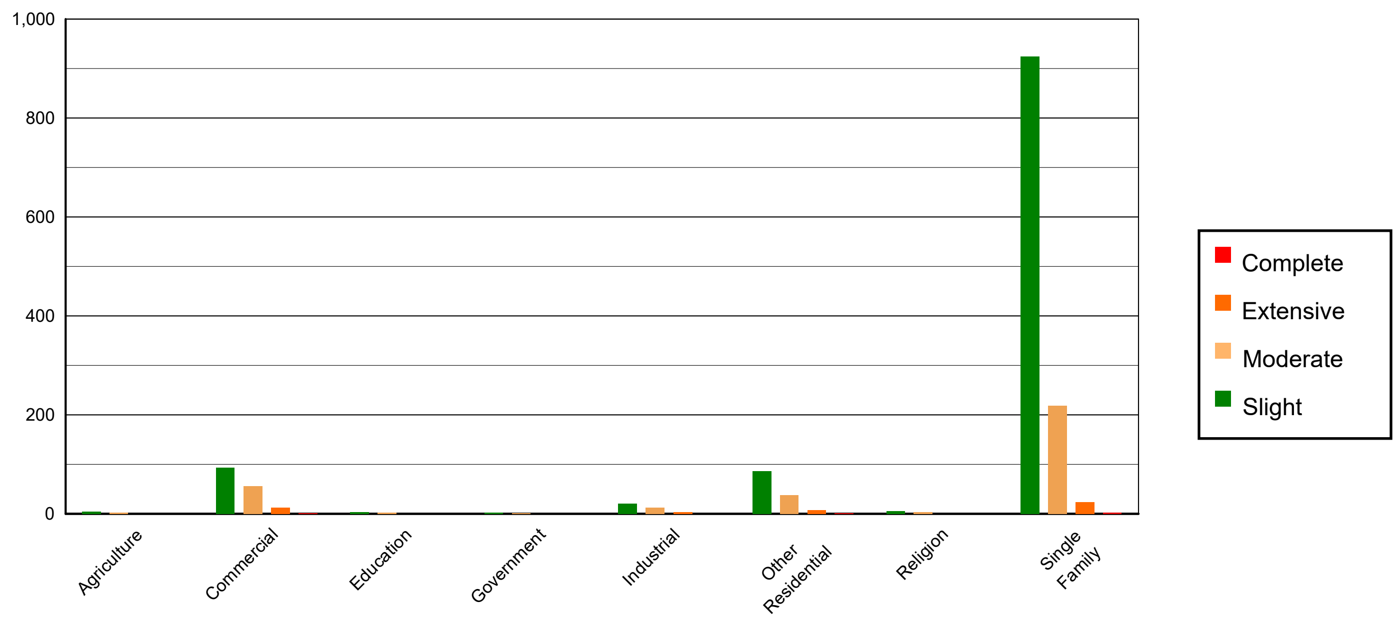


Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	19.11	0.29	4.33	0.38	2.08	0.62	0.44	0.88	0.04	0.74
Commercial	427.35	6.46	93.54	8.19	56.01	16.73	12.72	25.42	1.39	27.04
Education	19.95	0.30	4.04	0.35	2.44	0.73	0.51	1.01	0.06	1.21
Government	9.45	0.14	1.96	0.17	1.28	0.38	0.27	0.55	0.03	0.52
Industrial	102.12	1.54	20.85	1.83	13.74	4.10	3.02	6.03	0.27	5.33
Other Residential	461.03	6.97	86.28	7.55	37.64	11.24	7.99	15.97	1.05	20.53
Religion	28.66	0.43	5.98	0.52	3.39	1.01	0.85	1.70	0.12	2.31
Single Family	5548.84	83.86	925.46	81.01	218.30	65.19	24.22	48.43	2.17	42.32
Total	**6,617**		**1,142**		**335**		**50**		**5**	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	5817.61	87.93	951.17	83.26	198.04	59.14	14.23	28.45	0.01	0.22
Steel	285.28	4.31	51.86	4.54	34.90	10.42	6.37	12.73	0.35	6.78
Concrete	54.38	0.82	11.24	0.98	7.96	2.38	1.08	2.16	0.06	1.16
Precast	16.01	0.24	3.62	0.32	4.12	1.23	1.54	3.09	0.06	1.18
RM	89.48	1.35	13.81	1.21	13.16	3.93	3.77	7.53	0.04	0.84
URM	353.77	5.35	110.74	9.69	76.71	22.91	23.03	46.05	4.61	89.82
MH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**6,617**		**1,142**		**335**		**50**		**5**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had hospital beds available for use. On the day of the earthquake, the model estimates that only hospital beds (%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, % of the beds will be back in service. By 30 days, % will be operational.

Table 5: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	0	0	0	0
Schools	12	0	0	12
EOCs	2	0	0	2
PoliceStations	1	0	0	1
FireStations	2	0	0	2

Transportation Lifeline Damage

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations_				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	32	0	0	22	22
	Bridges	1	0	0	1	1
	Tunnels	0	0	0	0	0
Railways	Segments	17	0	0	9	9
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	3	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Table 6 provides damage estimates for the transportation system.

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	1	0	0	1	1

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (miles)	Number of Leaks	Number of Breaks
Potable Water	136	2	1
Waste Water	82	1	0
Natural Gas	21	0	0
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	8,144	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

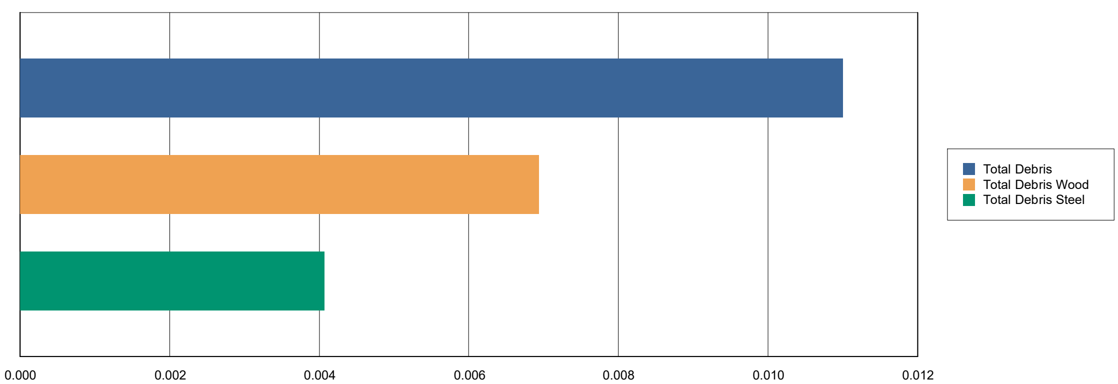
Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 0 ignitions that will burn about 0.00 sq. mi 0.00 % of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 11,000 tons of debris will be generated. Of the total amount, Brick/Wood comprises 63.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 440 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Earthquake Debris (millions of tons)



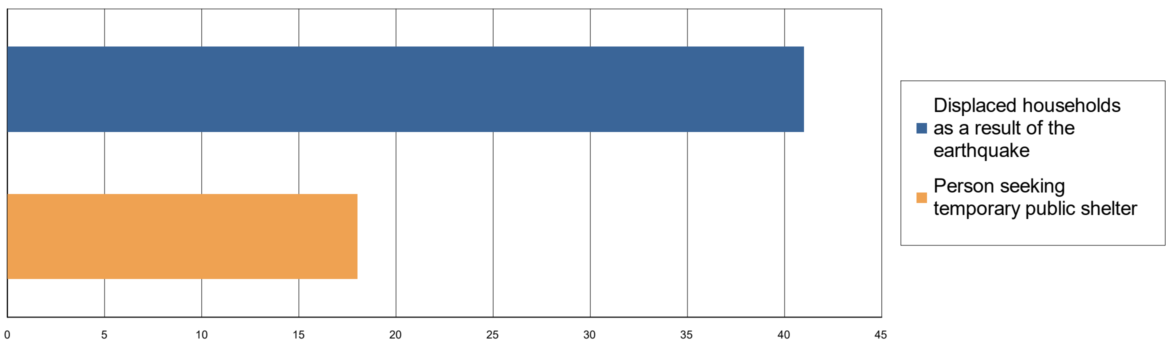
Brick/ Wood	Reinforced Concrete/Steel	Total Debris	Truck Load
0.01	0.00	0.01	440 (@25 tons/truck)

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 41 households to be displaced due to the earthquake. Of these, 18 people (out of a total population of 19,808) will seek temporary shelter in public shelters.

Displaced Households/ Persons Seeking Short Term Public Shelter



Displaced households as a result of the earthquake	Persons seeking temporary public shelter
41	18

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0.15	0.03	0.00	0.01
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.00	0.00	0.00	0.00
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.10	0.02	0.00	0.00
	Other-Residential	2.55	0.44	0.05	0.10
	Single Family	4.04	0.49	0.04	0.08
	Total	**7**	**1**	**0**	**0**
2 PM	Commercial	8.69	1.49	0.16	0.31
	Commuting	0.00	0.00	0.00	0.00
	Educational	2.82	0.49	0.05	0.10
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.76	0.12	0.01	0.02
	Other-Residential	0.50	0.09	0.01	0.02
	Single Family	0.78	0.10	0.01	0.02
	Total	**14**	**2**	**0**	**0**
5 PM	Commercial	6.04	1.05	0.11	0.22
	Commuting	0.00	0.00	0.00	0.00
	Educational	0.19	0.03	0.00	0.01
	Hotels	0.00	0.00	0.00	0.00
	Industrial	0.48	0.08	0.01	0.01
	Other-Residential	1.01	0.18	0.02	0.04
	Single Family	1.56	0.20	0.02	0.03
	Total	**9**	**2**	**0**	**0**

Economic Loss

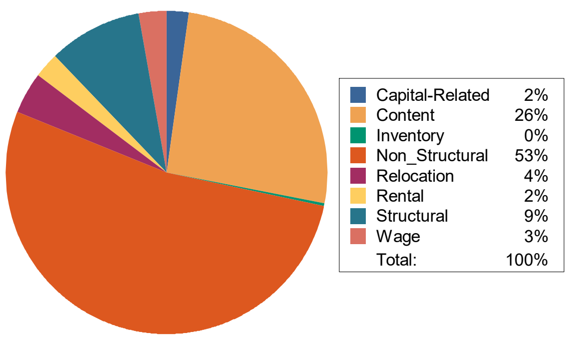
The total economic loss estimated for the earthquake is 93.51 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 93.49 (millions of dollars); 12 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 69 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Earthquake Losses by Loss Type ($ millions)



Earthquake Losses by Occupancy Type ($ millions)

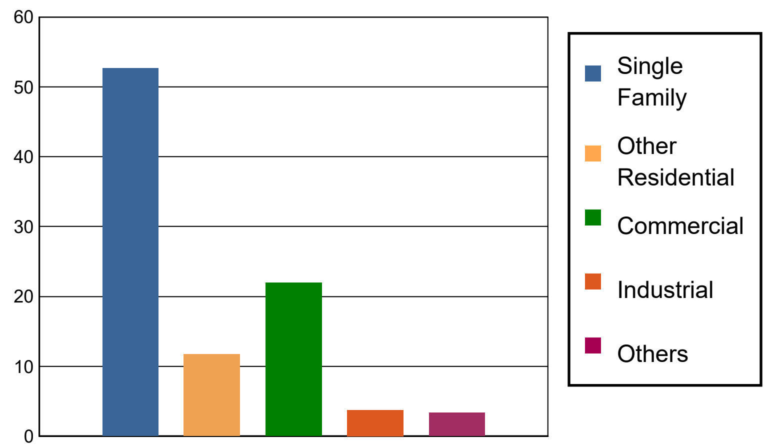


Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.0000	0.1981	2.1443	0.0526	0.1078	2.5028
	Capital-Related	0.0000	0.0842	2.0225	0.0315	0.0201	2.1583
	Rental	0.4995	0.6659	1.1080	0.0204	0.0307	2.3245
	Relocation	1.7227	0.4418	1.5100	0.1178	0.3111	4.1034
	Subtotal	**2.2222**	**1.3900**	**6.7848**	**0.2223**	**0.4697**	**11.0890**
Capital Stock Losses							
	Structural	4.9285	1.0482	2.0538	0.3541	0.4385	8.8231
	Non_Structural	31.1245	7.0055	7.9403	1.7109	1.4337	49.2149
	Content	14.3691	2.3199	5.1407	1.2578	1.0022	24.0897
	Inventory	0.0000	0.0000	0.0622	0.1958	0.0118	0.2698
	Subtotal	**50.4221**	**10.3736**	**15.1970**	**3.5186**	**2.8862**	**82.3975**
	Total	**52.64**	**11.76**	**21.98**	**3.74**	**3.36**	**93.49**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	240.3597	0.0000	0.00
	Bridges	0.8917	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Subtotal	**241.2514**	**0.0000**	
Railways	Segments	37.0610	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**37.0610**	**0.0000**	
Light Rail	Segments	17.9630	0.0000	0.00
	Bridges	0.0000	0.0000	0.00
	Tunnels	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**17.9630**	**0.0000**	
Bus	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Ferry	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Port	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Airport	Facilities	0.0000	0.0000	0.00
	Runways	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
	Total	**296.28**	**0.00**	

Table 13: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	4.3838	0.0093	0.21
	Subtotal	**4.3838**	**0.0093**	
Waste Water	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	2.6303	0.0047	0.18
	Subtotal	**2.6303**	**0.0047**	
Natural Gas	Pipelines	24.6218	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Distribution Lines	1.7535	0.0016	0.09
	Subtotal	**26.3753**	**0.0016**	
Oil Systems	Pipelines	0.0000	0.0000	0.00
	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Electrical Power	Facilities	0.0000	0.0000	0.00
	Subtotal	**0.0000**	**0.0000**	
Communication	Facilities	0.1160	0.0111	9.57
	Subtotal	**0.1160**	**0.0111**	
	Total	**33.51**	**0.03**	

Appendix A: County Listing for the Region

Essex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Essex	19,808	2,936	612	3,549
Total Region		**19,808**	**2,936**	**612**	**3,549**