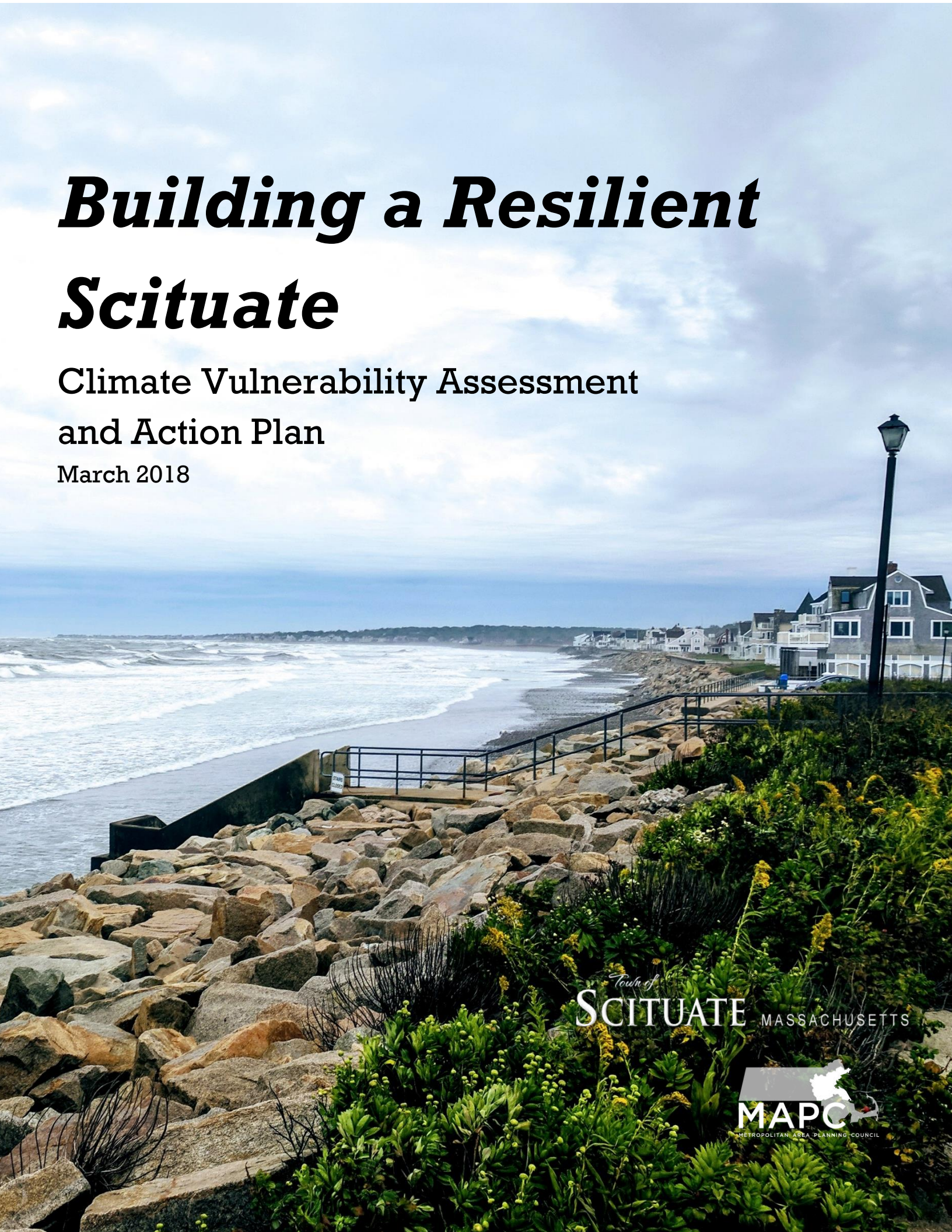
Building a Resilient Scituate

Climate Vulnerability Assessment and Action Plan

March 2018



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Building a Resilient Scituate

EXECUTIVE SUMMARY

Scituate, Winter Storm Riley, March 2018. Source: Simon Brewer

Climate change is the most compelling environmental, economic, and social issue of our time. Scituate, known for its numerous barrier beaches, prominent bedrock headlands, and rich cultural history, is one of the most vulnerable regions in Massachusetts. It is routinely hit hard with coastal storms causing massive storm surge and inundation with even just a lunar high tide. Projected sea level rise and changes in intensity of storm and precipitation events compel the need to assess the vulnerability of Scituate's people and places as well as plan for protecting its future. This report summarizes the latest climate risks, evaluates the vulnerability of Scituate's critical infrastructure and resources, and creates an action for incremental steps toward greater resilience and community vibrancy in an uncertain future.

Climate Change: Our Uncertain Future

2017 was the second warmest year on record and the period from 2006-2015 was the warmest decade since temperature has been measured. This has translated into an increase in the growing season by 10 days since 1980 [1]and model temperature projections anticipate more frequent heat waves.[2]

Scituate could experience five to 23 days over 90° by 2050 and nine to 58 days over 90°by 2100.[2]

Depending on various greenhouse gas emission scenarios, warming temperatures will cause ocean expansion and melting glaciers resulting in sea level rise. Sea level has risen by 11 inches over the last century and scientists anticipate this rate to accelerate.

Scituate could experience an additional eight inches sea level rise by 2030 and six and a half feet by the end of the century.[1,3]

In the last 50 years, precipitation in the Northeast US increased 71% in the amount of rain that falls in the top 1% of storm events. Projections suggest an increase in total precipitation, changes in precipitation patterns, and increased frequency of extreme storms such as hurricanes and nor'easters.[3]

Scituate could experience an increase of five inches of precipitation annually by 2050 and six inches by 2100 with the greatest increase during the winter.[1]

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[1] U.S. Environmental Protection Agency. 2016. Climate Change Indicators in the United States, 2016. Fourth meditation. EPA 430-R-16-004. www.epa/gov/climate-indicators Northeast Climate Science Center.
[2] Northeast Climate Science Center. UMass Amherst. Massachusetts Climate Change Projections. December 2017
[3] *Sea Level Rise Study. The Towns of Marshfield, Duxbury, Scituate, MA". 2013. Kleinfelder.*

Scituate's Strength and Vulnerability

Projected climate impacts are an intensification, increased frequency, or geographic expansion of existing challenges. Scituate already has significant planning, experience and strengths to bring to these challenges.

Scituate's seniors comprise 17% of the population and are the residents at greatest risk to climate change. Many seniors live in Humarock vulnerable to extreme heat and coastal flooding. But the Town is well prepared with programs that connect seniors to programs, cooling centers, and resources for their well-being and safety.

Scituate is at risk to increased occurrences of vector-borne diseases with warmer winters, standing flood waters, and extended growing seasons. But it has significant strengths in preventing heat-related illness with 48.8% tree canopy cooling the town, mitigating air pollutants, capturing stormwater, and sequestering carbon. There is a nominal risk to toxic exposure from flooding of hazardous materials storage sites.

Scituate has over 1,600 acres of salt marsh and over 100 acres of eelgrass meadows providing critical shoreline protection. The salt marshes are showing signs of degradation and saltmarsh grass decline and migration, but the eelgrass meadows have remained relatively stable since 1995. There are four designated impaired waters in its rivers, bays, and ponds requiring TDML, but Scituate also contains 10,033 acres of State-designated BioMap2 Aquatic Core habitat demonstrating viable wetland systems able to withstand the impacts of climate change.

Scituate's drinking water has two sources, but it is vulnerable to scarcity during periods of drought and potential intrusion from coastal flooding and inundation of its well infrastructure. Its waste water treatment plant is located within a 1% Annual Chance Flood Zone and the flood risk increases greatly with sea level rise in 2038 and 2088.

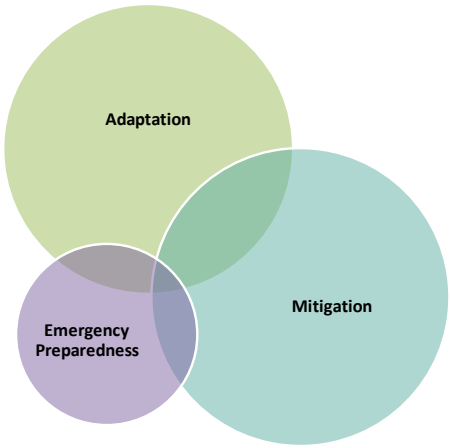
Scituate has suffered 3,681flood insurance claims totaling over $63 million.[4] Critical Infrastructure located in current or future flood zones includes two well heads, pump stations, wastewater treatment plant, two bridges and a few businesses, where Front St. is the most vulnerable. Sixteen roads are prone to flooding in a 1% Annual Chance Storm. Businesses located in a 2088 flood zone are valued today at over $57 million.

There 127 historic structures at risk to flooding in a 1% Annual Flood Chance Flood and approximately 60 historic structures vulnerable to sea level rise in 2088.

[4] VHB. Natural Hazard Mitigation Plan Scituate, Massachusetts. August 2, 2016

Scituate's Climate Action Plan

This climate action plan builds upon previous completed plans for hazard mitigation and coastal flooding, erosion, and resilience. It takes an adaptive management approach that combines emergency preparedness, mitigation, and adaptation. The Town's Climate Vulnerability Steering Committee created the prioritization of suggested climate actions agreed upon four guiding principles toward *Building a More Resilient Scituate*:



1. Balance growth, preservation, and resiliency to enhance our vibrant community and ensure its livability into the next century and beyond

2. Invest in infrastructure that promotes multiple benefits that address climate risks as well as beautification, economic growth, public programming, and public health.

3. Leverage the resources of multiple disciplines and sectors within municipal departments and across sectors to generate layers of resilience.

4. Approach *Building a More Resilient Scituate* as an ongoing effort to ensure Scituate's ongoing success leveraging capital improvement cycles and outside funding cycles.

Scituate is Proactive… Scituate is committed to Resilience

The top climate action priorities were those receiving the most significant concern and sense of urgency for Scituate's future livability and were recommended to be implemented as soon as possible. The top climate action priorities are as follows:

1. **Address the vulnerability of coastal business districts.** Lead a climate vulnerability and resilience workshop with stakeholders, property owners, residents, businesses, and municipal staff and officials for participatory visioning the future with sea level rise and coastal flooding. The goal of the workshop is to educate stakeholders to the current and future risks and ensure stakeholders are active participants in the waterfront's current and future resilience. Front Street is a priority for this action.
2. **Address the vulnerability of Scituate's municipal infrastructure.** A priority could be the Waste Water Treatment Plant, currently in a 1% Annual Chance Flood. Protection measures discussed include earthen berms and other natural shoreline protection as an incremental resilience measure while investigating more significant structural investments that addresses future risk.
3. **Initiate a public outreach and marketing campaign** with a sense of urgency on climate change and resilience in Scituate. The Town has demonstrated results in such an effort, when, during the 2016 drought where resident's behavior shifted sufficiently to mitigate drinking water scarcity during that time.

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Introduction

Climate change is the most compelling environmental, economic, and social issue of our time and the northeastern United States is one of the most vulnerable regions, particularly with projected sea level rise. Scituate, 35 miles from Boston, is a commuter town known for its numerous barrier beaches, prominent bedrock headlands, and rich cultural history. With its diverse coastal features, Scituate has extensive scenic, recreational, and economic amenities already at risk to storms and changing weather patterns. With projected sea level rise and changes in intensity of storm and precipitation events, the need to assess the vulnerability of Scituate's infrastructure, economy, and community as well as plan for protecting its future is critical.

The goal of this plan is to identify Scituate's most significant risks from sea level rise, inland flooding, extreme precipitation events, and extreme temperature on social, natural, economic, and physical infrastructure. The vulnerability analysis and Scituate's existing strengths will inform near and long-term strategies to ensure Scituate remains a resilient and vibrant town.

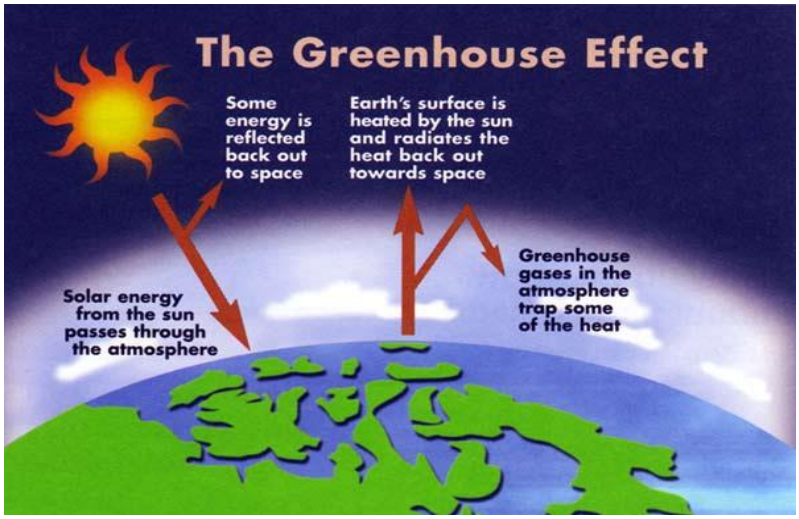
This Climate Vulnerability Assessment and Action Plan builds upon multiple studies around coastal vulnerability to climate change including:

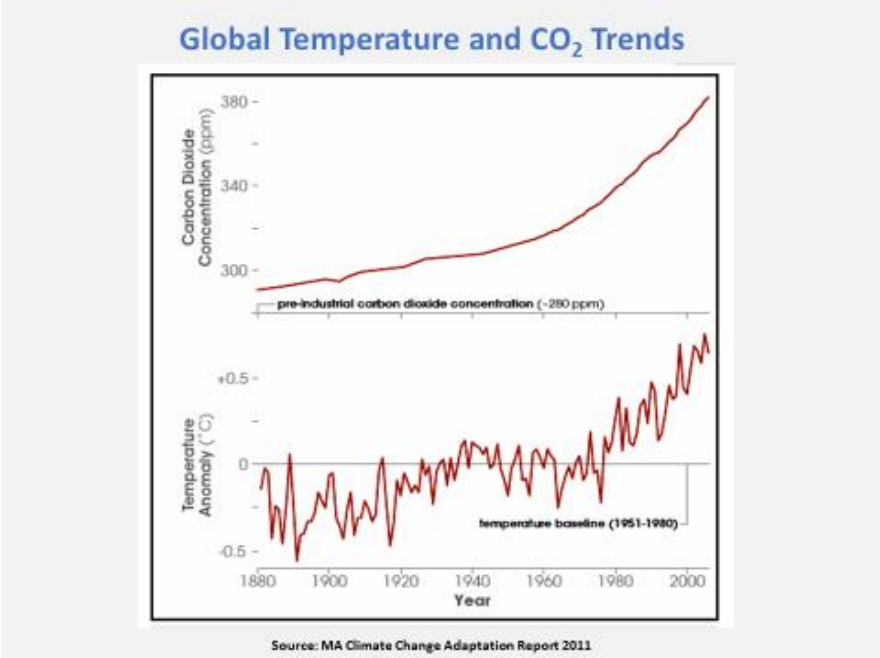
- *South Shore Coastal Hazards Adaptation Study*. MAPC, 2011
- *Sea Level Rise Study for the Towns of Marshfield, Duxbury, Scituate, MA*. Kleinfelder, 2013.
- *Coastal Erosion, Sediment Transport, and Prioritization Management Strategy Assessment for Shoreline Protection*. Applied Coastal, 2016.
- *Flood Resilience for Riverine and Coastal Communities*. Building Blocks for Sustainable Communities. Scituate, MA. Next Steps Memorandum. 2016. EPA
- *Natural Hazard Mitigation Plan*. VHB, 2016

I. CLIMATE CHANGE. OUR UNCERTAIN FUTURE

Our climate has always been regulated by gases, including carbon dioxide, methane, and nitrous oxide, that blanket the earth. These gases trap heat that would otherwise be reflected out to space; without them our planet would be too cold to support life. We refer to these gases as "greenhouse gases" (GHGs) for their heat trapping capacity. Changes in GHG concentrations occur naturally, due to such events as volcanic eruptions and variations in solar energy entering the atmosphere.

Figure 1The Greenhouse Effect and global temperature trends.



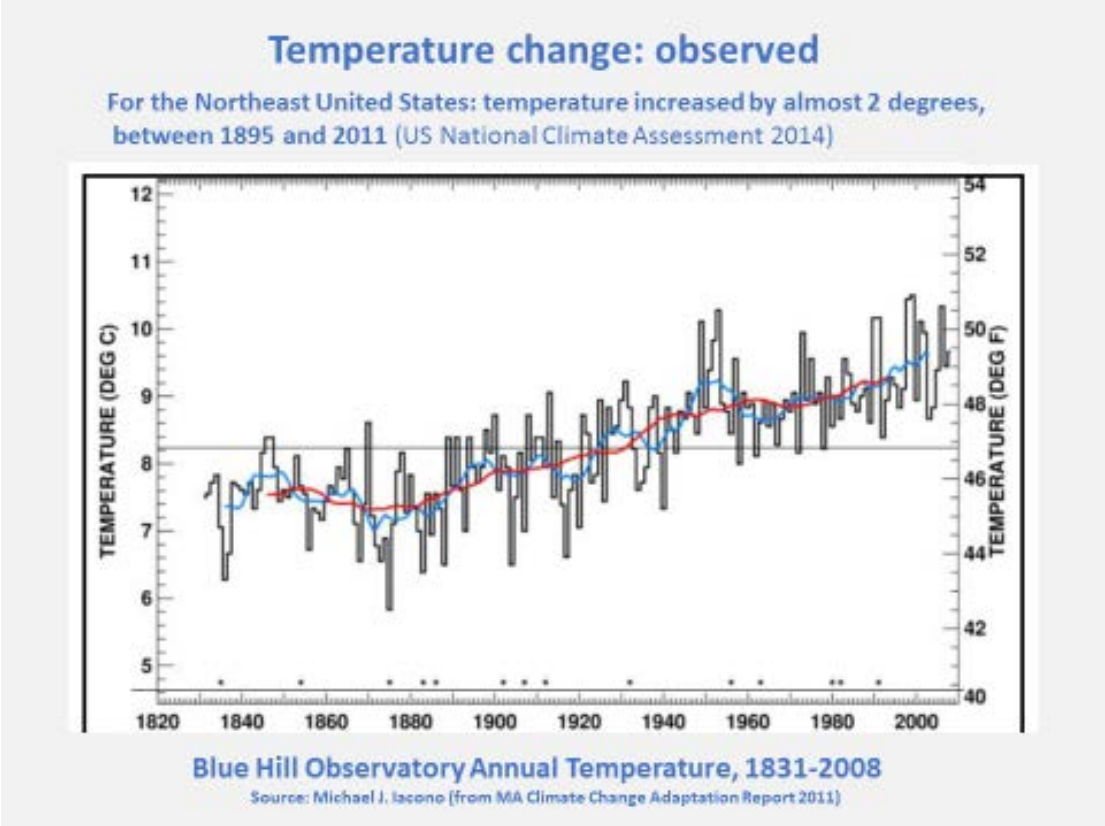


In the past century, human activity associated with industrialization has contributed to a growing concentration of GHGs in our atmosphere. The combustion of fossil fuels, our primary energy

source, releases GHGs into the atmosphere. As shown in Figure1, there is a correlation between increases in carbon dioxide concentrations and global warming and widespread consensus exists among scientists regarding the correlation. [1,2,3]

The following sections will review climate changes that have been observed to date and projections of future changes based upon the best available data. The focus of this report is on impacts relevant to Scituate. We utilize data for the northeast United States, Massachusetts and the Boston region including (i) the UMass Amherst Northeast Climate Science Center's evaluation of the Commonwealth's temperature, precipitation, and sea level rise changes; (ii) Climate Ready Boston "The Boston Research Advisory Group: Climate Change and Sea Level Rise Projections for Boston; (iii) the City of Cambridge, Climate Change Vulnerability Assessment of 2015; and (iv) the US Environmental Protection Agency Climate Change Indicators in the United States, Fourth Edition.

Figure 2 Local Observed Temperature Change.



Climate change observations come from a variety of data sources recorded in recent decades and centuries. Climate change projections, however, model future climate impacts based on data that is not yet observed. As a result, climate projections are generally expressed as a range of possible

[1] Third United States Climate Report (2014) (Chapter 2, page 12)
[2] Statement on Climate Change from 18 Scientific Organizations. (https://www.aaas.org/sites/default/files/migrate/uploads/1021climate_letter1.pdf)
[3] Intergovernmental Panel on Climate Change. *Climate Change 2014 Synthesis Report Summary for Policymakers.*

impacts influenced by the uncertainty of future global GHG emissions and/or land use, natural localized variability in climate, and inherent variations in climate projection models.[4]

Temperature

According to the National Ocean and Atmospheric Administration and NASA, 2017 was the second warmest year on record[5] and according to the EPA's US Climate Change Indicators report, the period from 2006-2015 was the warmest decade since temperature has been measured.[6] Data from the Blue Hill Observatory in Milton (Figure 2) located 28 miles from Scituate, reflects this trend. Future temperature projections for the Northeast indicate an increasing likelihood of heat waves, measured by the likely number of days over 90 and 100. The South Coastal Basin, where Scituate lies, may be cooler than other inland or dense urban areas in the Commonwealth due to the presence of offshore winds and this is demonstrated by differences in temperature projections. The South Coastal Basin could experience 8-13 days over 90˚ by 2030 and 9-57 days over 90˚by the end of the century. Metro Boston may experience 20-40 days over 90˚ by 2030 and 90 days over 90˚ by the end of the century.[7,8,9]

Table 1. South Coastal Basin area (SC) projected increases in average temperature in degrees Fahrenheit.

	Baseline 1961–2010	2030	2050-2070	2090-2100
SC Annual Average	50˚	52˚-58˚	52˚-58˚	53˚-60˚
SC Winter Average	31˚	33˚-35˚	33˚-39˚	34˚-40˚
SC Summer Average	69˚	71˚-73˚	71˚-78˚	72˚-81˚

Source: Northeast Climate Science Center. UMass Amherst. Massachusetts Climate Change Projections. December 2017

In addition to warming summer temperatures, winters are already warming and scientists project that to continue by an increase of 2˚-6˚ in 2030 and an increase of 4˚-12˚by the end of the century.[6,7,8]

[4] Daser, C., Philips, A., Bourette, V. et al. Climate Dynamics (2012) 38:527 https://doi.org/10.1007/s00382-010-0977-x

[5] https://www.washingtonpost.com/news/energy-environment/wp/2018/01/18/2017-was-among-the-planets-hottest-years-on-record-government-scientists-report/?utm_term=.77bff825293d

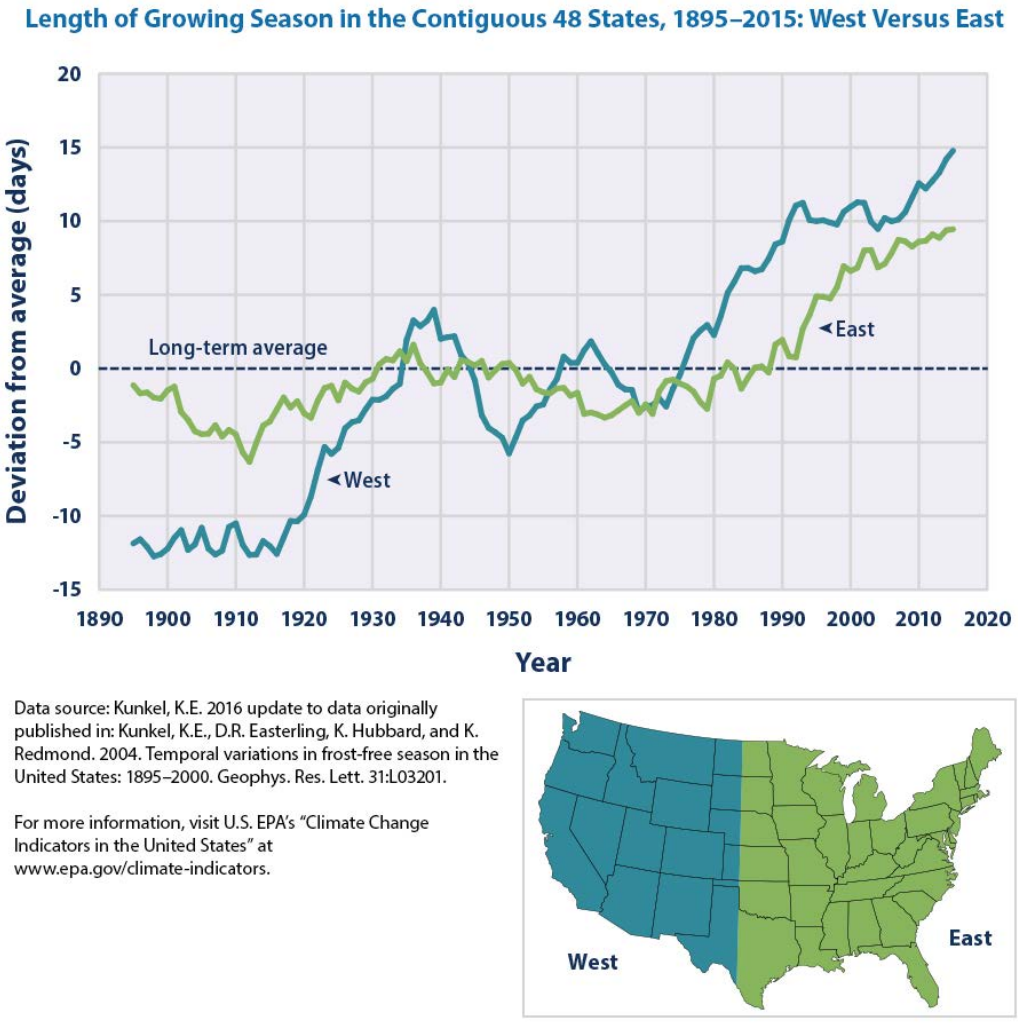
[6] U.S. Environmental Protection Agency. 2016. Climate Change Indicators in the United States, 2016. Fourth meditation. EPA 430-R-16-004. www.epa/gov/climate-indicators.

[7] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

[8] Under RCP 4.5 conditions. City of Cambridge, *Climate Change Vulnerability Assessment*, (City of Cambridge, 2015), http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx cited in BRAG.

[9]Northeast Climate Science Center. UMass Amherst. Massachusetts Climate Change Projections. December 2017

Figure 3 Increased length of days in growing season across the U.S.



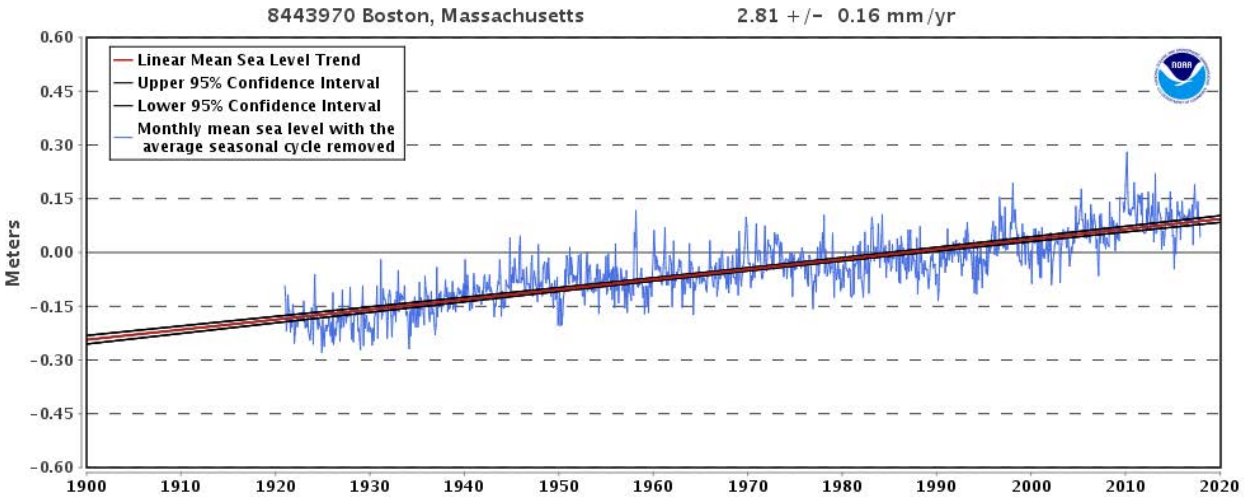
Even small changes in temperatures can have a dramatic effect, such as changing precipitation patterns and extending the growing season.[10] The implications of warmer winters and summers are a shift in the growing season and freeze/thaw cycle for the northeast. The Northeast has already seen a significant deviation from the long-term average growing season beginning in the late 1980s with nearly 10 days longer growing season (Figure 3). Future projected warming translates into a climate similar to North Carolina and Virginia in the[11] or to Alabama in the 2070s.[12] These shifts in temperature will have an important effect on food production, natural systems, species and vector borne disease migration, and public health. In addition, they will affect energy use for heating and cooling.

[10] Northeast Climate Science Center. UMass Amherst. Massachusetts Climate Change Projections. December 2017
[11] Northeast Climate Science Center. UMass Amherst. Massachusetts Climate Change Projections. December 2017
[12] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

Sea Level Rise

Over the last century, sea level rise has increased by 11 inches (Figure 4) and the Boston Research Advisory Group (BRAG) anticipates that the rate of increase will accelerate, anticipating an additional eight inches by 2030.[13,14] Warming temperatures contribute to sea level rise in two ways. First, warm water expands to take up more space. Second, rising temperatures are melting land-based ice which enters the oceans as meltwater. Another minor contributor to sea level rise in New England is a small amount of land subsidence (drop in elevation) in response to the last glacial period. During the last glacial period, pressure from the heavy ice compressed the land causing areas around the glacier to curl upward. With glacial retreat, the land is rebounding to create isostatic balance causing some portions of the east coast to rebound and some areas to subside.[15]

Figure 4 Observed Sea Level Rise.



Boston Tide Station from 1921-2016 which indicates over 11 inches of sea level rise in the last century.

There are several models and projections for sea level rise available. The majority derive results that are relatively similar based upon some key assumptions, such as emission scenarios.
In 2013, Kleinfelder performed sea level rise and storm surge modeling for the towns of Scituate, Marshfield, and Duxbury, projecting scenarios in 25, 50, and 75 years. Sea level rise was estimated using NOAA Technical *Report Global Sea Level Rise Scenarios for the United States National Climate Assessment* (December 2012) and storm surge was modeled using the hydronamic Sea, Lake, and Overland Surge from Hurricanes Model (SLOSH) developed by the National Weather Service. In 2018, we anticipate completion of a more comprehensive SLR and storm surge analysis for Scituate through the Massachusetts Department of Transportation Coastal Transportation Vulnerability Assessment. Comprised of the widely-accepted Advanced Circulation (ADCIRC) probabilistic model,

[13] U.S. Environmental Protection Agency. 2016. Climate Change Indicators in the United States, 2016. Fourth meditation. EPA 430-R-16-004. www.epa/gov/climate-indicators.
[14] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016
[15] Upton, J. Sinking Atlantic Coastline Meets Rapidly Rising Seas. Scientific American. April 2016.

this analysis is a high-resolution, hydrodynamic, probabilistic model that calculates probable future water flows as a result of tides, elevations, waves, winds, rivers, and various storms. It was used in Boston Harbor, called the Boston Harbor Flood Risk Model -(BH-FRM) and is one of the most detailed projections for coastal flooding available.[16] Finally, the Northeast Climate Science Center at UMass Amherst completed a SLR analysis for the Commonwealth in December 2017. This analysis is based upon the one used for Boston Harbor in *Climate Ready Boston* and a method recently used in Southern California.[17] This is a probabilistic model that projects changes in sea level based upon existing tide gauges. For Scituate, the closest analysis is the Boston tide gauge.

Table 2. Total Relative Sea Level Rise projections in Boston and South Shore for the "Highest" emission scenarios.

	2030	2050	2070	2100
Boston BH_FRM [18]	8.00 in	1.50 ft.	3.10 ft.	7.40 ft.
South Shore [19]	8.04 in	1.85 ft.	3.39 ft.	6.52 ft.
Boston Tide Gauge[20]	0.4-0.9 ft	0.8-1.5 ft	1.3-2.4	2.0-4.0

The Kleinfelder model was calculated using the "highest" emission scenario as directed through consensus with the municipalities and other local and statewide experts. The other models report both medium and high emission scenarios, but the highest emission scenarios are reported for total relative sea level rise in Table 2. The projections completed by the Northeast Climate Science Center vary from the BH_FRM and the Kleinfelder models and further research is likely required to ascertain the differences. For this report, we utilize the Kleinfelder model to analyze vulnerability in response to sea level rise and storm surge.

[16] Bosma, K., Douglas, E., Kirshen, P., McArthur, K., and Miller, S. MassDOT-FHWA Pilot Project Report. Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options for the Central Artery. June 2015.
[17] Northeast Climate Science Center. UMass Amherst. Massachusetts Climate Change Projections. December2017.
[18] Douglas, E.M., Kirshen, P.H., Bosma, K., et al. 2017. Simulating the Impacts and Assessing the Vulnerability of the Central Artery/Tunnel System to Sea level Rise and Increased Coastal Flooding. J Extreme Events 3 (4): 1650013 (28 pages).
[19] *"Sea Level Rise Study. The Towns of Marshfield, Duxbury, Scituate, MA". 2013. Kleinfelder.*
[20] Northeast Climate Science Center. UMass Amherst. "Massachusetts Climate Change Projections". December 2017

Precipitation

In the last 50 years, precipitation in the Northeast US increased 71% in the amount of rain that falls in the top 1% of storm events.[21] Projections for future precipitation suggest an increase in total precipitation, changes in precipitation patterns, and increased frequency of extreme storms such as hurricanes and nor'easters. Local precipitation projection models indicate that the frequency of these events and the amount of precipitation occurring during these events is likely to increase. For example, a 100-year storm is defined as a storm that would have a 1% chance of occurring in any given year. Historically this could create 8.9 inches of rain, but models project that amount could increase to10 inches of rain by 2044 and 11.7 inches of rain by 2084 (Figure 5).[22]

What is a "100-year" flood?

The term "100-year flood" is shorthand for a flood that has a 1% chance of happening in a given year. In reality, a 100-year flood could occur two years in a row, or not at all for 100 years. But each year, there is a 1% chance it will occur.

The 0.2% chance flood = 500-year flood
The 1% chance flood = 100-year flood
The 2% chance flood = 50-year flood
The 10% chance flood = 10-year flood

The 100-year flood zone is the location where there is a 1% chance of flooding each year. In the 500-year flood zone there is a 0.2% chance of flooding each year.

The actual amount of increased precipitation or number of extreme weather events per year is difficult to project into the future.[23,24] However, the Northeast Climate Science Center does report an anticipated increase in rainfall for Massachusetts in the spring and winter months and their climate projection models suggest that the frequency of high-intensity rainfall events will also increase.[25] Consequently, warming temperatures can cause greater evaporation in the summer and fall as well as earlier snowmelt,[23] leading to periods of drought or extreme snowfall. The Northeast Climate Science Center projects a small decrease in average summer precipitation into the century; this combined with projected higher temperatures could increase the frequency of episodic droughts.[23] Finally, scientists anticipate the Boston region will continue to experience significant snow events through 2100,[20] though at this time, winter precipitation will be more rain than snow due projected warmer winters.[23]

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[21] Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz, 2014: Ch. 16: Northeast. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 16-1-nn.

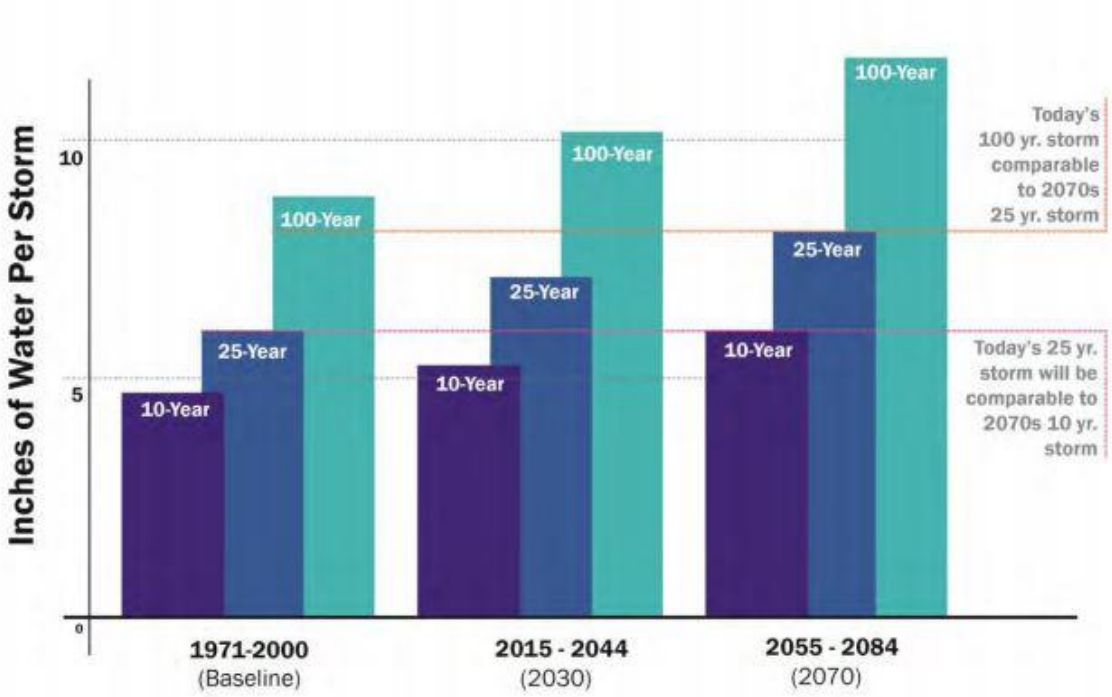
[22] City of Cambridge, *Climate Change Vulnerability Assessment*, (City of Cambridge, 2015), Temperature and Precipitation Projections (http://www.cambridgema.gov/CDD/Projects/Climate/~/media/A9D382B8C49F4944BF64776F88B68D7A.ashx)

[23] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

[24] Horton, R., G. Yohe, W. Easterling, R. Kates, M. Ruth, E. Sussman, A. Whelchel, D. Wolfe, and F. Lipschultz, 2014: Ch. 16: Northeast. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 16-1-nn

[25] Northeast Climate Center UMass Amherst. Massachusetts Climate Change Projections. December 2017.

Figure 5 Precipitation Projections.



Precipitation projections. Modeling from Kleinfelder and ATMOS indicates more rain in any given storm event above the baseline into the end of the century. Source: Cambridge Climate Vulnerability Assessment 2015. Kleinfelder based on ATMOS projections November 2015

II. VULNERABILITY ASSESSMENT

This climate vulnerability assessment is an effort to determine which Scituate community assets – people, places, infrastructure, and economy – may be susceptible to harm from climate change. Climate vulnerability assessments generally consider:

- Exposure – whether climate changes will have a negative effect on various assets in the community.
- Sensitivity – if affected by climate change, how much damage, or loss of function will occur.
- Adaptive Capacity – sensitivity will be lessened, or heightened, by the degree to which there may be ways for the community to cope, compensate, or be modified, to adjust to climate changes.

Once vulnerabilities are identified, Scituate can prioritize climate actions (Part III) and capital investments according to the perceived risk they present. Generally, this involves considering the probability of damage to an asset and the consequences of damage. As an example, flooding to a sewer pump station and a public park might be equally likely, but the pump station would presumably have higher priority as the consequence of failure is more severe.

Overall, projected climate impacts do not create new concerns, rather they are an intensification, increased frequency, or geographic expansion of existing challenges. Scituate already has significant planning, experience and expertise to bring to these challenges. Further, many initiatives to address climate impacts provide benefits to the Town (tree planting, open space preservation), can help address obligations (MS4 permit compliance), or combat already identified problems (coastal flooding).

Although disruptive storms may occur at any time, most of the predicted climate changes are happening relatively slowly over time. Identifying future vulnerabilities now gives Scituate has time to plan and enact programs, policies, and projects that ensure a more resilient community in the future.

Social Vulnerability

Just as some geographic areas in Scituate will be more vulnerable to climate impacts than others, climate change will not affect all residents of Scituate equally. In the context of climate change, vulnerable populations include those who may be more susceptible to climate impacts, and those who will have more difficulty adapting to, preparing for, and recovering from extreme weather events. "Social vulnerability" refers to characteristics such as income, age, health, race/ethnicity and proximity to environmental hazards, which influence vulnerability to climate change. Demographic information helps identify those residents that may be most vulnerable to climate change. It can also provide opportunities to build stronger community cohesion to enhance resilience.

Scituate's population is 18,133 which has grown slightly since 2000 and is expected to continue to grow (Figure 6). According to the 2010 Census, 17.2% of the population is over the age of 64 and 5.3% is under the age of five, two age groups typically identified as being higher risk to extreme weather events. Further, 24% are single-household residences and 41.1% are single female

Figure 6 Scituate's current population and projections.

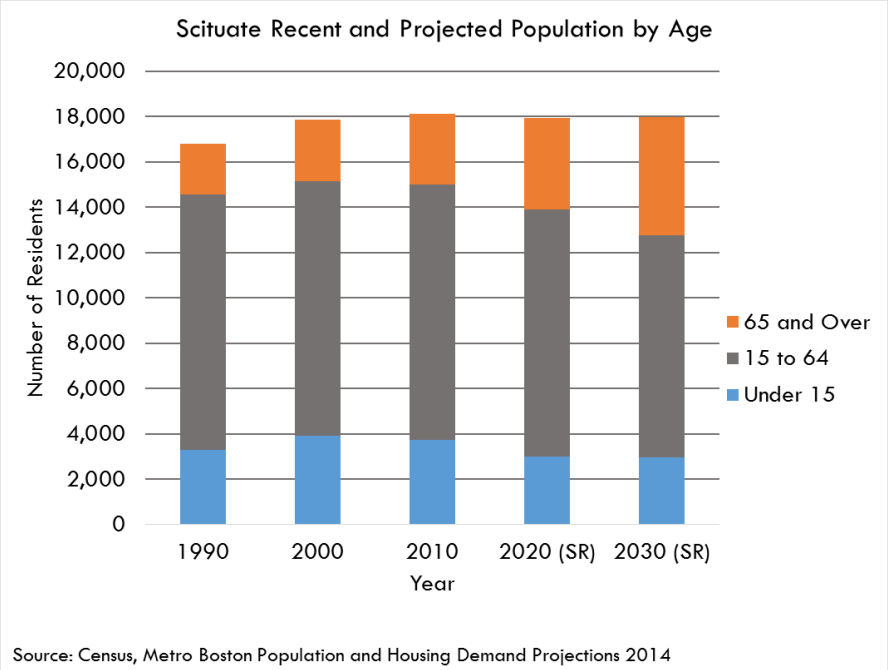
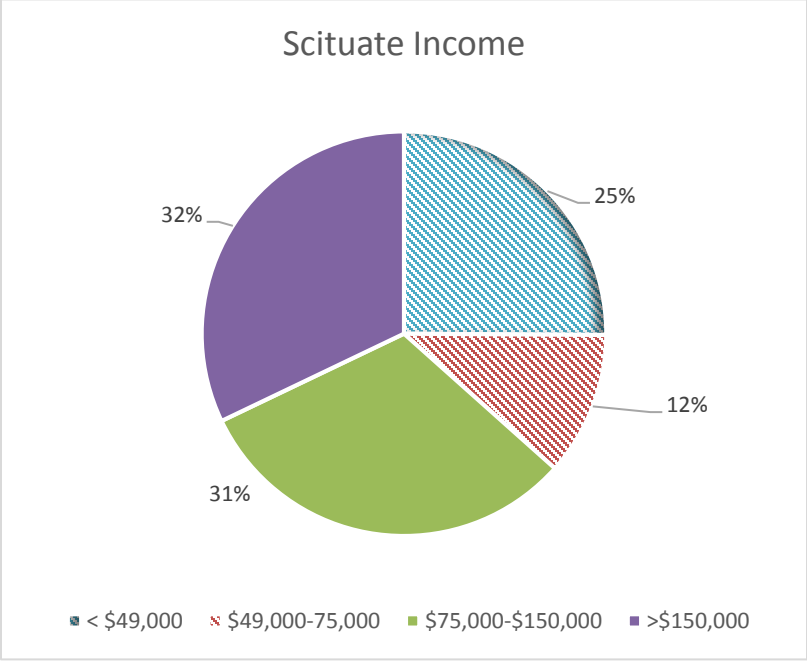


Figure 7 Scituate's residents' income.



households with their own children under 17. Scituate has a nominal population of people of color with 96% of residents identifying themselves as white. Other ethnicities include 1% Black, 1% Asian, and 2% other races. Consequently, we found no data suggesting Scituate has "limited English speaking" or "Linguistically isolated" households. Ninety-six percent of residents speak English only, but other spoken languages include Spanish, Indo-European, Asian and Pacific Islander. Twenty-five percent of residents are considered low income in Scituate with less than $49,000 annual income (Figure 7).
Based upon these demographics, we suggest low income residents, citizens over age 64, single households with children, and people of color may be at greater risk to the impacts of climate change.

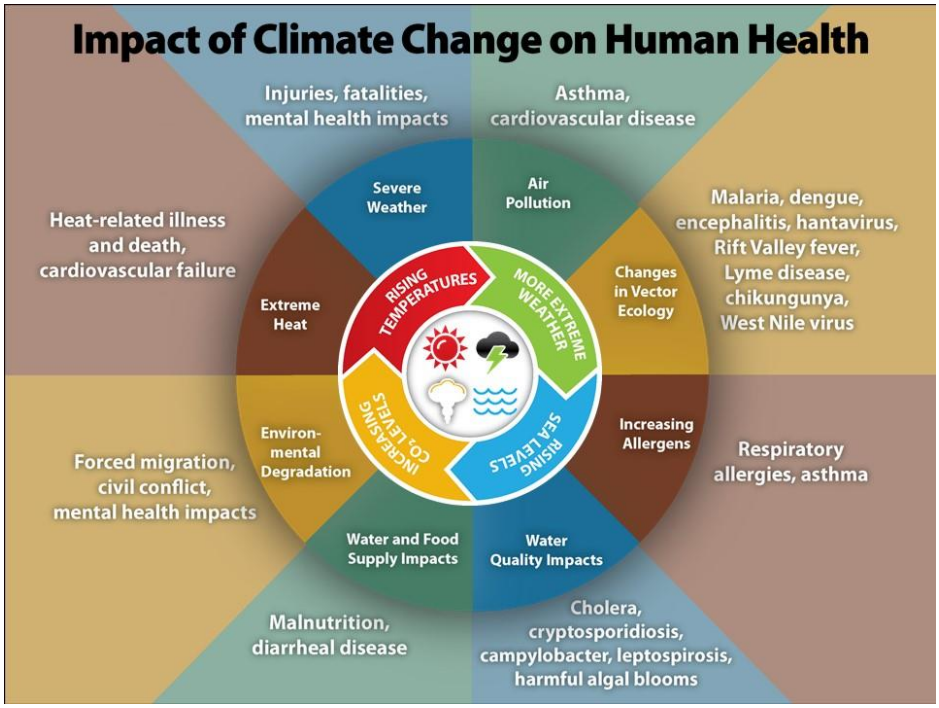
Addressing the needs of seniors and all its residents in extreme weather is one Scituate's greatest strengths. Scituate has one of the first recognized Community Organized to Aid in Disasters under the Commonwealth of Massachusetts Volunteer Organizations Active in Disaster, called SANDS. Recognized by FEMA for their emergency response efforts during Juno in 2015, SANDS assist in providing pre and post disaster recover for its residents. For example, they connect teens to seniors for shoveling. Also connect seniors to shelter during extreme heat events.

Humarock contains a higher population of seniors, who are at risk not only to coastal flooding but also extreme heat. Seniors over the age of 65 are the most likely at risk because of potentially declining health or chronic health conditions, fixed-income, and changes in social factors such as isolation. With fixed income, seniors (also low-income individuals) may have more limited access to healthcare services or be under-insured. After extreme weather events, they may be more susceptible to financial shocks having long-lasting impacts on financial security, securing safe shelter and meeting medical needs. Furthermore, they may have access to transportation, impairing their ability to relocate to emergency shelters or away from areas susceptible to climate impacts. Seniors may also have physical mobility constraints and may require special assistance with emergency response. However, Scituate is already providing extensive services through its Council on Aging and our community-based disaster relief organization called SANDS. The Council on Aging connects with seniors during extreme weather events and provides rides to shelters if requested.

Public Health Vulnerability

Climate change creates risks to public health, and those health risks are likely to increase in the future. The Center for Disease Control and Prevention illustrates in Figure 8 the intersection of climate change, impacts to human health and health outcomes as a result of exposure. In this section, we identify some of Scituate's important public health vulnerabilities and strengths in relationship to a changing climate.

Figure 8 Climate impacts and health outcomes roadmap.



Source: Centers for Disease Control and Prevention (https://www.cdc.gov/climateandhealth/effects/default.htm)

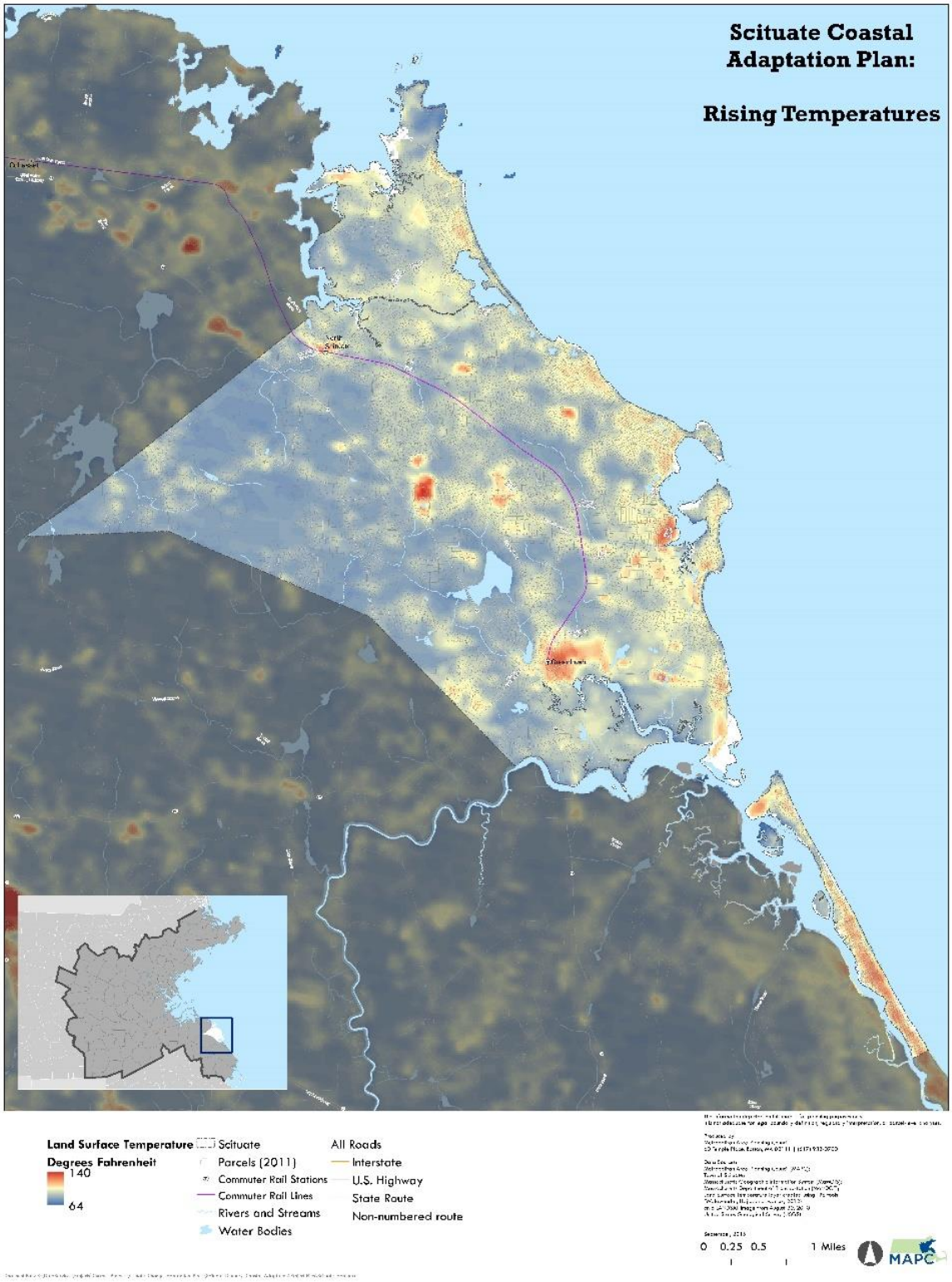
Extreme Heat

The projected increase in extreme heat and heat waves is the source of one of the key health concerns related to climate change. According to the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Association (NOAA), heat was the leading cause of weather fatalities in the United States from 1987-2016.[26] As noted earlier, scientists project up to 90 days over 90°F, and up to 28 days over 100°F annually, by the end of this century.

MAPC uses LANDSAT satellite data, a 30m downscaled average of land surface temperature every 16 days, during late June/July to locate heat islands. Heat islands are areas whose surface temperature are elevated in comparison to its surroundings because of land use or infrastructure such as impervious surface of lack of tree cover. Figure 9 illustrates the heat islands in Scituate.

[26] National Oceanic and Atmospheric Association, National Weather Service. Office of Climate, Water and Weather Services. 2-15.

Figure 9 Scituate heat islands.

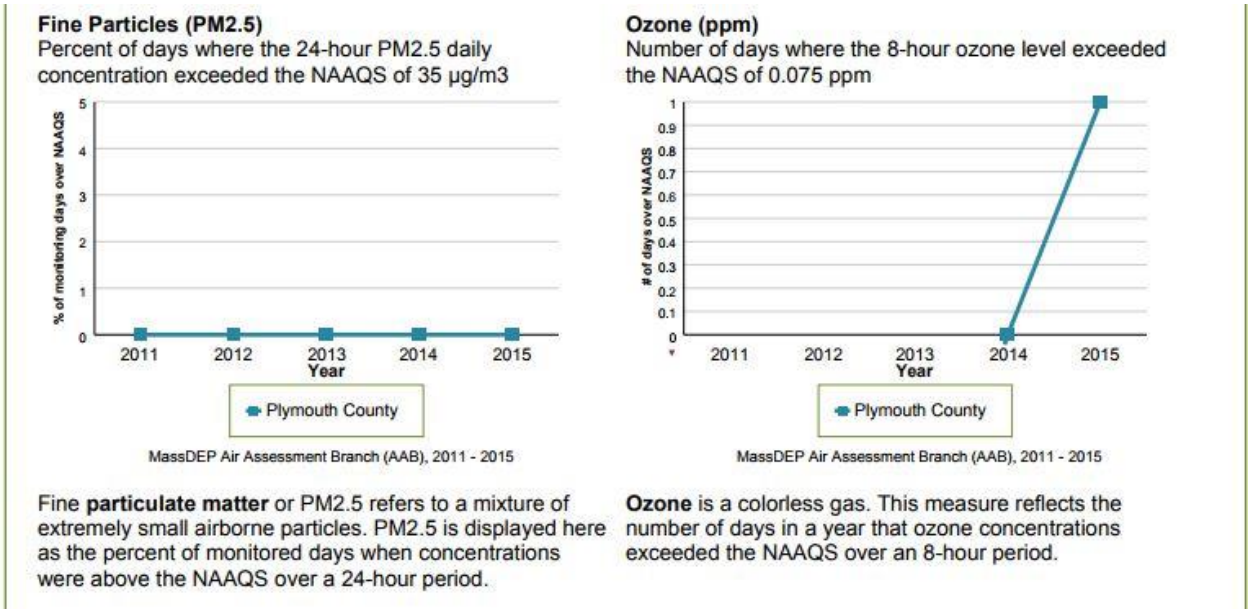


MAPC identifies heat islands using LANDSAT satellite data with elevated daytime land surface temperature (LST) during late June/early July. This data provides a 30m downscaled average of land surface temperature every 16 days.

Areas most vulnerable to extreme heat include Humarock, the Town Center including Town Hall and Scituate High School, the retail/commercial area on Front Street, and the Greenbush Commuter Rail station. Humarock and the Scituate High School areas are of greatest concern.

Humarock has a greater population of seniors. According to the Centers for Disease Control and Prevention, seniors are at particularly high risk to heat for several reasons. They may not adjust to sudden changes in temperature as quickly as younger people, they are more likely to have a chronic medical condition whose symptoms may be exacerbated by heat, and they are more likely to be taking prescription medications that affect their ability to control body temperature.[27,28,29] Vulnerability is increased if there is no access to air conditioning or cooling centers.

Figure 10 Air Quality Assessment in Scituate 2011-2015.



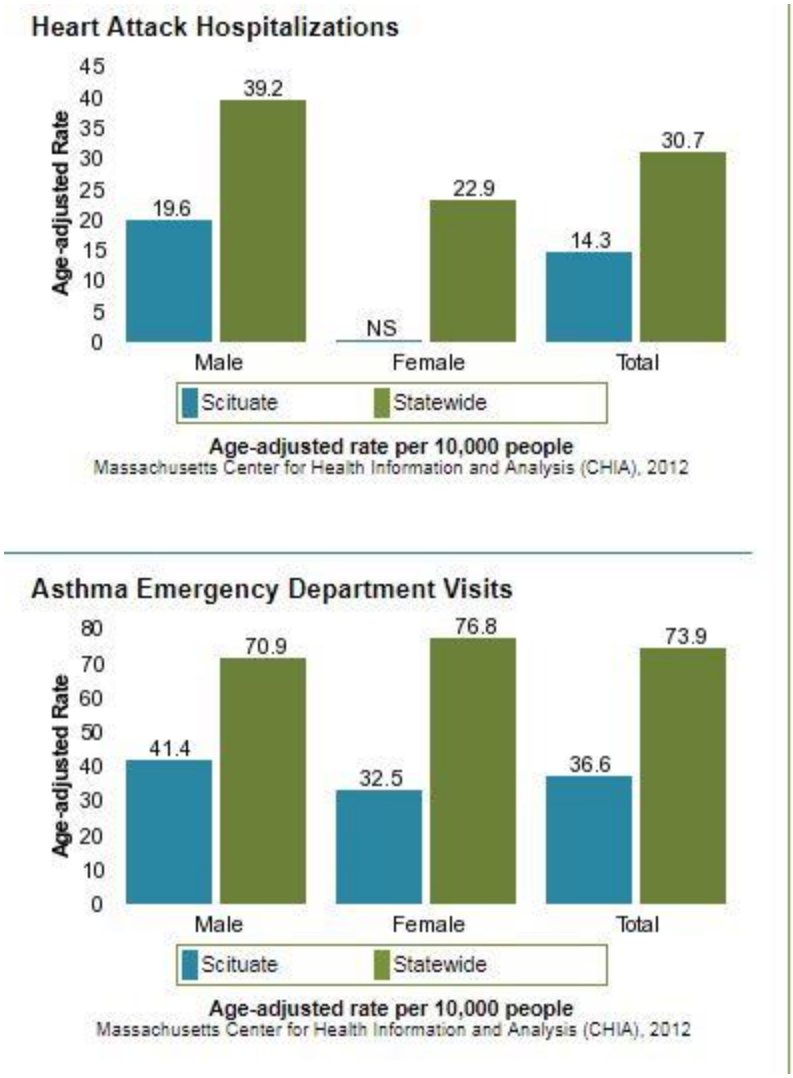
Source: MA Department of Public Health-Bureau of Environmental Health
https://matracking.ehs.state.ma.us/

Extreme heat can affect the general population even outside of heat islands. Individuals who work outdoors are at increased risk for heat-related illnesses. Extreme heat has the potential to contribute to greater levels of ground level air pollution and allergens. Heat helps form by chemical reactions between NOx and volatile organic compounds (VOCs) in the presence of sunlight. Breathing ozone

[27] Center for Disease Control and Prevention. http://www.nws.noaa.gov/om/hazstats.shtml(https://www.cdc.gov/disasters/extremeheat/older-adults-heat.html)
[28] Gamble, J. L., Hurley, B. J., Schultz, P. A., Jaglom, W. S., Krishnan, N., & Harris, M. (2013). Climate Change and Older Americans: State of the Science. *Environmental Health Perspectives*, *121*(1), 15–22. http://doi.org/10.1289/ehp.1205223
[29] Center for Disease Control and Prevention. Natural Disasters and Severe Weather. https://www.cdc.gov/disasters/extremeheat/older-adults-heat.html

can irritate the respiratory system, reduce lung function and heighten sensitivity to allergens.[30] Interestingly, in 2015, Plymouth County experienced one day where the 8-hour ozone level exceeded the National Ambient Air Quality Standards (NAAQS), but from 2011-2015 there were zero days during which fine particle daily concentrations exceeded the NAAQS (Figure 10). One indicator of risk to heat is hospitalizations related to chronic cardiovascular and respiratory conditions. Scituate in most cases where data is available has about half less than the State average for asthma and cardiovascular hospitalizations (Figure 11).

Figure 11 Heart attack and asthma hospitalization for Scituate 2012.



Source: MA Department of Public Health-Bureau of Environmental Health
https://matracking.ehs.state.ma.us/

[30] MassDEP, "Ground-Level Ozone," accessed on August 19, 2016, http://www.mass.gov/eea/agencies/massdep/air/quality/aq-ground-level-ozone.html

The youth at the high school may also be at risk with longer exposure to heat during sports and recreation periods. 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. Prolonged heat exposure can also exacerbate pre-existing conditions, including respiratory illnesses, cardiovascular disease, and mental illnesses.

Finally, power failures can occur during heat waves, where intense heat spikes electricity demand and stresses aging infrastructure. This occurred in June 2017 in the Town of Belmont, MA where intense heat caused a spike in electricity demand. With aging infrastructure, the combination of these factors led to equipment failure.[31] Loss of electricity not only impairs a resident's ability to cool but can cause significant medical emergencies for those who require electronic medical life support equipment or from consuming food-borne illnesses from contaminated food, ingested after loss of refrigeration.

Vector Borne Illness

Vector-borne illnesses are those that stem from contact with vectors such as mosquitos and ticks. The spread of vector-borne illnesses is influenced by vector type, weather conditions, built environment conditions, and human behavioral factors. The two most common mosquito-borne illnesses in Massachusetts are eastern equine encephalitis (EEE) and West Nile virus (WNV). There is no reported mosquito species in Scituate to have been found to carry WNV. As climate change is expected to bring heavy precipitation events (which increase areas of standing water) and warmer temperatures, mosquito populations may expand, and the transmission season may extend beyond its traditional late spring through early fall. Warmer temperatures also accelerate a mosquito's lifecycle and increase biting rates.

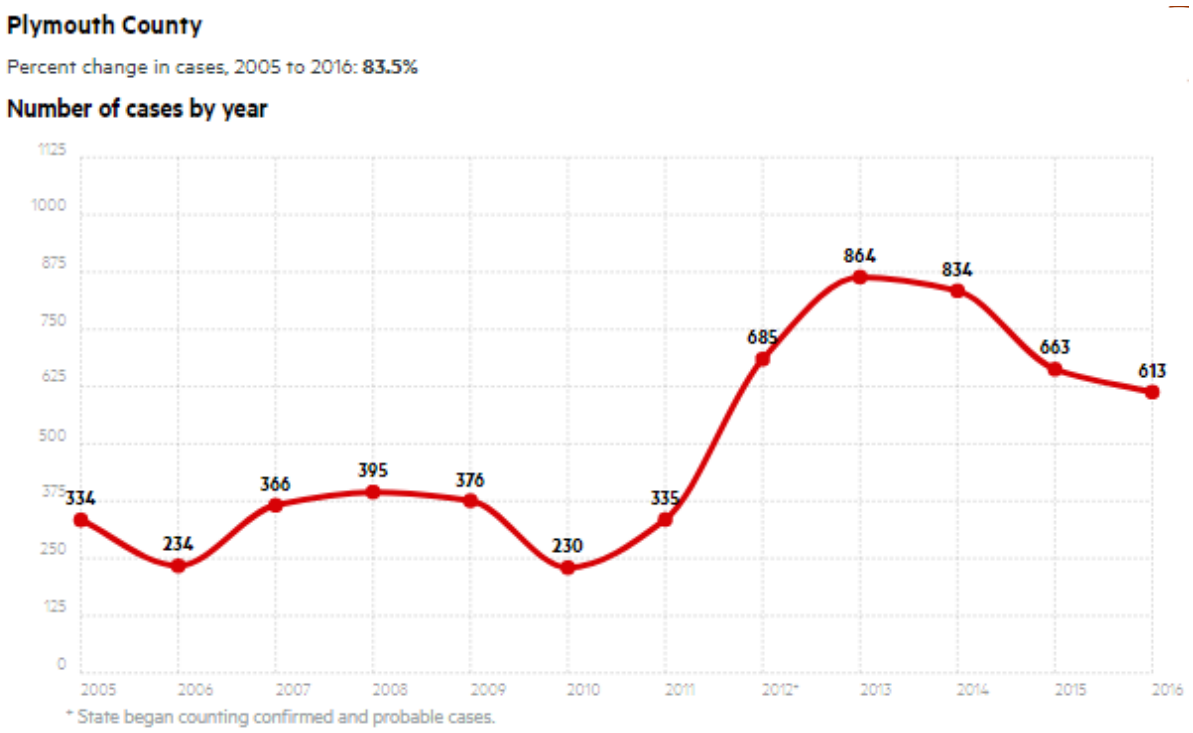
Tick-borne illnesses, particularly Lyme disease, babesiosis, and anaplasmosis have been on the rise in Massachusetts. From 2005-2016, there has been an 83.5% change in cases of Lyme disease in Plymouth County (Figure 12). Winter frost plays an important role in limiting tick populations; warmer winter may lead to more nymphs surviving into the spring months. As with mosquitos, warmer temperatures can lead to longer transmission seasons as ticks begin to seek hosts earlier in the season. Tick populations thrive with increased precipitation and humidity and may be more susceptible to annual fluctuations in precipitation than mosquitos.

Forecasting the spread of vector-borne illnesses and estimating risk due to climate change is very challenging, due to multiple factors at play. For example, research suggests that heavy precipitation in urbanized areas could reduce mosquito populations by flushing underground breeding habitat. Further, vector populations' size and range are dependent on the size and range of their host species (i.e., migratory birds, mice, and deer), which may shift as the climate changes. As the climate gets warmer, tropical vector species may expand their ranges north, which could bring with them vector-borne illnesses not typically found in the Northeast (i.e., dengue fever or chikungunya). As vector-

[31] Wicked Local Belmont "Power Outage in Belmont Affects 2,000 Customers" June 14, 2017. http://belmont.wickedlocal.com/news/20170612/power-outage-in-belmont-affects-2000-customers

borne disease outbreaks occur globally, residents may import vector-borne illnesses acquired during trips to other countries.

Figure 12 Lyme disease incidence in Plymouth County.



Vector Borne-Illnesses Source: Massachusetts Department of Public Health and WBUR "Map: Where Lyme Disease is Worsening in MA." http://www.wbur.org/commonhealth/2017/07/18/massachusetts-map-lyme-disease

People who spend a lot of time outdoors, or live close to vector habitats, are at greatest risk of exposure to vector-borne illnesses. The ability to protect oneself from mosquito-borne illnesses has been associated with socioeconomic status via housing conditions. Households that can afford air-conditioning and maintenance of windows/screens are less likely to encounter mosquitos in their home. Those most likely to experience severe vector-borne illnesses are children, people over the age of 50, and people with compromised immune systems.

Environmental Hazards Exposure

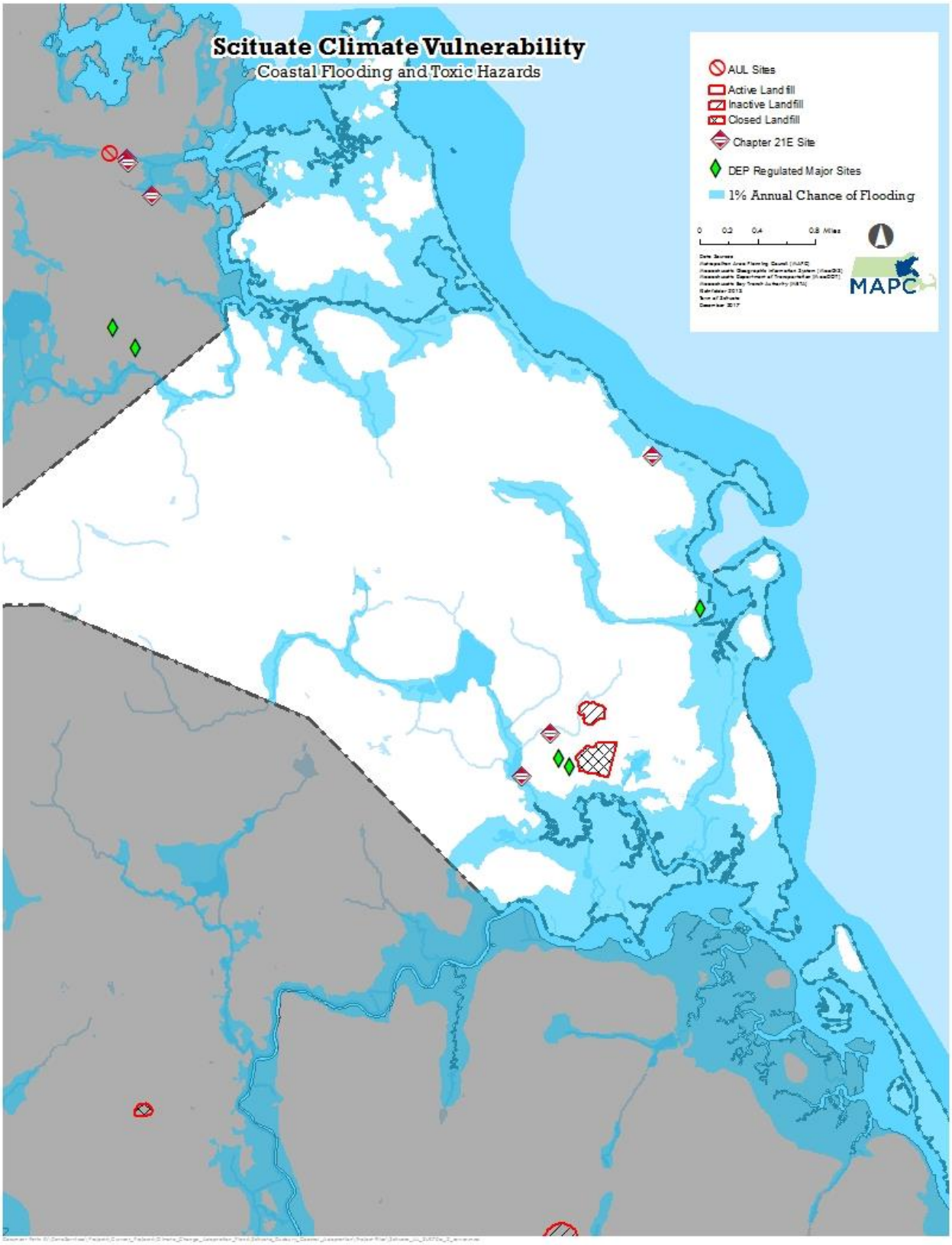
A significant public health risk in the face of extreme precipitation or storm events with subsequent flooding is exposure to environmental hazards and toxins, for both the immediate and long-term. EPA Tier 2 are sites where the release of oil or other hazardous material has occurred and are monitored by the MA Dept. of Environmental Protection (DEP). MA DEP BWP sites are facilities regulated by the MA DEP Bureau of Air and Waste (BWP) because of the presence of large quantities of hazardous waste, hazardous waste treatment, storage and/or disposal facilities, groundwater and/or surface water discharge permits, etc. In an extreme flooding event, potential exposure to these health-

threatening substances can cause water contamination, including bacteria, viruses, and chemicals that cause gastrointestinal diseases, dermatological conditions, toxicity/poisoning, and other illnesses. Often people encounter contaminated water when it floods onto their property but contact with contaminated water through recreation can be dangerous, too. Climate change is expected to increase the risk of residents encountering contaminated water in their parks, homes, schools, and places of work. The Commonwealth of MA in collaboration with MA regional planning agencies is providing training to businesses monitored or regulated for hazardous materials for climate resilience for emergency preparedness and resilient containment.

Figure 13 illustrates Scituate's risks related to potential toxic exposure from flooding. For immediate flooding concerns, there is one site currently in a FEMA 1% Annual Chance Flood Zone that could cause potential release of toxic or hazardous substances if structures and containments were damaged as a result of storm surge or coastal flooding. Other sites adjacent to the 1% include two 21E sites at 69 Kenneth Road and 20 Country Way and the closed and active landfills. There are no toxic sites within projected limits of SLR 2038 or 2088 or within either both those years with a Category 1 Hurricane, except DEP regulated CVS on Front Street.

An additional health concern is posed by mold. Long term risk with more frequent precipitation and/or localized flooding results in water damage to buildings – and the formation of mold. Chronic mold can be an ongoing challenge particularly in public housing, senior housing, and in buildings built before the 1980s. Mold triggers allergies and respiratory illnesses, such as asthma. Some strains of mold release airborne toxins, called mycotoxins, which can cause mold toxicity. Mold toxicity can influence the function of internal organs, the nervous system, and the immune system.

Figure 13 Scituate FEMA flood zones and potential environmental hazards.

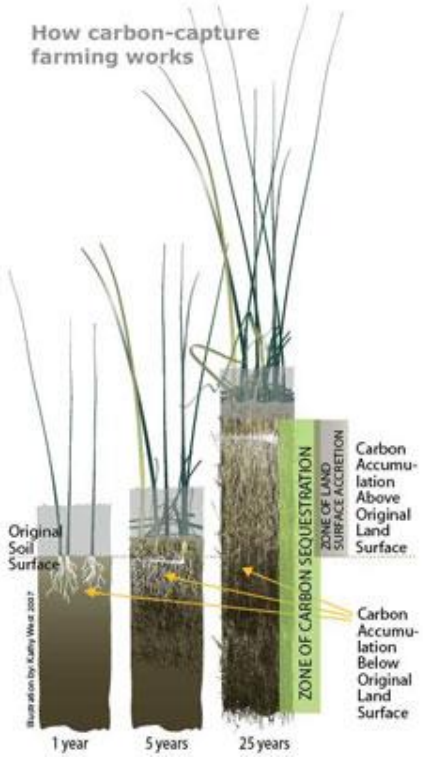


Natural Resources Vulnerability

Scituate is shaped by its seven miles of coastline with steep distinct bedrock headlands and several barrier and pebbly beaches, including Humarock. The Town also has important natural systems and resources providing significant ecological services, recreational amenities, economic drivers, and climate resilience. Of its 12,160 square miles, approximately 3,577 or 30% of the Town is protected open space and 1,340 or 11% is water, such as rivers, lakes, ponds, and streams. Healthy, intact ecosystems provide greater resiliency to the community from flooding, stormwater, and extreme heat while also providing clean air and clean water. However, these natural resources are also vulnerable to erratic and extreme precipitation patterns, sea level rise, ocean warming and acidification, and impacts related to warmer climate such as changes in the freeze/thaw cycle.

Coastal Environment

Extensive vulnerability analysis and recommendations for coastal adaptation to sea level rise and storm surge have been completed for Scituate. This section identifies ecological vulnerably in the coastal environment important to climate resiliency that are not addressed in Scituate's previous climate-related planning efforts.



Salt Marshes

Scituate has approximately 1,600 acres of salt marshes, the most extensive occurring within the sheltered bay (Cohasset Harbor) landward of Strawberry Point. Other marshes include the salt marsh at the North/South River and Kent Street Marshes. Salt marshes and estuaries are complex and highly productive ecosystems generally resilient to wide variations in temperature, salinity, and inundation.[32] Ecological benefits of salt marshes include floodwater storage, storm surge protection, carbon sequestration, nutrient removal and water

[32] Executive Office of Energy and Environmental Affairs and Adaptation Advisory Committee. 2011. *Massachusetts Climate Adaptation Report.*

quality improvements. Healthy marshes also support important commercial fish and shellfish habitat.[33] The sustainability of the system is a delicate balance of complex coastal processes. Salt marshes are typically found in low energy coastal areas; they require consistent tidal inundation but cannot survive if submerged. Salt marshes today are already threatened by several factors: nutrient loading/non-point pollution from stormwater runoff, extreme precipitation events, loss of tidal flow due to insufficient culverts, invasive species and persistent salt water inundation. Salt marshes are protected by the Wetlands Protection Act with a 100-foot buffer and no disturbance regulation. However, historic development has created hardened shorelines that affect the horizontal migration and vertical migration of the salt marsh. With climate change, the deteriorated conditions of many of Massachusetts' salt marshes will be exacerbated with sea level rise, lack of migration area from hardened shores, and extreme precipitation events flushing the salt marsh and creating an environment conducive to invasive species.

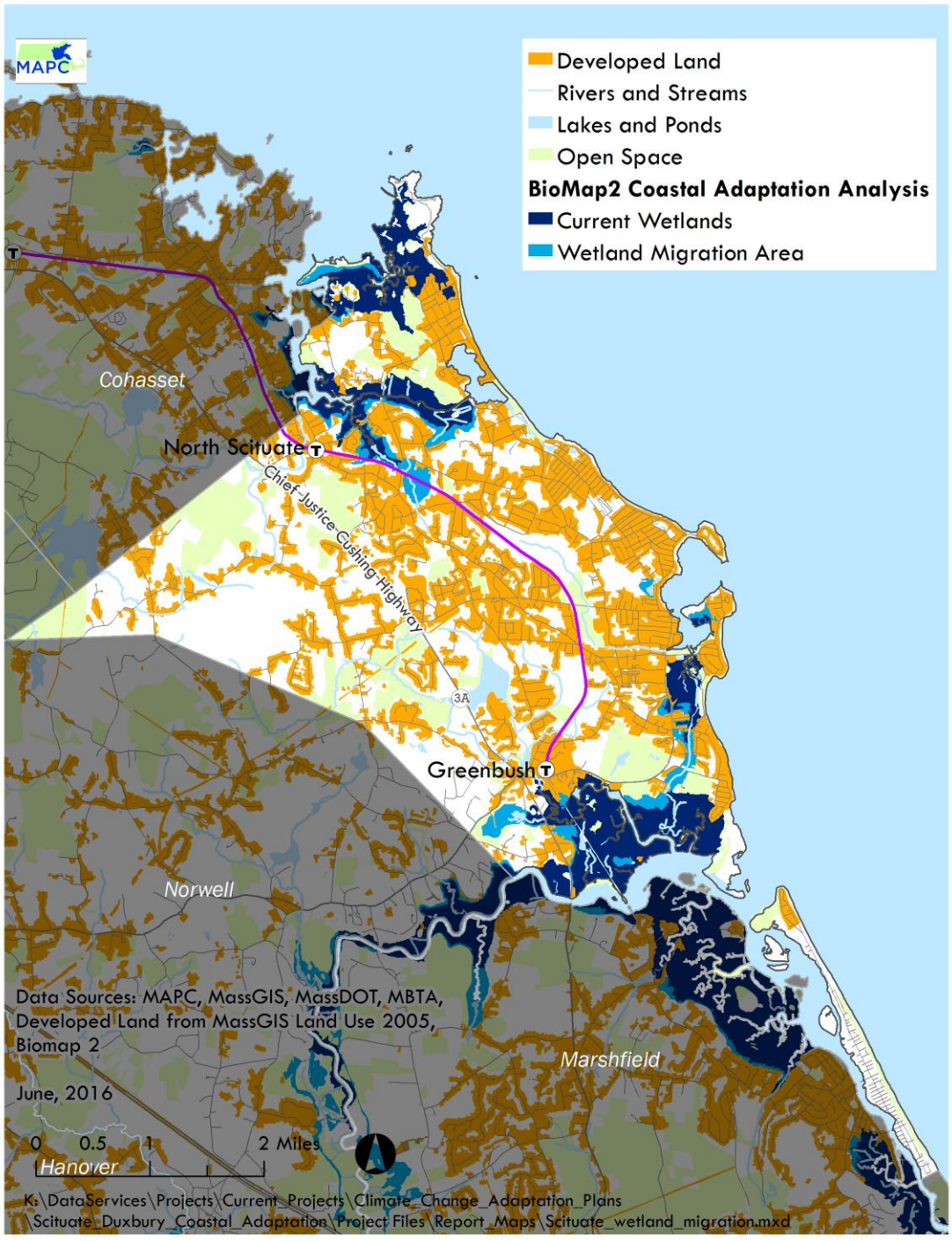
Salt Marsh at North/South River confluence. Photo by Darci Schofield

In Scituate, there is already evidence of marsh deterioration from sea level rise. Mass Bays is an EPA National Estuary Program that facilitates research and partnerships to create more resilient and sustainable estuarine ecosystems. They performed an evaluation of salt marsh grasses/vegetation in the South Shore including North River salt mars5hes, tested at Driftway Park and Scituate Conservation Area in Scituate. At Driftway Park in 2014, there has been an 81% increase in biomass of *Spartina alterniflora* (short saltmarsh cordgrass) in comparison to 2000. At Scituate Conservation, there was a decrease in three different types of high marsh species *Spartina patens* (-3%), *Distichlis spicata* (-11%), and *Iva frutescens* (-3%). The study suggests that salt water intrusion from frequent inundation may be causing the shift in species composition [34]where high marsh salt grasses are less tolerant of high levels of salinity. In this circumstance, the loss of marsh elevation prohibits optimal plant growth, and the salt marsh converts to a tidal mudflat or subtidal open water.

[33] Linda A. Deegan, David Samuel Johnson, R. Scott Warren, Bruce J. Peterson, John W. Fleeger, Sergio Fagherazzi & Wilfred M. Wollheim. Coastal eutrophication as a result of salt marsh loss. 2012. Nature 490: 388-392

[34] Grady, Sara and Mansfield, Alex. Hones, North, and South Rivers Salt Marsh Assessment. Mass Bays Program. January 29, 2015. http://www.mass.gov/eea/docs/mbp/publications/technical-report-jrwa-2014.pdf

Figure 14 Coastal wetland migration areas for climate resilience.



This map illustrates BioMap2 Coastal Adaptation Areas for marsh migration/climate adaptation. The Massachusetts Department of Fish & Game's Natural Heritage & Endangered Species Program (NHESP)

and The Nature Conservancy's Massachusetts Program developed BioMap2 to protect the state's biodiversity in the context of projected effects of climate change.[35]

Some studies indicate that allowing for salt marsh migration, horizontal and vertical, can help build resilience when thin layer deposition occurs at a rate consistent with sea level rise to enable sustainable ecosystem function. Coastal natural buffers for horizontal migration sustain the ecosystem balance of tall (*Spartina alterniflora*) and short (*Spartina patens)* marsh grass habitats. Figure 14 illustrates the Coastal Adaptation Analysis and the geographic extent needed coastal wetland migration. Furthermore, the MA DEP has listed Cohasset Harbor and North River as impaired waters which can further detrimentally impair salt marsh health. Shellfish growing areas are limited in Scituate Harbor and only conditionally approved at the Kent Street Marshes and around Cohasset Harbor.[36] Healthy salt marshes support healthy shellfish growing areas, and the combined interaction of these systems ensures greater resilience and shoreline protection for Scituate in the face of rising seas and warmer temperatures.

Bays

Cohasset Cove and Scituate Harbor are robust amenities to the Town of Scituate, seasonally active with boating, sailing, fishing, educational programs and tourism. In 2008, there were 1,200 recreational boaters during the summer and over 200 boat slips in the harbor.[37] The integrity of the bay ecosystem is critical not only as an economic and recreational asset but also in providing coastal resilience as it supports living shorelines already protecting Scituate's coast. However, there are several climate change risks that will have important effects on future resilience.

Table 3. Water Quality Impairments

Waterbody	Category		Impairment
Musquashcut Pond	5		Excess Algal Growth, Flow Regime Alterations, Dissolved O_2 saturation, Chlorophyll-a, Phosphorus, Fecal coliform.
Cohasset Harbor	5		Fecal coliform (no shellfish harvesting)
Aaron River Reservoir	4a		Mercury in fish tissue (atmospheric), fish passage barrier
North River	5		Fecal Coliform (not supporting shellfish harvesting)
South River	5		Fecal Coliform -Discharges from MS4 (no shellfish)
Herring River	5		Fecal Coliform-Municipal Point Source Discharges

Source: ENSR International, Massachusetts DEP, and US EPA New England Region 1. Final Pathogen TMDL for the South Coastal Watershed. Aguste 2014. CN 0255.0

[35] https://www.mass.gov/files/documents/2016/08/wi/biomap2-summary-report.pdf
[36] Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services
[37] Horsley Witten Group. Town of Scituate Open Space and Recreation Plan. February 2009.

The bays host important tidal flats that sustain a productive shellfish growing areas, seagrass, anadromous fish, and resident and migratory birds, some of which are threatened or of special concern. BioMap2 is a program created by the MA Department of Fish and Game Natural Heritage and Endangered Species Program (NHESP) and The Nature Conservancy to map important natural resource areas that will protect biodiversity and the nature of Massachusetts in the face of climate change.[38] Aquatic Cores are intact river corridors whose ecological processes are critical to supporting fish species and other aquatic Species of Conservation Concern as well are providing a myriad of important wetland ecosystem functions. The Spit and portions of the North and South River are NHESP designated Aquatic Core Habitat, an approximately 9,998-acre expanse which extends into Norwell and Marshfield along the North and South Rivers. This Aquatic Core supports 17 rare and uncommon species, including the globally rare Piping Plover, Common and Least Terns. This Core Habitat also contains the uncommon, structurally-diverse Freshwater Tidal Marsh and uncommon Fresh/Brackish Tidal Swamp. Further, there is designated Tern foraging habitat from Humarock, The Spit, to Scituate Bay and Cohasset Bay.[38]

Despite their significance, these waterbodies are also at risk to ecosystem loss and impairment from a variety of factors. Table 3 lists impaired waters from the 2014 "Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act." Scituate Harbor, Cohasset Bay and Musquashcot Pond are all designated as Category Five requiring Total Daily Maximum Loads (TDML), an EPA designation that establishes the maximum pollutant amount in a water body and serves as a planning tool for restoring water quality.[39] These water bodies also have use-restrictions such as limitations on shellfish harvesting from the presence of fecal coliform.

Since 1995, the MA Department of Environmental Protection has evaluated submerged aquatic vegetation at regular intervals, the majority of which is eelgrass (*Zostera marina)*. Though Scituate's bays have some impairment, they are supporting important eelgrass meadows. In 1995, Cohasset Bay contained approximately 125 acres and Situate Bay contained approximately 12 acres of eelgrass.[40] There has been a decline from 2010 in the meadow extent in some areas in Cohasset Bay and while other meadows have expanded when evaluated in 2012 (Figure 15). Seagrass/eelgrass meadows provide important ecological and climate resilience benefits. They capture sediment and take up nutrients ultimately providing better water clarity and provide important habitat for fish.[41] Importantly, eelgrass meadows will dissipate wave energy and wave height thereby reducing shoreline erosion.[42]

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[38] Natural Heritage and Endangered Species Program. Conserving the Biodiversity of Massachusetts in a Changing World-Scituate. 2012. http://maps.massgis.state.ma.us/dfg/biomap/pdf/town_core/Scituate.pdf

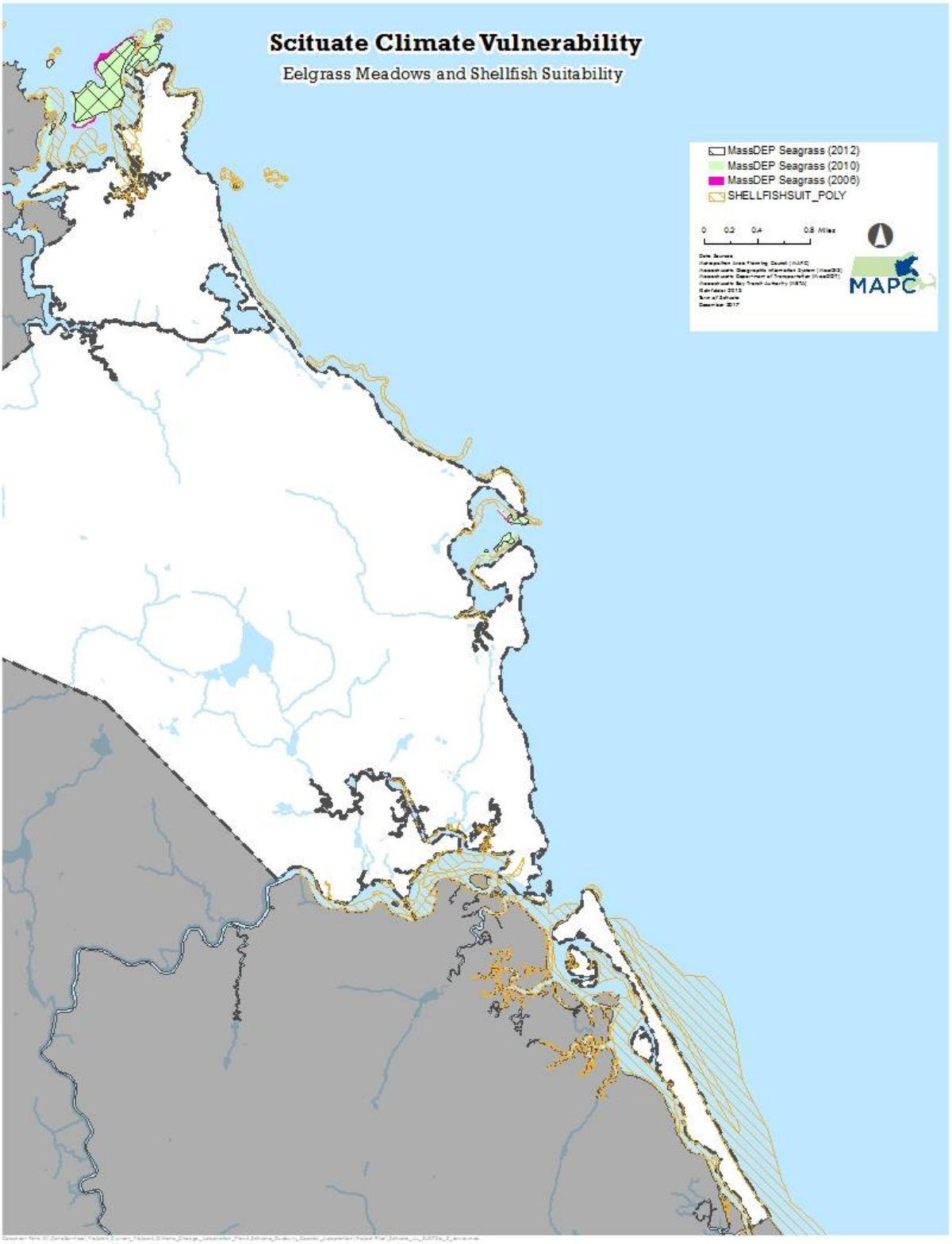
[39] https://www.epa.gov/tmdl

[40] Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services. http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/eelgrass2013.html

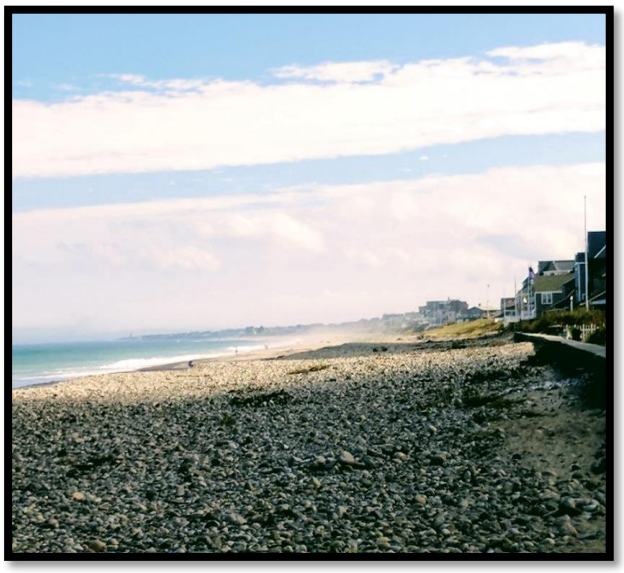
[41] Bjork, Mats; Short, Fred, Mcleod, Elizabeth, and Beer, Sven. 2008. Managing Seagrasses for Resilience to Climate Change. IUCN, Gland, Switzerland. 56pp

[42] Bradley, Kevin and Houser, Chris. 2009. Relative velocity of seagrass blades: Implications for wave attenuation in low-energy environments. Journal of Geophysical Research, Vol 114 F01004

Figure 15 Scituate eelgrass and shellfish suitability areas.



Eelgrass decline can be attributed to many factors such as pathogens, boating, and nutrient loading from stormwater, sewer systems, and fertilizers.[43] Sea level rise, warming ocean temperatures and increased runoff from extreme precipitation could also put these important ecosystems at risk.



Humarock Beach. Photo by Darci Schofield

Other future impacts of climate change to Scituate's Bays are ocean acidification and warmer temperatures. Oceans capture excess carbon released into the atmosphere through the burning of fossil fuels. The carbon when dissolved forms carbonic acid, ultimately affecting the typically basic pH levels in the ocean and causing acidification. Future ocean acidification may cause shellfish larvae to create smaller shells or not develop them at all[44] or reduce shellfish reproduction and growth rates. There is enough concern that Massachusetts Bays is seeking to install an ocean acidification monitor at the Mattakeeset Public Boat Launch in Duxbury.[45]

Increasing ocean temperatures locally can detrimentally affect ecosystem function, causing species migration, potential introduction of new pathogens, and harmful algal blooms.[46] In the last three decades, sea surface temperatures have been higher on average than over the last century, or ever since being recorded.[47] The MA Department of Public Health in partnership with the Department of Fish and Game and Division of Marine Fisheries, is monitoring pathogenic marine micro-organisms related to foodborne illness. There is a reported increase in *Vibrio parahaemolyticus* (Vp) whose geographic distribution has shifted to Massachusetts because of warming ocean temperatures. Vp is a naturally-occurring bacterium found in warm, brackish waters and its presence has caused strict regulation on oyster harvests as it causes illness when consumed in raw oysters.[48]

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[43] Short, Fred; Klein, Anita; Burdick, David; and Moore, Gregg. 2012. The Eelgrass Resource of Southern New England New York: Science in Support of Management and Restoration Success. NOAA Restoration Center Community-based Restoration Program. OMB Approval 0648-0472.

[44] Waldbusser, George G. et al. 2015. Saturation-state sensitivity of marine bivalve larvae to ocean acidification. Nature Climate Change 5, 273-280

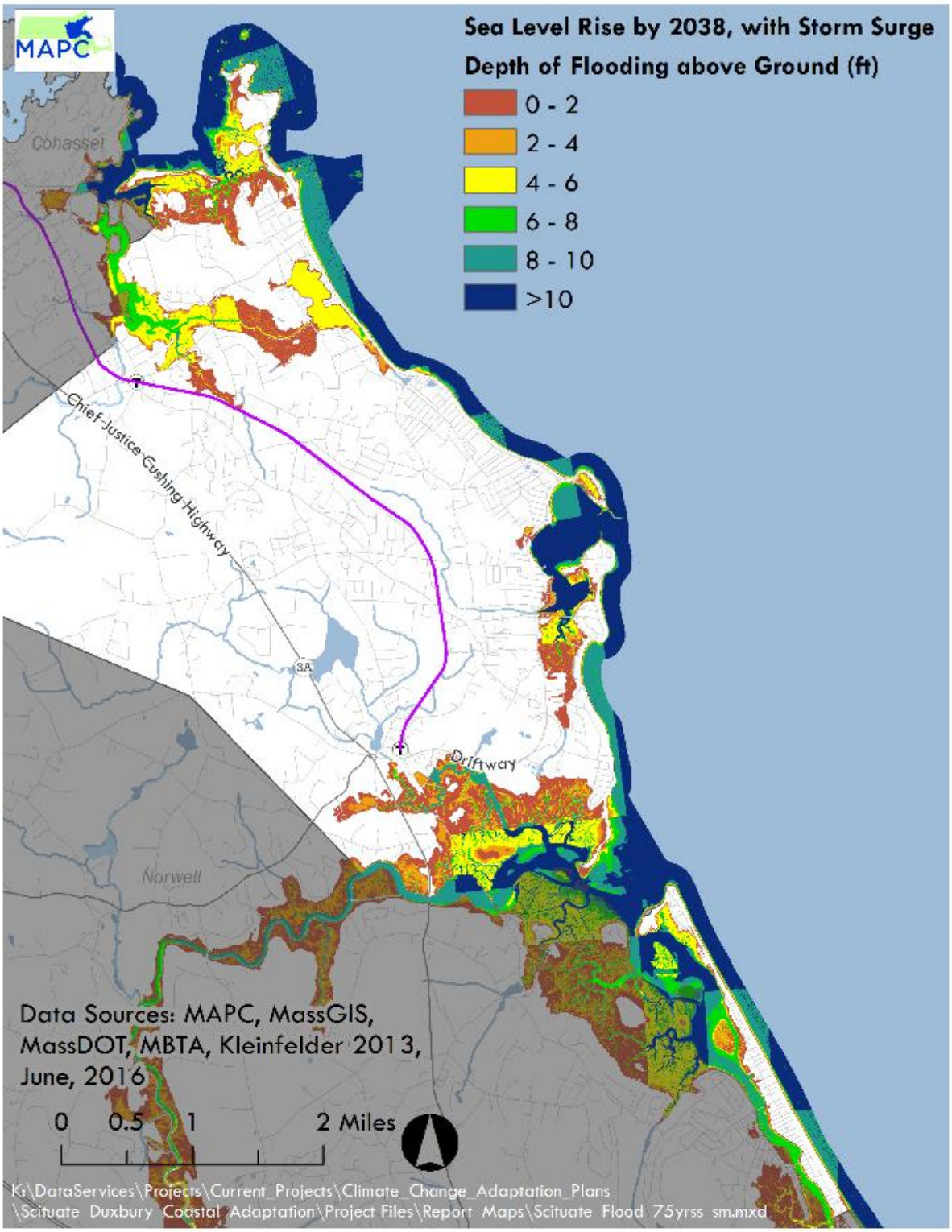
[45] Personal Communication. Sara Grady, South Shore Regional Coordinator, MassBays

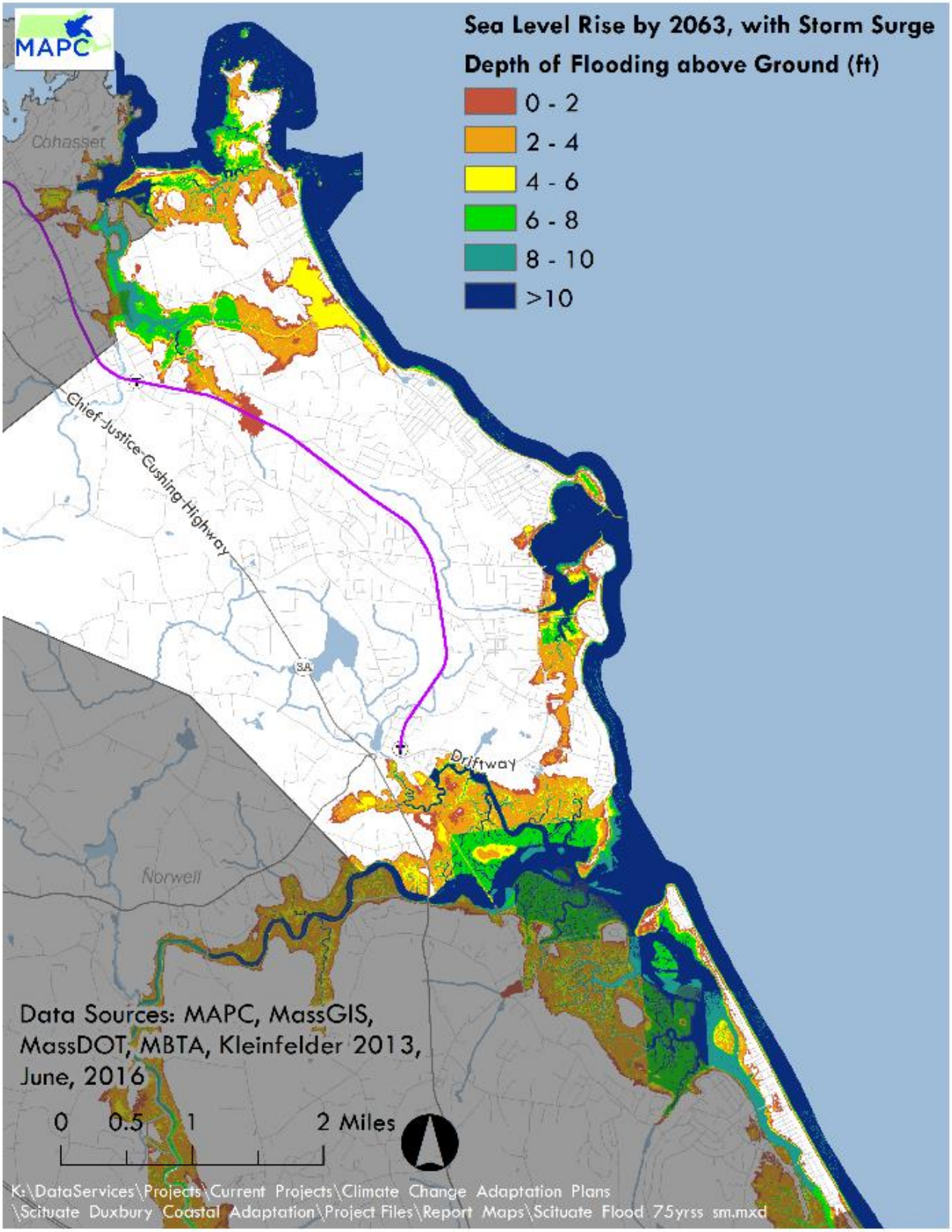
[46] Executive Office of Energy and Environmental Affairs and Adaptation Advisory Committee. 2011. Massachusetts Climate Adaptation Report.

[47] National Oceanic and Atmospheric Administration. 2016 Indicators. http://www.globalchange.gov/browse/indicators/indicator-sea-surface-temperatures

[48] Department of Fish and Game. Massachusetts Division of Marine Fisheries Annual Report 2016.

Figure 16 Sea Level Rise 2038 and 2063 (Kleinfelder 2013).




MAPC
Sea Level Rise by 2063, with Storm Surge
Depth of Flooding above Ground (ft)
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
>10
Cohasset
Chief Justice Cushing Highway
3A
Driftway
Norwell
Data Sources: MAPC, MassGIS, MassDOT, MBTA, Kleinfelder 2013, June, 2016
0
0.5
1
2 Miles
K:\DataServices\Projects\Current Projects\Climate Change Adaptation Plans\Scituate Duxbury Coastal Adaptation\Project Files\Report Maps\Scituate Flood 75yrss sm.mxd

Barrier Beaches

Scituate contains several important barrier beaches, important not only for their recreational amenities but also for building and maintaining coastal resilience. Beaches in Scituate include Minot Beach, North Scituate Beach to Egypt Beach, the barrier beach between First and Second Cliff, Peggotty Beach, The Spit, Fourth Cliff, and Humarock, one of the largest barrier beaches in Massachusetts. Applied Coastal Research and Engineering, Inc. in 2016 provided an important assessment of horizontal and vertical migration and loss to many of these beaches as well as recommendations for stabilization and management strategies for shoreline protection. Barrier beaches are a critical first line of defense for storm surge providing wave attenuation and energy dissipation, thereby protecting coastal infrastructure. However, many of the natural features of Scituate's beaches and barriers effectuating critical stabilization of the shore have been minimized or lost to development. Scituate's hardened shoreline from sea walls and revetments alters coastal geomorphology and is influencing the migration of sediments, lowering beaches substantially over the last sixty years.[49]

Scituate is already experiencing significant impacts from coastal storms. Figure 16 illustrates Scituate's coastal vulnerability to sea level rise and storm surge, where by 2088, many of these beaches will be completely submerged. Scituate's Hazard Mitigation Plan, "Coastal Erosion, Sediment Transport, and Prioritization Management Strategy Assessment for Shoreline Protection" by Applied Coastal and Kleinfelder's "Sea Level Rise Study in the Towns of Marshfield, Scituate, and Duxbury" have provided very important short-term mitigation strategies and long-term adaptation strategies for shoreline protection. Implementing these recommendations are critically important to prevent future loss of both infrastructure is natural systems.

Table 4: BioMap2 Core Habitat for Aquatic and Wetland Core in Scituate.

BioMap2 Aquatic Core Habitat	Location	Acres	Description
1033	North River	<1 ac	Species of Conservation- Seabeach Needlegrass
1326	North River	9,988	Wetland Core, Priority Natural Community, Species of Conservation
1472	Pond -Country Way	49	Aquatic Core, Species of Conservation
1412	South Swamp	294	Wetland Core, least disturbed wetland, support critical function into the future.

Fresh Water Resources

Rivers and Inland Wetlands

The Town of Scituate contains over 21 square miles of freshwater resources including rivers, streams, inland wetlands, and salt marshes. These systems are important for supporting clean drinking water,

[49] Applied Coastal Research and Engineering, Inc. *Coastal Erosion, Sediment Transport, and Prioritization Management Strategy assessment for Shoreline Protection.* August 2016.

flood control, and overall ecosystem health for climate resilience. Rivers include the North River, Herring River, Satuit Brook, Musquashcut Brook, First Herring Brook, and Bound Brook. Many of these rivers experience flooding at regular intervals in a 0.5%, 1%, and 2% storm, and existing water quality impairments (Table 1) could diminish the health of these natural systems, important for overall ecosystem function and services.

Connecting these rivers are extensive wetlands and ponds. Scituate contains over 10,300 acres of important BioMap2 Aquatic and Core Wetland areas and contains a Wetland Core that is among the largest 20% of Wetland Cores statewide. Bio Map 2 Wetland Core is an area that represents healthy, intact wetland systems sustaining critical ecosystem functions and biodiversity which are likely to maintain their function through our changing climate. Aquatic Cores are intact river systems and corridors supporting important ecosystem function and services for wildlife and water management.[50] The health of these wetlands is critical to mitigate flooding, filter contaminants from stormwater, and protect water quality. Several of these areas and rivers, including Bound Brook, Satuit Brook, the confluence of the Herring and North Rivers and at Old Oaken Bucket/Tack Factory ponds, contain anadromous fish habitats and/or runs.[51] Anadromous fish are ecologically important to an overall river system because they provide nutrient transfer from marine to fresh waters and a food source for predatory fish and birds, an indicator of ecosystem health.

Climate Risks to Freshwater Resources

Overall, the integrity of Scituate's wetland resources is at risk from climate change due to several factors: sea level rise and storm surge, drought, increasing temperatures and extreme precipitation events. A 2-4 foot of sea level rise and storm surge will significantly increase the extent of flooding of the North and South Rivers, Musquashcot Brook, the Gulf, Herring River, and Kent Street Marshes (Figure 16) spreading into many residential areas and some commercial areas, potentially overflowing culverts and causing significant road and bridge damage. Heavy precipitation accompanied by flooding can scour stream and river vegetation eroding banks and degrading ecosystem function. There is also has a negative effect on water quality, because it flushes ground pollutants – everything from dog waste, to oils on the road, to sand – into rivers, streams, and ponds. Existing and capped landfills could be vulnerable, impairing historic and existing wetlands, groundwater resources, or adjacent water bodies. Extreme rain events could result in structural damage to the cap and increase infiltration with toxic leachate into adjacent wetlands and/or waterbodies.[52]

Heat waves, hotter summers, and drought, combined with earlier spring run-off due to warmer temperatures and a shift from snow to rain, can lead to warmer waters and seasonal low-flow or no-flow events and potentially low levels of dissolved oxygen, impairing fish species habitat and vitality.

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[50] Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

[51] Natural Heritage and Endangered Species Program. *Conserving the Biodiversity of Massachusetts in a Changing World-Scituate*. 2012. http://maps.massgis.state.ma.us/dfg/biomap/pdf/town_core/Scituate.pdf

[52] Executive Office of Energy and Environmental Affairs and Adaptation Advisory Committee. 2011. *Massachusetts Climate Adaptation Report*.

If dry conditions persist, wetlands could shrink in area or lose some of their absorptive capacity and be more prone to runoff and erosion.

The combined effects of washing nutrients into lakes and ponds and warmer summer temperatures may lead to an increase in the growth of aquatic vegetation. For example, warmer winter temperatures and lack of ice cover extend the growing season enabling greater aquatic growth in ponds. Excessive aquatic vegetation can deplete dissolved oxygen and lead to die-offs of aquatic animals. Additionally, algae blooms can also lead to growth in toxic bacteria that makes water bodies unsafe for use by humans and pets.

Forests and Trees

Scituate's West End. Photo credit Town of Scituate

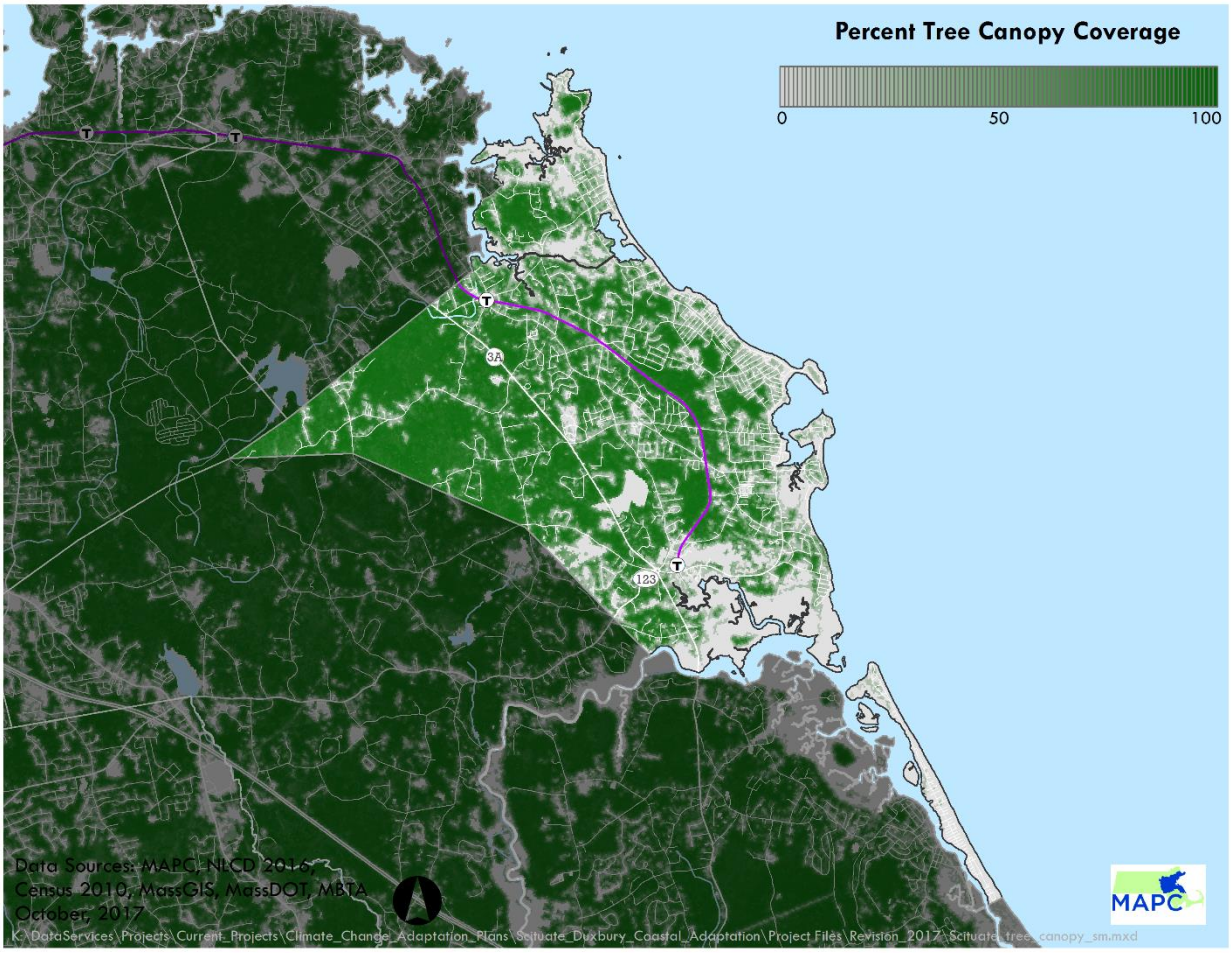
Scituate has a long history of acquiring and protecting land and contains 1,186 acres of protected land held by the Town, private land trust, and State.[53] Since the adoption of the Community Preservation Act in 2002, the Town has acquired 384 acres of additional open space. Of Scituate's 17.6 square miles, 48.8% is covered by forest canopy as of 2011, totaling 5,583 acres (Figure 17), and Scituate's canopy cover has grown by 10% in the last six years.[54] Approximately 1,588 acres or 14% of the Town is covered by impervious cover such as asphalt from roads and parking lots. The most notable contiguous tracts of open space in and around Scituate include Wompatuck State Park, Rivermoore Habitat Park and its abutting protected areas, Widow's Walk, the Ellis Estate, and West End Conservation Land.[48]

Scituate's natural lands, though susceptible to a changing climate, create a weave of resilience against climate risks and hazards. These areas mitigate flooding, alleviate stress on stormwater systems, serve to recharge and clean the Towns aquifer, mitigate air pollutants, and cool the town with evapotranspiration and shade. According to the EPA, suburban areas with mature trees are four to six degrees cooler than new suburbs without trees. Shaded surfaces can be 25-40

[53] Horsley Witten Group. *Open Space and Recreation Plan*. 2009
[54] MA Department of Public Health-Bureau of Environmental Health. Report created on Oct. 16, 2017. http://www.mass.gov/dph/matracking

degrees cooler than the peak temperatures of unshaded surfaces. Trees also absorb remarkable quantities of precipitation;[55] In addition to water uptake by roots, tree leaves intercept rainfall which is stored or evaporated back into the atmosphere, reducing the amount of stormwater runoff and flooding. They also serve to reduce energy use and demand through shading buildings, reducing the need for air condition, and reduce asphalt maintenance by preventing sun deterioration. Finally, trees sequester carbon dioxide, a greenhouse gas; this is a critical mechanism to mitigate climate change.

Figure 17 Scituate Tree Canopy.



Tree canopy cover in Scituate from National Land Cover Database of 2011. Scituate's land use contains over 48.8% forest and 20.7% open space and recreation land.

The peer-reviewed USDA Forest Service i-Tree software creates models of ecological services from forests and tree canopy. Based on this model, Scituate's 48.8% forest cover intercepts 525 million gallons of rain fall per year and avoids 71.3 million gallons of runoff worth $637,317 per year. Estimates of pollution reduction from Scituate's tree canopy in pounds per year include 537,856 of

[55] U.S. Environmental Protection Agency. 2008. Reducing urban heat islands: Compendium of strategies. Draft. https://www.epa.gov/heat-islands/heat-island-compendium

carbon monoxide, 39,256 of nitrogen dioxide, and 282,247 of ozone. The estimated value of Scituate's tree canopy for carbon storage is over $31 million while the value of annual carbon sequestration (tree growth minus loss due to decomposition and mortality) is over $594,343 per year, equivalent to 15,229 tons of carbon dioxide sequestration per year.[56] As a comparison, the City of Chelsea, a dense, urban environment, has a tree canopy that sequesters only 77.9 tons of CO^2. Scituate's tree canopy provides a significant quantifiable benefit, however there is a clear dearth of tree canopy along Scituate's coast. Though some of these areas (Figure 17) are salt marsh and not supporting tree growth, the remaining illustrates the dense development and significant vulnerability along the coastline.

Intact forest ecosystems are critical for maintaining long-term climate resilience, but forests will undergo stressors related to our changing climate, specifically longer growing seasons, periods of intense precipitation and/or drought, and warmer winters. Longer growing seasons and increased carbon in the atmosphere overall will benefit forest productivity. Historically, the growing season in the last 60 years has increased a week to 10 days.[57] Warmer winters may increase the incidence of ice storms, and extreme precipitation regimes could lead to severe rainfall in a single event causing flooding. These factors work in conjunction to cause several vulnerabilities to the forest: (i) favoring establishment of invasive and exotics establishments with gaps in the canopy due to wind and ice storms, (ii) migration of species to more northern climates and immigration of new species and/or pests; and (iii) weakened trees, with drought causing greater susceptibility to insects and diseases.[58] The overall impact is an anticipated shift in forest type in Southern New England from a Maple/Birch/Beech forest to forests characteristic of southern New York, New Jersey and Pennsylvania, an Oak/Hickory forests.[59] Table 5 lists species that will be more or less competitive with a changing climate. Managing forests and trees for climate adaptation will be an important strategy to retaining Scituate's forest health, air and water quality, and overall climate resilience.

[56] United States Forest Service. Itree. https://www.itreetools.org/resources/content/Landscape_factsheet.pdf
[57] Executive Office of Energy and Environmental Affairs and Adaptation Advisory Committee. 2011. *Massachusetts Climate Adaptation Report.*
[58] Catanzaro, P., A. D'Amato, E. Silver Huff 2016. Increasing Forest Resiliency for an Uncertain Future. UMass Extension Landowner Outreach Pamphlet. 28 pages
[59] U.S. Forest Service, *Changing Climate, Changing Forests*. The Impacts of Climate Change on the Northeast United States and Eastern Canada. 2011

Table 5: Tree Species predictions on adaptive capacity to climate change.

Southern New England Forest		
Tree Species	Low Emissions Scenario	High Emissions Scenario
Balsam Fir	--	--
Black Spruce	--	--
Eastern White Pine	--	--
Northern White Cedar	--	--
Paper Birch	--	--
Quaking Aspen	--	--
Red Spruce	--	--
White Spruce	--	--
Tamarack	--	•
American Beech	•	--
Red Maple	•	--
Northern Red Oak	•	--
Bear/Scrub Oak	•	•
Black Cherry	•	•
Sugar Maple	•	•
Bigtooth Aspen	+	•
Pitch Pine	+	•
American Basswood	•	+
Bitternut Hickory	+	+
Black Oak	+	+
Chestnut Oak	+	+
Shagbark Hickory	+	+
White Oak	+	+
Threatened by Current Forest Health Issues		
Black Ash	--	--
Eastern Hemlock	•	•
White Ash	•	•

The values indicate whether a species will decrease in habitat (–), stay the same (•), or increase in habitat (+). Source: Catanzaro, P., A. D'Amato, E. Silver Huff 2016. Increasing Forest Resiliency for an Uncertain Future. UMass Extension Landowner Outreach Pamphlet. 28 pages.

Critical Infrastructure Vulnerability

In August 2016, the Town of Scituate completed a Natural Hazard Mitigation Plan. The purpose of a Hazard Mitigation Plan is to evaluate the Town's vulnerability and mitigate presently existing natural hazards such as coastal and inland flooding, extreme heat, severe storms like hurricanes and Nor'easters, etc. The vulnerability of the Town's critical infrastructure to existing natural hazards is evaluated in this plan. This Critical Infrastructure Vulnerability section will evaluate future risks of Scituate's infrastructure as it relates to climate change projections for sea level rise, inland flooding, and extreme heat.

Drinking Water

With anticipated sea level rise, increased frequency and intensity of precipitation events and/or drought, extreme heat and shifting freeze/thaw cycles, climate change is expected to strain drinking water resources, both in quality and quantity. It is important to understand the extent of water supply and demand today, plan for the water demand for new residential, commercial, industrial, and agricultural growth into the future, and evaluate the system's vulnerabilities to meeting the Town's demands today and into future. Overall, vulnerabilities for Scituate's drinking water include the potential for a stressed water supply, contamination from flooding, and potential for salt water intrusion into groundwater aquifers along the coast.

Scituate's has two sources of drinking water, wells and surface water. The town maintains a water treatment plant, two booster stations, two water storage tanks, four corrosion control stations, and 124 miles of drinking water distribution pipes.[60] Scituate's six wells pump from three main aquifers and are located off Cornet Stetson Rd (#10 & 11); off Tack Factory Pond Rd (#17A); off the Driftway (#18B); off Chief Justice Cushing Highway (#19) near the Town Hall; and off Old Forge Rd (#22).[61] The land around these wells is regulated as Zone II groundwater recharge areas bounded by the extent of pump extraction for 180 days without precipitation recharge and physical/geomorphological features such as bedrock or till. Scituate has three Zone II areas, including 859 acres at First Herring Brook (expands into Norwell), 123 acres at Coleman Hills in the Scituate Conservation Park, and 418 acres at Webster Meadows, bounded by Herring

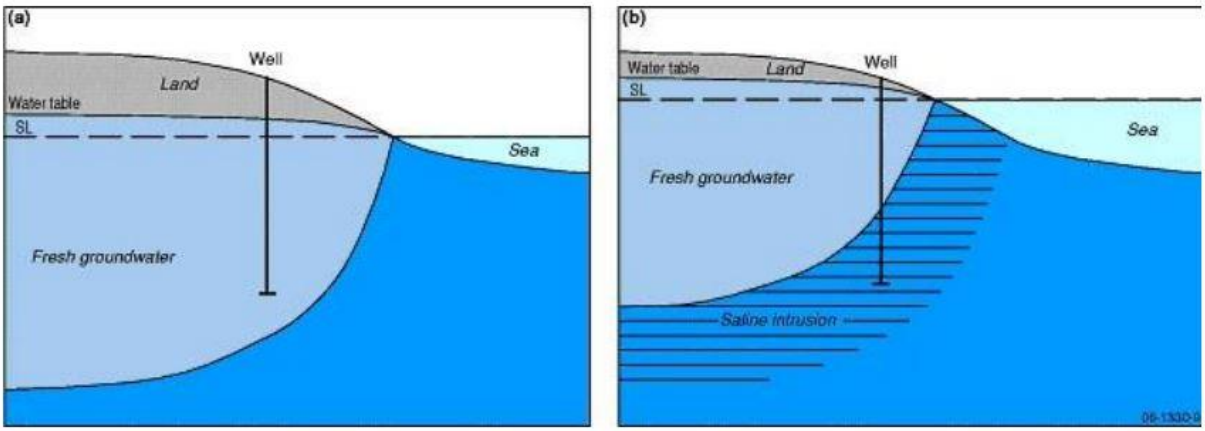
Patriot Ledger story on Scituate's Water Supply with the 2016 drought. March 2017. Photo credit Greg Derr.

[60] VHB. *Natural Hazard Mitigation Plan. Scituate, Massachusetts*. August 2, 2016.
[61] Scituate Water Department. Annual Water Quality Report. 2015. fttp://www.gemgrp.com/eReports/CNMA010684-1Y16.pdf

Brook and containing some protected conservation land.[62]

Scituate also has Surface Water Protection Areas. These include a 679-acre Zone A including First Herring Brook and Tributaries, Tack Factory Pond Reservoir, and a 372-acre Old Oaken Bucket Reservoir. Zone A is the surface water source and its upper boundaries and the Zone B land is the area within ½ mile of the upper boundary of the Zone A source.[63] Further, Scituate contains two major areas classified as "Outstanding Resource Waters" (ORW) protection under the Massachusetts Surface Water Quality Standards, including certain wetlands and their tributaries, because of their high quality water supply and contribution to the municipality and region. These include the 3,294-acre Old Oaken Bucket Pond ORW Public Water Supply Contributor and a portion of the 3,542-acre Aaron River Reservoir ORW.[64]

Figure 18 Salt water intrusion to fresh groundwater with SLR.

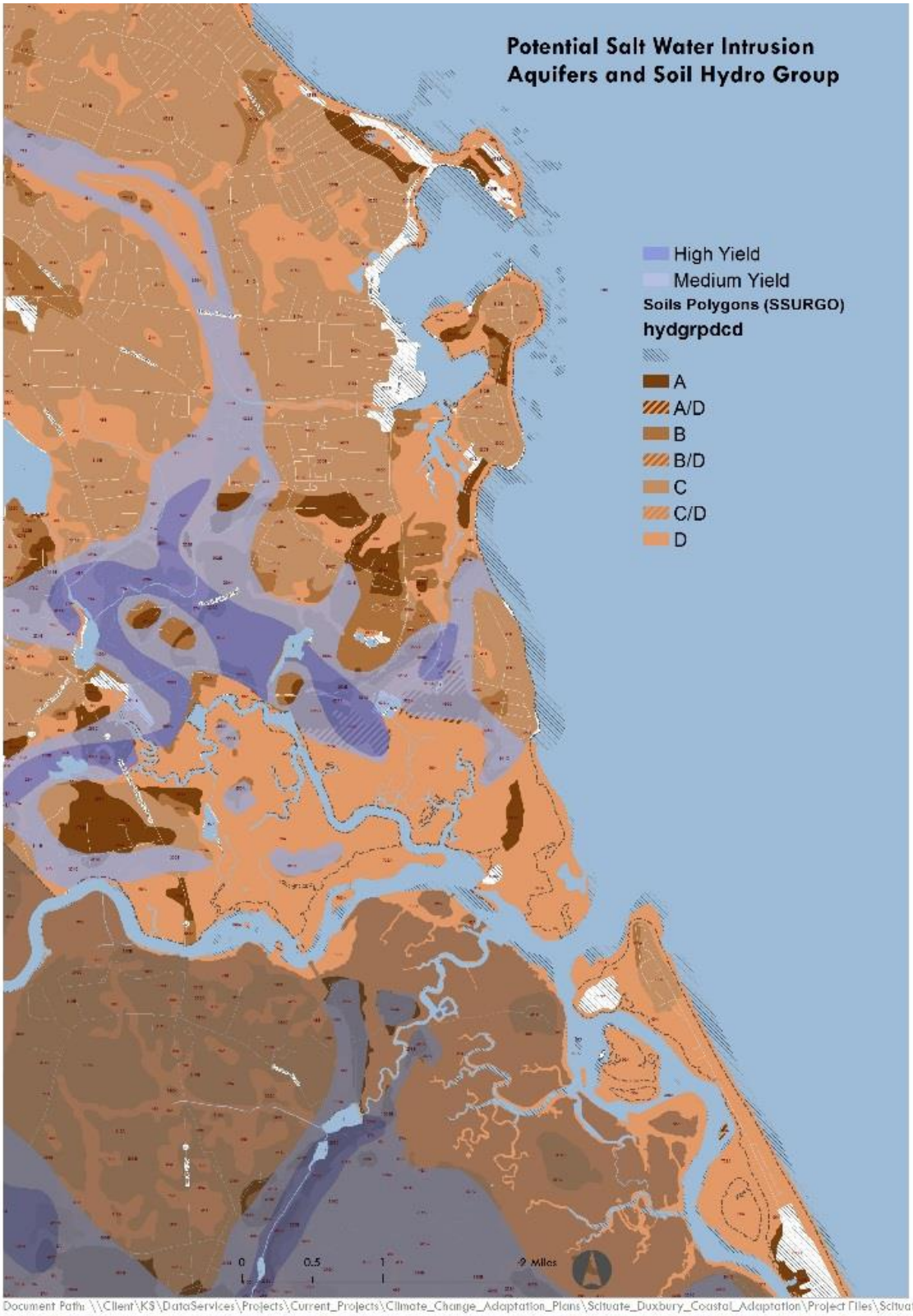


Source: *https://www.epa.gov/sites/production/files/2015-07/documents/soil-based_onsite_wastewater_treatment_and_the_challenges_of_climate_change.pdf*

A portion of one of Scituate's aquifers lies along the coastline. Scientists anticipate that sea level rise will reduce the barrier between the fresh groundwater and the ocean salt water as salt water migrates underground (Figure 18). Aquifers near the coastline are susceptible to salt water intrusion when the soil barrier between the salt water table and the aquifer is permeable or contains well-drained soils such as sand, gravel, and till. The area in Scituate potentially most vulnerable to salt water intrusion is the aquifer that touches the coast at Peggotty Beach. The coastal upland soils contain Broadbrook Very Fine Sandy Loam which is a well-drained soil. The same aquifer approaches "the Spit", however these soils are poorly drained, suggesting that it would be more difficult for salt water intrusion to occur (Figure 19).

[62] Horsley Witten Group. Town of Scituate Open Space and Recreation Plan. 2009
[63] Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services
[64] Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

Figure 19 Scituate's coastal aquifers and soil hydrologic group.

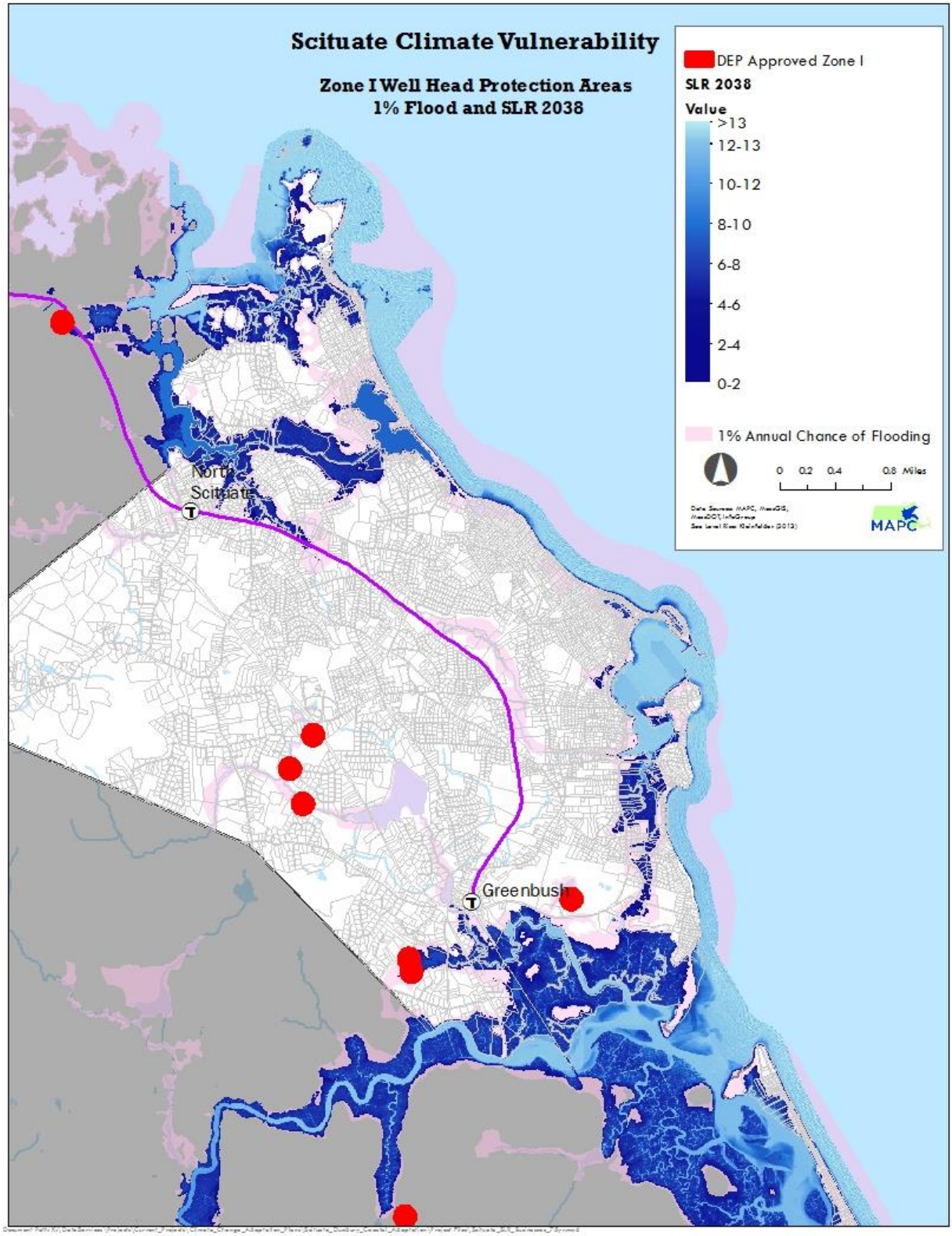


One drinking water well, Well #10, is vulnerable to sea level rise 2038 with a Category 1 Hurricane. Well #11 is adjacent to sea level rise 2038 Category 1 and Well #18b is adjacent to the extent of sea level rise in 2088 but neither are within inundation zones for 2038 or 2088. Wells that are currently within a FEMA 1% Annual Chance Flood zone include Well 18B, Well #22, Well #11, and Well #10 (Figure 20 and Appendix A). However, further hydrologic study is required to ascertain the potential and/or extent of salt water intrusion at aquifer and wells.

Effects on water supply with climate change will greatly depend on precipitation, both quantity and timing, and capturing rain and stormwater into the ground before it reaches streams, rivers, and the ocean-effectively keeping Scituate's water within its own aquifer and watershed system. MAPC performed a study in 2001 to ascertain drinking water supply challenges for municipalities in the region and Scituate was identified as a town facing water supply issues. These issues will arise from increased demand with new development and increased discharge of water outside of the watershed recharge area.[65] As of 2009, the Town was seeking opportunities to increase its water supply by expanding the reservoir and/or by acquiring new land to expand its wells.[66] In 2016, Massachusetts experienced severe drought conditions, the most severe since 1965, which caused a strain on many municipal drinking water supplies. During the drought, Scituate's Public Works Director reported that its Reservoir was precariously low.[67] As of October 18, 2017, the Water Department imposed a full water ban on all non-essential outdoor watering use because the reservoir had fallen to a level of 36 feet. When it is at that level, the MA DEP requires a water ban.[68]

[65] Metropolitan Area Planning Council. *South Coastal Basin Watershed Pilot Project*, Final Report. 2001
[66] Horsley Witten Group. Town of Scituate Open Space and Recreation Plan. 2009
[67] WBUR.Amid Drought, Scituate Reservoir Is Getting Precariously Low. August 12, 2016. http://www.wbur.org/morningedition/2016/08/12/scituate-reservoir-drought
[68] https://www.scituatema.gov/sites/scituatema/files/news/water_ban_10.18.17.pdf

Figure 20. Potential for salt water intrusion in wellhead protection areas with sea level rise.



Wastewater Infrastructure

Scituate's municipal sewer system is managed by the Sewer Division of the Department of Public Works. The Town has a treatment plant supported by six pump stations and 32 miles of sewer lines. The sewer system became operational in 1967, which was intended to treat approximately 1.3 million gallons per day (mgd) of waste water, though its current capacity has been upgraded to 1.6 mgd. The system has had two upgrades since its inception, in 1984 and 2000. Sewer Division disinfects its wastewater with ultraviolet light rather than chlorine. The Town has had several expansions to its collection system including Greenbush/Reservoir in 2005, Third Cliff in 2006, and First and Second Cliffs in 2007.[69] Phase 4, 5, and 6 of the sewer expansion are targeted for Front Street, North Scituate, and Minot. However, new development around existing sewer lines can tap into the existing systems causing concern with Town leaders and staff on existing sewer capacity

Mother's Day Storm—Infrastructure Overwhelmed!

The 2006 Mother's Day storm began Friday, May 12 and, for the next 100 hours, dumped up to 15 inches of rain on many North Shore communities in Massachusetts. A U. S. Geological Survey flood gauge at Lowell showed that the flood level in the Merrimack River reached 59 feet, making it a 40-year occurrence event. On May 13, two days before flood levels in the Merrimack River peaked, a force main to the Haverhill Wastewater Treatment Plant gave way, spilling 35 million gallons per day of untreated sewage into the Merrimack River. The break occurred when the rapidly moving river in a tributary washed out a culvert that ran beneath a section of a power easement roadway and the force main. As the storm continued, waters flowed over bridges and into the streets and basements throughout the region. It took almost a week to repair the break.

The Department of Environmental Protection estimates that, had the water level in the Merrimack risen another two to three feet, wastewater treatment plants in the Greater Lawrence Sewer District would have lost their pumping stations and power to their treatment plants, resulting in major additional discharge of untreated sewage to the Merrimack River. It is also likely the drinking water treatment facilities in Tewksbury, Lowell, and Lawrence would have also become incapacitated.

relative to future growth.[70]

Presently, nearly 72% of Scituate residences have private septic systems even though 85% of the soils in Scituate are considered not conducive to septic systems by the USDA Soil Conservation Services (now the USDA Natural Resources Conservation Services). Soil suitability is measured by percolation rate, depth to bedrock, depth to water table, compact/impermeable soils, steep slopes and flooding.[71]

Municipal Sewer System

Sea level rise, extreme precipitation, and flooding are the most important factors in understanding Scituate's sewer system vulnerability. Today, approximately half of the facilities at the North River Waster Water Pollution Control Plan at the Driftway are currently within a 1% Annual Chance Flood. And the Collier Road and Peggotty Beach Pump Stations are currently in a FEMA High Velocity Zone (VE)- coastal areas subject to 1% Annual Chance Flood with additional hazards from storm surge

[69] https://www.scituatema.gov/sewer-division
[70] Scituate DPW Director, Board of Selectmen meeting. November 21, 2017.
[71] Horsley Witten Group. Town of Scituate Open Space and Recreation Plan. 2009

(Table 6). Today, Scituate's sewer system is already experiencing coastal flooding along Ocean Drive, taking in sea water and far exceeding its capacity (up to 5-6 million gallons a day) when waves overtop the seawalls in that location. This has occurred with just a very high tide only, though now the sea wall has been replaced and improved. The vulnerability of the municipal sewer lines is significant for the 1% Annual Chance Flood for inundation with storm surge, where Cedar Point and most of Oceanside Drive sewer lines are submerged. The municipal sewer lines in critical areas become inundated by sea level rise in 2088, but not by 2038 (Figure 21).[72]

Table 6: Sewer Pump Stations and their vulnerability to coastal flooding.

Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038	SLR 2088
104	Chain Pond Pump Station	310 Hatherly Rd.	Sewer Pump Station		x	(x)	
105	Sand Hills Pump Station	0 Scituate Ave.	Sewer Pump Station		x	(x)	x
106	First Parish Pump Station	106 First Parish Rd.	Sewer Pump Station				
107	Country Way Pump Station	220 Country Way	Sewer Pump Station				
108	Herring Brook Pump Station	15 New Driftway	Sewer Pump Station		x	x	
109	Collier Road Pump Station	31 Collier Rd.	Sewer Pump Station	x			
110	Peggotty Beach Pump Station	22 Peggotty Beach Rd.	Sewer Pump Station	x		x	x
111	First Cliff Pump Station	137 Edward Foster Rd.	Sewer Pump Station		x	x	x

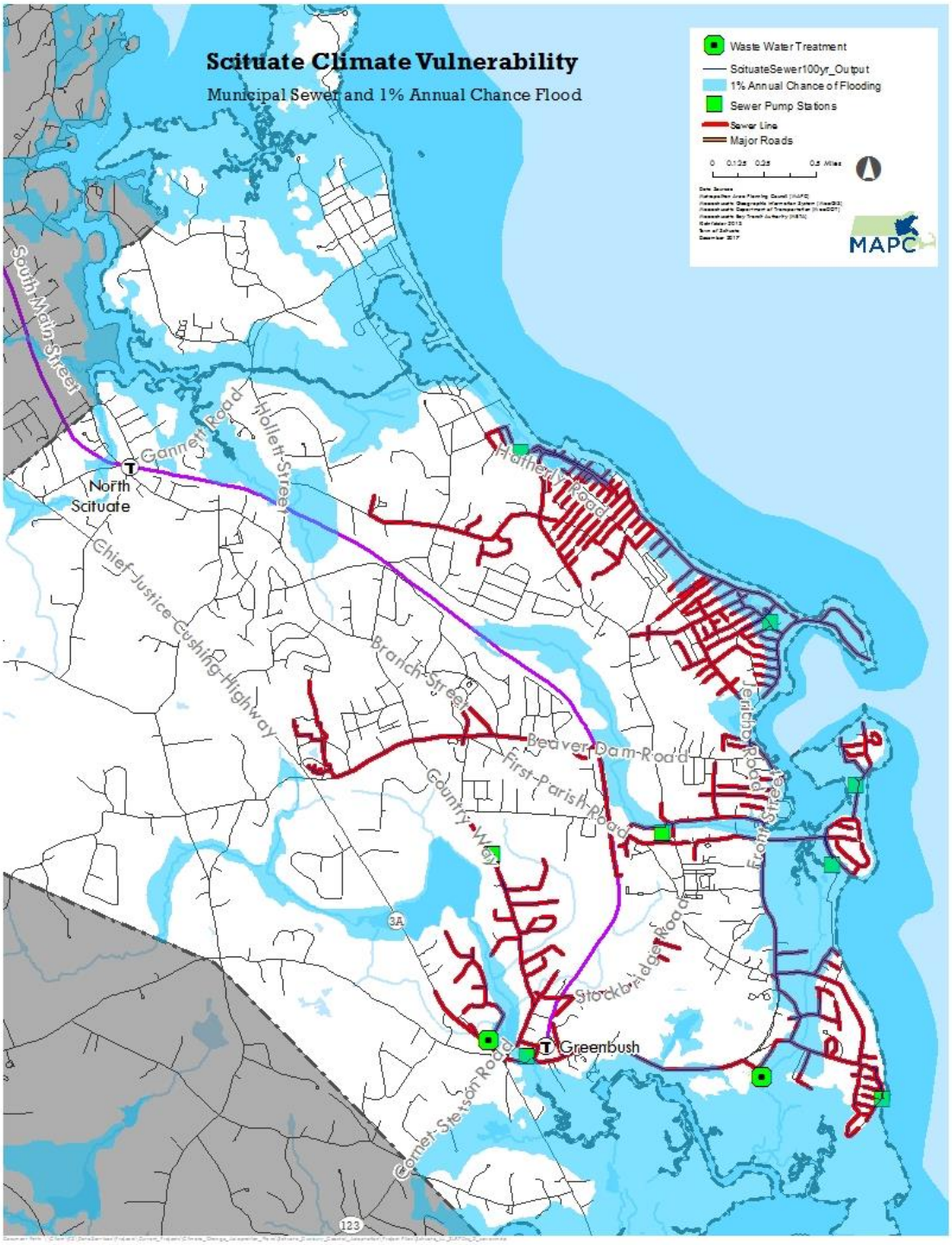
Pump stations exposed to current future coastal flooding. See Figure 23 for locations on the map.

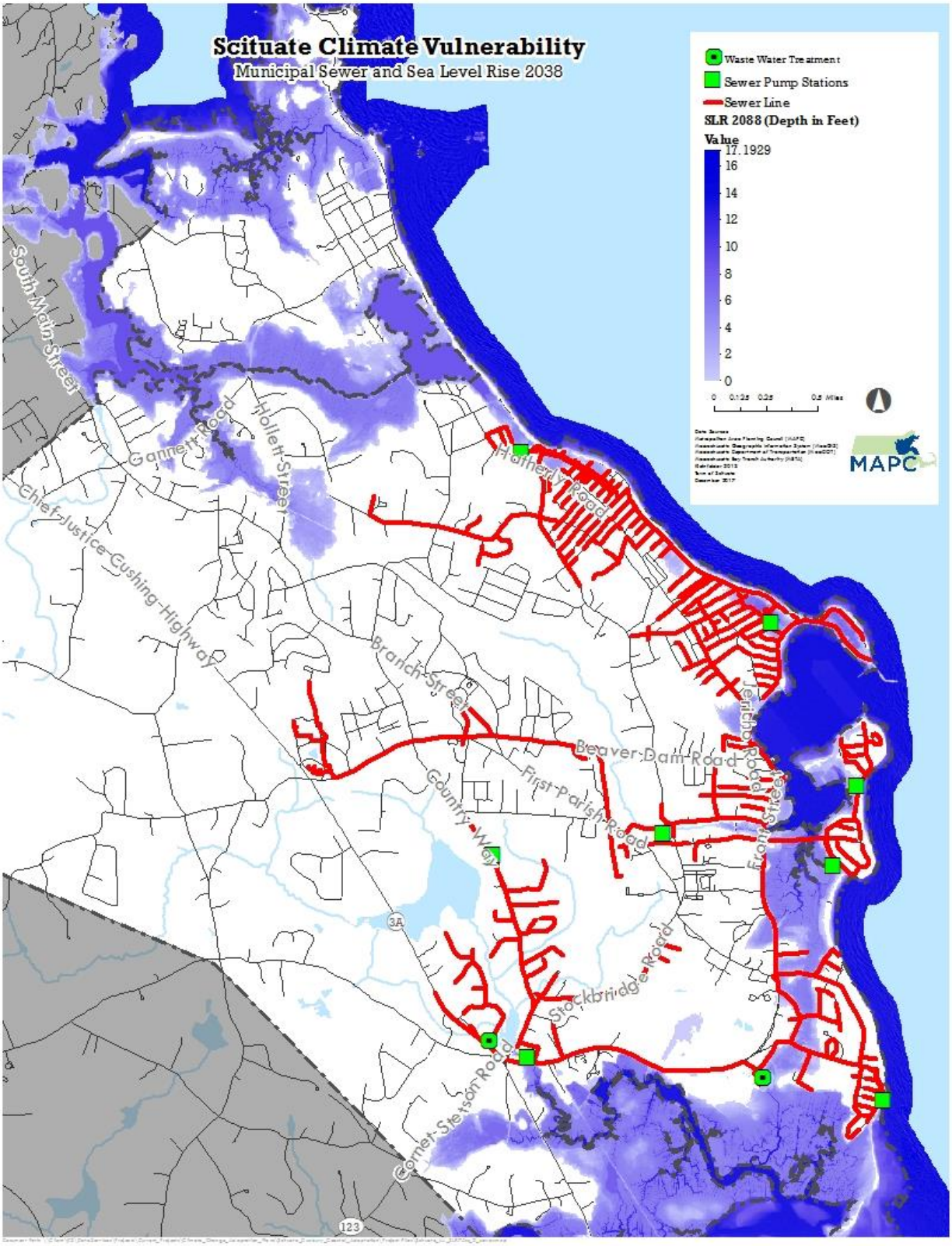
Future extent of sea level rise extends just to the waste water treatment plant (WWTP) boundary in 2038 with a Category 1 storm surge. However, it isn't until 2088 that the WWTP becomes nearly submerged by two to four feet of water from sea level rise and/or storm surge (Figure 23). In addition, the treatment plant has the potential for flooding with a Category 2 Hurricane.[73] First Cliff, Peggotty Beach, and Herring Brook Pump Stations are all within flood zones for sea level rise 2038 and Category 1 Hurricane and sea level rise in 2088 (Figure 21 and Appendix A).

The impact of inundation by sea level rise and/or storm surge is significant, potentially causing an overload to the system and/or electricity failures resulting in the release of raw sewage and hazards to drinking water systems. For example, during Hurricane Sandy, many water utilities lost

Figure 21 Municipal wastewater infrastructure, coastal flooding and sea level rise (SLR) in 2088.

[72] Scituate DPW Director, Board of Selectmen meeting. November 21, 2017.
[73] Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services


Scituate Climate Vulnerability
Municipal Sewer and 1% Annual Chance Flood
Waste Water Treatment
ScituateSewer100yr_Output
1% Annual Chance of Flooding
Sewer Pump Stations
Sewer Line
Major Roads
0 0.125 0.25 0.5 Miles
MAPC
South Main Street
Gannett Road
Hollett Street
North Scituate
Chief Justice Cushing Highway
Branch Street
Beaver Dam Road
First Parish Road
Country Way
Stockbridge Road
Greenbush
Cornet Stetson Road
3A
123



electricity and did not have back-up generators. Counties in New York and New Jersey had drinking

water advisories and boil water notices. The Passaic Valley treatment plant was forced to release billions of gallons of raw and partially treated sewage into New York Bay.[74]

Onsite Waste Water Treatment

Scituate's private septic systems are vulnerable to sea level rise, extreme precipitation events and warming temperatures. Septic systems or On-Site Wastewater Treatment (OSWT) proximate to rivers, wetlands, and the coast, where the groundwater table would be most affected by sea level rise or flooding from extreme precipitation events, are geographically the ones at risk. At the coast, sea level rise will displace and potentially intrude into near-shore fresh groundwater tables, bringing the fresh groundwater (which is less dense) closer to the surface. This mechanism could cause several complications. First, sea level rise and storm surge could ultimately expose and/or destroy the OSWT completely (Figure 22). Residents in Humarock, Peggotty Beach, and Minot, most of whom have OWST, are most vulnerable. Second, there will more shallow depth to ground water limiting septic leachate area. With less area, there is reduced microbial activity needed to properly filter wastewater potentially releasing fecal coliform and phosphorus.[75]

Figure 22 Exposed septic system after coastal storm, CT.

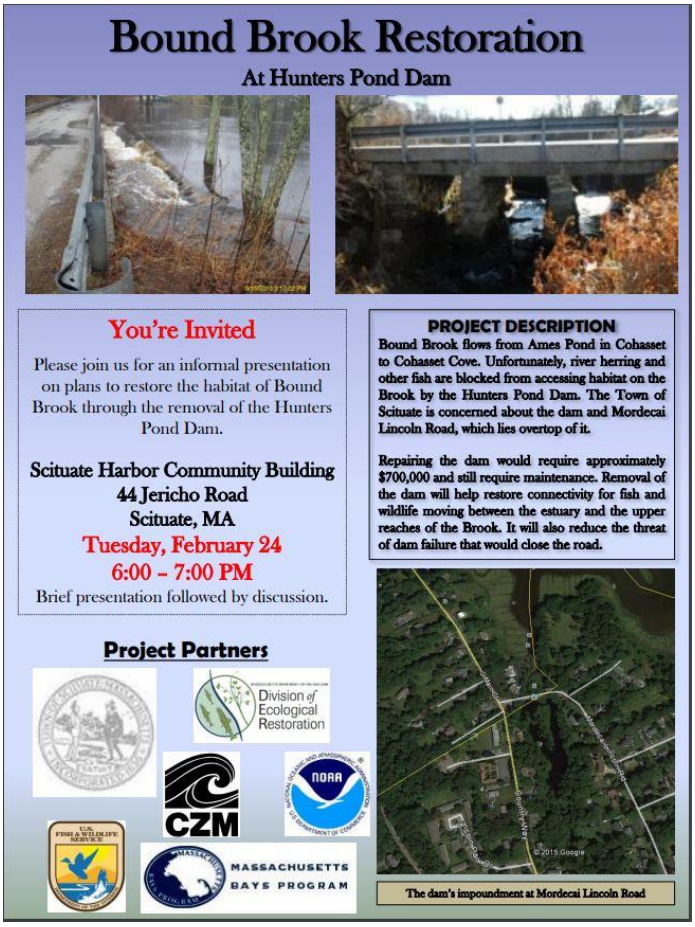
Source: https://www.epa.gov/sites/production/files/2015-07/documents/soil-based_onsite_wastewater_treatment_and_the_challenges_of_climate_change.pdf

Third, OSWT will be susceptible to groundwater infiltration of leach fields, particularly during severe precipitation events and during times of inland and/or coastal flooding. Finally, groundwater and/or

[74] http://www.mwra.com/monthly/wac/presentations/2014/030714-climatechange.pdf
[75] Amador, J. Loomis, G., Cooper, J. and Kalen. D. Soil-Based Onsite Wastewater Treatment and the Challenges of Climate Change. Laboratory of Soil Ecology and Microbiology New England Onsite Wastewater Training Center University of Rhode Island Kingston, RI https://www.epa.gov/sites/production/files/2015-07/documents/soil-based_onsite_wastewater_treatment_and_the_challenges_of_climate_change.pdf

salt water intrusion of pipes with sea level rise, storm surge and inland flooding can cause deterioration of the system itself.

Dams



The Department of Conservation and Recreation (DCR) Office of Dam Safety monitors the condition of the state's dams. DCR requires that dams with low hazard ratings be evaluated every decade while the dams which are rated significant and high hazard are inspected every five years.[76]

DCR potential hazard ratings are high, significant, and low; conditions are rated good, satisfactory, fair, poor, or unsafe. The State Hazard Mitigation Plan uses the term "High Hazard Potential" for dams located where failure will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities, main highways, or railroads. A "Significant Hazard Potential" dam is one located where failure may cause loss of life and damage homes, industrial or commercial facilities, secondary highways, or railroads; or cause interruption of use or service of relatively important facilities. "Low Hazard Potential" dams are located where failure may cause minimal property damage to others, and loss of life is not expected.

In 2015, Scituate worked with the MA Division of Ecological Restoration, NOAA, MA Coastal Zone Management and others to restore the aquatic habitat of Bound Brook with the removal of the Hunter's Pond Dam.[77] Hunter's Pond Dam was the only dam located in a future sea level rise zone in 2088. Scituate's removal of this dam is a perfect example of taking action today which will have great impact in protecting the municipality in the future.

Scituate's Hazard Mitigation Plan identifies three dams that are currently at significant risk as a result of FEMA flood zones, and these are of immediate concern. Since FEMA floods zones are determined by historic flooding events among other factors, the impact of sea level rise with storm surge on the existing dam structures are an even greater risk into the future. The dams at risk are summarized in Table 7. The Massachusetts Climate Adaptation Report notes that increased intensity of precipitation

[76] https://www.scituatema.gov/sites/scituatema/files/file/file/hunters_public_meeting_invite_january_2015.pdf
[77] VHB. Natural Hazard Mitigation Plan Scituate, Massachusetts. August 2, 2016.

is the primary concern regarding dams as they typically have been likely designed based on historic weather patterns. A potential effect of increased significant rain events is the failure and/or overtopping of existing dams.

Table 7: Scituate's dams and vulnerability.

Dam	Owner	Hazard Severity with Failure	Current FEMA Flood	Hurricane Surge Storm Current	2038 SLR
Old Oaken Bucket Pond Dam	Town of Scituate	Significant	1% Annual Flood Risk with BFE	Category 4	Yes
First Herring Brook Reservoir Dam	Town of Scituate	High	1% Annual Flood Risk with BFE	N/A	No
Tack Factory Pond Dam	Town of Scituate	N/A	1% Annual Flood Risk with BFE	N/A	No
Mordecai Lincoln Rd. Pond Dam	Private Association	Significant	1% Annual Flood Risk with no BFE	Category 1-2	Yes
Bound Brook Control Dam	Town of Cohasset	Significant	1% with no BFE	N/A	No
Satsuit Meadow Dam	Town of Scituate	N/A	0.2% Annual Flood Risk	N/A	No
Picture Pond Dam	State DCR	N/A	1% Annual Flood Risk with BFE	N/A	No

Scituate's dams by hazard status, current flood risk and future flood risk. There are no dams located in a zone of sea level rise in 2088.

Built Environment

Loss of electricity and lack of back-up energy source is a vulnerability due to extreme heat and high energy demand. The most significant threat to municipal and critical infrastructure (such as medical services) is flooding from coastal storms and extreme precipitation events. Other vulnerabilities to the built environment are extreme heat impacting electricity demand and supply as well as deterioration to infrastructure. In this section, we review future risks to the built environment where sea level rise may alter flood locations and depths. Because there are no inland flooding projection models, only FEMA flood maps which are based upon historical data, there are challenges to projecting future inland flooding and damages, including varying impacts when rain falls on dry, frozen, or saturated land; and varying impacts between long and short-duration rain events. Flooding associated with storm drainage infrastructure is also particularly difficult to project.

Figure 23 Coastal flooding in Scituate, 2014.

News report on Scituate's coastal flooding of residences and streets along 6th and 7th avenue after a blizzard in 2014.

Yet there are ways to assess and consider future vulnerabilities that might result from increases in precipitation. Reviewing extreme events that may become more frequent is valuable for identifying where damage occurred and where it might have extended had rainfall amounts been greater (Figure 5). Since we anticipate that future precipitation regimes are expected to increase in

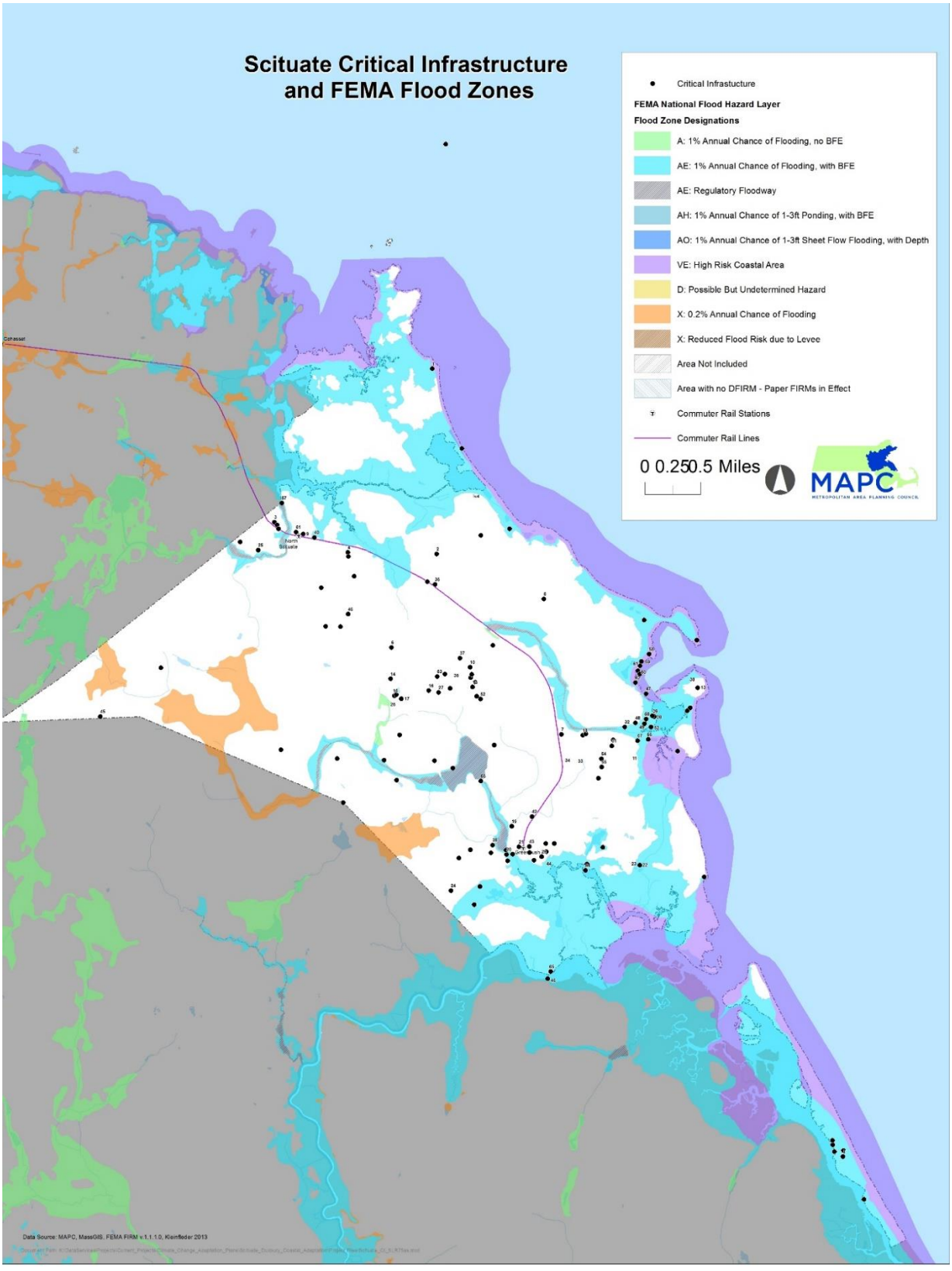
frequency and intensity, we evaluate FEMA mapped 0.2% and 1% Annual Chance flood (500-year storm) to assess inland flooding vulnerability. As noted above, understanding the condition and location of culverts and storm drains is important, because of their potential for blockages and flooding.

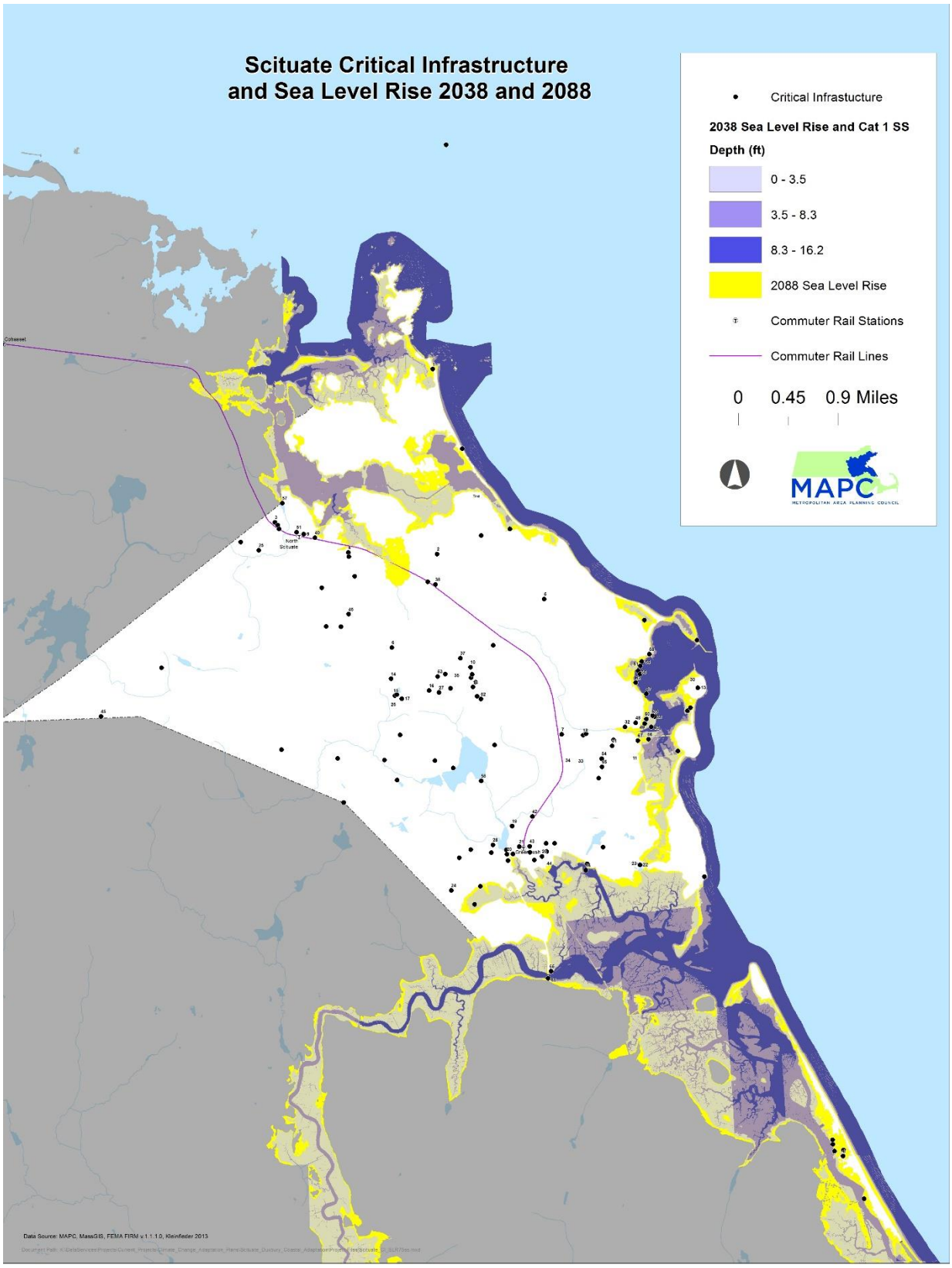
Scituate's 2016 Hazard Mitigation Plan illustrates that through November 2015, the Town of Scituate had 1,472 flood insurance policies with coverage of over $382 million, and 3,681 submitted losses. The total payment on those losses was $63 million.[78] Applied Coastal Research and Engineering in 2016 reports, according to the Federal Emergency Management Agency/National Flood Insurance Program, 1,732 repetitive loss claims in Scituate since 1978, with the greatest number of these in 1991 "Perfect Storm" with 446 FEMA repetitive loss claims totaling $34,505,788.[79] Scituate participates in the Community Rating System (CRS) which provides reduced insurance costs for property owner's flood insurance if the Town accomplishes certain mitigation actions to reduce its vulnerability to flooding. In 2015, the Town's Class 7 rating afforded 15% decrease in flood insurance payments. Further, Scituate has embarked upon a robust public education program on flooding including fact sheets, handbooks, and public workshops.[80]

Appendix A lists all critical facilities and their location within a FEMA high velocity zone (VE), FEMA 1% Annual Chance Flood, sea level rise in 2038 with a Category 1 hurricane, and sea level rise in 2088. It is significant to note that none of Scituate's critical infrastructure lies within a FEMA 0.2% Annual Chance Flood. Some notable critical infrastructure subject to sea level rise in 2038 and 2088 includes the Coast Guard Station, Harbormaster Office and piers. Notable infrastructure subject to sea level rise in 2038 only includes the CVS block on Front Street, North River and Sea Street bridges, Scituate Harbor Marina, and Satuite Waterfront Club. Figure 24 illustrates Scituate's critical infrastructure in a FEMA flood zone and in SLR 2038 and 2088.

[78] VHB. Natural Hazard Mitigation Plan Scituate, Massachusetts. August 2, 2016
[79] Applied Coastal Research and Engineering, Inc. *Coastal Erosion, Sediment Transport, and Prioritization Management Strategy assessment for Shoreline Protection*. August 2016.
[80] VHB. Natural Hazard Mitigation Plan Scituate, Massachusetts. August 2, 2016

Figure 24 Critical Infrastructure and flooding.





Scituate's Critical Infrastructure and Flooding from the FEMA flood zones and sea level Rise in 2038 and in 2088. Appendix A contains the corresponding list of critical infrastructure.

Economic Vulnerability

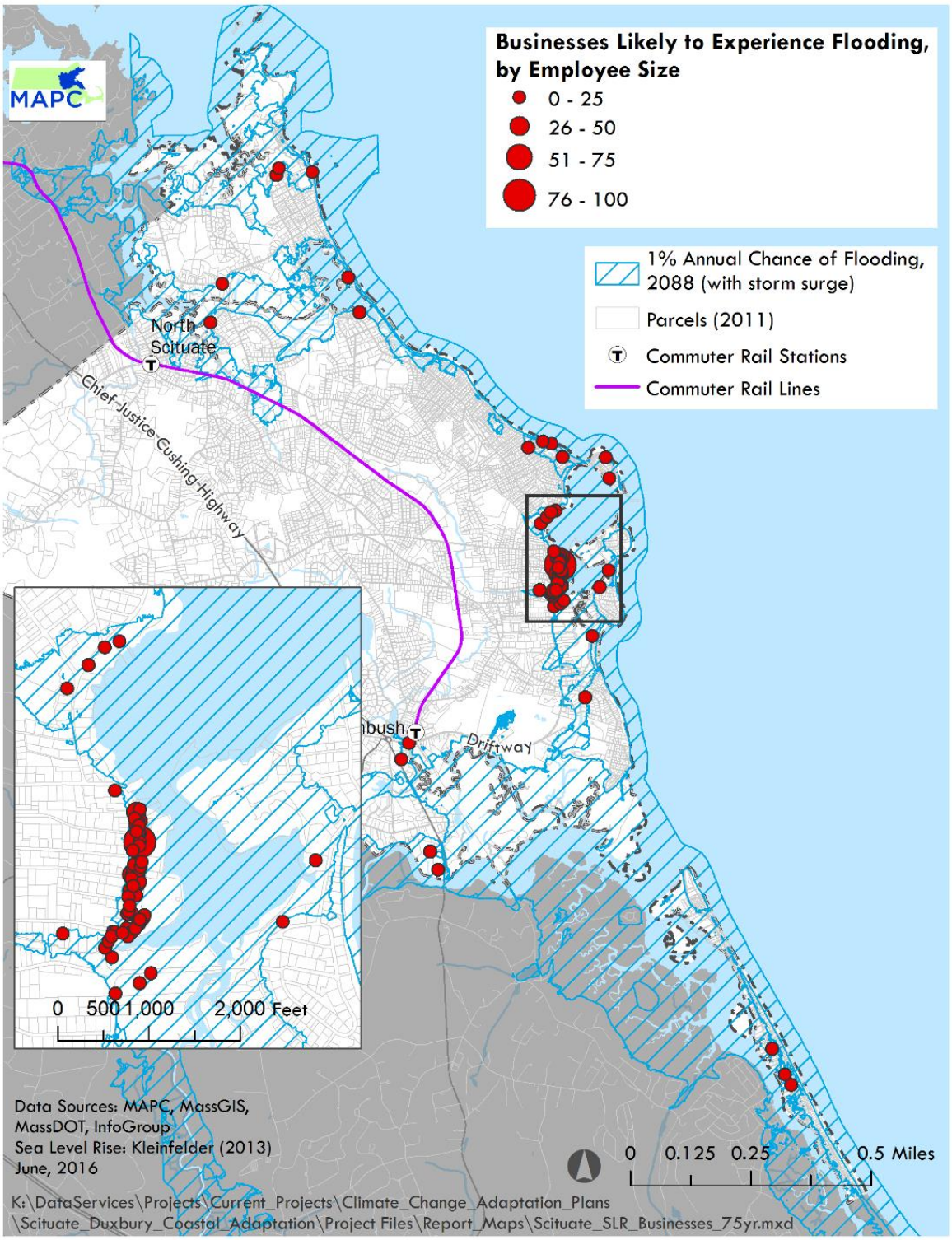
Extreme weather events are important factors in determining economic vulnerability for Scituate in climate change. These include extreme temperatures, extreme precipitation and flooding from coastal storms. Economic vulnerability arises from the loss of transportation to work, the inability to operate business due to lack of staff, loss of utilities, lack of accessibility and/or damage to business infrastructure itself, or loss of productivity from unexpected childcare with school closures. Extreme weather events have already caused significant loss of productivity and economic loss in the Boston region in recent years. For example, in 2014, the Polar Vortex caused extreme cold temperatures that resulted in $5 billion in economic losses globally, a 2.1% drop in the GDP. These were largely due to loss of productivity from school and business closures from damaged infrastructure-frozen pipes and heating systems and delayed or cancelled transportation, like airlines.[81,82]

In 2015, for 33 consecutive days from late January to late February, Massachusetts experienced significant snow and several blizzards resulting in over 103 inches of snow accumulations in Plymouth County. For this period, Plymouth County endured expenses totaling over $20 million for debris removal, emergency services, public infrastructure repairs, and additional snow removal. The January 26-28, 2015 blizzard alone cost $5.9 million, most of which was for snow removal, tree limb removal, and the heavy equipment and overtime required. These costs exclude any loss of productivity due to business closures, displacement, and loss of revenue from decreased spending on non-essential retail and commercial products and services.[83]

For future potential economic losses, we evaluate economic infrastructure impacted by sea level rise in 2088 with a category 1 storm surge, using land use data and Infogroup 2011. Figure 25 illustrates the results of potential economic losses from coastal flooding and inundation, the majority of which is clustered in the Front Street downtown area. There are 156 businesses employing 932 people at risk. The assessed value of parcels in the 2088 SLR flood zone include: $57,821,600 in commercial parcels, $46,421,600 in municipal parcels, and $1,666,552 in residential parcels.

[81] http://money.cnn.com/2014/10/30/news/economy/us-gdp-3-and-half-percent-beats-expectations/?iid=EL
[82] https://www.cbsnews.com/news/economic-impact-of-polar-vortex-could-reach-5b/
[83] http://www.mass.gov/governor/docs/news/attachment-a-severe-winter-weather-pattern-impacts-supplemental-info.pdf

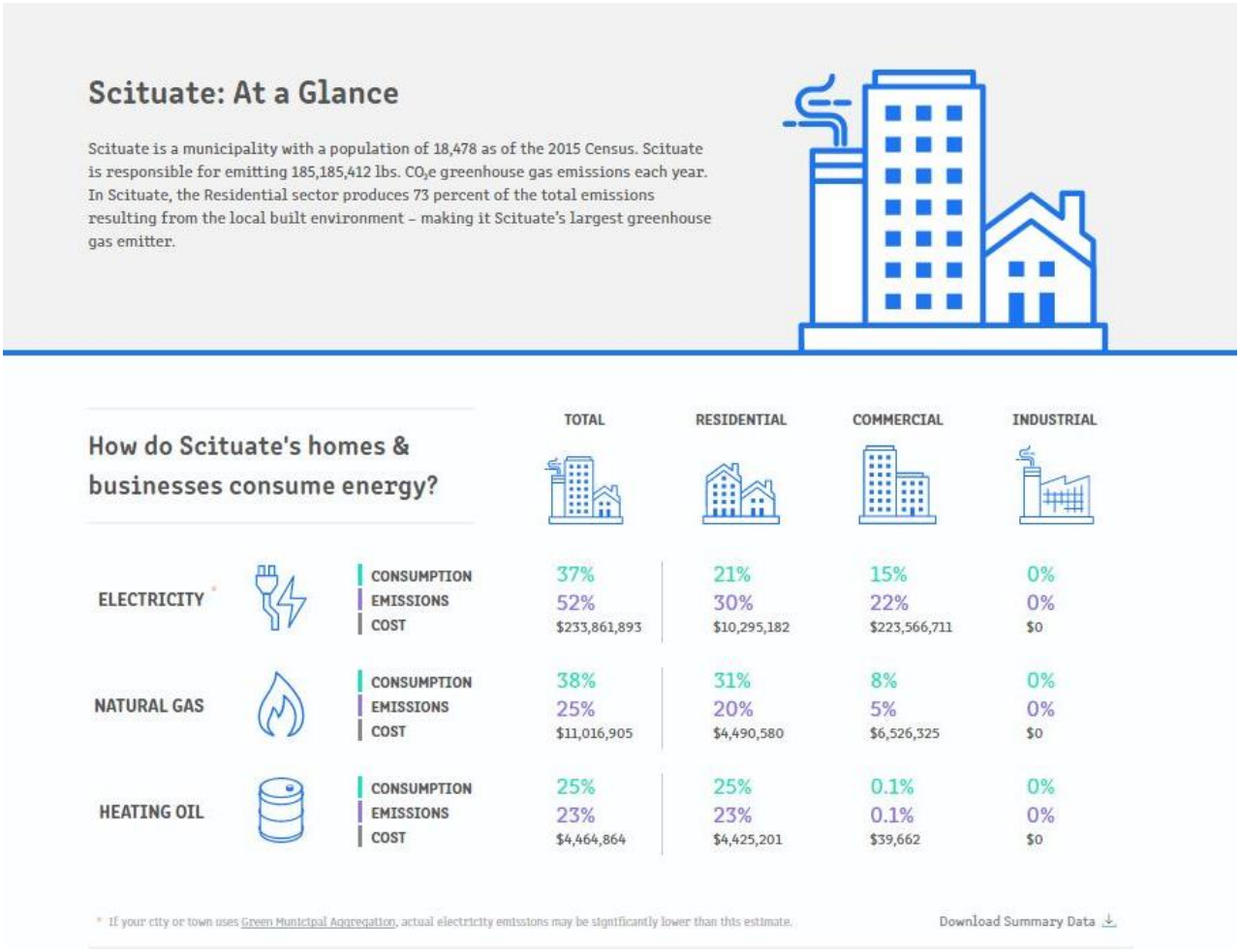
Figure 25 Potential economic loss with 2088 sea level rise in Scituate.



Utility Vulnerability

Figure 26 illustrates the breakdown of energy use by sector in Scituate and its implications on carbon emissions, from the MAPC's Local Energy Action Dashboard (lead.mapc.org). This platform serves to explore and compare energy use, emissions, and cost estimates. It provides a high-level understanding the extent of potential loss during a storm but also as a baseline to assist communities in developing clean energy programs, important for reducing our carbon emissions and reducing sea level rise extent in the future.

Figure 26 Energy and emissions analysis, Scituate.



An analysis of Scituate's energy consumption, emissions, and cost from the Metropolitan Area Planning Council's Local Energy Action Dashboard (https://lead.mapc.org/cities/duxbury).

Scituate owns a wind turbine and solar farm at the Driftway, advancing clean energy and climate mitigation strategies as well as saving money on electricity for municipal buildings. Other utilities include Columbia Gas Company for natural gas, and Eversource and National Grid for electricity.[84] Because energy infrastructure is not publicly available, we have limited data on the geographic

[84] https://www.scituatema.gov/quick-links/pages/utilities

locations of substations. Nonetheless, we have evaluated the overall vulnerability of utilities and here report on how Scituate's companies are addressing climate resilience.

Electricity

Electrical infrastructure is vulnerable to extreme weather, particularly winter storms, heat waves, and floods. Ice storms, freeze/thaw cycles, and flooding can cause severe damage. Winter storms and hurricanes can increase loads on utility infrastructure, such as power lines and utility poles, from precipitation and wind strain. Additionally, over 90% of power outages are caused by fallen trees and limbs during storms. Heat waves are also damaging to infrastructure, because of disruptions to cooling equipment within transformers, which are already overburdened during times of increased demand on the electric grid. Flooding can corrode critical infrastructure and prevent electronic components from functioning.

Eversource is currently implementing initiatives to bolster the resiliency of their critical assets. These initiatives include emergency preparedness trainings for staff, flood-proofing vulnerable substations, and updating design standards for increased precipitation and flooding. Eversource has also partnered with the University of Connecticut for a variety of research and model programs to enhance emergency repair response, forest management, climate adaptation and mitigation activities in preparation for sea level rise and flooding. They are also advancing projects with a resilience cost benefit analyses and utilizing technology to create a three-dimensional model of local and utility infrastructure. Eversource is also utilizing and providing clean energy such as solar and wind to its customers. [85]

National Grid is part of the U.S. Department of Energy's *Partnership for Energy Sector Climate Resilience*, a program for utilities to enhance resilience of its infrastructure from extreme weather events and climate change. Through this partnership, National Grid has committed to evaluate climate vulnerability, create an action plan for resiliency, evaluate the cost and benefits of resilient strategies to prioritize response, and share best practices with the partnership. The Department of Energy provides technical assistance such as tools for assessing vulnerabilities and climate data, facilitates collaboration within the partnership and provides recognition for leaders in climate resilience.[73] In addition, National Grid has initiated a Yearly Improvement Program targeted at enhancing resiliency in areas that have suffered repeat flood outages. In these high-risk areas, they will be upgrading low pressure distribution systems to high pressure distribution systems and flood-proofing aboveground infrastructure that may be affected by flooding. Finally, National Grid has made a commitment toward climate mitigation by providing low-carbon energy solutions and to pledge reduce their greenhouse gas emissions by 45% by 2020 and 80% by 2050.[86]

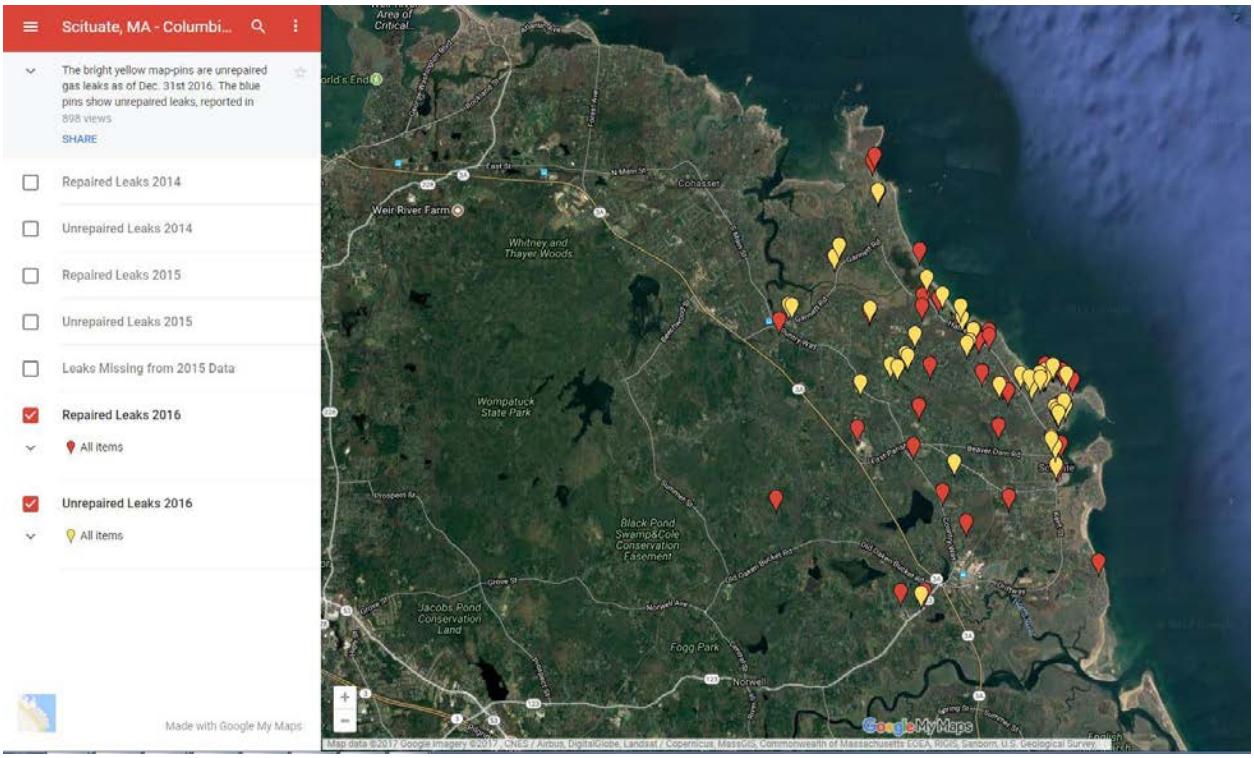
[85] http://www.eversource.uconn.edu/wp-content/uploads/2016/11/brochure-eec-october-2016.pdf
[86] https://www.nationalgrid.com/group/responsibility-and-sustainability/environmental-sustainability/our-climate-commitment

Natural Gas

Scituate's natural gas infrastructure is provided by Columbia Gas. Critical gas infrastructure includes pipelines, compressor stations, storage facilities, and control stations. This infrastructure is necessary to transport, store, and distribute natural gas.

Flooding from heavy precipitation poses a threat to underground gas infrastructure. Gas pipes rely on internal pressure to keep natural gas flowing. Water intrusion can disturb this internal pressure and result in service disruption. Gas pipes within low pressure distribution systems are the most vulnerable to flooding, because they do not have the hydrostatic pressure necessary to keep water out. Aboveground infrastructure, such as compressor stations, metering stations, and control stations are also vulnerable to flooding. Freeze/thaw events can cause gas mains to break. Older cast iron pipes are the most vulnerable to freeze/thaw events. Extreme heat does not pose significant threats to gas infrastructure. For example, during winter storm Riley in March 2018, a downed utility wire ignited a gas line in the Town of Wenham causing a 30-foot fireball to rise into the sky and an ongoing plume of fire on the street until the issue was resolved.[87]

Figure 27 Natural gas leaks and repaired leaks in Scituate as of December 2016.



Source: https://www.heetma.org/squeaky-leak/natural-gas-leaks-maps/

Massachusetts has a gas leakage problem that adds complexity to addressing future climate impact. The natural gas system is one of the oldest in the country; cast iron pipes are susceptible to breaks from frost heaves, ground movement, and construction. Unprotected steel pipes are subject to

[87] https://whdh.com/news/30-foot-fireball-rises-over-wenham-when-downed-wire-ignites-gas-line/

corrosion. As of December 2016, Scituate had 45 unrepaired gas leaks and 43 leaks repaired in 2016(Figure 27).[88] Many of these are located within a FEMA 1% Annual Chance Flood or within SLR for 2038 and 2088. Gas leaks release methane, the most powerful greenhouse gas, into the soil and the air and can cause serious environmental and health risks, including suffocating the root systems of trees and forming ground-level ozone (an asthma trigger). In 2014, the Massachusetts legislature passed a law that requires gas companies to accelerate the replacement of leak prone pipes. Gas companies are required to submit annual Gas Safety Enhancement Plans. In 2015, Columbia Gas had over 800 miles of leak-prone pipes. To meet compliance, Columbia gas began working with municipalities to improve the process of construction for repairs including consensus on project start dates, identification of municipal special requests, and sequencing of gas main replacement with paving and/or water and sewer improvement projects. This collaborative approach enables cost-savings mechanism for municipalities and Columbia Gas in sharing expenses related to utility and road (paving) improvements.[89] In addition, Columbia Gas, National Grid, and Eversource are working with the Home Energy Efficient Team (HEET) to address natural gas leaks through a "Shared Action Plan." Specifically, they are targeting the Grade 3 large volume leaks that are the greatest risks to health and the environment.[90]

Telecommunications

Telecommunications infrastructure is the technology that transmits information electronically, including phone and computer networks, and the internet. This infrastructure plays a critical role in emergency response and recovery. Telecommunications infrastructure is vulnerable to extreme heat, precipitation, and storms. Most heat-related service disruptions are caused by power outages resulting from increased demand on the electric grid. Extreme heat can also cause critical infrastructure to overheat or malfunction, leading to equipment failure and reduced lifespan. Flooding from heavy precipitation, sea level rise, and storm surges are primary concerns for underground infrastructure and critical facilities with potential for corrosion and erosion. Heavy ice formation and snow accumulation can increase the load on telecommunication lines and infrastructure, resulting in damage. Heavy precipitation and increased humidity can interfere with the signal transmission on which wireless systems rely on.

Aboveground infrastructure is vulnerable to strong winds and lightning. Wired infrastructure and utility poles are particularly vulnerable to damage from falling trees and limbs. Many providers utilize shared fiber networks that reduce redundancy and therefore increase vulnerability to systems disruption during extreme weather.

Some service providers, such as Verizon, are taking steps to protect their infrastructure from the impact of climate change. They are creating backup power capability on critical sites, implementing emergency fuel plans for generators, hardening buildings and structures to withstand flooding and precipitation, deploying mobile communications units to heavily affected communities, and training

[88] https://www.heetma.org/squeaky-leak/natural-gas-leaks-maps/
[89] [75] http://fixourpipes.org/case-studies/
[90] https://www.columbiagasma.com/en/about-us/newsroom/news/2017/11/07/columbia-gas-of-massachusetts-plans-reliability-projects

staff to respond to emergencies. Specific data on the location of telecommunications infrastructure and networks is not publicly available.

Transportation Vulnerability

MBTA

The MBTA provides services to Scituate residents and businesses via the Greenbush Commuter Line and two commuter stops, North Scituate and Greenbush. Data from the MBTA Ridership and Services Statistics 2014 Report reveals that the Greenbush line services approximately 5,400 riders daily, including approximately 500-1000 from the North Scituate Commuter Station. Though the Greenbush Commuter line is not the most heavily used, its ridership has increased by over 3,000 since 2010.[91] While Greenbush line ridership increases significantly starting at the Quincy Center station, the notable growth in ridership both locally, statewide, and nationally on public transportation presents this line as a clear asset to the Town.[92]

Figure 28 Heat kink on MBTA track.

Heat kinks in the Orange Line tracks cause cancellations and delays.

MBTA infrastructure in Scituate is at risk from climate change. The Greenbush Station is in a 1% Annual Chance Flood and the North Scituate station is adjacent to a regulatory floodway and a 1% Annual Chance Flood Zone. Both are low lying and generally prone to flooding today. [93] Portions of the commuter line rail itself is susceptible to 0.2% flooding between the North Scituate and Cohasset Stations. Some portions of the rail line exist within a current 1% Annual chance of flooding. Furthermore, the Greenbush station is located within an existing urban heat island.

MBTA climate concerns extend to extreme heat and warmer winters. Also, temperatures in excess of 85°F can cause buckled rails (Figure 28), overheated equipment, regional power failures, wear and tear on paved surfaces, and health and safety issue for workers and passengers. Warming temperatures could lead to more damage from ice storms if temperatures hover around freezing.

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[91] MBTA State of the Service Commuter Rail. 2015.
http://old.mbta.com/uploadedfiles/About_the_T/Board_Meetings/StateofCommuterRailSystem.pdf
[92] American Public Transportation Association. Public Transportation Ridership Report. 2014.
http://www.apta.com/resources/statistics/Documents/Ridership/2014-q4-ridership-APTA.pdf
[93] Personal Communication, Nancy Durfee, December 2017.

Extreme weather events were the greatest cause of delays in service in 2015 with 4,743 incidents. The MBTA is committed to creating a resilient transportation system and employing incremental steps to address climate resilience. New architectural and engineering plans must now address historic and future vulnerabilities by the 30% design stage. New improvement projects must indicate how they will improve climate resilience and are prioritized by climate resilience function. The MBTA has completed the Blue Line Vulnerability Assessment, and Kenmore Square and Charlestown studies are underway to ascertain flood risk in stations effected by future sea level rise and storm surge projections. Additionally, they are pursuing a system-wide analysis of climate vulnerability.

Figure 29 Scituate coastal flooding on roadways.

Emergency response was required to walk to site of emergency because of road flooding during a storm. Photo Credit SANDS.

Roadways

Transportation infrastructure would likely experience an acceleration in deterioration of its components, like asphalt, from the combination of extreme temperatures, increased precipitation and flooding. Extreme temperatures for long periods would cause thermal expansion of metal structures and stress bridge infrastructure. This would also affect roadway materials through softening and expanding, which can lead to rutting and potholes.[94] While a warmer climate may lead to a decreased need to provide snow and ice removal, more rapid freezing and thawing cycles could cause more acute damage sustained during the warmer months.

Roadways in Scituate subject to heat damage from heat island effects include (i) roads adjacent to the North Scituate Commuter Rail Stop including Gannet Road and Country Way, (ii) roads adjacent

[94] National Research Council. The Potential Impacts of Climate Change on U.S. Transportation, Transportation Research Board Special report 290. 2008.

to the Greenbush Commuter Rail Station including the Driftway, Stockbridge Road and Country Way, (iii) the municipal buildings complex off Route 3A including the Scituate High School, Gates Middle School, and Scituate Town Hall, (iv) Front Street at retail center, and (v) roads in and around Humarock.

Flooding has the potential to block roadways for both regular and emergency transportation access. There are approximate 16 major roads and streets prone to major flooding from a1% Annual Chance Flood Zone. These are listed in the Table 8.

Table 8: Major roads prone to flooding in 1% Annual Chance Flood.

Road	1% Annual Chance Flood Zone
Gannet	X
Surfside	X
Hatherly	X
Glades	X
Hollet	X
Oceanside	X
Rebecca	X
Lighthouse	X
Jericho	X
Front	X
Edward Foster	X
Kent	X
The Driftway	X
Central Ave	X
Gilson	X
River St.	X

Historic Assets Vulnerability

Scituate is rich with cultural assets contributing significant interest and beauty to the Town. Indeed, one resident noted that its historic assets "are the very essence of our Town." [95] Some notable historic sites include the Scituate Lighthouse, the Stockbridge Grist Mill, Lawson Tower, and Old Oaken Bucket House. Scituate has a historical commission, a historical society, a demolition delay bylaw, and compliments the Community Preservation Act. The MA Historic Commission has inventoried 972 historic structures and buildings in Scituate, and the Scituate Historical Society has completed 18 historic preservation Community Preservation Projects. Because of their richness, historic and cultural assets are important to consider for future planning, growth, and climate change resilience. With projected changes in temperatures, storm severity, and precipitation regimes, new preservation methodologies may need to be explored.

Historic assets in Scituate are vulnerable to climate change. First, locations in flood zones, coastal areas, and heat islands may impact the integrity of historic structures, but in addition, studies have indicated that our changing climate could accelerate the deterioration of stone and brick buildings. Masonry building deterioration is caused by water infiltrating the stone, evaporation and/or freezing and thawing.[96] This process can typically occur over centuries but is likely to accelerate with increased temperatures and increased frequency of freeze/thaw cycles. Increased temperatures could also encourage fungal and plant growth and insect infestation which could further deteriorate building materials.[97]

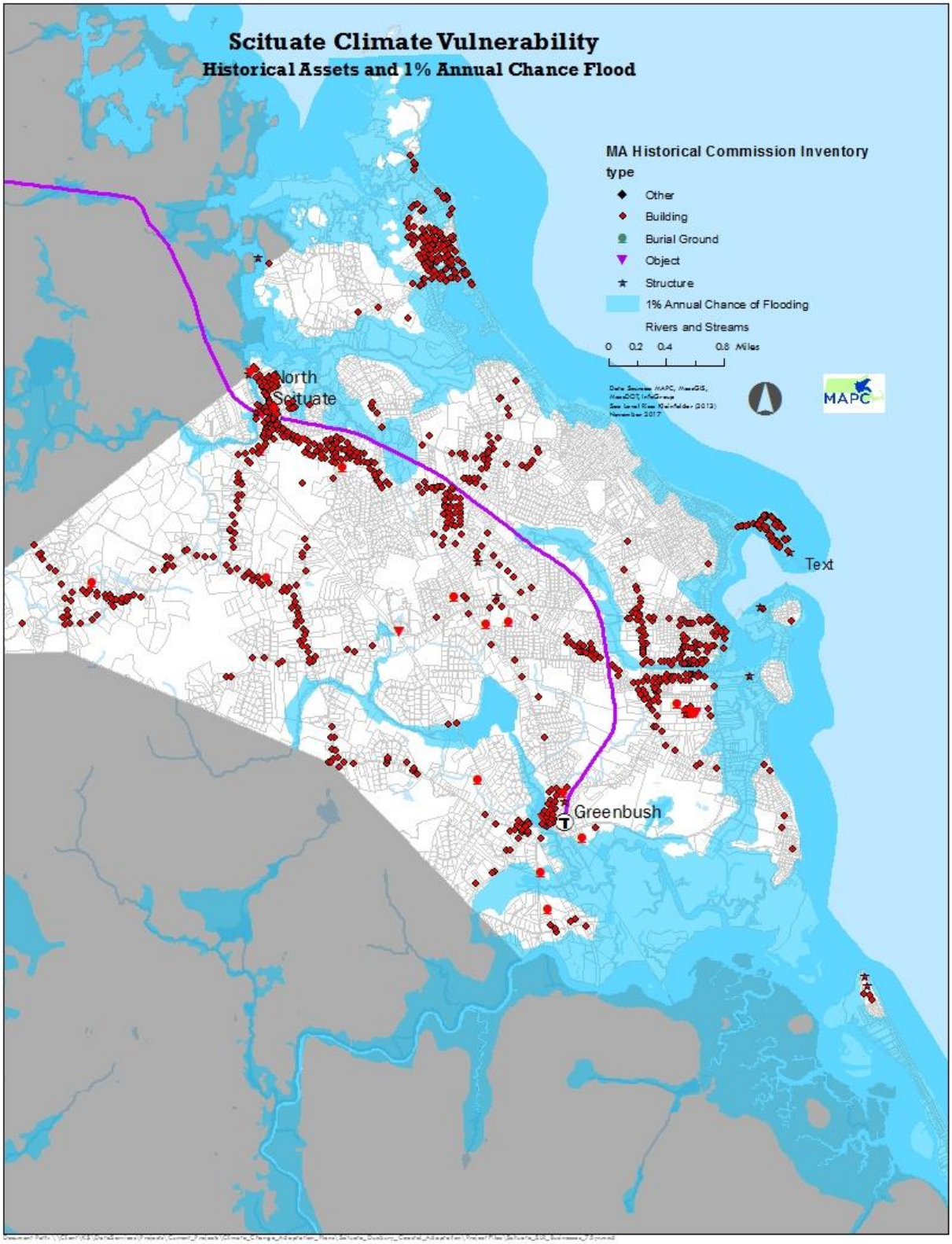
Of Scituate's 972 historic structures, 127 are at risk to flooding in a 1% Annual Flood Chance according to FEMA flood risk maps. These include the South Shore Railroad Bridge, the Scituate/Cohasset Border Marker, the Scituate Lifeboat Station, and Scituate Lighthouse. In addition, there are approximately 60 historic structures vulnerable to sea level rise in 2088, with approximately 1-2 feet of flood depth (Figure 30).

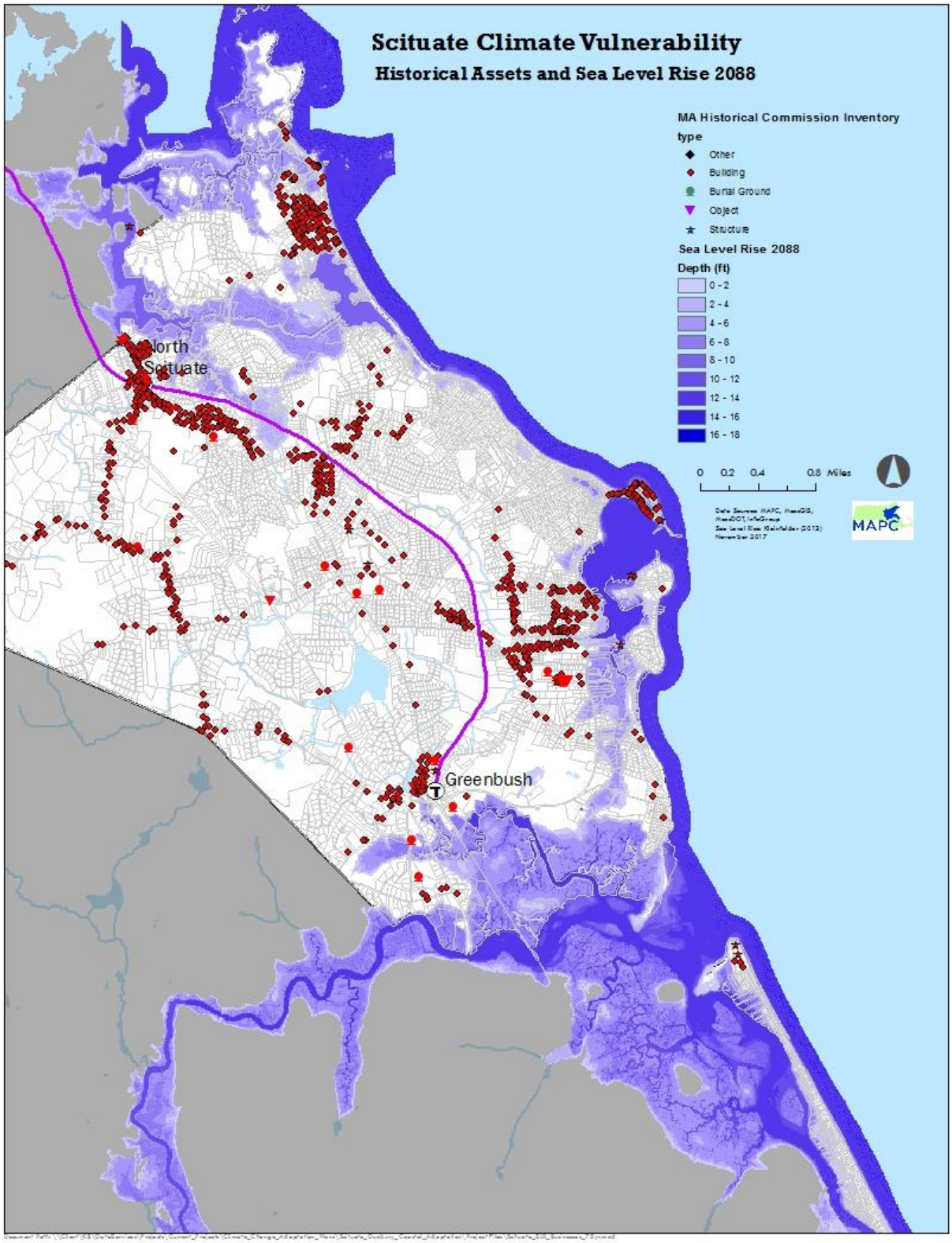
[95] http://scituate.wickedlocal.com/x1551268428/Scituate-Historical-Commission-History-is-in-the-home

[96] https://www.sciencedaily.com/releases/2010/08/100823113422.htm

[97] https://historicengland.org.uk/research/current/threats/heritage-climate-change-environment/what-effects/

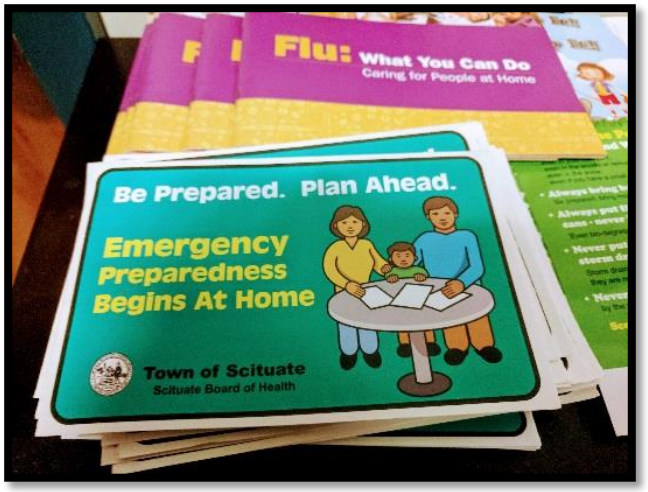
Figure 30 Historic structures within a 1% Annual Chance Flood and SLR.




Scituate Climate Vulnerability
Historical Assets and Sea Level Rise 2088
MA Historical Commission Inventory type
Other
Building
Burial Ground
Object
Structure
Sea Level Rise 2088
Depth (ft)
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16 - 18
0 0.2 0.4 0.8 Miles
MAPC
North Scituate
Greenbush

III. Climate Action Plan

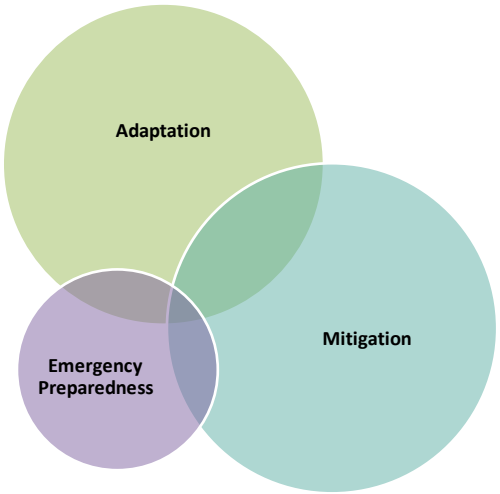
Scituate already experiences intense coastal flooding and storm surge and will face new risks in the coming decades with changing oceans, waterfronts, rivers, and weather events whose related impacts may occur more frequently and more intensely than they have in the past. Climate change resilience will require an increase in response to these new conditions. As climate change extends beyond municipal boundaries, municipal leaders, residents, adjoining towns and the South Shore engagement and collaboration in visioning and participating in climate action response will be critical for effective climate mitigation and adaptation.



Mitigation, Adaptation, and Emergency Preparedness are Inter-connected.

Responses to climate change include emergency preparedness, mitigation and adaptation strategies (Figure 31).[98] Of the three, emergency preparedness planning is generally in place already. However, emergency preparedness is a process that requires continuous updating and the strategies used are likely to change in response to climate change.

Figure 31 Interconnections of mitigation, adaptation, and emergency preparedness.



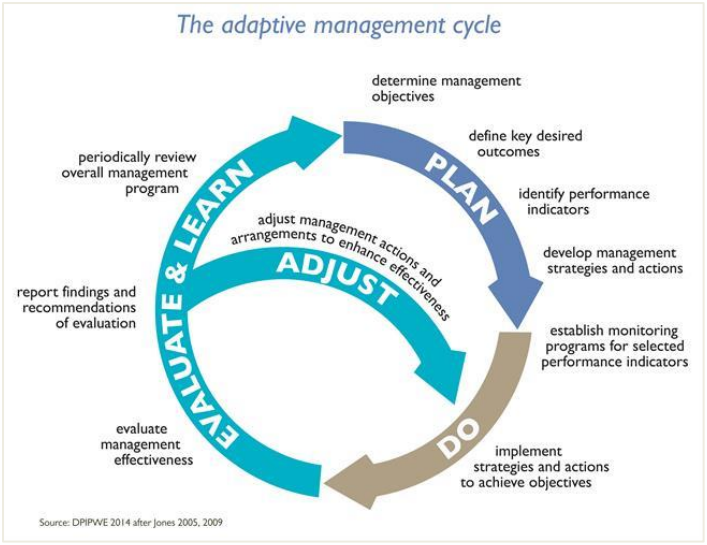
These three elements are interconnected, as action in one dimension can help address the causes or outcomes that another is also trying to tackle. For example, mitigation activities address the causes of climate change (e.g., GHG emissions), and in reducing the magnitude of impacts, efforts may, in turn, affect what adaptation actions are needed to address and/or the extent that emergency preparedness and planning activities are necessary. An instance of this would be clean energy

[98] Emergency preparedness typically encompasses four sets of actions: preparation, response, recovery, and mitigation.

investments that reduce GHG emissions through solar or wind operations. If done under certain circumstances, the solar array could be connected to a microgrid[99] that would enable a set of homes or neighborhoods to maintain electricity during outages and reduce the demand on emergency responders and utility companies. Each dimension – adaptation, mitigation, and emergency preparedness - provide valuable perspectives and tools that are needed to holistically address the causes and potential impacts.

The most desirable response strategies embrace an approach that considers climate resilience a mechanism that creates more livable and vibrant communities regardless of shifting paradigms or patterns of climate change, a "no regrets" approach. They include action items that should be considered regardless as they intend to generate economic, environmental, and social benefits. They include evidence-based and best practices for environmental protection, public health and safety, sustainable economic growth, and a reduction in disparities. An example is the use of green infrastructure and low impact development (LID) techniques that reduce stormwater runoff, provide additional green space, reduce cooling cost due to less impervious ground cover, and recharge water in the local ecosystem. This change would provide benefits even if climate change were not occurring as it would expose more residents to green space, reduce demands on municipal stormwater drainage systems, and support the needs of local ecosystems.

Figure 32 Adaptive Management Framework.



Source: Parks and Wildlife Service, Tasmania

Adaptive Management Framework

The strategies in Figure 32 embrace the concept of Adaptive Management. This concept is used to address issues that involve uncertainty. It relies on iterative processes that use continuous monitoring and assessment to understand what actions are working, which are not, and how these actions could potentially come into conflict with one another. It operates best when new information (e.g.,

[99] Department of Energy, "How Microgrids Work", https://energy.gov/articles/how-microgrids-work, accessed April 5, 2017.

projections, estimates, etc.) can be integrated quickly so that new approaches can be better evaluated and modified to maximize impact under changing conditions.

An adaptive management operating approach is likely to face many challenges in a municipal framework. The concept requires decision-making to be agile and capable of working quickly in the face of evolving information, potentially a challenge for town governments and residents. Therefore, a general proposal is needed to identify how adaptive management concepts can be tested and used to make enhancements in municipal decision-making to best address climate response action.

Strengths and Guiding Principles

Scituate's Natural Hazard Mitigation Plan of August 2016 presents a summary of Scituate's planning efforts concerning coastal remedies and issues from several recent planning efforts. The climate action items presented in this report are intended to supplement, prioritize, and expand upon action items delineated in previous planning documents

The Town's Climate Vulnerability Steering Committee created the prioritization of suggested climate actions in a workshop on December 20, 2017. This prioritization intends to achieve "early-win" resilient efforts that will have a profound impact on stakeholder engagement, public awareness, and protection of critical facilities and areas. Responses and prioritization from the meeting are illustrated in Appendix B. In addition, the Steering Committee agreed upon four guiding principles toward *Building a More Resilient Scituate* in its climate action approach. These are to:

1. Balance growth, preservation, and resiliency to enhance our vibrant community and ensure its livability into the next century and beyond

2. Invest in infrastructure that promotes multiple benefits that address climate risks as well as beautification, economic growth, public programming, and public health.

3. Leverage the resources of multiple disciplines and sectors within municipal departments and across sectors to generate layers of resilience.

4. Approach *Building a More Resilient Scituate* as an ongoing effort to ensure Scituate's ongoing success leveraging capital improvement cycles and outside funding cycles.

Scituate has significant strengths today that will minimize the impact of climate change and inform a shared agenda for climate action by the Town and the South Shore Region. Maintaining these strengths as guideposts for action will be essential in an uncertain future. They will serve as reminders of existing adaptive capacities and provide direction regarding new capabilities that are needed to respond to a changing climate. Scituate's strengths are:

Scituate is proactive. The Town's propensity to act is demonstrated by its participation in multiple planning efforts concerning sea level rise and climate change, hazard mitigation planning, and master planning, and emergency management. Scituate's foresight will create a foundation for incremental resilience improvement programs and projects to ensure it remains a vibrant community into the next century and beyond.

- Plans and procures grants procurement for shoreline protection;
- Launched the Commonwealth's first Volunteer Organization Active in Disaster, SANDS, providing -emergency preparedness and community cohesion before, during, and after natural disasters.
- Coordinates with CZM and Mass Bays on healthy marine environment;
- Leads a robust outreach and education program on flooding and emergency preparedness;
- Demonstrates strong leadership and community support for climate resilience;
- Provides an ongoing educational campaign on preventing Lyme Disease
- Engages in programs and services committed to its seniors' health and safety with a dedicated Licensed Social Worker and Council on Aging programs on emergency preparedness and community cohesion.

Scituate is committed to resilience. This is evident in town's extensive planning and investment in protecting its shorelines and natural resources from coastal flooding, inundation, and coastal erosion. The Towns initiatives in this area include:

- Ongoing evaluation of its seawalls, dikes, jetties and natural barriers to prioritize maintenance and repairs;
- Completion of the North Scituate Beach Nourishment Project;
- Reconstruction of the Oceanside Drive Seawall;
- Completion of the Edward Foster Road Seawall Reconstruction;
- Completion of the South River Dredge and Dune Nourishment Project;
- Collaboration with the Towns of Hull and Cohasset on the feasibility of a regional sewer system;
- Since 1997, provisions of funding assistance to residents to elevate their homes or utilities for nearly 70 homes and utilities;
- Acquisition vacant flood-prone lands;
- Participation in the Community Rating System and Public Information Program.
- Completion of a coastal resiliency assessment to prioritize natural and hard shoreline protection infrastructure;
- Implemented a stormwater bylaw;
- Sewer System upgrades on Cedar Point to address coastal flooding and mitigate potential contamination;
- Retention of a Coastal Resource Officer, Department of Public Works, Emergency Management and Coastal Advisory Commission to address the significant needs and resources of Scituate's prominent coast.

Climate Actions

The Scituate Climate Vulnerability Steering Committee determined the top priorities for *Building a Resilient Scituate* as well as rating other important climate action items for future efforts. The top priorities were those receiving the most significant concern and sense of urgency for Scituate's future livability and were recommended to be implemented as soon as possible. The Town's top priorities are as follows:

1. **Address the vulnerability of coastal business districts.** Lead a climate vulnerability and resilience workshop with stakeholders, property owners, residents, businesses, and municipal staff and officials for participatory visioning the future of Front Street with sea level rise and coastal flooding. The goal of the workshop is to educate stakeholders to the current and future risks and ensure stakeholders are active participants in the waterfront's current and future resilience. Front Street is a priority for this action.
2. **Address the vulnerability of Scituate's municipal infrastructure.** A priority could be the Waste Water Treatment Plant, currently in a 1% Annual Chance Flood. Protection measures discussed include earthen berms and other natural shoreline protection as an incremental resilience measure while investigating more significant structural investments that addresses future risk.
3. **Initiate a public outreach and marketing campaign** with a sense of urgency on climate change and resilience in Scituate. The Town has demonstrated results in such an effort, when, during the 2016 drought where resident's behavior shifted sufficiently to mitigate drinking water scarcity during that time.

The following tables of climate change mitigation actions indicate the top items that the Steering Committee would like to pursue in some capacity within the next seven years. With the intent to maximize multiple benefits in any climate action investment, corresponding mitigation and adaptation benefits are checked by each action item. Scituate's Climate Resilience Task Force (Overall Best Practices Action Item) should designate a lead entity to initiate these actions. The Steering Committee does want to recognize that working across sectors is critically important for success and that staff capacity can present challenges, but the importance of this task must override the obstacles. Finally, potential public funding and technical assistance programs related to implementing these action items are categorized and listed in Appendix C.

Category / Asset	Climate Action Item	Benefits					
		Managing Changing Temperatures	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth
Overall Best Practices	Establish and maintain a Climate Resilience Task Force that works across departments and commissions for a comprehensive approach across sectors. Task Force to assess all plan recommendations for coastal and climate resilience, prioritize mitigation actions, and identify and pursue funding for project implementation.	X	X	X	X	X	X
	Establish neighborhood Resilience Zones for specialized community-based participatory planning where residents, businesses, and neighborhood stakeholders create a shared vision of positive change/adaptation to current and future risks.	X	X	X	X	X	
	Perform a community-based participatory visioning process for Scituate's Waterfront around Front Street. Include business owners, residents, fishermen, and other stakeholders to collectively create solutions for the future of Front Street that address current and future coastal flooding in addition to pubic benefits and economic growth.	X	X	X	X	X	X
	Seek out new funding opportunities to implement climate resilience investments. These may include local surcharges similar in concept to the Community Preservation Act that can provide a dedicated source of funding for climate improvement projects.	X	X	X	X	X	X
Drinking Water	Explore new drinking water sources both inside and outside of the Town.		X				X
	Advocate for Net Blue bylaws to achieve no net increase in water use with future development.	X		X			X
	Evaluate well vulnerability to salt water intrusion for wells and aquifers near the coastline.		X	X	X		
	Relocate or elevate well field pump houses that are in the flood zone in the future.			X	X		X

Category/ Asset	Climate Action Item	Managing Changing Temperatures	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth
Built Environment	Evaluate all zoning, bylaws, and codes for barriers to improvements for climate resilience measures in the built, natural, and landscaped environment (i.e., minimize impervious surface using pervious pavers, minimize parking requirements, and shared driveways, use Low Impact Development, Green Infrastructure, etc.)	X	X	X	X	X	X
	Consider establishing a Coastal Business Improvement District. This could as a consistent source of revenue that could fund climate resilience improvement projects in addition to creating public programming and encouraging business patronage along the waterfront.	X	X	X	X		X
	Evaluate culverts, bridges, river and stream crossings for effectiveness in water flow during floods. Use MA Stream Crossing Standards.			X	X		
	For additional interim protection prior to raising critical infrastructure and residences, consider building soft shoreline protection features such as earthen berms with living shorelines to protect buildings located in low energy flood zones.						
Transport-ation	Create a municipal working group to inform design standards on raising roads in response to current and future coastal flooding. Consider also the implications for commercial, industrial, and residential building egress. See Recommendations, Dutch, and Climate Ready Boston	X		X	X	X	X
	Institute a Complete Streets Ordinance. Apply Complete Streets where appropriate and space allows such as on primary and secondary roads. Work with the State to advocate for Complete Streets on route 3A (commuters to Train Station from Marshfield) to promote walking and biking to encourage less vehicle miles travelled.	X		X	X	X	X

		Benefits					
Category/ Asset	**Climate Action Item**	**Managing Changing Temperatures**	**Improving Public Health**	**Reducing Inland flooding**	**Managing Coastal Flooding**	**Reducing GHG Emissions**	**Promoting Economic Growth**
Natural Resources	Strengthen local wetlands bylaw restrictions in buffer zones to restore original 100ft. no-build buffer of resource areas under the Wetland Protection Act. Consider stormwater management as part of wetlands protection to percolate water into the ground and out of rivers/oceans.			X	X	X	
	Revise Stormwater bylaw so all new and redevelopment captures at least first 1" of rain onsite, using Low Impact Development and other strategies, or evaluate the design standards that consider sea level rise and/or the 1% Annual Chance Flood.		X	X	X		
	Salt Marsh Restoration (i) Contract a formal evaluation on salt marsh health and long-term monitoring and maintenance such as citizen science groups; (ii) Initiate short-term marsh restoration techniques such as invasive removals; (iii) Evaluate wetlands protection act and land acquisition opportunities to plan for, protect, and/or acquire land for horizontal marsh migration. (iv) Perform recommendations for salt marsh restoration based upon formal evaluation; and (iv) collaborate with the Town of Marshfield on salt marsh evaluation and restoration.		X	X	X	X	
	Continue beach and dune nourishment.				X		X
	Install sacrificial dunes, sand fences, seawalls and other coastal infrastructure investments.						

Category/ Asset	Climate Action Item	Managing Changing Temperatures	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth
Waste Water/ Sewer Resilience	Evaluate vulnerability of critical systems in water and sewer pump stations to a 1% and a 0.2% Annual Chance Flood and prioritize infrastructure improvements that enhance resilience.			X	X	X	
	As an interim step to elevating critical infrastructure, install structures to protect critical systems from floods such as self-rising flood walls around pump stations or berms with living shorelines in low-energy coastal areas.			X	X		
	Prepare a list of key utility facilities that require critical power restoration and inform the power company of locations of the facilities to expedite electricity restoration during an outage.			X	X		
People	Advocate for new and redeveloped affordable housing and/or public housing includes building resilience to ensure residents can "shelter in place" during an emergency and have healthy, safe places to live through a changing climate.	X		X	X	X	
	Create a Heat Emergency Action Plan. Prioritize creating cooling centers for those most vulnerable to heat, systematic communications strategies, and back-up energy plans. Stress the importance of tree canopy for cooling buildings.	X					
Energy	Maintain Green Communities designation.	X	X			X	X
	Support green building standards and energy use reduction for retrofits and new development. Incentivize when possible.	X	X			X	
	Explore implementing Community Shared Solar (CSS) to institute Town-wide renewable energy efforts. CSS can provide solar energy benefits to resident, non-profits, and business that are unable to install solar on their properties while reducing Town-wide carbon emissions.	X		X	X	X	X
	Implement renewable back-up energy strategies for municipal buildings and critical infrastructure such as wells and waste water pump stations.			X	X	X	

IV. APPENDIX

Appendix A

Critical Infrastructure susceptible to coastal flooding and sea level rise (SLR).

Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
66	Scituate Animal Shelter	780 Chief Justice Cushing Highway	Animal Shelter				
67	Driftway Animal Hospital	53 Driftway	Animal Shelter				
57	Satuate Boat Club	66 Jericho Rd	Boat Club	x		(x)	
61	Cole Park Way Launching Ramp	Cole Parkway Rd	Boat Launch		x	x	x
62	Driftway Park Launching Ramp	Driftway	Boat Launch		x	x	
93	Boat Launch	Humarock	Boat Launch		x	x	
58	State Launch Ramp	Jericho Road	Boat Ramp	x		x	
44	North River Bridge	Rt 3A	Bridge		x	x	
68	Francis R. Powers Bridge	Humarock/Marshfield	Bridge		x		
69	Sea St. Bridge	Humarock/Marshfield	Bridge		x	x	
43	Cell Towers		Cell Tower				
70	Cell Towers	604 Chief Justice Cushing Hwy.	Cell Tower				
71	Cell Towers	280 Driftway	Cell Tower				
72	Cell Towers	1006 Chief Justice Cushing Highway	Cell Tower				
50	Cudward Cemetery	Cudworth Rd	Cemetery				
51	Fairview Cemetery	Fairview Ave	Cemetery				
52	Union Cemetery	Stockbridge Road	Cemetery				

Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
53	Old St Mary's Cemetery	Meetinghouse Lane	Cemetery				
73	Mount Hope Cemetery	Clapp Rd.	Cemetery				
74	Groveland Cemetery	Mann Lot Rd.	Cemetery				
64	St Mary's Hall	Edward Foster Road	Church		x	(x)	
65	St Mary's Church	Kent Road	Church		x		
75	Harbor United Methodist Church	55 First Parish Rd.	Church				
76	First Parish Unitarian Church	330 First Parish Rd.	Church				
77	First Baptist Church	660 Country Way	Church				
78	First Trinitarian Congregational Church	381 Country Way	Church				
79	Christ Lutheran Church	460 Chief Justice Cushing Highway	Church				
80	Saint Francis Cabrini Church	78 Mann Hill Rd.	Church				
81	Union Chapel	315 Old Oaken Bucket Rd.	Church				
38	Coast Guard	102 Cole Park Way	Coast Guard		x	x	x
123	MBTA Commuter rail tracks	Through entire town	Commuter Rail Tracks				
54	Herring Brook Reservoir Dam		Dam		x		
55	Hunters Pond Dam		Dam		x	x	x
35	DPW Garage	Captain Pierce Road	DPW				
82	Scituate Reservoir	400 Chief Justice Cushing Highway	Drinking Water Reservoir				

Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
3	Lincoln Park Elder Housing	791 Country Way	Elder Housing				
4	Community Residence	644 Country Way	Elder Housing				
10	Central Park Housing	Central Park Dr.	Elder Housing			x	
12	Wheelar Park 2	Wheeler Park Dr.	Elder Housing				
15	Wheeler Park I	Wheelar Park Dr.	Elder Housing				
20	Community Residence	412 First Parish Rd.	Elder Housing				
23	Cardigan Nursing Home	59 Country Way	Elder Housing				
32	Life Care Center	309 Driftway	Elder Housing				
17	Environmental Police	175 Edward Foster Rd.	Environmental Police				
7	Fire Dept.	143 First Parish Rd.	Fire Department				
8	Fire Dept.	4 River St. Humarock	Fire Department		x		
21	Fire Dept.	596 Chief Justice Crushing Hgwy.	Fire Department				
39	Anderson Fuel	331 Gannet Road	Fuel Depot				
41	Fitts Mill	Bearce Lane	Fuel Depot				
46	Village Market	71 Front Street	Grocery Store		x		
37	Harbor Master	Cole Park Way	Harbor Master		x	x	x
47	Joseph's Hardware Store	Front Street	Hardware Store		x		x
28	Heliport		Heliport				
83	Lawson Tower	330 First Parish Rd.	Historic Site				
84	Scituate Lighthouse	100 Lighthouse Rd.	Historic Site	x		(x)	

Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
85	Minot Lighthouse	Minot's Ledge, Massachusetts Bay	Historic Site				
86	GAR Hall	353 Country Way	Historic Site				
87	Maritime Mossing Museum	301 Driftway	Historic Site				
88	Little Red School House	43 Cudworth Rd.	Historic Site				
89	Stockbridge Mill	6 Country Way	Historic Site		x		
90	Mann Farmhouse	107 Greenfield Lane	Historic Site				
91	Old Oaken Bucket Homestead	47 Old Oaken Bucket Rd.	Historic Site				
92	Cudworth House & Barn	317 First Parish Rd.	Historic Site				
36	Scituate Public Library	85 Branch Street	Library				
59	Scituate Harbor Marina	Jericho Rd	Marina	x		x	
60	Satuit Water Front Club	20 Jericho Road	Marina	x		x	
63	North River Marina	12 Chief Justice Cushing Hwy	Marina		x		
122	Village at South River Marina	33 Central Ave., Humarock	Marina		x		
24	Driftway Medical Facility Center	7 New Driftway	Medical Facility		x		
95	Driftway Medical Facility Center	56 Driftway	Medical Facility				
96	Jacob Hatch Building	2 Country Way	Medical Facility				
13	Scituate Town Hall	600 Chief Justice Cushing Hwy.	Municipal				
97	Pier 44 (Town-owned)	44 Jericho Rd.	Municipal	x		x	

Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
98	Ellis House	Country Way	Municipal				
119	Water Dept. Business Office	4 Old Oaken Bucket Rd.	Municipal				
94	Scituate Marine Park	119 Edward Foster Rd.	Municipal & Marina			x	
34	C M Senior Center	25 Brook Street	Nursing Home				
48	CVS	92 Front Street	Pharmacy		x	x	x
49	Scituate Pharmacy	372 Gannet Street	Pharmacy				
45	Town Pier	Front Street	Pier	x		(x)	
19	Police Dept.	604 Chief Justice Crushing Hgwy.	Police Department				
1	Us Post Office	76 Glades Rd.	Post Office		x	(x)	(x)
9	Us Post Office	365 Gannett Rd.	Post Office				
22	Us Post Office	108 First Parish Rd.	Post Office				
25	Us Post Office	23 Ford Place	Post Office				
121	Humarock Post Office	10 Central Ave., Humarock	Post Office		x		
29	North Scituate Sub Station	H.t. Bailey Rd.	Power Substation				
30	Scituate Sub Station	First Parish Rd.	Power Substation				
99	Well #10	87A Cornet Stetson Rd.	Public Drinking Water Well		x	x	
100	Well #11	87 Cornet Stetson Rd.	Public Drinking Water Well		x	(x)	
101	Well #19	381 Chief Justice Cushing Highway	Public Drinking Water Well				

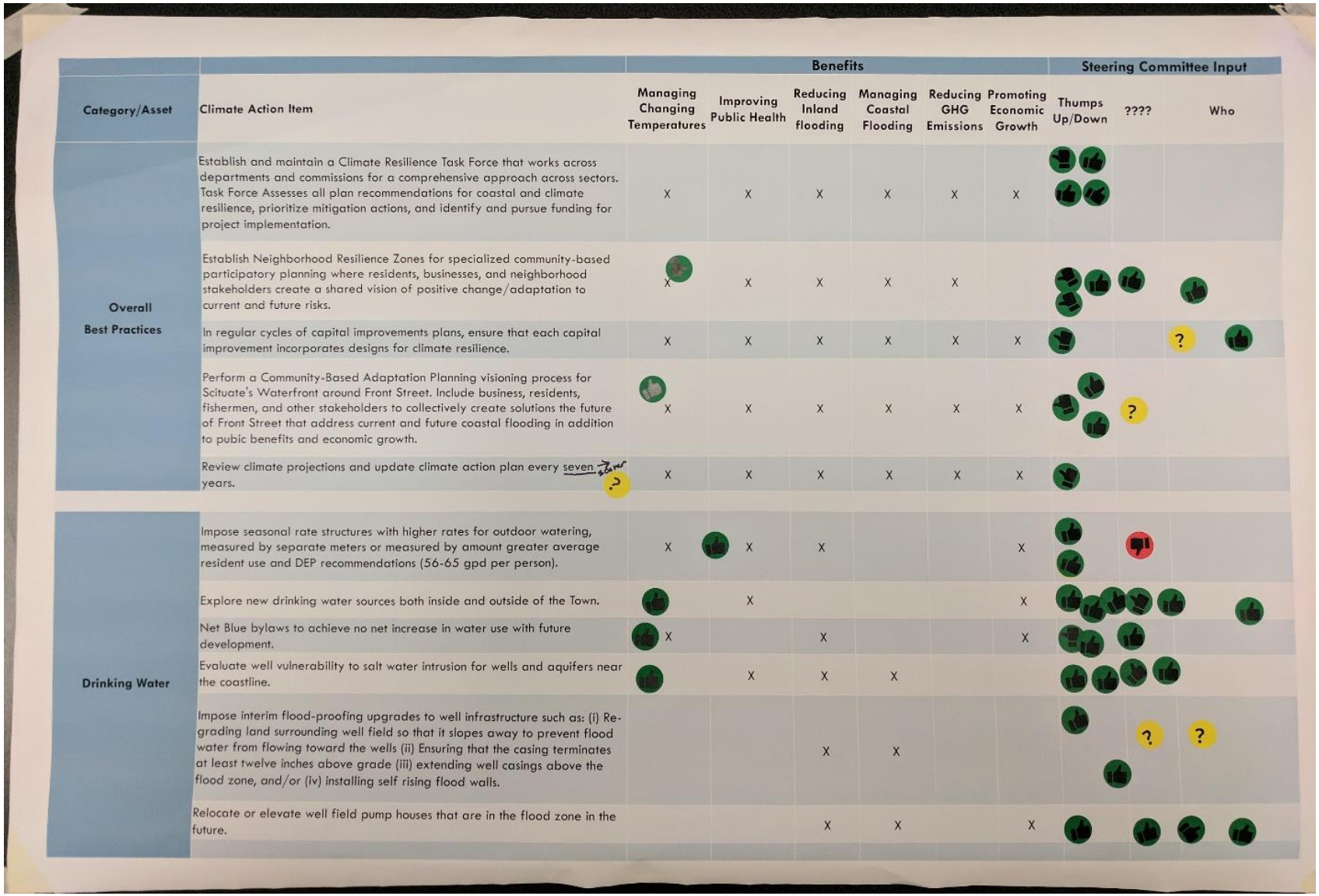
Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
102	Well #17A	98 Tack Factory Pond Dr.	Public Drinking Water Well				
103	Well #22	6 Old Forge Rd.	Public Drinking Water Well		x		
118	Well 18B	250 Driftway	Public Drinking Water Well		x		(x)
2	Hatherly School	72 Ann Vinal Rd.	School				
5	Wampatuck Elementary School	266 Tilden Rd.	School				
6	Cushing Elementary School	1 Aberdeen Dr.	School				
16	Gates Jr. High School	327 First Parish Rd.	School				
18	Scituate High School	606 Chief Justice Cushing Hwy.	School				
27	Montessori Community	46 Watch Hill Drive	School				
33	Jenkins Elementary School	61 First Parrish	School		x		
124	Seawalls	Minot to Third Cliff, Humarock	Seawall	x		x	x
104	Chain Pond Pump Station	310 Hatherly Rd.	Sewer Pump Station		x	(x)	
105	Sand Hills Pump Station	0 Scituate Ave.	Sewer Pump Station		x	(x)	x
106	First Parish Pump Station	106 First Parish Rd.	Sewer Pump Station				
107	Country Way Pump Station	220 Country Way	Sewer Pump Station				

Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
108	Herring Brook Pump Station	15 New Driftway	Sewer Pump Station		x	x	
109	Collier Road Pump Station	31 Collier Rd.	Sewer Pump Station	x			
110	Peggotty Beach Pump Station	22 Peggotty Beach Rd.	Sewer Pump Station	x		x	x
111	First Cliff Pump Station	137 Edward Foster Rd.	Sewer Pump Station		x	x	x
112	Transfer Station	280 Driftway	Solid Waste Transfer Station				
14	Meeting House Estates	12 Meeting House Lane	Special Needs				
113	Community Residence	129 Vernon Rd.	Special Needs				
40	Stand Pipe	Creelman Drive	Stand Pipe				
114	Pincin Hill Standpipe	164 Grove St.	Stand Pipe				
11	Bell Atlantic	First Parish Rd.	Telephone Exchange			(x)	
42	MBTA Greenbush Layover Station	Off Driftway	Transportation Facility				
117	MBTA North Scituate Station	Off Country Way	Transportation Facility				
26	North River Waste Water Pollution Control Plant	161 Driftway	Waste Water Treatment		x		
31	Scituate Water Treatment Plant	Chief Justice Cushing Hwy.	Waste Water Treatment				
115	Walnut Hill Booster Pump Station	27 Woodworth Lane	Water Booster Pump Station				

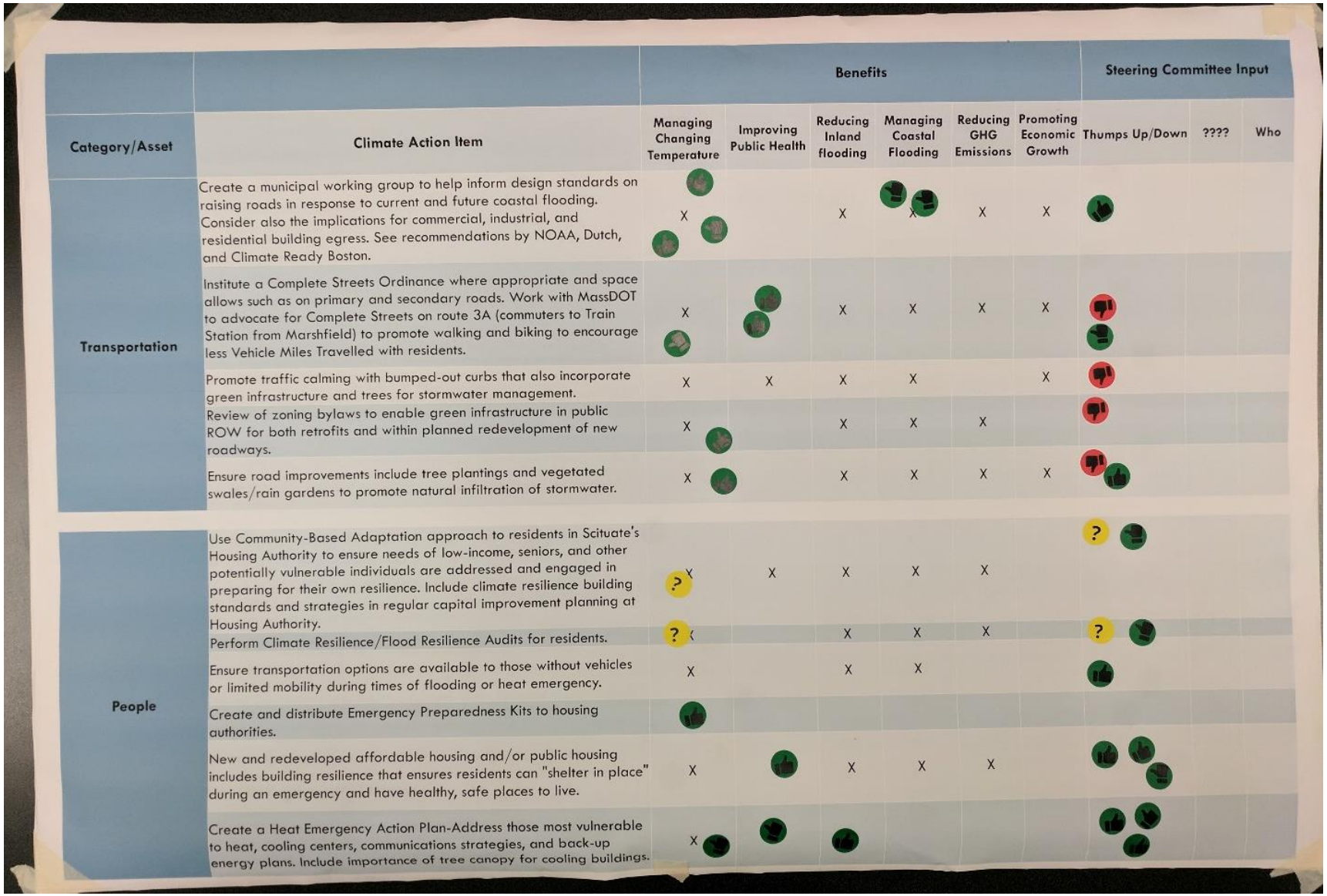
Critical Infrastructure ID	Name	Address	Type	FEMA VE	FEMA 1%	SLR 2038 Cat 1	SLR 2088
120	Mann Lot Booster Station	136 Mann Lot Rd.	Water Booster Pump Station				
56	Scituate Harbor Yacht Club	84 Jericho Road	Water Facility	x			
116	Wind Turbine	167 Driftway	Wind Turbine		x	x	

Appendix B

Climate Steering Committee Meeting #2 Climate Action Plan prioritization notes.



		Benefits						Steering Committee Input		
Category/Asset	Climate Action Item	Managing Changing Temperatures	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth	Thumps Up/Down	????	Who
Overall Best Practices	Establish and maintain a Climate Resilience Task Force that works across departments and commissions for a comprehensive approach across sectors. Task Force Assesses all plan recommendations for coastal and climate resilience, prioritize mitigation actions, and identify and pursue funding for project implementation.	X	X	X	X	X	X			
	Establish Neighborhood Resilience Zones for specialized community-based participatory planning where residents, businesses, and neighborhood stakeholders create a shared vision of positive change/adaptation to current and future risks.	X	X	X	X	X				
	In regular cycles of capital improvements plans, ensure that each capital improvement incorporates designs for climate resilience.	X	X	X	X	X	X			
	Perform a Community-Based Adaptation Planning visioning process for Scituate's Waterfront around Front Street. Include business, residents, fishermen, and other stakeholders to collectively create solutions the future of Front Street that address current and future coastal flooding in addition to pubic benefits and economic growth.	X	X	X	X	X	X			
	Review climate projections and update climate action plan every seven → four years.	X	X	X	X	X	X			
Drinking Water	Impose seasonal rate structures with higher rates for outdoor watering, measured by separate meters or measured by amount greater average resident use and DEP recommendations (56-65 gpd per person).	X	X	X			X			
	Explore new drinking water sources both inside and outside of the Town.		X				X			
	Net Blue bylaws to achieve no net increase in water use with future development.	X		X			X			
	Evaluate well vulnerability to salt water intrusion for wells and aquifers near the coastline.		X	X	X					
	Impose interim flood-proofing upgrades to well infrastructure such as: (i) Re-grading land surrounding well field so that it slopes away to prevent flood water from flowing toward the wells (ii) Ensuring that the casing terminates at least twelve inches above grade (iii) extending well casings above the flood zone, and/or (iv) installing self rising flood walls.			X	X					
	Relocate or elevate well field pump houses that are in the flood zone in the future.			X	X		X			



		Benefits						Steering Committee Input		
Category/Asset	Climate Action Item	Managing Changing Temperature	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth	Thumps Up/Down	????	Who
Transportation	Create a municipal working group to help inform design standards on raising roads in response to current and future coastal flooding. Consider also the implications for commercial, industrial, and residential building egress. See recommendations by NOAA, Dutch, and Climate Ready Boston.	X		X	X	X	X			
	Institute a Complete Streets Ordinance where appropriate and space allows such as on primary and secondary roads. Work with MassDOT to advocate for Complete Streets on route 3A (commuters to Train Station from Marshfield) to promote walking and biking to encourage less Vehicle Miles Travelled with residents.	X		X	X	X	X			
	Promote traffic calming with bumped-out curbs that also incorporate green infrastructure and trees for stormwater management.	X	X	X	X		X			
	Review of zoning bylaws to enable green infrastructure in public ROW for both retrofits and within planned redevelopment of new roadways.	X		X	X	X				
	Ensure road improvements include tree plantings and vegetated swales/rain gardens to promote natural infiltration of stormwater.	X		X	X	X	X			
People	Use Community-Based Adaptation approach to residents in Scituate's Housing Authority to ensure needs of low-income, seniors, and other potentially vulnerable individuals are addressed and engaged in preparing for their own resilience. Include climate resilience building standards and strategies in regular capital improvement planning at Housing Authority.	? X	X	X	X	X		?		
	Perform Climate Resilience/Flood Resilience Audits for residents.	?		X	X	X		?		
	Ensure transportation options are available to those without vehicles or limited mobility during times of flooding or heat emergency.	X		X	X					
	Create and distribute Emergency Preparedness Kits to housing authorities.									
	New and redeveloped affordable housing and/or public housing includes building resilience that ensures residents can "shelter in place" during an emergency and have healthy, safe places to live.	X		X	X	X				
	Create a Heat Emergency Action Plan-Address those most vulnerable to heat, cooling centers, communications strategies, and back-up energy plans. Include importance of tree canopy for cooling buildings.	X								

		Benefits						Steering Committee Input		
Category/Asset	**Climate Action Item**	**Managing Changing Temperatures**	**Improving Public Health**	**Reducing Inland flooding**	**Managing Coastal Flooding**	**Reducing GHG Emissions**	**Promoting Economic Growth**	**Thumps Up/Down**	**????**	**Who**
Energy	Maintain Green Communities designation.	X	X		👍	X	X			
	Develop municipal energy and GHG emissions baselines to inform short and long-term clean energy planning.	X	X			X		👎		
	Adopt Net Zero plans or policies at the municipal level.	X	X	X	X	X				
	Work with Sustainability groups and organizations to build capacity and resident's knowledge on net zero planning, education and outreach.	X	X	X	X	X				
	Support green building standards and energy use reductions retrofits and new development, incentivize if possible.	X	X			X		👍		
	Retrofit municipal buildings with energy efficiency lightbulbs, appliances, and machinery.		X			X		👎		
	Replace all municipal street lights with LED bulbs.					X		👎		
	Explore implementing Community Shared Solar (CSS) to institute Town-wide renewable energy efforts. CSS allows communities to provide benefits of solar to residents, non-profits, and businesses that are unable to install solar on their properties.	X		X	X	X	X	👍 👍		
	Implement renewable back-up energy strategies for municipal buildings, critical infrastructure such as wells and waste water pump stations.			X	X	X		👍		
Built Environment	Evaluation all zoning, bylaws, and codes for barriers and improvements for climate resilience measures in the built, natural, and landscaped environment. (i.e., minimize impervious surface with pervious pavers, minimizing parking requirements, shared driveways, use Low Impact Development, Green Infrastructure, etc.)	👍	X	X	X	X	X	👍 👍		
	Develop a climate resilient building/landscape checklist with planning board, conservation commission, building inspector, DPW, and other municipal staff/ stakeholders.	👍 X	X	X	X	X	X	👍		
	Ensure planning board/ZBA/Building Inspectors consider checklist for proposals, approvals, and permits.	👍 X	X	X	X	X		👍		This is what we do
	Takes steps to codify climate resilience building/landscape checklist.	X	X	X	X	X	X			
	Require residents with damaged septic systems to comply with Title 5 with statement from engineer that system is in working order. Consider condemnation of residences if non-compliant within a certain time frame.	👍	X		X					We do this already to some degree— alternatives to septics in beaches
	Consider establishing a Coastal Business Improvement District. This can serve as a consistent form of revenue that could fund climate resilience improvement projects in addition to creating public programming and encouraging business patronage around the waterfront.	X 👍	X	X	X		X	👍 👍		
	Remove the Tack Dam and other dams as they become redundant or unnecessary.	?		X	X					
	Evaluate culverts, bridges, river, and stream crossings for effectiveness in water flow during floods. Use MA Stream Crossing Standards.	👍		X	X			👍 👍 👍		
	For additional interim protection prior to raising critical infrastructure and residences, consider building soft shoreline protection features such as an earthen berm with living shoreline to protect buildings located in low energy flood zones.		👍	X	👎			👍 👍 👍		

		Benefits						Steering Committee Input		
Category/Asset	Climate Action Item	Managing Changing Temperature	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth	Thumps Up/Down	????	Who
Transportation	Create a municipal working group to help inform design standards on raising roads in response to current and future coastal flooding. Consider also the implications for commercial, industrial, and residential building egress. See recommendations by NOAA, Dutch, and Climate Ready Boston.	X		X	X	X	X			
	Institute a Complete Streets Ordinance where appropriate and space allows such as on primary and secondary roads. Work with MassDOT to advocate for Complete Streets on route 3A (commuters to Train Station from Marshfield) to promote walking and biking to encourage less Vehicle Miles Travelled with residents.	X		X	X	X	X			
	Promote traffic calming with bumped-out curbs that also incorporate green infrastructure and trees for stormwater management.	X	X	X	X		X			
	Review of zoning bylaws to enable green infrastructure in public ROW for both retrofits and within planned redevelopment of new roadways.	X		X	X	X				
	Ensure road improvements include tree plantings and vegetated swales/rain gardens to promote natural infiltration of stormwater.	X		X	X	X	X			
People	Use Community-Based Adaptation approach to residents in Scituate's Housing Authority to ensure needs of low-income, seniors, and other potentially vulnerable individuals are addressed and engaged in preparing for their own resilience. Include climate resilience building standards and strategies in regular capital improvement planning at Housing Authority.	X	X	X	X	X		?		
	Perform Climate Resilience/Flood Resilience Audits for residents.	?		X	X	X		?		
	Ensure transportation options are available to those without vehicles or limited mobility during times of flooding or heat emergency.	X		X	X					
	Create and distribute Emergency Preparedness Kits to housing authorities.									
	New and redeveloped affordable housing and/or public housing includes building resilience that ensures residents can "shelter in place" during an emergency and have healthy, safe places to live.	X		X	X	X				
	Create a Heat Emergency Action Plan-Address those most vulnerable to heat, cooling centers, communications strategies, and back-up energy plans. Include importance of tree canopy for cooling buildings.	X								

		Benefits						Steering Committee Input		
Category/Asset	Climate Action Item	Managing Changing Temperatures	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth	Thumps Up/Down	????	Who
Natural Resources	Strengthen local wetlands bylaw restrictions with a 100 foot no-build buffer zone of resource areas under the Wetland Protection Act. Consider stormwater management as part of wetlands protection to bring water into the ground and out of rivers/oceans.			X	X	X				Cons Dept.
	Consider updating the stormwater requirement and the wetlands By-law requirements to reflect NOAA 14 or Northeast Regional Climate Center design standards so development projects address rainfall projections for their planned life plan.			X	X	X				Planning Bylaw change
	Create a Forest Management plan for public and private tree canopy in Scituate to maintain the financial and ecological benefits of trees through storms, extreme heat, changing precipitation, and coastal flooding.	X		X	X	X	X		?	cons.
	Revise Stormwater bylaw so all new and redevelopment captures at least first 1" of rain onsite, through the use of Low Impact Development and other strategies or evaluate the design standards that consider sea level rise and/or the 1% Annual Chance Flood.		X	X	X			?		Planning
	Salt Marsh Restoration (i) Conduct a formal evaluation of salt marsh health and ensure long-term monitoring and maintenance by employing a non-profit or citizen science group; (ii) Initiate short-term marsh restoration techniques such as invasive removals; (iii) Evaluate land acquisition opportunities to plan for, protect, and/or acquire land for horizontal marsh migration. (iv) Perform recommendations for salt marsh restoration based upon formal evaluation; and (iv) collaborate with the Town of Marshfield on salt marsh evaluation and restoration.		X	X	X	X				apply for grants
	Continue beach nourishment, sacrificial dunes, sand fences, seawall and other coastal infrastructure investments.				X		X			grants
	Work with CZM to monitor ongoing health of submerged aquatic vegetation, such as eelgrass beds. If necessary, expand and/or restore eelgrass beds and perform measures to eradicate invasives such as green crabs.				X					?
Waste Water/Sewer	Evaluate vulnerability of critical systems in water and sewer pump stations to a 1% and a 0.2% Annual Chance Flood and prioritize infrastructure improvements that enhance resilience.			X	X	X				?
	As an interim step to raising waste water and sewer infrastructure, install structures to protect critical systems from floods such as self-rising flood walls around pump stations or berms with living shorelines in low-energy coastal areas.			X	X					
	Install backflow preventers on low-lying overflow pipes to protect finished water.			X	X					
	Prepare a list of key utility facilities that require critical power restoration and include the physical locations of the facilities to the power company during an outage to expedite electricity restoration.			X	X					

Category/Asset	Create your own Climate Action Item	Managing Changing Temperatures	Improving Public Health	Reducing Inland flooding	Managing Coastal Flooding	Reducing GHG Emissions	Promoting Economic Growth	Thumps Up/Down	????	Who
	Where we can incorporate climate change in every aspect of gov't.									
	Tackle low hanging fruit in order to create a more resilient Scituate sooner.									
	Vulnerability of Front Street									

Appendix C

Potential Funding Sources to Implement Climate Action Plan

Overall Best Practices Climate Action.

EEA Planning Grant. The Executive Office of Energy and Environmental Affairs provides funding to municipalities and Regional Planning Agencies to pursue Massachusetts Sustainable Development Principles that preserve natural resources, ensure sufficient and diverse housing, and prepare for climate change. Eligible requests include zoning for sustainable housing production, actions implementing the results of a climate vulnerability assessment or MVP program, or mitigation of climate change through zoning or other regulations that reduce energy use and greenhouse gas emissions. In 2017, EEA awarded $1,296,219 to 37 applicants. https://www.mass.gov/service-details/planning-assistance-grants

Municipal Vulnerability Preparedness Program. The Executive Office of Energy and Environmental Affairs provides financial assistance to municipalities to pay for technical assistance to complete assessments and planning using the Community Resilience Building workshop guide (CRB). Municipalities who complete this process and develop a final report will be designated as an MVP Community, which may lead to increased standing in future funding opportunities and signify the commitment of this municipality to building resiliency and preparing for climate change. https://www.mass.gov/municipal-vulnerability-preparedness-program

Drinking Water Climate Action

The Clean Water State Revolving Fund program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a variety of water quality infrastructure projects: wastewater treatment, stormwater management, nonpoint source pollution control, and watershed and estuary management, including retrofit projects and certain types of "green" projects. Most loans are for a 20-year period and some are zero interest. Loans in Massachusetts are implemented by MassDEP.
http://www.mass.gov/eea/agencies/massdep/water/grants/clean-water-state-revolving-fund.html

Massachusetts DEP Drinking Water Supply Protection Grant (DWSP). The DWSP grant program provides financial assistance to public water systems and municipal water departments for the purchase of land or interests in land for the following purposes: 1) protection of existing DEP-approved public drinking water supplies; 2) protection of planned future public drinking water supplies; or 3) groundwater recharge. The program is a reimbursement grant with a maximum award of $300,000 and 50% project cost reimbursement rate.

The National Drought Resilience Partnership (NDRP, or the Partnership) is a partnership made up of Federal departments and agencies that have roles or responsibilities in planning for and/or responding to drought. The purpose of the Partnership is to harness and coordinate distinct efforts by individual agencies already underway to assist in building resilience to drought on the ground. Two distinct roles are envisioned: one, as a policy coordinating body, and two, as an entity to align Federal agencies around their individual roles in drought planning and risk mitigation. This will help the Federal government to deliver expertise and resources to facilitate community preparedness and strengthen the Nation's resilience to drought.
https://www.drought.gov/drought/resources/national-drought-resilience-partnership

Mass DEP Water Utility Resilience Program. This new program provides technical assistance, partnership opportunities, adaptation planning, asset management, vulnerability assessments and training to enhance the resilience of water and waste water utilities from hazards weather events related to climate change. https://www.mass.gov/files/documents/2016/08/mo/circuit-rider-for-resiliency.pdf

Built Environment Climate Action

EEA Planning Grant. The Executive Office of Energy and Environmental Affairs provides funding to municipalities and Regional Planning Agencies to pursue Massachusetts Sustainable Development Principles that preserve natural resources, ensure sufficient and diverse housing, and prepare for climate change. Eligible requests include zoning for sustainable housing production, actions implementing the results of a climate vulnerability assessment or MVP program, or mitigation of climate change through zoning or other regulations that reduce energy use and greenhouse gas emissions. In 2017, EEA awarded $1,296,219 to 37 applicants. https://www.mass.gov/service-details/planning-assistance-grants

FEMA Hazard Mitigation Assistance. FEMA provides three different grant programs for mitigation planning and projects that are designed to minimize loss and protect life and infrastructure from natural hazards such as flooding and extreme heat. Grant programs include Hazard Mitigation Grant Program (long-term planning and projects after federal declared emergency), Pre-Disaster Mitigation Program (hazard mitigation planning grant) and Flood Mitigation Assistance (planning and projects to reduce or eliminate risk of flood damage insured by NFIP).

HUD Loan Guarantee Program. The US Department of Housing and Urban Development's Section 108 Loan Guarantee Program allows future Community Development Block Grant allocations to be used to guarantee loans for neighborhood revitalization projects, including construction and installation of public facilities and infrastructure. Section 108-guaranteed projects can incorporate green infrastructure into their design and construction.https://portal.hud.gov/hudportal/HUD?src=/states/massachusetts

HUD Sustainable Communities Regional Planning Grants.This HUD program supports metropolitan and multijurisdictional planning efforts to integrate housing, land use, economic and workforce development, transportation and infrastructure investments to empower communities and help them meet challenges of economic competitiveness and revitalization, social equity, inclusion and access to opportunity, energy use and climate change, and public health and environmental impact. https://portal.hud.gov/hudportal/documents/huddoc?id=greeninfrastructsci.pdf

Massachusetts Community Preservation Act. The Community Preservation Act (CPA) has been adopted by 172 cities and towns in Massachusetts representing 60 percent of the state's residents. CPA funds bring an annual match from the state CPA Trust Fund, and leverages investments from state, federal and private sources. Each year, CPA provides funding for affordable housing; historic resources, and outdoor recreation/open space, and is flexible to help fund all types of creative improvements. Funds for open space and recreation, for example, can be used to acquire and restore land and water resources and to acquire and improve parks, playgrounds, ball fields, parks, greenways, farms and gardens that use nature-based solutions to help cities and towns become more resilient to climate change impacts. http://communitypreservation.org/projectsdatabaseaccess

Massachusetts Office of Coastal Zone Management (CZM). CZM administers the Coastal Resilience Grant Program to provide financial and technical support to municipalities to reduce risks associated with coastal storms, flooding, erosion, and sea level rise. The grant is managed through CZM's StormSmart Coasts program. Eligible projects include Vulnerability and Risk Assessment; Public Education and Communication; Local Bylaws, Adaptation Plans, and other Management Measures; Redesigns and Retrofits; Natural Storm-Damage Protection Techniques. Recipients receive up to $500k and are required to provide at least 25% of the total project cost. The program is open to the 78 municipalities located within the MA coastal zone. Certified 501(c)(3) nonprofit organizations with vulnerable coastal property that is open and accessible to the public are also eligible for funding. http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/grants/

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Transportation Climate Action

Congestion Mitigation and Air Quality Program. The Congestion Mitigation and Air Quality program allocates federal funding for infrastructure projects that reduce congestion and improve air quality. Bicycle transportation and pedestrian walkways are eligible, and can be designed to include green infrastructure features, such as permeable surfaces for trails, and bioswales and bioretention for areas adjacent to trail surfaces.
http://www.massdot.state.ma.us/planning/Main/PlanningProcess/FundingConsiderations.aspx

Transportation Investment Generating Economic Recovery. Transportation Investment Generating Economic Recovery (TIGER) Discretionary Grant program provides funding for investments in road, rail, transit and port projects, and can include green stormwater management components. TIGER grants funding can be distributed to any public entity, including local governments.
https://www.transportation.gov/tiger

Transportation Alternatives Program. The Transportation Alternatives Program provides funding for transportation "alternatives" that improve transportation networks by efficiently and cost-effectively mitigating street and alley flooding. Projects can include green infrastructure components of trails and sidewalks for non-motorized transportation, such as permeable pavements.
http://www.massdot.state.ma.us/planning/Main/PlanningProcess/FundingConsiderations.aspx

Waste Water/Sewer Climate Action

Mass DEP Water Utility Resilience Program. This new program provides technical assistance, partnership opportunities, adaptation planning, asset management, vulnerability assessments and training to enhance the resilience of water and waste water utilities from hazards weather events related to climate change. https://www.mass.gov/files/documents/2016/08/mo/circuit-rider-for-resiliency.pdf

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The Clean Water State Revolving Fund program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a variety of water quality infrastructure projects: wastewater treatment, stormwater management, nonpoint source pollution control, and watershed and estuary management, including retrofit projects and certain types of "green" projects. Most loans are for a 20-year period and some are zero interest. Loans in Massachusetts are implemented by MassDEP.
http://www.mass.gov/eea/agencies/massdep/water/grants/clean-water-state-revolving-fund.html

EPA Water Infrastructure and Resiliency Finance Center. This program administered by the EPA provides technical assistance, toolkits, and resources to help decision makers building wastewater infrastructure projects that protect human and environmental health.
https://ofmpub.epa.gov/apex/wfc/f?p=165:1::::::

People Climate Action

EPA Smart Growth and Technical Assistance Program. The EPA administers a variety of technical assistance and planning grant programs to help communities improve the quality of the built environment, protect public health, and protect the environment. https://www.epa.gov/smartgrowth/smart-growth-technical-assistance-programs

Municipal Vulnerability Preparedness (MVP) Program. The Executive Office of Energy and Environmental Affairs provides financial assistance to municipalities to pay for technical assistance to complete assessments and planning using the Community Resilience Building workshop guide (CRB). Municipalities who complete this process and develop a final report will be designated as an MVP Community, which may lead to increased standing in future funding opportunities and signify the commitment of this municipality to building resiliency and preparing for climate change.

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George Climate Center Federal Funding Compendium for Urban Heat Adaptation. This compendium provides a comprehensive analysis on diverse federal programs that can be applied to mitigate extreme heat. http://www.georgetownclimate.org/files/report/Federal%20Funding%20Compendium%20for%20Urban%20Heat%20Adaptation.pdf

Energy Climate Action

Weatherization and Intergovernmental Program-The US Department of Energy's Weatherization and Intergovernmental Program provides grants, technical assistance, and information tools to states, local governments and community action agencies for their energy programs. The funding can be used to encourage installation of green infrastructure, such as green roofs, as part of the weatherization process. https://energy.gov/eere/wipo/weatherization-and-intergovernmental-programs-office

Massachusetts Clean Energy Center's (MassCEC) Community Microgrids Program. This program helps municipalities harness the innovative microgrid technology that lowers customer energy costs, reduces greenhouse gas (GHG) emissions, and provides increased energy resilience. In February, In February 2018, MassCEC awarded over $1 million to 14 different projects across Massachusetts. http://www.masscec.com/community-microgrids-program

MA Clean Energy Center (CEC) Government and Non-Profit Clean Energy Programs. MassCEC manages the Massachusetts Renewable Energy Trust Fund for the state and has diverse programs that promote clean energy, energy efficiency, and wastewater treatment plant innovation. Grant programs include solar energy, clean heating and cooling, hydro projects, organics to energy projects and many more. http://www.masscec.com/get-clean-energy/government-and-non-profit

Natural Resources Climate Action

Coastal

The National Coastal Wetlands Conservation Grant Program. This program annually provides grants of up to $1 million to coastal and Great Lakes states, as well as U.S. territories to protect, restore and enhance coastal wetland ecosystems and associated uplands. The grants are funded through the Sport Fish Restoration and Boating Trust Fund, which is supported by excise taxes on fishing equipment and motorboat fuel. Typically states, local governments, private landowners, and conservation groups will provide additional funds for projects. All states with a coastline are eligible. https://www.fws.gov/coastal/CoastalGrants/

National Oceanic and Atmospheric Administration (NOAA). The NOAA Coastal Resilience Program is a federal funding offers two categories of funding activities: 1) Strengthening Coastal Communities and 2) Habitat Restoration. The Strengthening Coastal Communities provides funding for activities that improve capacity of multiple coastal jurisdictions (states, counties, municipalities, territories and tribes) to prepare and plan for, absorb impacts of, recover from, and/or adapt to extreme weather events and climate-related hazards. The Habitat Restoration grant provides funding for activities that restore habitat to strengthen the resilience of coastal ecosystems and decrease the vulnerability of coastal communities to extreme weather events and climate-related hazards. Typical awards range from $250,000 to $1million for projects lasting up to 35 months. The minimum request is $100,000 and the maximum request is $2million. Non-profits, private, institutions of higher education, regional organizations, and municipalities are eligible. https://coast.noaa.gov/funding/_pdf/NOAA-NOS-NRPO-2017-2005159-FFO.pdf

Massachusetts Office of Coastal Zone Management (CZM). CZM administers the Coastal Resilience Grant Program to provide financial and technical support for local efforts to increase awareness and understanding of climate impacts, identify vulnerabilities, conduct adaptation planning, redesign vulnerable public facilities and infrastructure, and implement non-structural approaches that enhance natural resources and provide storm damage protection. The grant is managed through CZM's StormSmart Coasts program. Eligible projects Vulnerability and Risk Assessment; Public Education and Communication; Local Bylaws, Adaptation Plans, and Other Management Measures; Redesigns and Retrofits; Natural Storm-Damage Protection Techniques. Recipients receive up to $500k and are required to provide at least 25% of the total project cost. The 25% local match could be cash or in-kind contributions or a combination of the two. The Coastal Resilience Grant Program is open to the 78 municipalities located within the MA coastal zone. Certified 501(c)(3) nonprofit organizations with vulnerable coastal property that is open and accessible to the public are also eligible for funding for natural storm-damage protection (or green infrastructure) projects. http://www.mass.gov/eea/agencies/czm/program-areas/stormsmart-coasts/grants/

Stormwater/Water Quality Funding

Stormwater Utility/Enterprise Fund. Several cities and towns in Massachusetts and hundreds of communities across the country have adopted a stormwater utility to help fund the costs of stormwater programs, including the costs of capital improvements and repair or replacement of green infrastructure. Such fees create a dedicated and stable funding source to address

stormwater impacts. To help understand if a stormwater utility is practical to implement, MAPC and its partners developed a Stormwater Utility/Funding starter kit to help municipalities evaluate and pursue a stormwater utility for local water quality. https://www.mapc.org/resource-library/stormwater-bylaws-toolkit/

Clean Water Act Nonpoint Source Grants. Under Section 319 of the federal Clean Water Act, the US EPA provides states with funds to support a variety of activities to reduce nonpoint source pollution, including technical and financial assistance, education and training, technology transfer, demonstration projects and monitoring to assess the success of projects. EPA has stated specifically that such grants can be used to reduce pollution from stormwater runoff and other sources, recognizing the importance of green infrastructure in managing stormwater. Grant awards very widely in among and scope; a 40 percent non-federal funding match is required. Note 319 grants may not be used for stormwater activities that directly implement municipal separate storm sewer system (MS4) National Pollutant Discharge Elimination System (NPDES) permits.http://www.mass.gov/eea/agencies/massdep/water/grants/watersheds-water-quality.html#2

Massachusetts Environmental Trust (MET) Grant. The MET grant provides funding to support programs, research, and other activities that promote the responsible stewardship of the Commonwealth's water resources. MET's goal is to encourage development of new approaches and ideas and to spur innovation among grantees or partnering organizations. To achieve these outcomes, the Trust supports projects that: improve water quality or quantity, conserve aquatic habitat and species, reduce runoff pollution, mitigate the effects of climate change on water resources, promote human health as it relates to water resources, and/or other efforts consistent with the Trust's mission. There are three types of grants, one with a specific focus on the Mystic River. Awards range from $5,000 to $100,000. http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/mass-enviro-trust/met-grants.html

Division of Ecological Restoration (DER). DER initiates projects that restore our rivers, streams, wetlands, and watersheds. DER partners with nonprofits, towns, individuals, and groups to implement projects. These projects improve habitat for wildlife and provide many benefits such as reduced flooding, improved water quality, and public safety. Programs include culvert and dam removal as well as coastal wetland, inland wetland, and river restoration. DER provides technical assistance, helps secure funding, and coordinates project management until completion. https://www.mass.gov/orgs/division-of-ecological-restoration

Rivers, Trails, and Conservation Assistance Program. The National Park Service Rivers, Trails and Conservation Assistance Program (RTCA) assists community-led natural resource conservation and outdoor recreation initiatives. RTCA staff provides guidance to communities on: conserving waterways, preserving open space, and developing trails and greenways. https://www.nps.gov/orgs/rtca/apply.htm

Natural Resources-Land and Forest

National Urban and Community Forestry Program. Under the US Forest Service, this program's objectives are to establish sustainable community forests that improve the public's health, well-being, and economic vitality, and create resilient ecosystems for present and future generations. When funds are available, cost-share grants support urban projects that have national and multistate application and impact. https://www.fs.fed.us/managing-land/urban-forests/ucf

Massachusetts Urban and Community Forestry. The Massachusetts Urban and Community Forestry Program assists communities and nonprofit groups in protecting, growing, and managing community trees and forest ecosystems, to improve the environment and enhance livability. The program includes grants, technical assistance, training and recognition awards, and provides guidance on urban forestry policy issues. http://www.mass.gov/eea/agencies/dcr/conservation/forestry-and-fire-control/urban-and-community-forestry.html

Parkland Acquisitions and Renovations for Communities (PARC). PARC assists cities and towns in acquiring and developing land for park and outdoor recreation purposes. Any city that has an authorized park or recreation commission is eligible to participate and use grant funds to acquire land, develop new parks or renovate existing outdoor public recreation facilities (which may include green infrastructure). Access by the general public is required. Municipalities must have a current open space and recreation plan to apply, and the land must be open to the general public. Awards range from $50,000 to $500,000. http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/dcs/grant-programs/massachusetts-parkland-acquisitions-and.html

Conservation Partnership. The Conservation Partnership Program within the Executive Office of Energy and Environmental Affairs (EEA) provides funding to nonprofit organizations to acquire land and interests in land (i.e., easements known as Conservation Restrictions) for conservation or recreation purposes, as part of a nature-based solution. The average grant size is $52,000. The maximum grant is $85,000. A 1:1 match is required. http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/dcs/grant-programs/conservation-partnership-grant.html

Local Acquisitions for Natural Diversity (LAND). LAND is a state grant program implemented by EEA provides grants for the acquisition of land for passive parks or conservation areas in cities and towns – which can include green infrastructure. Grants are up to $400,000 with reimbursement rates ranging from 52%-70% of the total project cost. Municipalities must have a current open space and recreation plan to apply, and the land must be open to the public. https://www.mass.gov/files/2017-06/LAND%20fy-18%20grant%20summary_1.pdf

Massachusetts Community Preservation Act. The Community Preservation Act (CPA) has been adopted by 172 cities and towns in Massachusetts representing 60 percent of the state's residents. CPA funds bring an annual match from the state CPA Trust Fund, and leverages investments from state, federal and private sources. Each year, CPA provides funding for affordable housing; historic resources, and outdoor recreation/open space, and is flexible to help fund all types of creative improvements. Funds for open space and recreation, for example, can

be used to acquire and restore land and water resources, and to acquire and improve parks, playgrounds, ball fields, parks, greenways, farms and gardens that use nature-based solutions to help cities and towns become more resilient to climate change impacts.
http://www.communitypreservation.org/