Photo credit: Sky Skipper Drones

Climate-Ready Healthy Plymouth

MUNICIPAL VULNERABILITY PREPAREDNESS

JUNE 2020

Plymouth Massachusetts

Old Colony Planning Council

MAPC

Acknowledgements

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Dorie Stolley	Community Member
Judy Savage	Community Member
Evelyn Strawn	Community Member
Joanne Zygmunt	Senior Planner, OCPC

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Acronyms

ADCIRC	Advanced Circulation sea level rise and storm surge model
AUL	Activity and Use Limitations in environmental remediation sites
BH_FRM	Boston Harbor Flood Risk Model
BID	Beth Israel Deaconess Hospital-Plymouth
BID-SA	Beth Israel Deaconess Hospital Plymouth Service Area
CZVM	Coastal Zone Vulnerability Matrix
DCR	Massachusetts Department of Conservation and Recreation
DEP	Massachusetts Department of Environmental Protection
DPH	Massachusetts Department of Public Health
EEA	Massachusetts Executive Office of Energy and Environmental Affairs
EEE	Eastern Equine Encephalitis
EPA	Federal Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gases like carbon dioxide and methane
MAPC	Metropolitan Area Planning Council
MVP	Massachusetts Municipal Vulnerability Preparedness program
OCPC	Old Colony Planning Council
OSWS	Onsite Wastewater Systems
RAO	Response Action Outcome in environmental remediation sites
SC	South Coastal Basin
SLR	Sea Level Rise
TMDL	Total Maximum Daily Load
WHO	World Health Organization

I. Introduction

Mayflower II sets sail in Plymouth Harbor. Photo credit: Prince George Citizen

The year 2020 marks the 400th Anniversary of the Mayflower voyage, the end of the "Great Dying" of the Wampanoag, and a new beginning with the establishment of the colony of Plymouth with the Pilgrims. The Pilgrims arrived on the Mayflower at the onset of winter and struggled through the hardship of bitter cold, snow and ice to establish themselves in the New World. The Wampanoag suffered a devasting plague and great loss of their Nation with the death of 10,000s of their people.[1] Nonetheless, the people of Plymouth, both colonists and Wampanoag, persisted creating a 400 year legacy that is being celebrated locally, nationally, and internationally in this commemorative year. As history comes full circle, with our changing climate and the COVID-19 global pandemic, *Climate-Ready Healthy Plymouth* in 2020 could not be more relevant. As climate change is a global crisis, residents of Plymouth have lain out a plan to thrive in the face of its adversity.

Climate change is a global emergency affecting our environment, economic, and humanity and the northeastern United States is one of the most vulnerable to our changing climate, particularly with projected sea level rise (SLR), extreme heat, and flooding with extreme precipitation events. Plymouth contains a rich fabric of cultural and natural assets and is internationally renowned for its history as "America's Hometown" and the First Thanksgiving Feast. It is one of the oldest municipalities in the New England and the United States covering 134 square miles, 37 miles of coastline and 450 ponds. Plymouth is home to one of the largest contiguous tracts of the globally rare Atlantic Coastal Pine Barren forest and contains some of the most endangered species in Massachusetts. The Town through time has had the foresight to protect and promote these assets to uphold its cultural character and healthy, livable community. However, the climate change hazards threaten not only these assets but also the health of the Plymouth community. *Climate-*

[1] "OUR"STORY: 400 YEARS OF WAMPANOAG HISTORY. https://www.plymouth400inc.org/our-story-exhibit-wampanoag-history/

Ready Healthy Plymouth analyzes how past and projected climate change hazards through the lens of Plymouth's Social Determinants of Health to evaluate the implications on Plymouth's infrastructure, environmental, and society and opportunities to adapt for better health outcomes. This project was funded by an expanded scope of the Massachusetts Executive Office of Energy and Environmental Affairs Municipal Vulnerability Preparedness (MVP) Planning Grant and completed in partnership with Old Colony Planning Council.

Table 1 Members and affiliation of the Climate-Ready Health Plymouth Core Team, responsible for guiding the development of the project and engaging and leading the public throughout the process.

Core Team Members	**Affiliation**
Lee Hartmann	Planning and Development
Laurie Muncy	Principal Planner, OCPC
Karen Keane	Public Health
Rich Vacca	Conservation
Jonathan Beder	Public Works
Henry Lipe	Emergency Management
David Gould	Marine and Environmental
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Evelyn Strawn	Community Member
Joanne Zygmunt	Senior Planner, OCPC

This plan was guided by a highly engaged Core Team which included municipal staff, municipal volunteers from the Board of Health and Planning Board, Old Colony Planning Council, Beth Israel Deaconess Hospital, and a team of dedicated volunteers (Table 1). The Core Team was instrumental in guiding the development of the analysis and overall project, in providing facilitation and leadership during public engagement events, and securing substantial public participation in the project. The Core Team had seven meetings, two of which were virtual whose

agendas are included in Appendix D Core Team Meeting Documentation. Hard copies of sign-in sheets were not accessible for this report due to COVID-19 social distancing and office closures.

Importantly, *Climate-Ready Health Plymouth* is a reflection and compilation of the expertise of Plymouth residents, businesses, stakeholders, and organizations through a series of public engagement events as follows:

Town-wide Public Forum	January 27, 2020	Plymouth North High School
Cedarville/Manomet Focus Group	January 30, 2020	Plymouth's Historic Simes House
Downtown Plymouth Focus Group	February 5, 2020	Plymouth Town Hall Shallop Room
North Plymouth Focus Group	February 12, 2020	The Loring Center
South Plymouth Focus Group	February 18, 2020	Plymouth South High School
West Plymouth Focus Group	February 19, 2020	Plymouth Municipal Airport
MVP Workshop	April 9-May 19, 2020	Virtual Online
Final Public Forum Online	May 26, 2020	Virtual Online and Live Streamed on MAPC's and All Things Plymouth Facebook pages.

All materials, including posters and presentations were posted on the Town's website at

https://www.plymouth-ma.gov/planning-development/pages/climate-change-municipal-vulnerability-preparedness

The DRAFT final *Climate-Ready Healthy Plymouth* report was posted on the Town's website for two weeks after the Final Public Forum for public comment. Three comments were received and are posted in Appendix E. The virtual MVP workshop can be found here: https://www.mapc.org/resource-library/plymouthmvp/.

The Summary of Findings Report, summarizing the Community Resilience Building Workshop hosted virtually online from April 9-May 19, 2020 and the affiliation of participants can be found in Appendix B MVP Workshop Summary of Findings. A summary of public responses from focus groups and public forums is included in Section V. Public Engagement Analysis and Summary.

II. Climate Change: A New Paradigm

In the last five years, Massachusetts has experienced increasingly more frequent and severe weather events. Record-breaking snowfall in 2015, a wide-spread and severe drought in 2016, the warmest year on record in 2017, and four Nor'easters in one month and flooding comparable to the Blizzard of 1978 in 2018. Additionally, Massachusetts in 2018 saw the most precipitation ever recorded since1890, according to the Blue Hills Weather Station. Climate Change is not imminent but affecting the people and cities and towns of the Commonwealth today, particularly those in coastal communities like Plymouth. Climate change hazards typically affect infrastructure, environment, and society/public health in three ways: (i) warming temperatures, (ii) shifting precipitation patterns leading to severe weather events such as severe nor'easters, drought, and heavy rain events, and (iii) sea level rise and storm surge. This section summarizes historic climate change patterns and projections as modeled by scientists particularly relevant to Plymouth and is summarized in Table 2

Table 2 Summary of climate change impacts historically and projected mid and late century.

Climate Risk	1900-Present	2050	2100
Sea Level Rise	11" in Boston Harbor	≤4.2 feet	≤7.4 feet
Temperature	2° globally	~22 days over 90°	~50 days over 90°
Precipitation	>10% increase in Boston; 70% increase NE US	10 days with >1" Precipitation Events	1% Chance Storm becomes a 25% Chance Storm

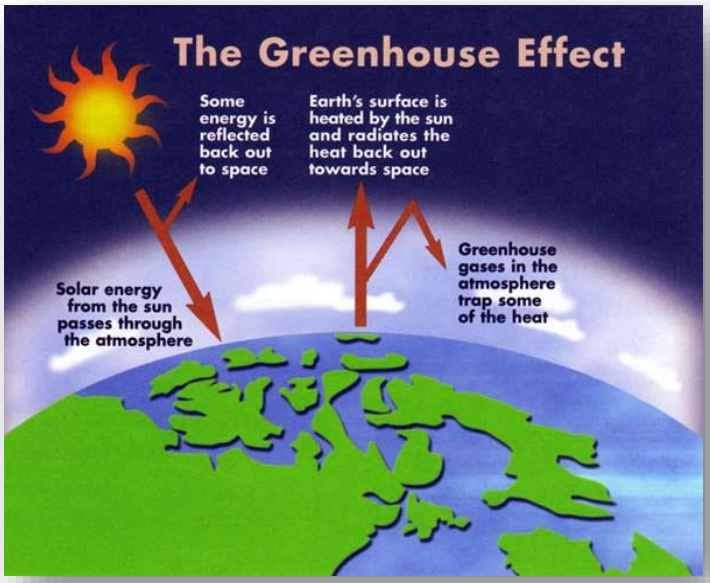
2.1 Temperature

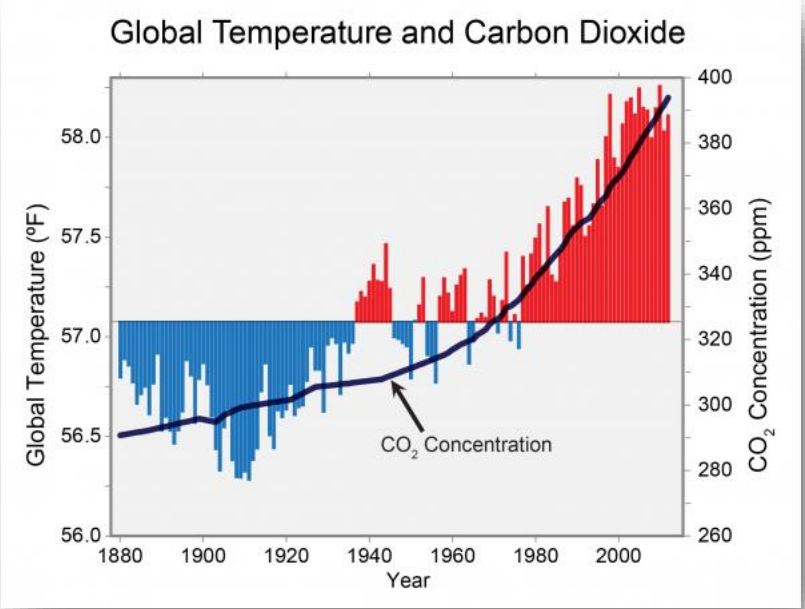
Our climate has always been regulated by gases, including carbon dioxide, methane, and nitrous oxide, that blanket the earth. These gases trap heat that would otherwise be reflected out to space; without them our planet would be too cold to support life. We refer to these gases as "greenhouse gases" (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.

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 in the age of industrialization, releases GHGs into the atmosphere. There is a direct correlation between increases in carbon dioxide concentrations and global temperature. There is by now widespread consensus among scientists regarding the warming of our climate and its causes (Figure 1).

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 Plymouth lies, may be cooler than other inland or dense urban areas in the Commonwealth due to

Figure 1 An illustration of how greenhouse gases such as carbon dioxide and methane cause the greenhouse effect and warming of the Earth. A graph of how increasing concentrations of carbon dioxide has contributed to an accelerated warming of the earth.





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.[2,3,4] 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]

Even small changes in temperatures can have a dramatic effect, such as changing precipitation patterns and extending the growing season.[5] 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 14.3 days longer growing season.[6] Future projected warming translates into a climate like Georgia mid-century or to Louisiana in the late century. 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.

Table 3 South Coastal Basin area (SC) projected increases in average temperature in degrees Fahrenheit.

South Coastal Basin	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

2.2 Sea Level Rise

From 1921 to 2018 in Boston Harbor, the rate of sea level rise has occurred at approximately 2.8 mm/ year with a total of 0.93 feet in the last century (Figure 2) measured at Boston Tide Gauge. Sea level rise in Massachusetts results from confluence of several factors, the most

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

[3] 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.

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

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

[6] Climate Central. 2018. POLLEN PROBLEMS: Climate Change, the Growing Season, and America's Allergies.

significant is caused by global warming through from accelerated rates of greenhouse gas emissions in our atmosphere. Sea level rise is caused by the following factors:

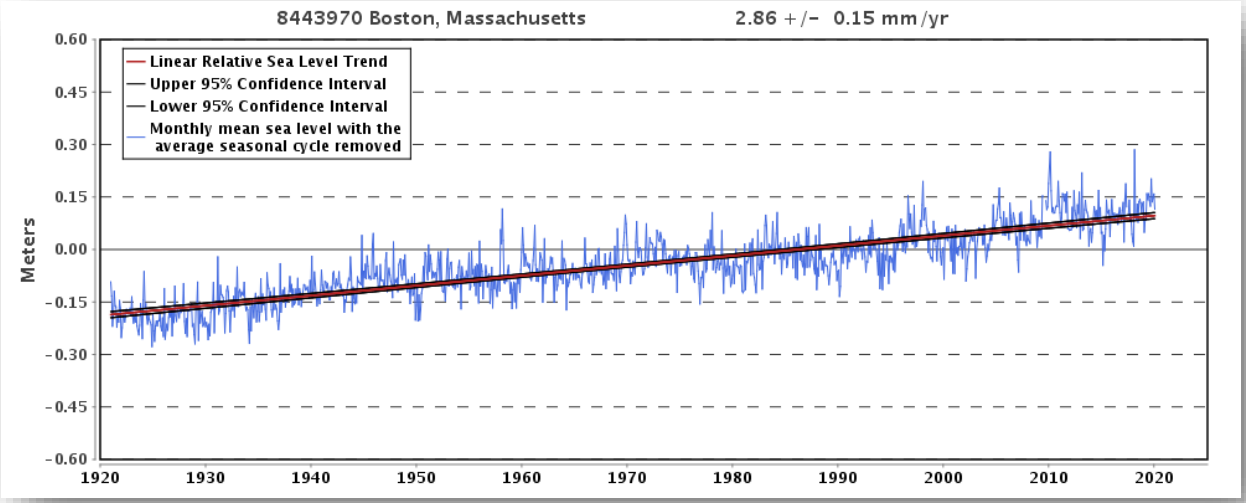
1. Increase of water into the ocean system as a result of glaciers melting at an accelerated rate.

2. Global warming causes ocean warming and thermal expansion of oceans.

3. Land subsidence (minor influence) along the east coast in response to the last glacial period which causes coastlines to sink and greater extent of oceans on the land. With glacial retreat, the land is very slowly reshaping its elevation (returning to an isostatic balance) causing some portions of the east coast to rebound (rise), and some areas to subside (sink).

4. Magnetic pull is a minor influence on sea level rise. Shifts in our magnetic pull are naturally occurring at geologic time scales. Changes in magnetic pull can influence the extent globally where sea level rise occurs to a greater or lesser extent.

Figure 2 Sea level rise over the last century as measured at Boston Tide Gage.



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, glacial melting, wind, tides, etc. The Boston Harbor Flood Risk Model (BH_FRM) utilizes the widely accepted Advanced Circulation (ADCIRC) probabilistic model. This model 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, accounting for inland storm runoff interaction with the coastal water activity at their interface in the model, with respect to state

Table 4. Total Relative Sea Level Rise projections in Boston and South Shore for the "Highest" emission scenarios and graphic on how reducing greenhouse gas emissions can reduce the impact of SLR.

	2030	2050	2070	2100
Boston BH_FRM[7]	8.00 in.	1.50 ft.	3.10 ft.	7.40 ft.
Boston Tide Gauge[8]	0.4-0.9 ft.	2.4 ft.	4.2 ft.	7.6 ft.

The Boston Tide Gauge model was derived from a similar process as the BH_FRM with more localized resolution. Neither of these models area available spatially for the Town of Plymouth. Therefore, this study utilizes the National Oceanic Atmospheric Administration (NOAA) sea level rise spatial data derived from the Bathtub model that accounts for local and regional tidal variability and hydrological connectivity for spatial analyses of vulnerability. The studied utilized a depth of 4.0 feet of NOAA Sea Level Rise based upon the depths projected by the Boston models for mid-century or 2050.

Scientists anticipate that the rate of sea level rise will increase and accelerate, anticipating an additional eight inches by 2030.[9,10] Several local and state-wide sea level rise projection models indicate similar levels where Massachusetts could experience 6.5-7.5 feet of sea level rise by the end of the century (Table 4).[11] In the near term, sea level rise has exasperated the extent of coastal flooding cause by hurricanes, nor'easters, and blizzards.

2.3 Precipitation

For the last fifty years, precipitation has increased 70% in the Northeast in the amount of rain that falls in the top 1% of storm events.[12] November and fall of 2018 is the wettest November and fall on record since 1891 and third wettest year on record.[13] Due to several stormy periods during the year, annual precipitation was very high and totaled 67.20 inches, which was more than 18 inches wetter than the long-term mean and nearly 14 inches more than the 30-year normal.

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. For example, a 100-year storm is defined as a storm that would have a 1% chance

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[7] 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).

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

[9] 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.

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

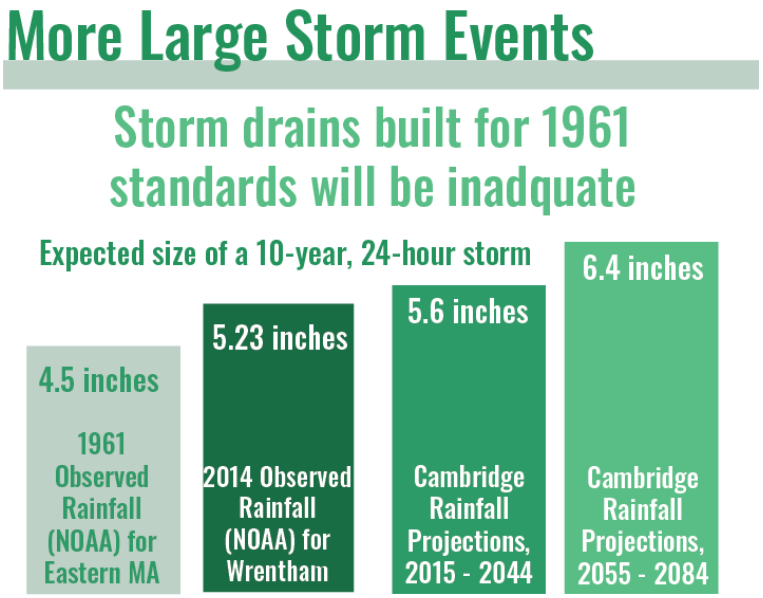
[11] MAPC. 2018. Duxbury Climate Vulnerability Assessment and Action Plan. Pp.15-16

[12] USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.

[13] Blue Hill Observatory & Science Center. 2019. http://bluehill.org/observatory/2018/02/2018-precipitation/

of occurring in any given year or consecutive years. Historically this could create 8.9 inches of rain, but that could increase to 10 inches of rain by 2044 and 11.7 inches of rain by 2084 (Figure 3).[14]

Figure 3. Future Precipitation Projections for Design Storms. Source: Cambridge Climate Vulnerability Assessment.



The actual amount of increased precipitation or number of extreme weather events per year is difficult to project into the future.[15,16] 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.[17] Consequently, warming temperatures can cause greater evaporation in the summer and fall, as well as earlier snowmelt,[28] leading to periods of either 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.[29] 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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[14] 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)

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

[16] 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

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

III. Plymouth Public Health

Many factors influence individual and community-level health outcomes, and they include much more than genetics and access to healthcare. There is agreement among public health experts that health outcomes are highly influenced by social, environmental, and behavioral conditions shaped by the context in which we live.[18] These conditions are collectively termed the social determinants of health. In Massachusetts, the MA Department of Public Health (DPH) groups social determinants of health into six categories: Built and Neighborhood Environment, Education, Employment, Housing, Violence (called Safety in this report) and Social Environment, which are described in Figure 4.

Figure 4 The Massachusetts Department of Public Health Social Determinants of Health as identified by the 2017 Massachusetts State Health Assessment.

	Transportation/streets
	Buildings/Infrastructure
	environmental exposure
	open spaces
	Formal education in schools
	Activities in community groups
	Informal Education
	Income
	Poverty
	Unemployment
	Rental/Own
	Homelessness
	Affordability
	Neighborhoods/access to parks
	Toxic Exposure
	Mental Health
	Domestic and Self Violence
	Collective (Large-scale conflict)
	Repression/Neglect
	Social Inequality
	Interpersonal
	Community
	Society

Social determinants of health are driven by policies and values established across social and economic systems. Systemic inequities result in an unequal distribution of poor health outcomes (i.e.

[18] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017 as originally published in: Tarlov AR. Public policy frameworks for improving population health. Ann N Y Acad Sci. 1999;896:281-93.

health disparities). Racial and ethnic minorities, people with lower education attainment and income, and people living in areas with greater toxic exposure and unequal access to healthcare, education, housing, employment, etc. may experience higher rates of chronic disease, hospitalizations, and premature births and deaths.

Health disparities are also indicators of social vulnerability. Social vulnerability refers to social, economic, demographic, or health factors that may make groups of people less resilient to climate change impacts and other stressors. For example, older adults, young children, pregnant women, people with disabilities, and people with pre-existing health conditions are more vulnerable to extreme heat and poor air quality. Low-income people are often more susceptible to financial shocks, after extreme weather events. This can impact financial security and the ability to secure safe shelter and medical needs. Social isolation can also influence vulnerability, as it limits access to critical information, municipal resources, and social support systems. People at the most risk for social isolation include those living alone and people with limited English language proficiency. Certain vulnerabilities tend to be correlated; for example, older adults are more likely to have a disability and live alone than younger adults. Finally, people who live or work in vulnerable locations such as coastal or inland floodplains, areas prone to wildfire, or urban heat islands[19] may be more likely affected by climate impacts.

Because social vulnerability and health disparities are inter-related, Plymouth can promote better health outcomes for all, particularly in the face of climate change. Strategies for adapting to a changing climate should work to eliminate health disparities and protect those most socially vulnerable. This section reviews some of the socio-economic and public health strengths and vulnerabilities in the Town of Plymouth.

3.1 Social Vulnerability in Plymouth

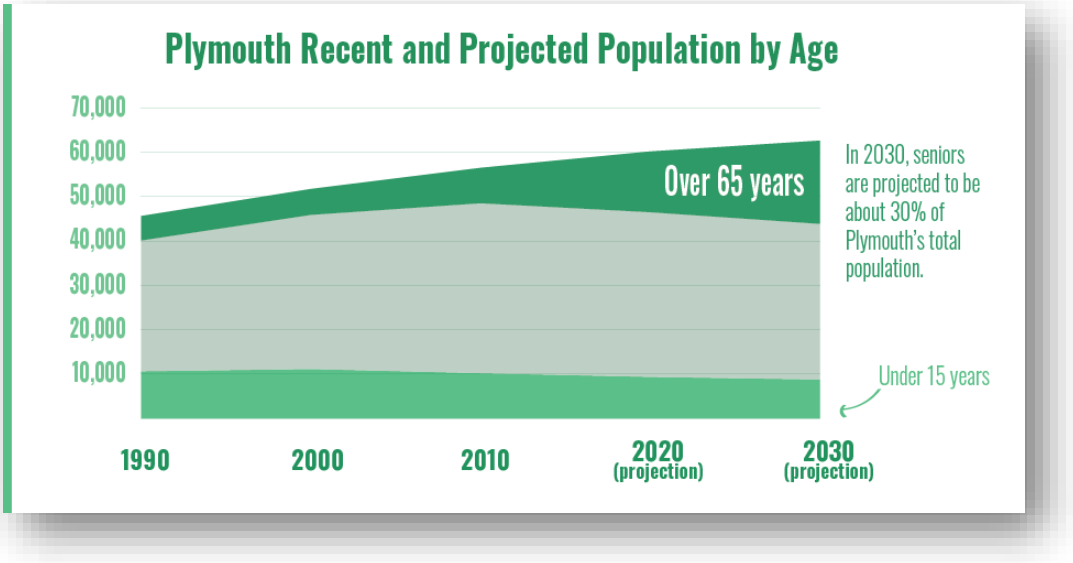
As of the 2010 census, there were 58,000 people in Plymouth, projected to over 60,000 in 2018 according to Census projections for 2018. MAPC's projected growth of Plymouth was a population over 60,000 by 2030. [20] The town has experienced 7.7% population growth in the last decade alone.[21] There is a declining population of children and increasing population of seniors, 20% in 2018 and project at 30% of total population in 2030 (Figure 5).

Of Plymouth's population, 93% are white, 2.4% are Hispanic or Latino, 2% are Black, 0.1% are Native American and the remaining are Asian, Pacific Islander, or two or more races. Nearly 8% of Plymouth residents speak a language other than English and 30% of those speak English poorly (Figure 6). Racial or ethnic groups may also be more likely to have certain social vulnerabilities than others. For example, Black and Latino populations have a much higher rate of asthma hospitalizations than other groups. Housing and mortgage discrimination practices forced

[19] Urban heat islands experience higher temperatures than surrounding areas as a result of low vegetation and large surface area of impervious cover.
[20] Metropolitan Area Planning Council. 2014 "Population and Housing Demand Projections for Metro Boston" https://www.mapc.org/learn/projections/
[21] https://www.census.gov/quickfacts/plymouthtownplymouthcountymassachusetts

people of color to certain neighborhoods, ones that have less tree cover and poor air quality. Both conditions can contribute to greater incidences of asthma and respiratory distress.

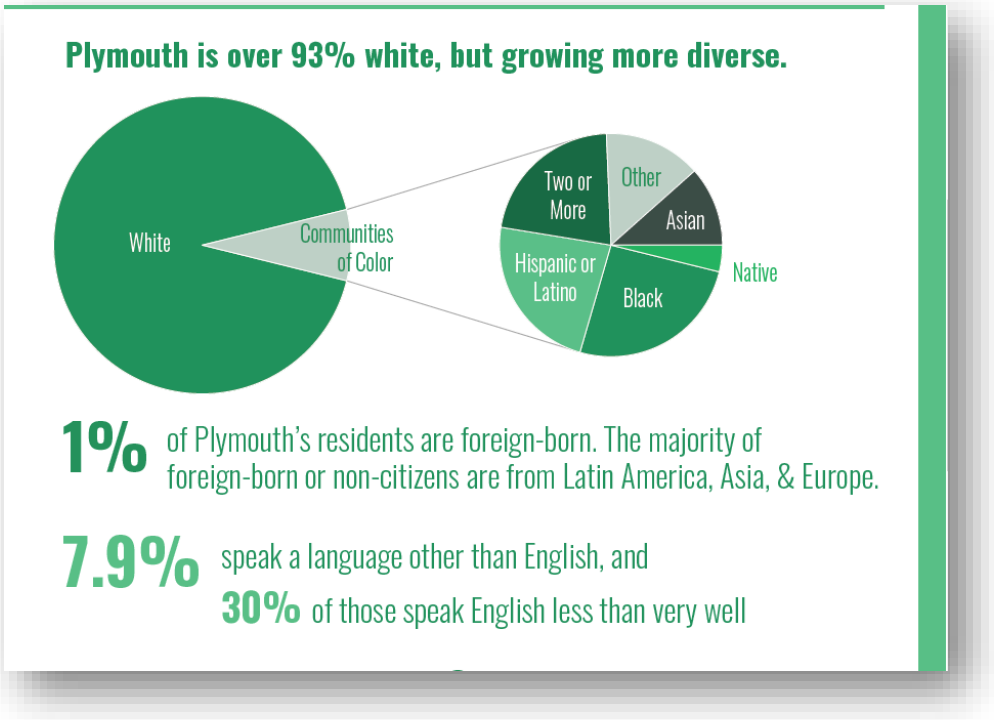
Figure 5 Population growth in Plymouth according to population and housing demand projections completed by MAPC in 2014.



There are over 23,000 households in Plymouth of which 79% were owner-occupied. Only 3% of households have no car and 79% have two or more cars indicating that most residents have secure access to transportation. Renters in Plymouth are typically paying more than 35% of their annual income on rent, 5% above the recommendation of 30% of income on housing (Section 4.3 Housing provides more information on housing and affordability in Plymouth). Fourteen percent of Plymouth households are unmarried with dependents and 10% are unmarried female head of households with dependents. Overall, there are 23% of households are persons living alone. Fifty percent of those living along are over the age of 65. Hence, seniors, unmarried female heads of households, renters and people of color are the most significant socially vulnerable demographics.

The median income for Plymouth is $83,745 which is higher than the Massachusetts median income of $77,385 and surrounding towns of Kingston, Carver, and Wareham. Census 2010 data indicated a 7.5% poverty level though projections for 2018 indicate a decrease of poverty to 6.6%. This is less than the Commonwealth's poverty level of 10.4%. Poverty level is a family of four with a household income of $24,900. However, 7.1% of the population relies on State services for food and females over the age of 65 are the greatest demographic living in poverty. Finally, the average male income is 3.4 times the average female income. This data suggests that females are the most constrained by income and more likely to have greater vulnerability in recovering from financial loss due to extreme weather events or pandemics associated with climate change.

Figure 6 Communities of color and linguistic isolation in Plymouth.



Overall, Beth Israel Deaconess Hospital in Plymouth, according to its 2019 Community Health Needs Assessment, identified youth, older adults (seniors), low to moderate income individuals and families, and individuals with chronic complex conditions as their Priority Populations in prioritizing implementation strategies that eliminate barriers to health, service gaps, or adverse social determinants of health.[22]

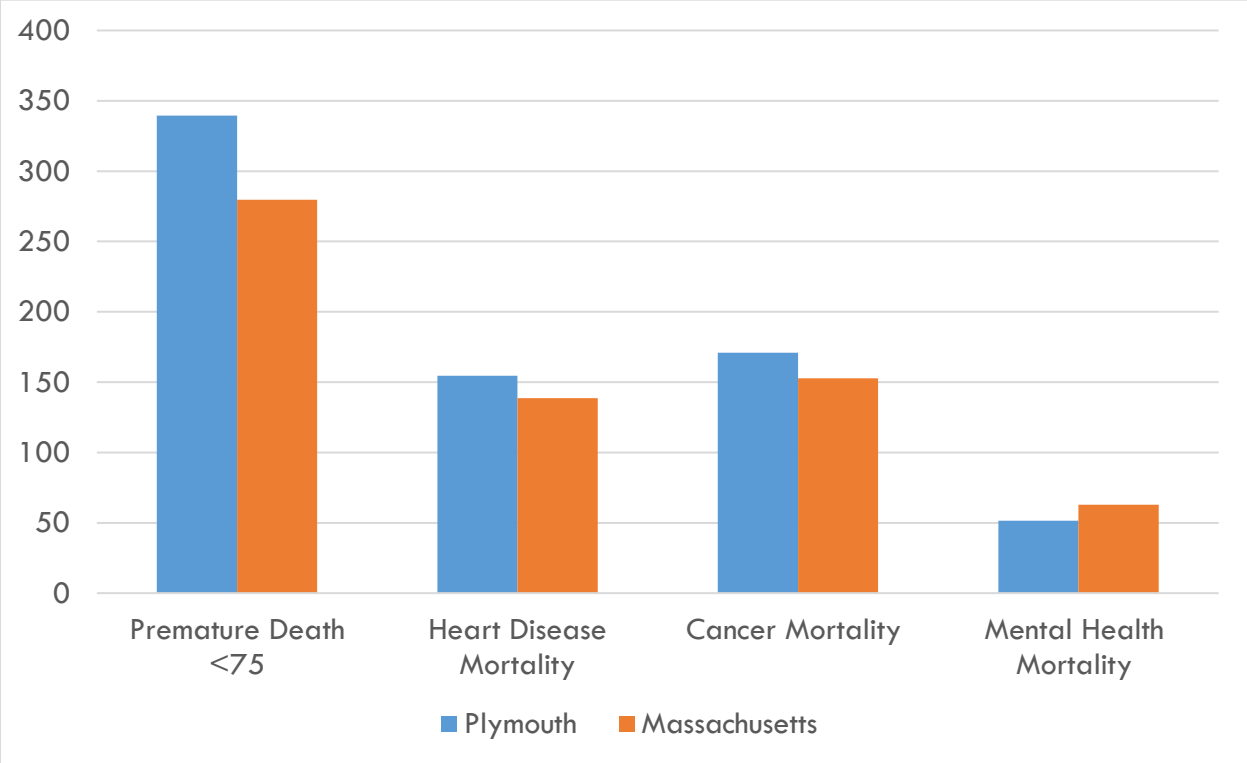
3.2 Public Health Strengths

The Town of Plymouth has a strong culture of community, history, and appreciation for its natural areas that contribute to significant public health benefits across the Town. For example, 86% of Plymouth's residents live with a 10-minute walk of a park, open space, or natural area, and parks are distributed largely equally across race, income, and age. The average United States city has

[22] Beth Israel Deaconess Hospital-Plymouth: Community Health Needs Assessment 2019. P. 40

54% of its residents within a 10-minute walk of a park.[23] Nearly 40 years of scientific research has documented the public health benefits of parks and open spaces. These range from safety from traffic, crimes, and violence, more active living, healing and therapy to trauma, stress, and anxiety, improved mood, mental acuity, greater mindfulness and creativity, and greater social capital.[24] All these characteristics promote a strong foundation for public health. Plymouth boasts many parks and 30% of its area is protected open space. Further, during the COVID-19 pandemic and social distancing, residents gathered in the Town's parks for all the reasons described above. These parks were so populated during this time, demonstrating a strong affinity and demand for the resource, the Town made the decision to close many parks to avoid large congregations and spread of the COVID-19 virus.

Figure 7 Rates of chronic disease in Plymouth per 100,000 residents in the service area of Beth Israel Deaconess Hospital-Plymouth.[25]



Most Plymouth residents have access to healthy foods. Plymouth has over five groceries stores well-distributed throughout the Town. There are several farms such as the protected Plymouth County Farm and Cranberry Hill Organic Farm and a two farmer's markets at Downtown Plymouth and Plimoth Plantation. Additionally, there are several places with food pantries in Plymouth, some of these include churches such as Zion Evangelical Lutheran Church, Christ Church, and Blessed Kateri Church. There are also food pantries at the Salvation Army/Plymouth Pantry

[23] ParkServe ™https://www.tpl.org/city/plymouth-massachusetts
[24] University of Washington. 2018. "Green Cities: Good Health" https://depts.washington.edu/hhwb/
[25] Beth Israel Deaconess Hospital-Plymouth: Community Health Needs Assessment 2019. Pp. 28-38

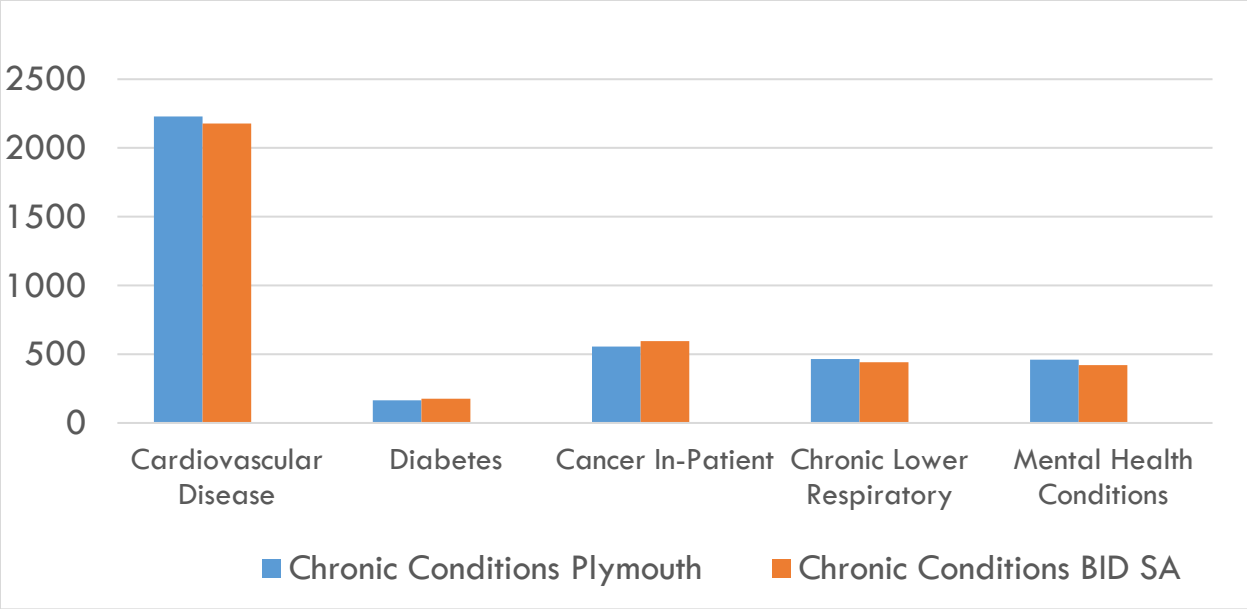
and the South Shore Community Action Council. Additionally, Plymouth schools provide free and reduced breakfast and lunch. During COVID-19 when schools were closed, Plymouth continued to provide free and reduced breakfast and lunch at the Hedge School in North Plymouth.

Plymouth is a safe place to live. There are approximately 283 aggravated assault crimes per 100,000 people in 2018 but this is a slight increase from 2017of 252 per 100,000. This is less than the County at 373 crimes per 100,000 and less than Boston and Brockton at 406 and 631 per 100,000 respectively. Property crime was the most frequent crime at 638 per 100,000 and rape, murder/manslaughter and arson were the least frequent crimes at 12, 2, and 2 per 100,000 people respectively.[26]

Finally, Plymouth has less incidences of diabetes than the Commonwealth of the Beth Israel Deaconess Service Area (BID-SA) which includes Plymouth Carver, Duxbury, and Kingston (Figure 7). Plymouth also has lower rates of Pneumonia/influenza mortality than Kingston and Carver and lower rates of mental health disorder mortality in comparison to the Commonwealth (

Figure 8).

Figure 8 Mortality rates per 100,000 deaths for various conditions in Plymouth and Massachusetts.

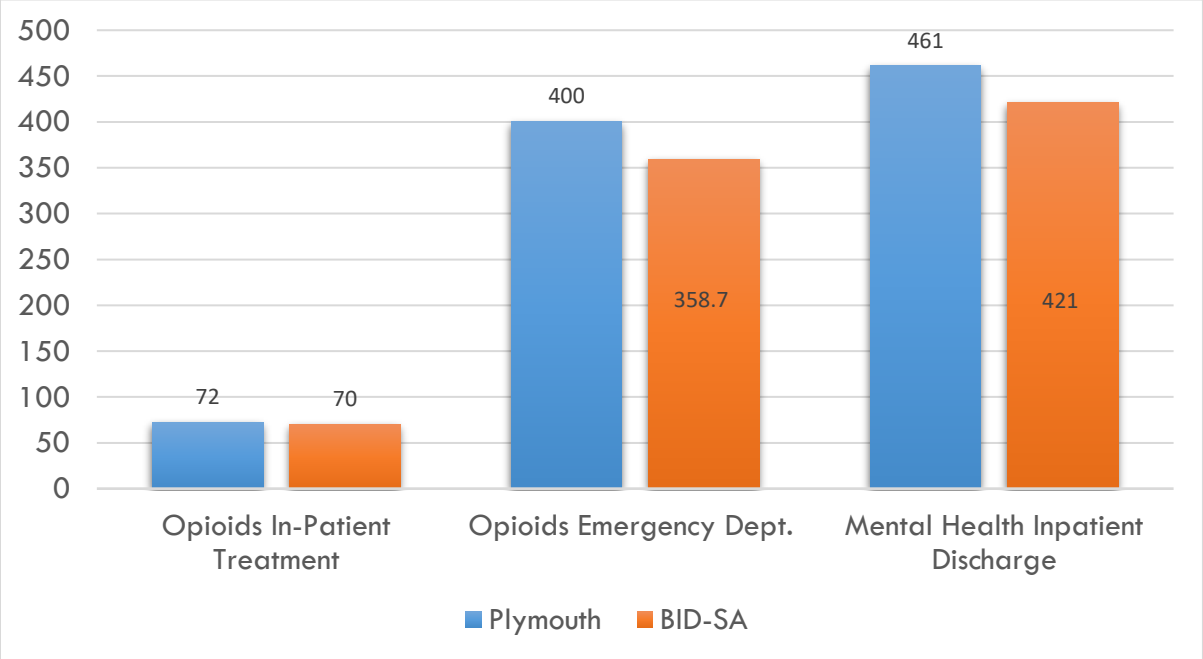


[26] 2018 Federal Bureau of Investigation Crime Data. Socrata. Open Data Network. https://www.opendatanetwork.com/entity/1600000US2554275/Plymouth_MA/crime.fbi_ucr.count?crime_type=Aggravated%20assault&year=2018

3.3 Public Health Challenges

The Beth Israel Deaconess Hospital (BID)- Plymouth's Community Health Needs Assessment determined that the most prevalent and challenging health issues in their service area are substance abuse and mental health disorders. BID also reports that these issues are having a profound impact on individuals, families, and the community at-large. Heroin was the primary substance abuse in Plymouth at 48.5% whereas the primary substance abuse in Duxbury and Kingston was alcohol at 39.2%and 51.3% respectively. In 2017, there were 106 Plymouth resident deaths by from opioids, notably greater than Carver (27), Duxbury (7) and Kingston (14).[27] There were 72 incidences of Plymouth residents per 100,000 people receiving in-patient care for opioid use in 2018 and 400 emergency department opioid treatments in Plymouth. These are both greater than rates across the BID-SA. Further, there were 461per 100,000 residents discharge from in-patient treatment of mental health conditions in 2018, greater than rates across the BID-SA.

Figure 9 Opioid and mental health treatment rates in 2018 per 100,000 adults in Plymouth and Massachusetts.



BID notes that access that there are extremely limited Behavioral Health Services in the region or that the demand for services far exceeds the supply of services. BID noted that access is particularly difficult for LGBQT, limited proficiency English speakers, cultural perspectives, people of color and recent immigrants.

[27] Beth Israel Deaconess Hospital-Plymouth: Community Health Needs Assessment 2019. Pp. 28-38

Plymouth has notably higher rates of infectious and chronic diseases than the surrounding communities in the BID-SA and in some cases the higher rate is statistically significant to rates in the Commonwealth. Plymouth residents had notably higher rates of Chlamydia, Hepatitis C, and gonorrhea. Pneumonia/influenza mortality rate in Plymouth at 20.7 deaths per 100,000 deaths is higher than the rate in the Commonwealth at 17.1 deaths per 100,000. The leading cause of death for the residents in the BID service area include heart disease, cancer, stroke, diabetes, and respiratory disease the leading causes of death. And though 86% of residents have access to a park, most 23% of residents in Plymouth County are inactive and 11% of Plymouth County residents have diabetes.

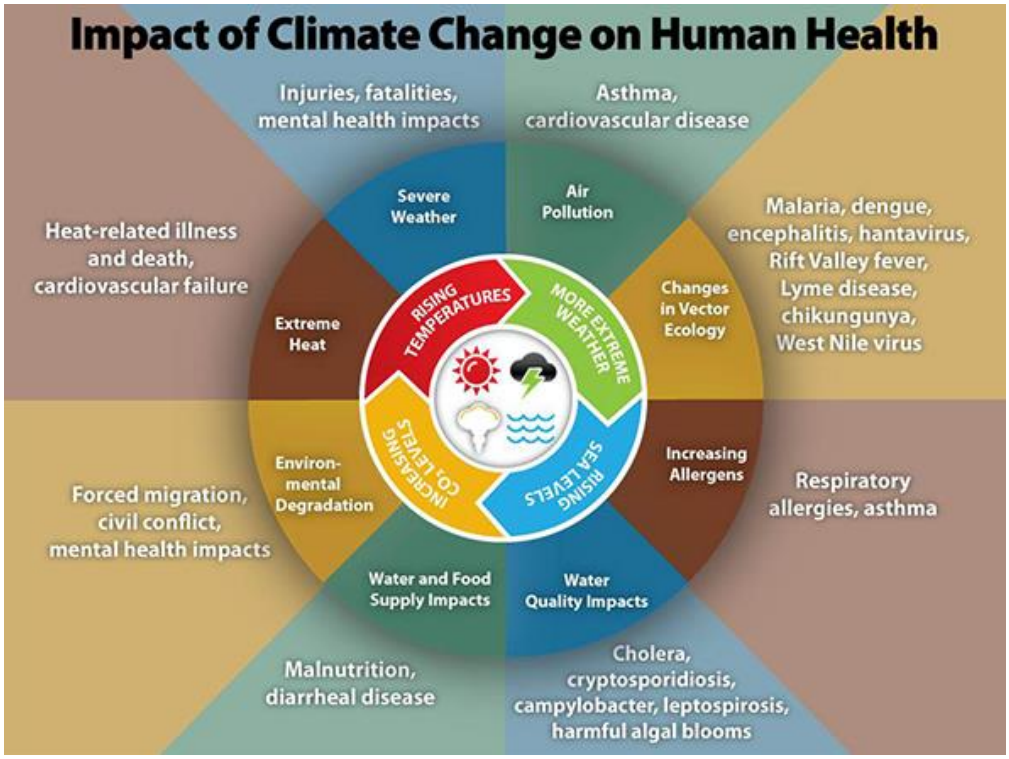
From a more social public health perspective, BID noted that residents of their service area had difficulty navigating the medical care system and accessing and/or coordinating social services. Residents most challenged by this were older adults, low income individuals, people of color, limited proficiency English speakers, and individuals with complex and chronic conditions. [28] Conditions that leader to poor health outcomes in children were lack of healthy-eating, lack of physical activity, obesity, tobacco/vaping, alcohol and stress. Additionally, 10.6% of children in Plymouth have asthma.

[28] Beth Israel Deaconess Hospital-Plymouth: Community Health Needs Assessment 2019. Pp. 3-5

IV. Plymouth Climate and Health Vulnerability

Climate change affects health in numerous ways. Beyond direct impacts such as heat illness, exposure to flood waters, or injury during a storm, climate change affects the social and environmental conditions that contribute to poor long-term health outcomes, such as food insecurity, poor air and water quality, and displacement. When public health and climate change are considered together, strategies to minimize and adapt to climate change also provide tremendous public health benefits while ensuring resilient and healthy communities into the future.

Figure 10 The Center for Disease Control and Prevention graphic on the interconnectivity between climate change and public health.



By evaluating climate risks through the social determinants of health, Plymouth can prioritize actions so that all residents, workers, and business owners can thrive in the face of our changing climate. For example, poverty can limit access to healthy foods, safe neighborhoods, unstable housing or substandard education. Addressing climate change and health disparities or public health challenges requires transformational change in systems that support the community of Plymouth.

Climate-Ready Healthy Plymouth is therefore an effort to institute systemic change that promotes climate resilience and community health for generations to come. This effort is guided by the following fundamentals:

1. Humans have a right to the resources necessary for health.
2. People and their physical environment are interdependent.
3. Climate Change threatens the fundamentals that sustain life and health.
4. Everyone, everywhere is affected.
5. Health risk and impacts of climate change not equally distributed across people, communities, or nations.
6. Climate change exacerbates existing health inequities.

Source: Climate Change, Health, and Equity: A Guide for Local Health Departments. Pp. 2-4

This section will evaluate climate change impacts in relationship to the MA DPH identified Social Determinants of Health. The following climate change and public health vulnerabilities and strengths are specific to the Town of Plymouth and informed public engagement for this planning process and the Municipal Vulnerability Preparedness workshop to create a five-year action plan for climate and public health resilience.

4.1 Neighborhood and Built Environment

Built environment is a critical social determinant of health that shapes the physical character of the places where we live, learn, work, travel, and play. The Neighborhood and Built Environment category includes infrastructure such as critical facilities, transportation, parks and open space, streets, utilities and the systems that connect them such as roads, bridges, parks, etc. It as includes the environmental exposure that threatens them.[29]. Healthy, livable communities are ones that have minimal exposure to environmental and climate risks, well-maintained and highly functioning infrastructure (sewer systems, stormwater systems, well-maintained buildings, etc.) and a thoughtful and complete network that connects these systems. Sea level rise, changing precipitation, and warming temperatures, and other climate hazards have a profound impact on the category Neighborhood and Built Environment through increased risk of flooded buildings, toxic exposure, disconnection of networks, utility system malfunction, wildfire damage, and tree felling damage. In this section, we explore how climate change affects Plymouth's critical facilities, utilities, transportation systems, and parks and open space.

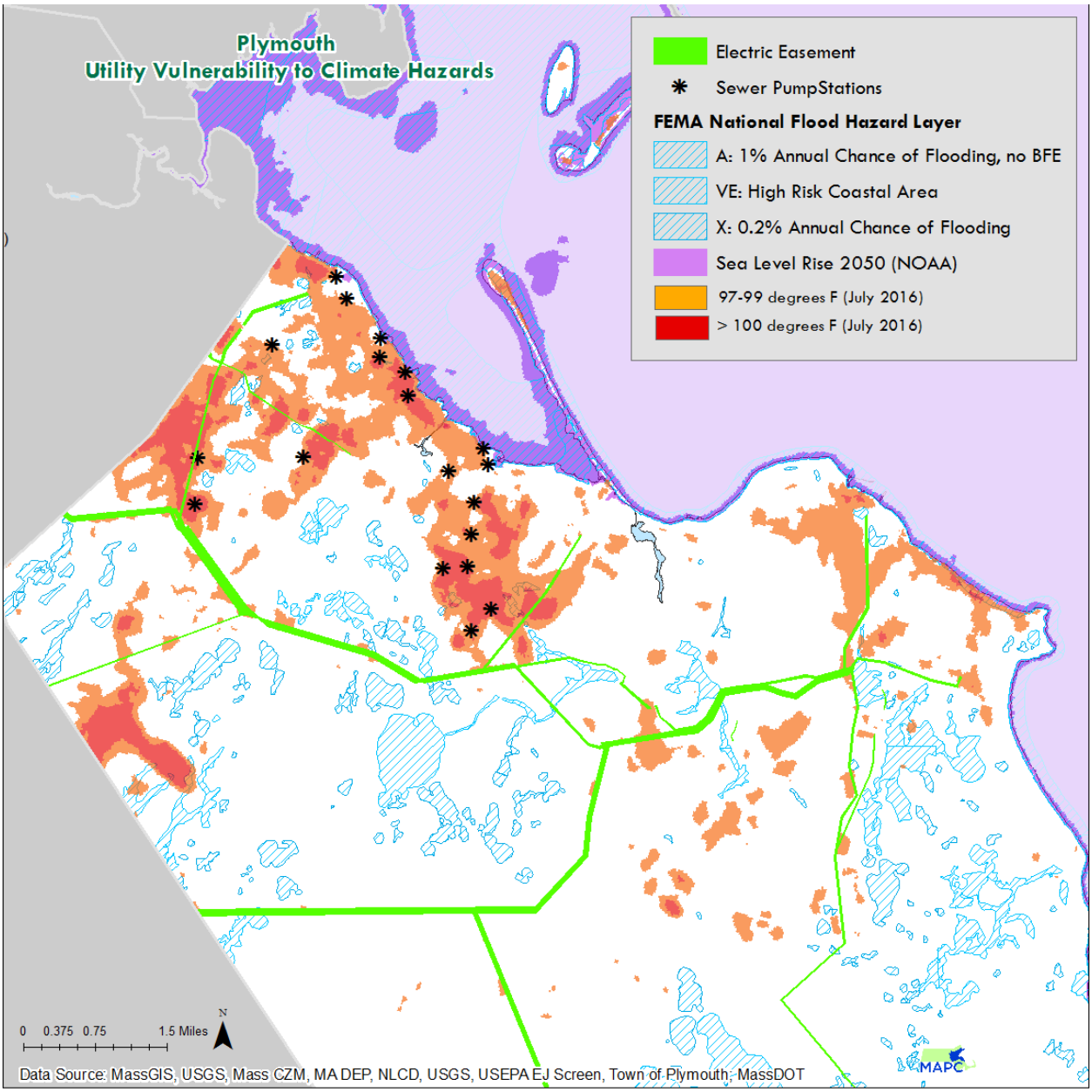
4.1.1 Critical Facilities

Critical Facilities are defined as important infrastructure that enable a community to function on a day to day basis or in an emergency or are facilities that provide special services to vulnerable populations. These include municipal buildings like Town Hall that allow the Town to function, Emergency Services such as police and fire, public housing, schools, long-term care facilities, dams, correctional facilities, and energy facilities. This study evaluated critical facilities in Plymouth in relation to sea level rise, storm flooding at the 1% and the 0.2% Annual Chance Flood event, and urban heat islands and are depicted in Figure 11 and listed in Table 5. Most critical facilities that serve the Town's function and emergency response are safe from climate hazard zones with some exceptions.

There are seven critical facilities located in an urban heat island, importantly these include affordable housing and long-term care; these are discussed in greater detail in 4.3.3 Housing Vulnerability. The critical facilities most vulnerable to flooding, both of which are located in open water areas to serve their function, are dams (**Error! Reference source not found.**) and s tormwater outfalls (

Figure 13 Map of Plymouth's sewer pump station and electric company easements and climate vulnerability to SLR, inland flooding and extreme heat.

[29] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017



Most residents in Plymouth have onsite wastewater systems. Because 95% Plymouth's soils are excessively drained, conditions are suitable for Onsite Wastewater Systems (OSWS) and wastewater from OSWS recharges the groundwater aquifer. OSWS 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 OSWS completely (). White Horse Beach OSWS are most vulnerable because of its low-lying area and residences located in a VE: High Risk Flood Zone (Section 4.3.3 Housing Vulnerability and Table *17*). 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.

Figure 14 Exposed septic system after coastal storm in Westport, CT.

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

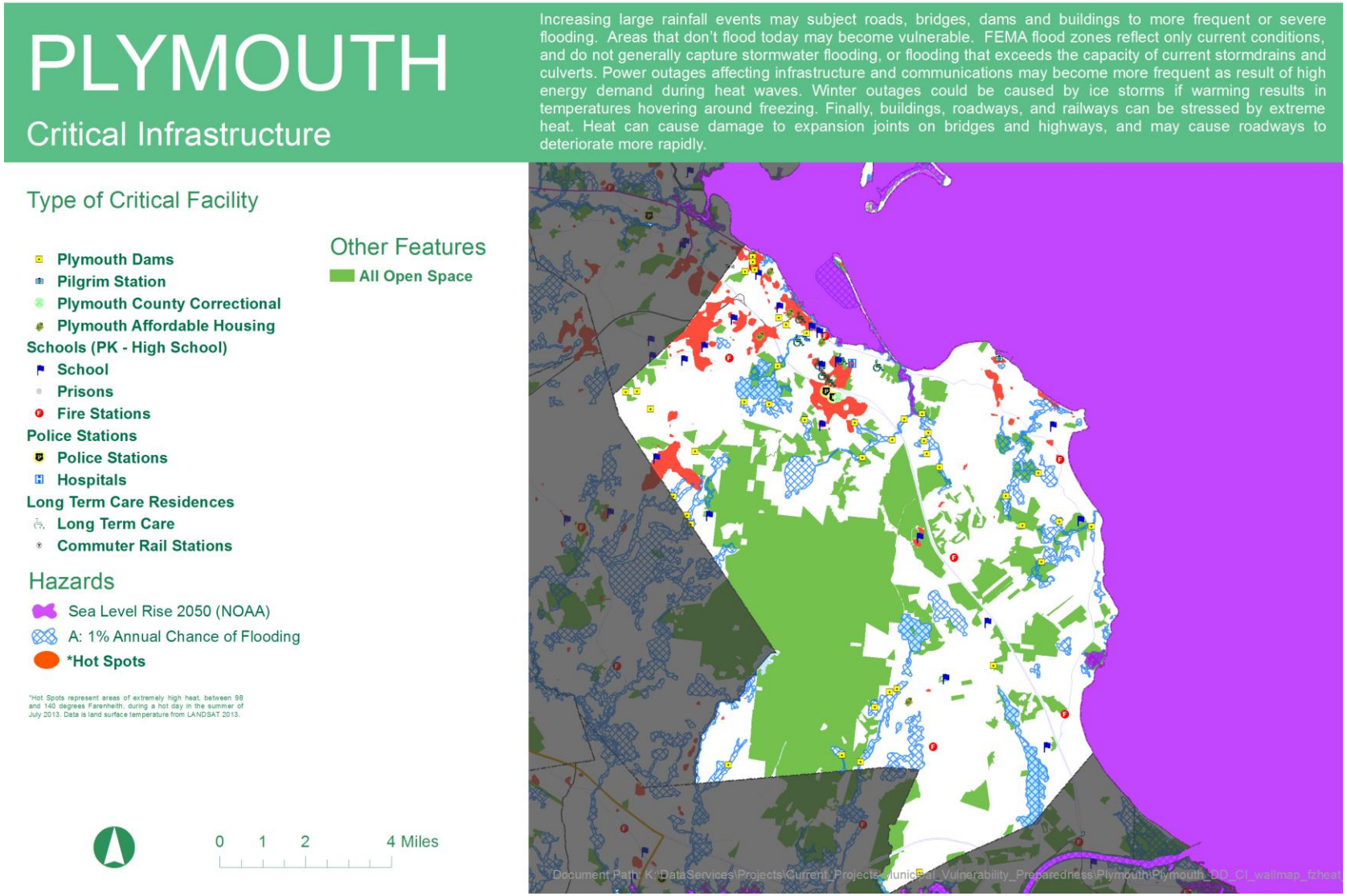
4.1.2.3 Stormwater Systems). Pilgrim Station is vulnerable to the 1% and 0.2% Annual Chance flood and SLR 2050. There are seven parks vulnerable to the 1% Annual Chance Flood and SLR 2050.

Table 5 List of Critical Facilities in Plymouth and exposure to climate risks such as urban heat island, sea level rise in 2050, and the 1% and 0.2% annual chance flood as determined by FEMA.

Critical Facilities	Urban Heat Island	Sea Level Rise 2050	FEMA 1% Annual Chance Flood	FEMA 0.2% Annual Chance Flood
Spring Hill (AH)	X			
Harborwalk (AH)	X			
Algonquin Terrace (AH)	X			
Chilton House Rest Home	X			
Radius Health Care and Pediatric Center	X			
Plymouth Crossing	X			
Life Care Center of Plymouth	X			
Pilgrim Station		X		
Dams				
Fresh Pond Dam			X	
Cold Bottom Pond Dam			X	
Forge Pond			X	
Whipple Reservoir Dam			X	
Federal Pond Dam			X	
Indian Brook Dam			X	
Briggs Reservoir #2 Dam			X	
Shallow Pond Dam			X	
Besse Bog Reservoir Dam			X	
Fawn Pond Dam			X	
Kennard Reservoir Dam			X	
Store Pond Dam			X	
8 Acre Reservoir Dam			X	
United Cape Cod Cranberry Co. #1 Dam			X	
Long Island Pond Dam			X	
C.C. Of America Dam #1			X	
Five Mile Pond Dam			X	
Cooks Pond Dam			X	
Frogfoot Reservoir Dam			X	
Warrens Wells Pond Dam			X	
Saw Mill Pond Dam			X	

Critical Facilities	Urban Heat Island	Sea Level Rise 2050	FEMA 1% Annual Chance Flood	FEMA 0.2% Annual Chance Flood
Billington Sea Dam			X	
Hayden Pond Dam			X	
Clifford Road Dam			X	
Jenny (Arms House) Pond Dam			X	
Russell Mill Pond Dam			X	
Island Pond Dam				X
Darby Pond West Outlet				X
Darby Pond Outlet				X
Little Grassy Pond Dam				X
Sawmill Pond Dam				X
Hedges Pond Dam				X
Eagle Hill Reservoir Dam				X
Grassy Pond Dam				X
Four Mile Brook Dam				X

Figure 11 Town of Plymouth Critical Facilities and Climate Change Hazards of Sea Level Rise, 1% Annual Chance Flood and Urban Heat Islands



Brewster Gardens at Town Brook, Downtown Plymouth. Photo credit SeePlymouth.com.

4.1.1.1 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.[30]

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.

[30] https://www.scituatema.gov/sites/scituatema/files/file/file/hunters_public_meeting_invite_january_2015.pdf

Since FEMA floods zones are determined by historic flooding events among other factors, the impact of sea level rise with storm surge on existing dam structures poses an even greater risk to current classified dam hazards with climate change. Increased intensity of precipitation, more frequent and intense storms, as well as storm surge flowing up coastal rivers are the primary concerns regarding dams. Dams were designed on historic weather patterns and the increased flows could cause additional stress to old dam structures. Many dam structures across Massachusetts have already aged beyond their design life[31] making dam restoration, removal, and safety a regional challenge and opportunity. A potential effect of increased significant rain events is the failure and/or overtopping of existing dams causing rapid overland flow and excessive flooding of adjacent structures, such as bridges, roads, culverts, and other buildings. Because soils in Plymouth have the capacity to drain very quickly composed of sand deposits, rivers are less flashy and flood hazards are reduced. Currently, there are three Town-owned dams that are currently classified as significant hazard dams. These include Fresh Pond dam, Store Pond dam, and Jenny (Arms House) Pond dam (Table 6).

However, the Town of Plymouth has been very proactive and successful in minimizing the risks of climate change and dam hazards. In recent years, Plymouth has removed nine dams. These include Standish Pond dam, two dams at Town Brook, Water Street, Wellingsley Brook, Russel Mill Pond dam, and two dams on Beaver Dam brook. The Town Brook restoration project is an iconic beautification, natural resource restoration and climate resilience project the Town has worked to complete for the 400th Anniversary celebration. Town Brook is a first order stream originating at the 269-acre Billington Sea pond and flows to Plymouth Harbor. It is a natural and cultural resource iconic of Plymouth's history, running through Brewster Gardens and the drinking water source for the Pilgrims.[32] The restoration project included the removal of three dams, reconstruction of fish passage at Jenney Pond Gristmill, improvements to stream flow for habitat and flooding, and the reconstruction of Brewster Park with new drainage, paths, and other amenities throughout the park. It also included dredging of the brook to improve fish passage.

Table 6 Dams in the Town of Plymouth and their hazard classification by the Department of Conservation and Recreation.

Dam Name	Regulatory Authority	Owner	Dam Hazard
Billington Sea Dam	Non-Jurisdictional - Other	Town of Plymouth	N/A
Fresh Pond Dam	Office of Dam Safety	Town of Plymouth	Significant Hazard
Cold Bottom Pond Dam	Non-Jurisdictional - Other	Private	N/A
Forge Pond	Non-Jurisdictional - Other	Private	N/A
Whipple Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
Federal Pond Dam	Non-Jurisdictional - Other	Private	N/A
Indian Brook Dam	Office of Dam Safety	DOT - Dept. of Transportation	High Hazard

[31] AECOM. 2018. Commonwealth of Massachusetts Climate Adaptation and Hazard Mitigation Plan.
[32] https://www.seeplymouth.com/things-to-do/brewster-gardens

Briggs Reservoir #2 Dam	Non-Jurisdictional - Other	Private	N/A
Shallow Pond Dam	Non-Jurisdictional - Other	Private	N/A
Hayden Pond Dam	Office of Dam Safety	Private	Low Hazard
Clifford Road Dam	Office of Dam Safety	Town of Plymouth	Low Hazard
Island Pond Dam	Office of Dam Safety	Town of Plymouth	Low Hazard
Dam Name	Regulatory Authority	Owner	Dam Hazard
Darby Pond West Outlet	Non-Jurisdictional - Other	Private Association or other non-profit	N/A
Darby Pond Outlet	Non-Jurisdictional - Other	Private	N/A
Besse Bog Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
Fawn Pond Dam	Non-Jurisdictional - Other	Private	N/A
Kennard Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
Little Grassy Pond Dam	Non-Jurisdictional - Other	Private	N/A
Sawmill Pond Dam	Non-Jurisdictional - Other	Town of Plymouth	N/A
Hedges Pond Dam	Non-Jurisdictional - Other	Town of Plymouth	N/A
Store Pond Dam	Office of Dam Safety	Town of Plymouth	Significant Hazard
Jenny (Arms House) Pond Dam	Office of Dam Safety	Town of Plymouth	Significant Hazard
8 Acre Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
United Cape Cod Cranberry Co. #1 Dam	Non-Jurisdictional - Other	Private	N/A
Long Island Pond Dam	Non-Jurisdictional - Other	Private	N/A
C.C. Of America Dam #1	Non-Jurisdictional - Other	Private	N/A
Five Mile Pond Dam	Non-Jurisdictional - Other	Private	N/A
Russell Mill Pond Dam	FERC Jurisdiction	Private	Significant Hazard
Cooks Pond Dam	Non-Jurisdictional - Other	Private	N/A
Frogfoot Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
Eagle Hill Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
Grassy Pond Dam	Non-Jurisdictional - Other	Private	N/A
Warrens Wells Pond Dam	Office of Dam Safety	Private	Low Hazard
Saw Mill Pond Dam	Non-Jurisdictional - Other	Town of Plymouth	N/A
Four Mile Brook Dam	Non-Jurisdictional - Other	Private	N/A
Nye Bog Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
Briggs Reservoir Dam #1	Non-Jurisdictional - Other	Private	N/A
Cordage Pond Dam	Non-Jurisdictional - Other	Private	N/A
Jackson Brook Dam	Non-Jurisdictional - Other	Private	N/A
Frogfoot Reservoir Dam	Non-Jurisdictional - Other	Private	N/A
Little Hedge Pond Dam	Non-Jurisdictional - Other	Private	N/A

4.1.2 Utilities

Disruption in utilities (stormwater, sewer, drinking water, electricity) can have significant health implications to residents of Plymouth and with climate change, scientist project more extreme and more frequent weather events. Preparation and emergency response during extreme weather events can minimize the public health risk associated with the loss of utilities. This section evaluates which utilities are at greatest risk to climate hazards and the public health outcomes associated with it. A map of Plymouth's utilities and climate change hazards is depicted in Figure 13.

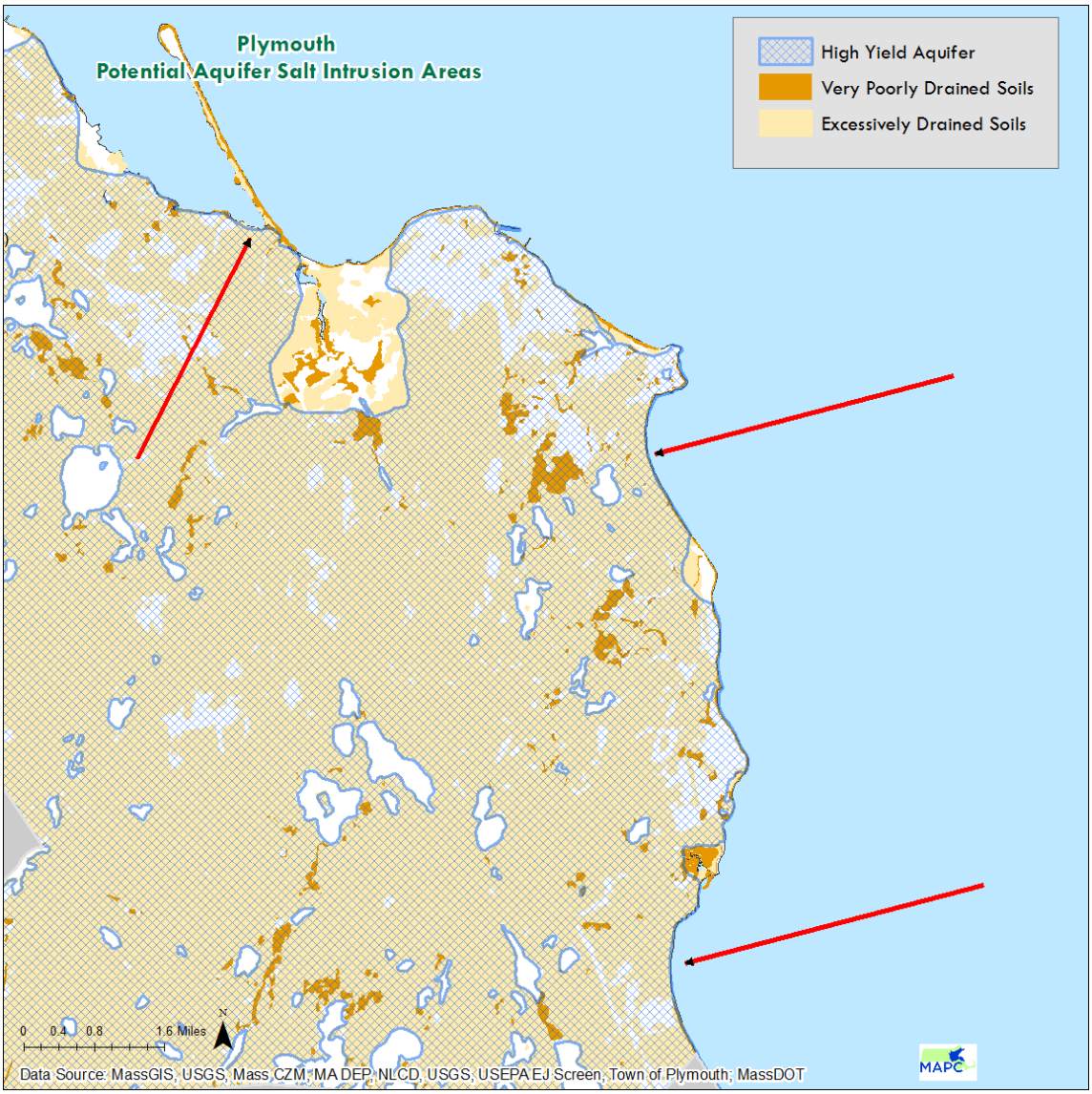
4.1.2.1 Drinking Water Systems

The Plymouth-Carver Sole Source Aquifer, the second largest in the State, provides drinking water to Plymouth residents and six surrounding towns providing over 500 billion gallons of water. Plymouth also receives its drinking water from an additional, medium yield aquifer. There are 12 wells at 10 different site locations in Plymouth that enable 14,000 different service connections.[33]

Because of its expanse, approximately 80% of the Town is covered with an Aquifer Protection Zoning District. This zoning overlay regulates density, use, and wastewater discharge requirements

Figure 12 Saltwater intrusion of Plymouth's aquifer can occur in areas where the aquifer meets the coast and is overlain by excessively drained soils.

[33] Town of Plymouth. 2017. Open Space and Recreation Plan



to minimize the impact of land use on the water quality. Importantly, ground water presents as surface water in most of Plymouth's ponds. Plymouth has grown significantly in the last decade with over 800 new housing units on over 300 acres of land and residents' and stakeholders' engagement indicated grave concerns on the ongoing supply of clean drinking water with rapid growth and a potential need to create new wells, pumps, and other infrastructure to meet future demand. In addition, water quality was a grave concern for residents and stakeholders. Because the groundwater presents itself at the surface, aquifer contamination from stormwater runoff, non-point source pollution, and nitrification is another critical concern. Further, the Plymouth Water Division has concerns about aquifer contamination from cross-connections, a point where a drinking water line connects to equipment of water sources of questionable quality (boilers, garden hoses, air conditioning systems, irrigation systems, etc.). Contamination occurs when the drinking water

line pressure drops, and contaminants are sucked from outside sources into the drinking water line.[34]

Water quality and water quantity concerns as well as their public health implications are magnified with climate change. With projected 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.

For coastal aquifers such as Plymouths, saltwater intrusion or salinization is a potential water quality and quantity issue when the aquifer is within excessively drained soils and without a hydrogeologic barrier like clay that can prevent contamination. Most of Plymouth is comprised of sandy, excessively drained soils indicating a significant potential risk of saltwater intrusion on the aquifer. Also, scientists anticipate that rising seas infiltrating the land will raise the ground water table closer to the surface reducing the barrier between the fresh groundwater and the ocean salt water. Saltwater intrusion can also occur if the well head and/or pump station is submerged by the underlying salt water with SLR effectively pushing salt water onshore. Spatial analysis of Plymouth's wellhead protection areas indicates that none of the Town's wells are vulnerable to SLR. However, excessive coastal erosion can cause greater exposure of the aquifer to salt water. As discussed in 4.2.2. Coastal Natural Areas, coastal erosion is a significant challenge for Plymouth enhancing the risk to saltwater intrusion in some areas where the aquifer intersects with the eroding coastline(Figure 12).[35]

The impacts of climate change through sea level rise and changing precipitation patterns span Plymouth' infrastructure, environment, and society/public health. There will be a loss of potable water if the aquifer is intruded by salt water or if stormwater pollutants infiltrate kettle ponds where groundwater presents at the surface. Loss of potable water could affect economic growth, particularly for the business community and developable property. Ground water elevation could reduce the areas suitable for septic systems and could cause persistent flooding to existing residences and homes. For the environment, reduced fresh water combined with increased withdrawals can reduce pond, river, stream, and wetland levels. This not only affects the viability of the natural systems these aquatic systems support such as wildlife habitat but also reduce flood storage functions of wetlands and rivers.[36]

4.1.2.2 Wastewater Systems

Plymouth wastewater is managed in three different systems. There are 50 miles of public sewer that collects, treats, and transports wastewater from the most densely developed North Plymouth

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[34] Plymouth Water Division Water Quality Report 2018. https://www.plymouth-ma.gov/sites/plymouthma/files/pages/2018_water_quality_report.pdf

[35] Masterson, J.P., and Walter, D.A., 2009, Hydrogeology and groundwater resources of the coastal aquifers of southeastern Massachusetts: U.S. Geological Survey Circular 1338, 16 p.

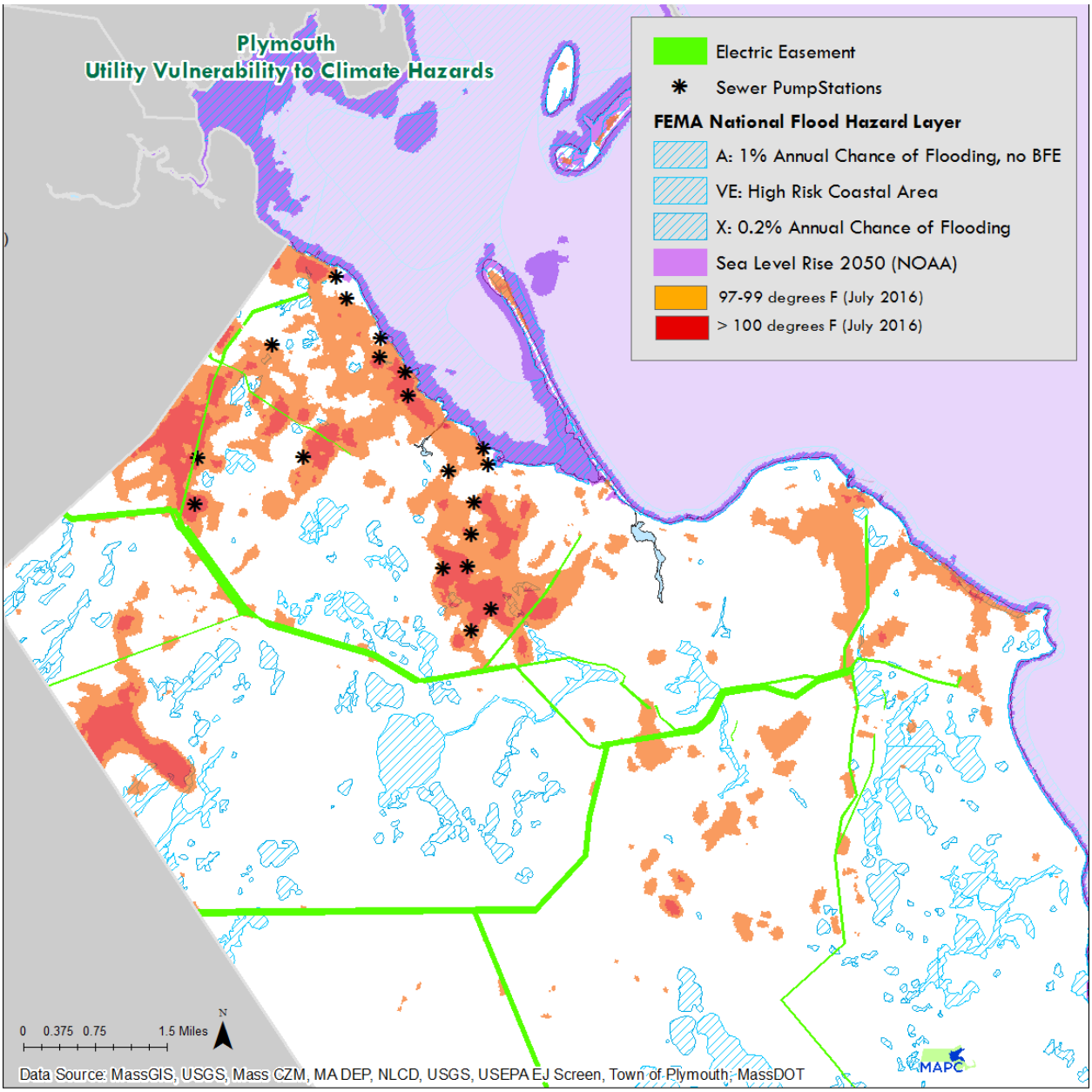
[36] Masterson, J.P., and Walter, D.A., 2009, Hydrogeology and groundwater resources of the coastal aquifers of southeastern Massachusetts: U.S. Geological Survey Circular 1338, 16 p.

and Downtown Plymouth and is utilized by 10% of all Plymouth residences and major commercial and industrial facilities.[37] The recently developed a new wastewater system that is located behind Camelot Drive Industrial Park, away from both coastal and inland flooding. In sewered areas, treated wastewater is managed both with infiltration at the wastewater treatment plant and to an ocean outfall.[38] There are five areas where sewer pipes are located within SLR 2050, 1% or 0.2% flood zone flood zones. The areas include Cordage Park, Nelson Park, Downtown Plymouth, Town Brook, and Stephens Field (Appendix A Stormwater and Sewer Infrastructure Vulnerability). Plymouth also has 10 small-scale sewage treatment plants which includes Plymouth South High/Middle School, the Pine Hills, White Cliffs, Brookdale Senior Living Center, Plymouth Municipal Airport, Entergy Power Plant, AD Makepeace-Red Brook, and Village Crossing.

With excessively drained soils, there is potential concern that with sea level rise, sewer pipes could become corroded over time with exposure to the saline waters. The public health risk is exposure to untreated sewage entering into beaches and recreation waters. Untreated sewage can cause Escherichia coli diarrhea, gastroenteritis, salmonellosis, Hepatitis A, cryptosporidiosis, dysentery, typhoid fever, and cholera.[39] In addition there are four sewer pump stations that are exposed to flooding, though only one is located in a SLR 2050 zone, Knapp Terrace Station (Appendix A Stormwater and Sewer Infrastructure Vulnerability and Figure 14). Flood pump stations could cause major damage to the system and disrupt wastewater services to resident during coastal storms, causing residential exposure to wastewater during major storm or flooding events. SLR 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 electricity and did not have back-up generators. Counties in New York and New Jersey had drinking water advisories and boil water notices, and Passaic Valley was forced to release billions of gallons of raw and partially treated sewage into New York Bay.[40]

Figure 13 Map of Plymouth's sewer pump station and electric company easements and climate vulnerability to SLR, inland flooding and extreme heat.

[37] Town of Plymouth 2017 Open Space and Recreation Plan
[38] Town of Plymouth 2017 Open Space and Recreation Plan
[39] https://www.in.gov/isdh/22963.htm
[40] [65] http://www.mwra.com/monthly/wac/presentations/2014/030714-climatechange.pdf



Most residents in Plymouth have onsite wastewater systems. Because 95% Plymouth's soils are excessively drained, conditions are suitable for Onsite Wastewater Systems (OSWS) and wastewater from OSWS recharges the groundwater aquifer. OSWS 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 OSWS completely (). White Horse Beach OSWS are most vulnerable because of its low-lying area and residences located in a VE: High Risk Flood Zone (Section 4.3.3 Housing Vulnerability and Table *17*). 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.[41]

Figure 14 Exposed septic system after coastal storm in Westport, CT.

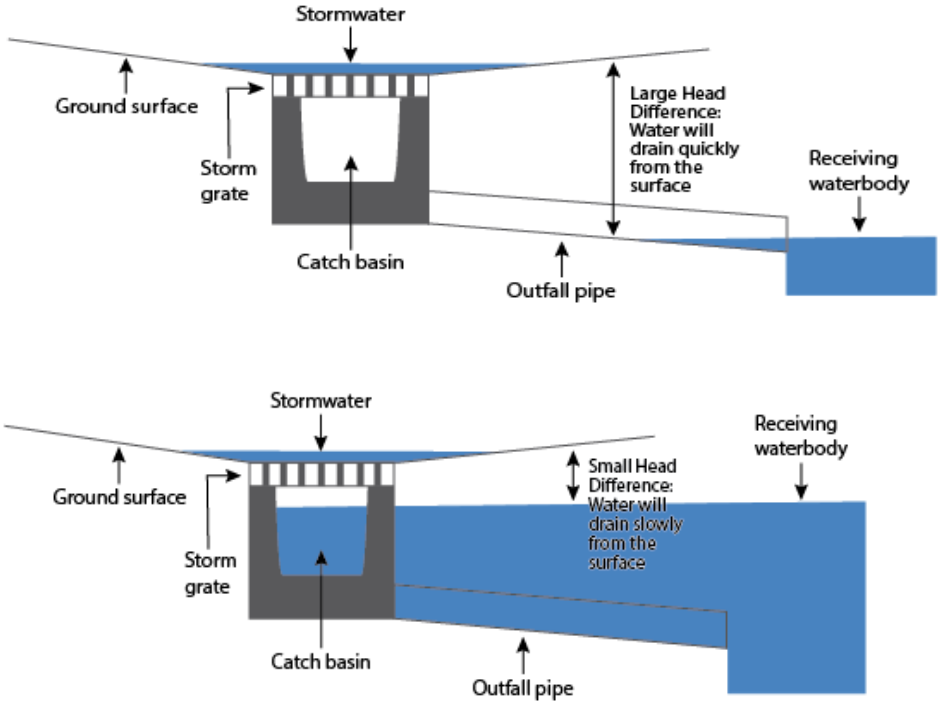
Source: https://www.epa.gov/sites/production/files/2015-07/documents/soil-based_onsite_wastewater_treatment_and_the_challenges_of_climate_change.pdf

4.1.2.3 Stormwater Systems

Because stormwater systems are largely designed by gravity, infrastructure is often located in low-lying areas prone to flooding. In Plymouth, several stormwater outfalls and catch basins are within SLR 2050, 1% and 0.2% Annual Chance flood zones (Appendix A Stormwater and Sewer). The public health concern arises with major precipitation events or coastal storms associated with climate change that can (i) the amount of precipitation and runoff far exceeds the capacity of the system causing back-ups into streets and neighborhoods and/or (ii) ocean waters from storm surge entering the stormwater system through outfalls inhibiting the stormwater runoff to empty the system (Figure 15). The public health risk of flooding the stormwater system includes pollutant exposure to runoff pollutants to residents in the event of overflow into the streets and degraded water quality if stormwater is not able to filter through the catch basin. In addition, most water body pollutants are caused by stormwater runoff. These are discussed in more detail in section 4.1.4 Environmental Exposure.

[41] 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

Figure 15 Diagram of a stormwater catch basin and outfall. During normal conditions (top), the infrastructure is designed to enter the catch basin then flow to the outfall by gravity. If outfalls are at or near sea level (bottom) such as during coastal storms or with future sea level rise, coastal waters will enter the system preventing drainage of the stormwater and potentially causing flooding in the streets or damage to the system. Graphic adapted from Charlston, N.C. Mayor's Office of Emergency Management.



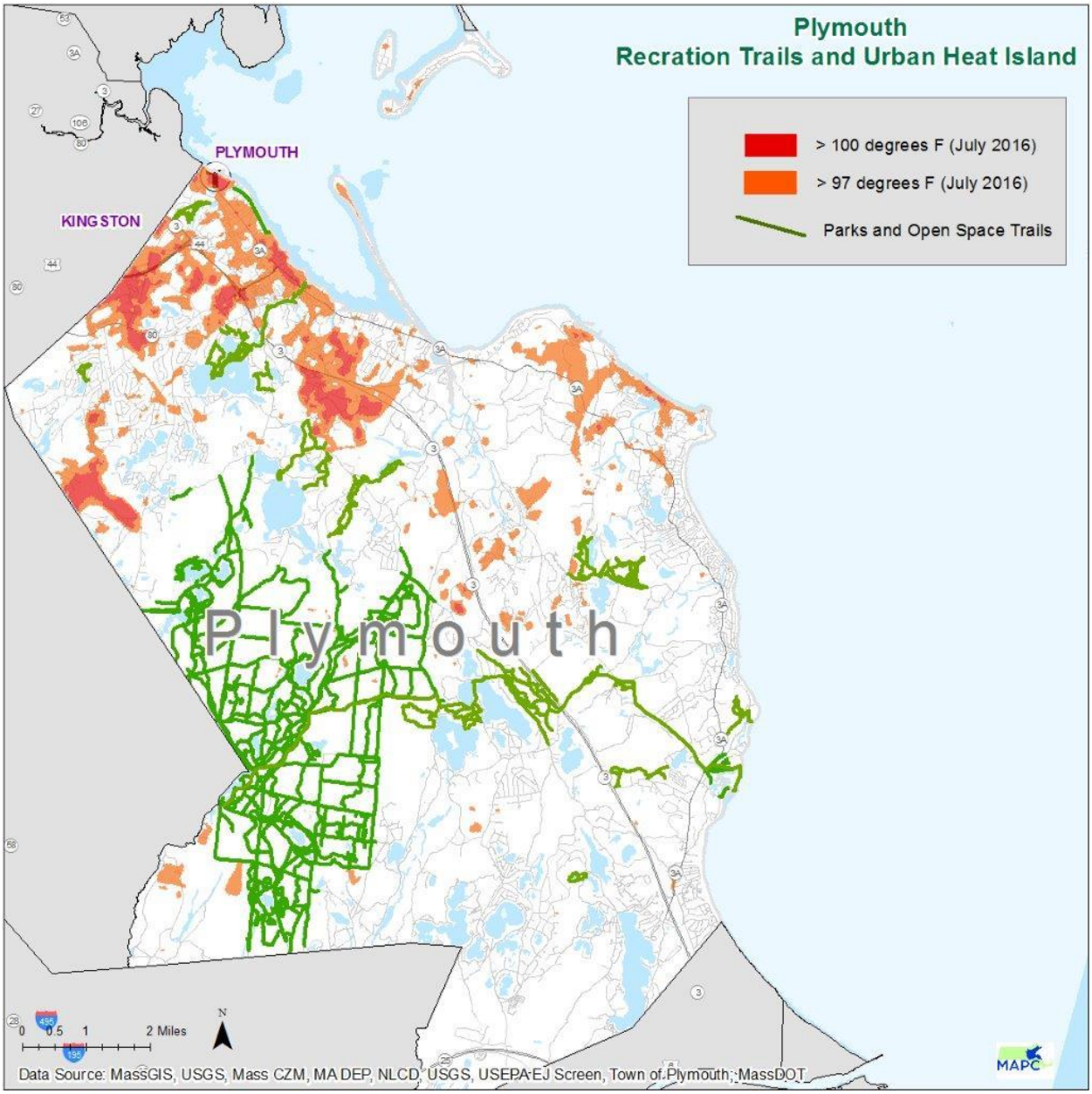
4.1.3 Transportation

The Town of Plymouth has approximately 570.8 mils of roadway, 38% are town-owned, 49% private and 13% state-owned roads. In addition, Plymouth is unique to eastern Massachusetts in that it contains 18 miles of gravel and stone roads. Plymouth spends approximately $1.5 million on infrastructure upgrades and an additional $1.5 million in State Chapter 90 funds annually.[42]

[42] Town of Plymouth. Open Space and Recreation Plan. 2017

The Greater Attleboro Taunton Regional Transit Authority (GATRA) provides service to Plymouth and neighboring towns in the South Shore. It is a very affordable public transportation service that connects North Plymouth to South Plymouth along the coastline and to neighboring towns such as Kingston, Duxbury, Pembroke, Scituate, Onset/Wareham, and Middleboro. The GATRA also provides medical transportation for seniors and persons with disabilities in North Plymouth. It connects residents to many major service centers and amenities, particularly from neighborhoods with a greater percentage of seniors such as The Pine Hills and some public/affordable housing facilities such as Algonquin Heights. However, the GATRA has infrequent service, as described by focus group participants, and does not have links to western portions of the Town, making this a very car-dependent community. Plymouth also has one Massachusetts Bay Transit Authority commuter rail station providing service to Boston from North Plymouth. The train is not only infrequent but also departs late in the morning rendering it impractical for residents commuting to Boston for work. Participants in focus groups and public forums mentioned their frustration with the limited MBTA service and wanted to explore alternative transportation options to Boston such as water taxis and/or ferries. The Plymouth and Brockton commuter coach bus has been providing reliable and regular commuter and Logan Airport service for over 150 years. It is headquartered in Plymouth and contains two convenient stops at Long Pond Road in Plymouth and Cranberry Crossing in nearby Kingston.

Figure 16 Map of pedestrian and bicycle opportunities and safety. North Plymouth has the most sidewalks and the greatest area of urban heat island, creating a safety hazard for pedestrians and bicyclists.



North Plymouth has the greatest number of sidewalks within Plymouth's transportation network and it also contains a 0.7-mile coastal greenway along the shoreline from Cordage Park to Nelson Park in Downtown Plymouth. This is a highly utilized greenway that connects several coastal parks and provides safe pedestrian and bike access to the economic and tourist center of "America's Hometown." There is also a Town Brook walkway connecting Brewster Gardens to Morton Park in Downtown Plymouth. Myles Standish State Park has 15 miles of paved bike trails through the forest and numerous hiking trails throughout the 12,500-acre park. In addition, the Town of Plymouth instituted a Complete Streets policy in 2013 continuing to install sidewalk and bicycle lanes with new or reconstructed transportation improvements. Residents of West and South Plymouth have expressed a great concern for pedestrian safety, an interest in increasing options for a safe active transportation network including trail connectivity, bike lanes and sidewalks. Also, residents wanted greater connectivity to the extensive park system in Plymouth. In 2014 and

2015, there were no reported pedestrian and/or bicycle crashes from vehicles.[43] However, most sidewalks and walkable neighborhoods in Plymouth are located in areas with extreme heat (Figure 16).

The transportation network is both a contributor to and vulnerable to climate change. The transportation sector is the largest source of greenhouse gas emissions in Massachusetts and the US. Emissions also contribute to poor air quality which increases the risk for heart disease, asthma/respiratory disease, cancer, premature, death, adverse birth outcomes, and adverse lung and brain development in children. Excessive pavement contributes the urban heat island effect, increasing ground surface temperatures and heat-related illnesses and respiratory and circulatory distress. Many residents expressed a strong interest in reducing car-dependent land-use patterns and design to reduce greenhouse gas emissions and improve air quality. Furthermore, motor vehicle crashes are the top cause of injury, disability, and death in the U.S. for children and young adults. In 2015, Plymouth had 863 vehicle crashes that resulted in 332 non-fatal injuries and 2 fatalities. This is a slight decrease from 2014 with 882 reported crashes resulting 392 non-fatal injuries and 5 fatalities.[44]

Finally, too little physical activity has been attributed to heart disease, stroke, diabetes, obesity, osteoporosis, depression and all-cause mortality. Car-dependent land-use, housing and transportation networks promote more sedentary lifestyles.[45] As mentioned in Section III, though Plymouth residents have access to exercise opportunities but respondents repeated requested greater accessibility and safety for walking and biking.

Climate change can have a significant impact on the degradation, safety, and integrity of transportation systems. For example, sea level rise, storm surge, and coastal flooding can render roads unusable. Some coastal storms can deposit significant rubble onto roads causing expensive and time consuming clean up and restoration. Flooded roads can impede emergency response during extreme weather events where residences become inaccessible due to flooding. In addition, salinization and increasing heat further degrades asphalt over time increasing the cost of repairs and replacement to the Town. They can also create more dangerous travel conditions increasing the chance of motor vehicle accidents. Coastal erosion over time exacerbated increasing frequency of coastal storms and sea level rise could make some roads dangerous or inoperable with the undercutting of the dunes on which they are built upon. Manomet Point Road (Figure 17) is an example of a road with a high rate of coastal erosion since 1970 and whose bank was severely undercut during Winter Storm Riley in March 2018. The Town has completed restoration efforts in this area.

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[43] Massachusetts Department of Transportation (MassDOT) Highway Division, Traffic Engineering and Safety Section. From the Registry of Motor Vehicles 2017.

[44] Massachusetts Department of Transportation (MassDOT) Highway Division, Traffic Engineering and Safety Section. From the Registry of Motor Vehicles 2017.

[45] Rudolph, L., Harrison, C., Buckley, L. & North, S. (2018). Climate Change, Health, and Equity: A Guide for Local Health Departments. Oakland, CA and Washington D.C., Public Health Institute and American Public Health Association.

Figure 17 Manomet Point Road with severe coastal erosion over time, in some places nearly 15 feet since 1890. The Town completed significant restoration to the road and dune after storm surge from Winter Storm Riley rendered the road too dangerous for travel.

Table 7 lists Plymouth's roads at risk to sea level rise in 2050, 1% or 0.2% Annual Chance Flood, urban heat island with land surface temperatures greater than 100 degrees during a 90-degree day in July 2016, and coastal erosion greater than three feet since 1970. Most road flooding is with the 0.2% Annual Chance flood from flooding of Plymouth's many ponds. Private roads associated with cranberry bog farms were not included in this analysis, though many are susceptible to flooding, depending on farming practices at the time. Water Street is the most vulnerable road in Plymouth exposed to all four hazards. It is an incredibly important road hosting the Downtown, businesses, municipal operations, the historic Mayflower, and many festivals and community events.

*Table 7 Climate Change hazards and Plymouth's roads for sea level rise, flooding, urban heat island, and greater than three feet of coastal erosion from 1970-2009. * denotes roads with a high frequency of use and very close to climate hazards but not within a delineated hazard zone.*

Street Name	SLR 2050	FEMA 1% or 0.2%	Urban Heat Island (>100°)	>3 Feet Erosion since 1970
Agawam Road		0.2%		
Aldrin Road			>100°	
Algonquin Terrace			>100°	
Archer Street		0.2%		
Armstong Road			>100°	
Bayberry Road		1%		Yes
Bayshore Drive		0.2%		
Black Cat Road		0.2%		
Boat House Lane	X	1%		
Boundary Street	X	1%		
Bourne Road		0.2%*		
Bradlee Lane		1%		

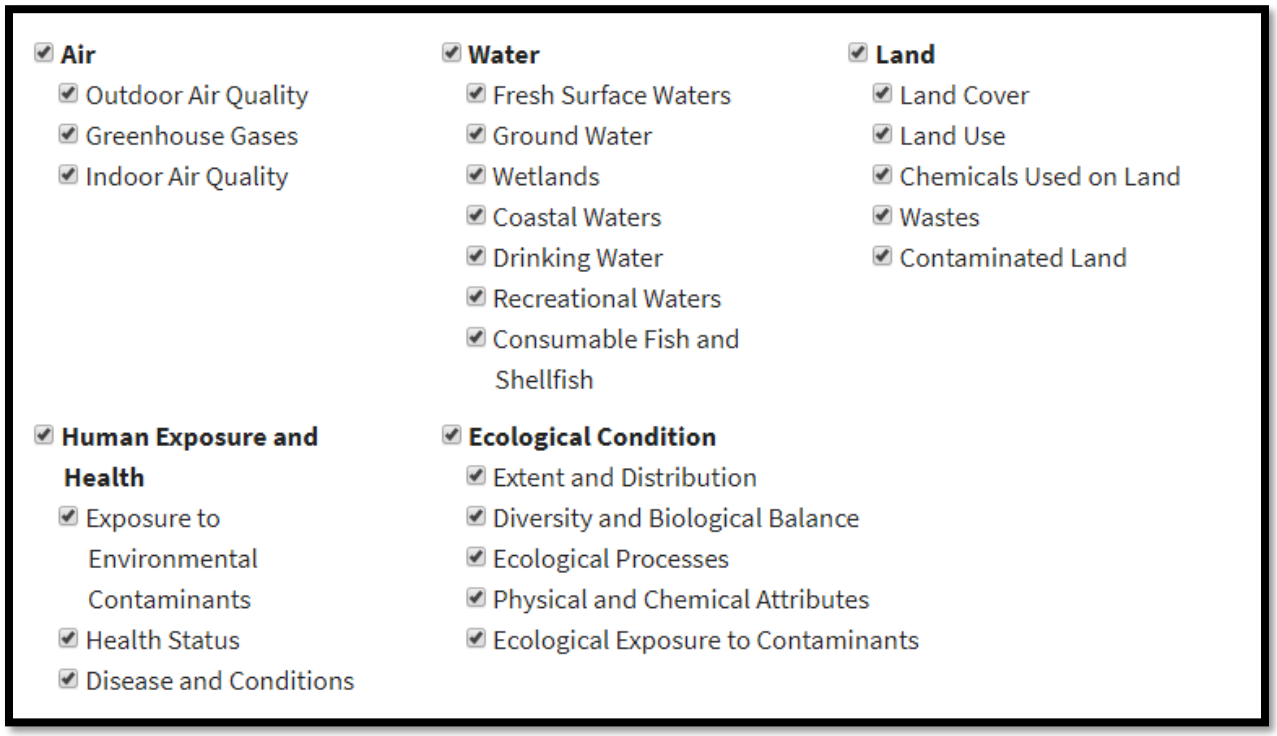
Street Name	SLR 2050	FEMA 1% or 0.2%	Urban Heat Island (>100°)	>3 Feet Erosion since 1970
Brewster Street			>100°	
Burgess Avenue	X	1%		
Camelot Drive		0.2%		
Carolyn Drive		0.2%		
Carver Road		0.2%	>100°	
Caswell Lane		1%		
Center Hill Road				X
Chandler Street		0.2%		
Chilton Street			>100°	
Commerce Way			>100°	
Court Street			>100°	
Doten Road		0.2%		
Downey Street		0.2%		
Ellisville Road	X	1%		X
Federal Furnace Road		0.2%*		
Fire House Road		0.2%		
Fishermans Lane		1%		
Fort Street	X	1%		
Hanks Avenue	X	1%		
Harlow's Landing	X	1%		
Holman Road		0.2%		
Howland Street			>100°	
Industrial Park Road			>100°	
Island Lake Road		0.2%		
Jackson Street		0.2%		
Kelley Street		0.2%		
King Arthur Road	X	1%		
Kings Pond Plain Road		1%		
Landfall Lane				X
Lisa Avenue			>100°	
Lookout Point Road	X			
Main Street			>100°	
Manomet Avenue				X
Manomet Point Road				X
Massasoit Avenue				X
Memorial Drive			>100°	
Middle Street			>100°	

Street Name	SLR 2050	FEMA 1% or 0.2%	Urban Heat Island (>100°)	>3 Feet Erosion since 1970
Milford Street		0.2%		
Nelson Street			>100°	
Ninth Street	X	1%		
North Street			>100°	
Old Beach Road		1%		
Pilgrim Hill Road			>100°	
Priscilla Beach Road				X
Red Brook Road	X	0.2%		
Resnik Road			>100°	
Robert J Way		0.2%		
Route 25*		0.2%		
Route 3A	Frequent Flooding Reported			
Route 3 at Exit 6a			>100°	
Route 44			>100°	
Ryder Way	X	1%		X
Salt Marsh Lane	X			
Samoset Street			>100°	
Sandy Beach Road		0.2%		
School Street			>100°	
Scobee Circle			>100°	
Seaview Drive				
Shoreline Way		1%		
South Park Avenue			>100°	
South Russell Street			>100°	
Stage Point Road		0.2%		
Taylor Avenue		1%		
Taylor Avenue at Thomas				X
The Loop	X	1%		
Union Street	X			
Union Street			>100°	X
Wareham Road		0.2%		
Water Street	X	1%, 0.2%	>100°	X
Warren Avenue	Frequent Flooding Reported			
Watercure Street	X			

4.1.4 Environmental Exposure

Environmental exposure is the risk of human interaction with physical, chemical, biological, and radiological contaminants in the environment, or the interaction between humans and contaminants in the air, land, and water. Additionally, health disparities between race, income, sexual orientation, and other protected classes of people often exist due to disproportionate exposure to environmental contaminants. [46] With changing weather patterns, increased warming and precipitation and/or drought periods, the risk of environmental exposure is greater through climate change. The indicators of environmental exposure are listed in Figure 18. For example, toxic sites exposed to flood water can cause exposure to these health-threatening substances such as bacteria, viruses, and chemicals that cause gastrointestinal diseases, dermatological conditions, toxicity/poisoning, and other illnesses. People can encounter contaminated water when it floods onto their property or contact with contaminated water through recreation. Climate change is expected to increase the risk of residents encountering contaminated water in their parks, homes, schools, and places of work. This section will review potential hazardous and toxic environmental exposure and their potential elevated harm to public health with climate change.

Figure 18 Environmental Protection Agency's Report on the Environment Indicators of environmental exposure for risk assessments.



[46] Environmental Protection Agency. Report on the Environment. Human Exposure and Health.

4.1.4.1 Toxic Exposure

According to the 2017 Open Space and Recreation Plan and the MA Department of Environmental Protection, there are eight Response Action Outcome (RAO) hazardous sites, ones that have achieved some form of environmental site assessment, remediation, and/or solution. The sites and their potential additional exposure to climate change impacts are listed in Table 8.

Table 8 List of Response Action Outcome hazardous spill sites in Plymouth.

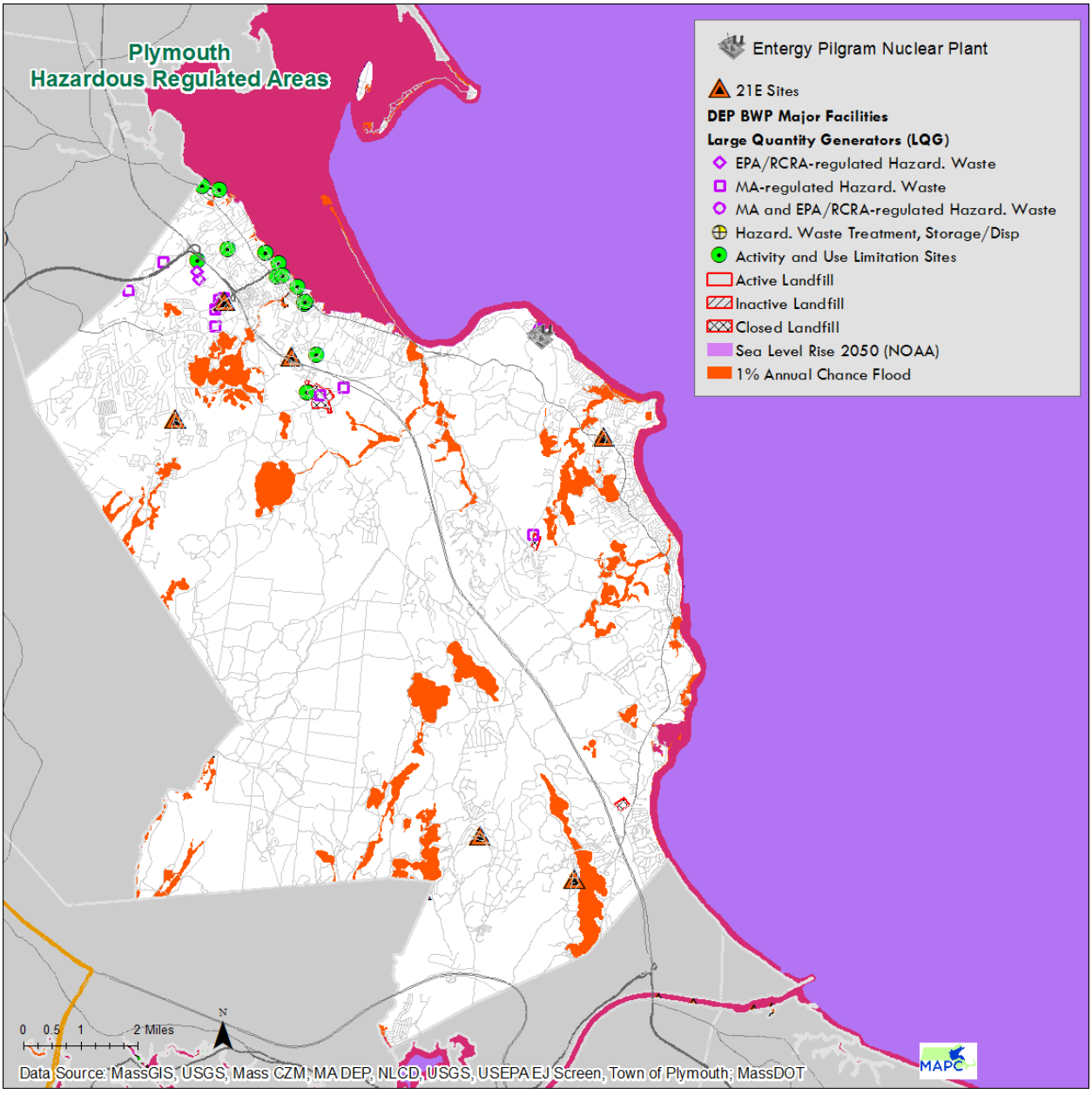
Location	Year Reported	Action	Climate Risk
62 Long Pond road	2005	Activity and Use Limitations (AUL) implemented.	
106 Obery Street	1995	No remediation, no significant risk, AUL implemented	
14 Union Street	1998	AUL implemented	1% Annual Chance Flood, SLR 2050
Town Wharf	2001	Remediated	1% Annual Chance Flood, SLR 2050
Aldrin Road	1994	No significant risk, no AUL	
17 Court Street	1997	No significant risk, AUL implemented	
Water Street	2008	Temporary cleanup, not a substantial hazard, evaluated for five years.	
Cordage Park	1997	AUL Implemented	1% Annual Chance Flood, SLR 2050
Entergy Pilgrim Station Nuclear Waste Holding Tank	N/A	N/A	

Factors that increase environmental exposure with flooding occur in several ways: location in a flood zone, structural integrity of containment, emergency preparedness and response, and disruption of emergency response pathways. Floods and/or rising waters can displace, damage, and rupture containment of hazardous materials, flood waters can mix and react with water causing a toxic reaction, fire, or explosion, and runoff can enter stormwater systems, groundwater, and surface water systems increasing exposure to humans. Finally disruption of emergency response can occur via floodwaters making pathways inaccessible or if toxic exposure poses safety issues to emergency response.[47] Plymouth has three RAO sites that are vulnerable to flooding, Cordage Park Parking Lot 1A, Town Wharf at Brewers Marine, and 14 Union Street, the site of the former Weathervane Restaurant. All three areas are densely populated but have excessively drained soils. Hence the risk of exposure could be less. In addition, the Commonwealth

[47] Word Health Organization. 2018. Chemical Releases Associated with Floods.

of MA has provided training to businesses monitored or regulated for hazardous materials for climate resilience, emergency preparedness and resilient containment.

Figure 19 Sites regulated by the MA Department of Environmental Protection for hazardous waste management and/or toxicity and their risk to exposure from flooding by the 1% Annual Chance Flood or SLR 2050.



Importantly, there are several affordable housing sites that are adjacent to toxic or hazardous waste sites regulated by the MA DEP. These are listed in Table 9.

Importantly, Pilgrim Nuclear Energy Station is the most significant critical facility in a SLR 2050 zone. A large portion of the property's waterfront and a portion of the building nearest the shoreline are susceptible to SLR by 2050. Many public and stakeholder participants have

expressed serious concern about the risk of exposure of the radioactive waste stored on the premises with sea level rise. Now that the plant is decommissioned, Plymouth is less

Table 9 Affordable housing sites proximate to hazardous or toxic sites regulated by the MA DEP.

Housing	AUL	21E
Harborwalk	Revere Copper & Brass	
	Cordage Parking Lot 1A	
133 Court Street	Revere Copper & Brass	
	I/S Water St. and Lothrop St.	
Algonquin		Mobil Station Store 101
Mt. Pleasant School House	Commercial Property-109R Sandwich St. (2 sites)	
	Souzas Service Station (2 sites)	

vulnerable to radioactive exposure and severe and acute health impacts. However, the production of nuclear energy creates radioactive waste and there are no officially designated permanent waste repositories in the US for this waste. Hence, waste generated at the Entergy Pilgrim will remain onsite. Typically waste is stored in either cooling pools or in dry storage.[48] Nuclear material requires a minimum of five years to cool before transfer and hundreds of thousands of years before it decays (i.e., Plutonium 239 has a half-life of 24,000 years).[49,50] Pilgrim Station ceased operations in May 2019 and was acquired by Holtec International in August 2019 to enable the site to enter immediate decommissioning. Holtec is currently working with Town staff and official to relocate the dry cast storage of nuclear waste in a location and height that is safe from storm surge, sea level rise, and inland flooding. The risk of acute injury to radiation exposure is minimized with the plant closure. With the new containment, the exposure risk is even further minimized.

4.1.4.2 Water Contamination Exposure

According to the MA Department of Environmental Protection, there are seven water bodies that are included in the 2014 and 2016 "Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act," as Category Five,

[48] http://www.beachapedia.org/Coastal_ISFSI_for_Nuclear_Waste

[4949] https://www.surfrider.org/campaigns/get-nuclear-waste-off-californias-coast

[50] https://www.newscientist.com/article/dn7591-rising-sea-levels-may-destroy-nuclear-dump/

requiring regulation on discharge of pollutants or Total Maximum Daily Loads (TMDL) A TMDL refers to a plan for restoring water quality in accordance with the Clean Water Act. It identifies the maximum amount of a given pollutant that a water body may receive and still achieve water quality standards.[51] Most of contamination is due to algal growth and/or harmful toxic algae. These are listed in Table 10.

Table 10 Water bodies in Plymouth regulated by the Clean Water Act for Total Maximum Daily Loads (TMDL) and pollutants monitored.

Water Body	TMDL	Reason
Plymouth Harbor-High Cliff to Plymouth Beach	*5*	Fecal coliform, nutrient eutrophication, biological indicators, supporting primary and secondary recreation.
Russel Millpond	*5*	Not supporting aesthetic fish consumption, fish passage, other aquatic wildlife, and primary contact recreation. Excessive algal growth.
Ellisville Harbor	*5*	Fully supporting primary and secondary contact recreation.
Billington Sea	*5*	Not supporting aesthetic for turbidity and excess algal growth. Not supporting primary contact recreation or primary contact for excess algal growth and turbidity.
Halfway Pond	*5*	Harmful algal bloom
Savery Pond	*5*	Harmful agal bloom

Harmful agal blooms occur when colonies of algae have excessive population growth. Some algae will produce toxins harmful effects on people and wildlife. Other algae deplete all the oxygen in the waters causing disruption to fish and other marine or aquatic life. Harmful algal blooms are typically caused by warmer waters and nutrient pollution such as runoff from fertilizers. With shifting precipitation patterns with climate change as well as higher concentrations of carbon dioxide can enhance algal growth. Heavy precipitation events can produce more stormwater runoff carrying nitrogen and phosphorus into water bodies enhancing growth. Warming temperatures creates warmer water bodies that are ideal for excessive algal blooms. Periods of no precipitation can cause changes in salinity causing marine algae to invade freshwater ecosystems.[52] The implications of harmful algal blooms include disruptions and death to marine ecosystems, harmful toxins, increased treatment costs for drinking water, and diminished productivity and income for water-dependent industries. Cyanobacteria, commonly known as blue-green algae, is a photosynthetic bacteria that lives symbiotically with plants and can spread rapidly in still waters. Cyanobacteria capture oxygen and block sunlight affecting the overall aquatic systems and release cyanotoxins that are highly toxic to humans and animals. Exposure

[51] https://www.epa.gov/tmdl/overview-total-maximum-daily-loads-tmdls
[52] https://www.epa.gov/nutrientpollution/climate-change-and-harmful-algal-blooms

occurs from drinking water, bathing in contaminated water, and swimming. Cyanobacterial increased presence is attributed to non-point pollution as described above.

White Horse Beach. Photo Credit AirBNB

There are two beaches in Plymouth monitored by the Massachusetts Department of Public Health Bureau of Environmental Health for *Enterococcus* bacteria. The two beaches include two sampling stations each at Plymouth Long Beach and White Horse Beach. *Enterococcus* bacteria live in the intestinal tract of mammals including humans and their presence in water bodies is an indicator of contamination by fecal waste. This can occur from un-managed dog waste, stormwater runoff, leaking or ill-functioning septic systems, sewage discharge, or wastewater treatment plant effluent. The Massachusetts Enterococcus Bacterial Standard is 104 colony forming units/100 mL of liquid. In the last decade, there have been a total two samples over this standard at Plymouth Beach and six samples over the standard at White Horse Beach.[53] The majority of the high *Enterococcus* concentrations occurred at the White Horse Beach Sampling Station at the corner of White Horse Road and Taylor Avenue. The high *Enterococcus* concentrations often occurred after a storm event where excess stormwater runoff carrying pollutants or potentially ill-functioning septic systems due to a temporary high-water table.

Warming ocean temperatures can also cause shifting ecosystems and species ranges. For example, 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. Since 1980, sea surface temperatures have been higher on average than over the last century, or ever since being recorded.[54] Vp is a naturally-occurring bacterium found in warm, brackish waters

[53] https://ma-beaches.healthinspections.us/beaches.cfm?bID=12320&func=details

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

and its presence has caused strict regulation on oyster harvests as it causes illness when consumed in raw oysters.[55]

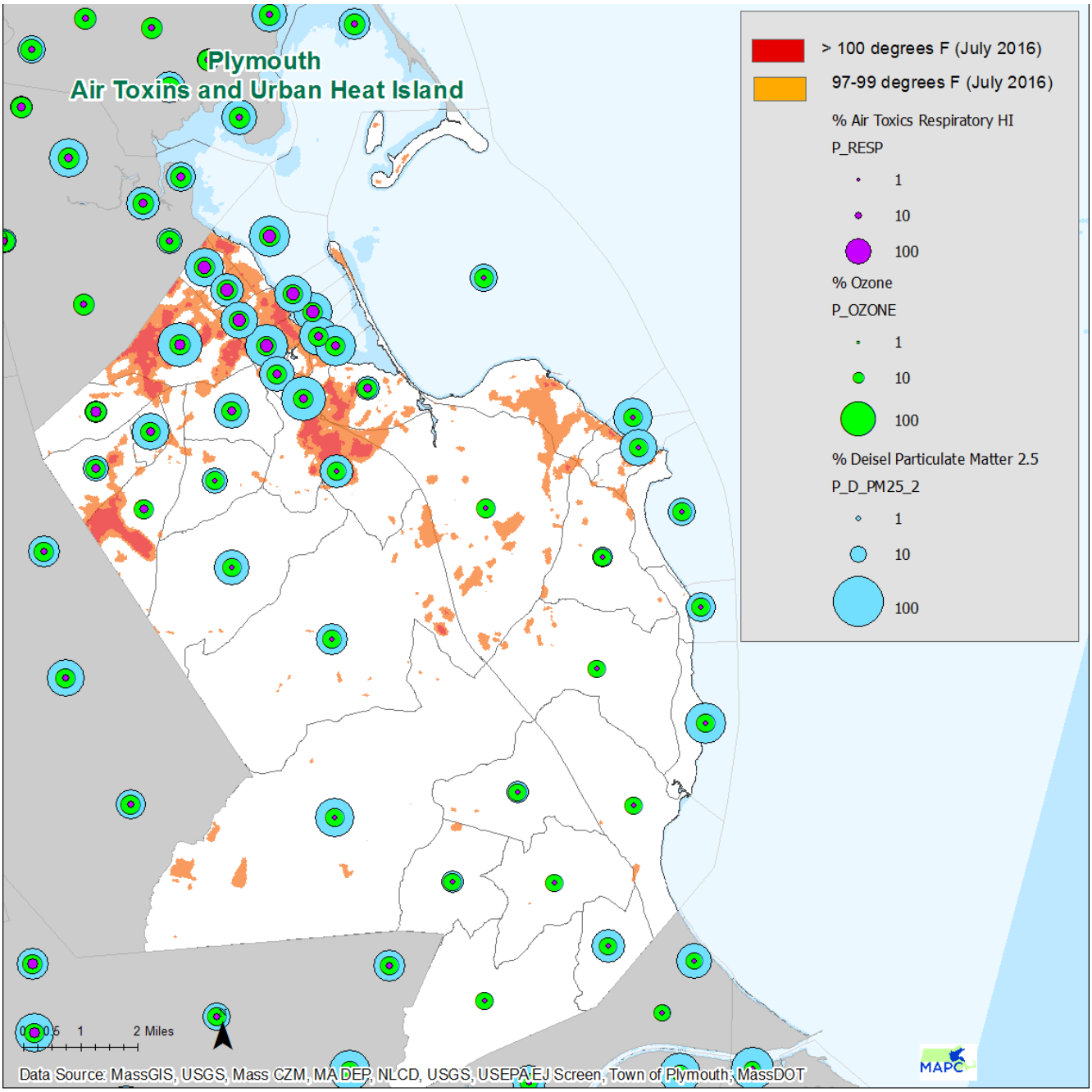
The public health implications of water quality challenges presented by these conditions include greater exposure to pathogens that cause gastrointestinal illness, diarrheal disease, and other bacterial and parasitic infections such as leptospirosis and cryptosporidiosis.[56] Vibrio exposure can cause gastrointestinal duress or severe and/or lethal skin infections.

4.1.4.3 Air Toxic Exposure

Climate change will affect both indoor and outdoor air quality from overall warming, extreme heat days, and shifting precipitation regimes. Air quality toxicity can create or exacerbate several health conditions and causing increasing mortality to chronic medical conditions. These include higher risks of cardiovascular disease, lung cancer, low birth weight, preterm birth, and asthma. In addition, outdoor activities which promote overall health are compromised by poor outdoor air quality have long term impacts on health such as cardiovascular health, bone health, obesity prevention, and mental health.[57] With increasing frequency and intensity of storms, excessive moisture can lead to mold growth in homes, businesses, and municipal facilities, particularly for older home stock and historic structures. Increasing high heat days will cause greater air condition use causing air pollutions from fossil fuel-based electricity production. Additionally, during extreme heat days, individuals with chronic medical conditions or on medication that limit the body's ability to regulate temperature can become mortally ill if there is no access to cooling. This is a concern when shelter-in-place is enacted.

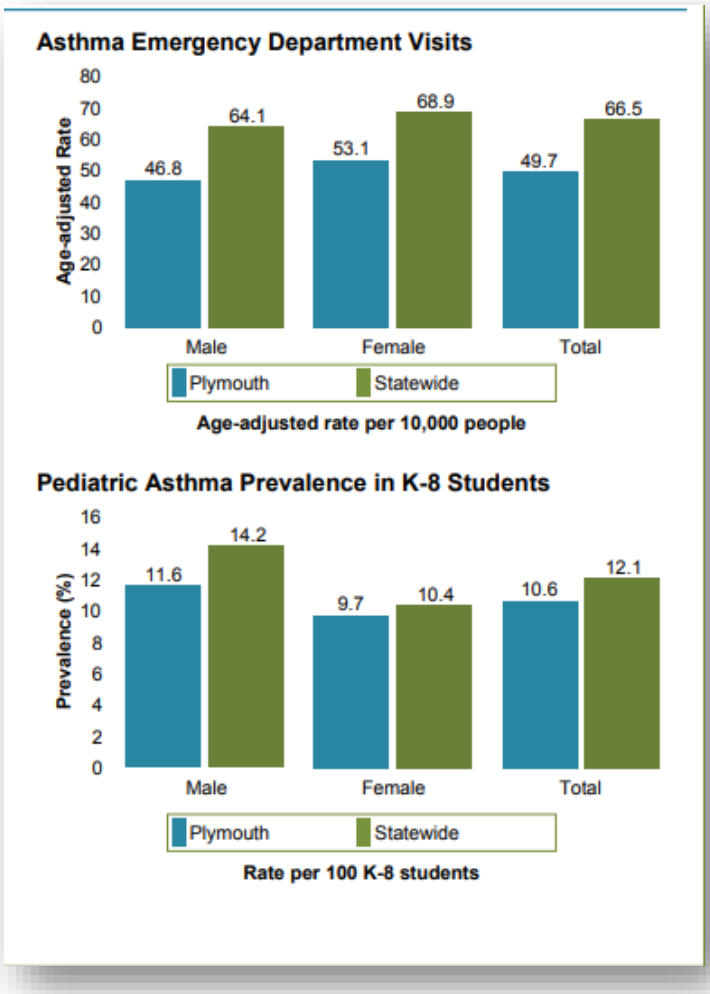
[55] Department of Fish and Game. Massachusetts Division of Marine Fisheries Annual Report 2016.
[56] USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. Chapter 14 Human Health
[57] American Public Health Association. 2018. Climate Equity and Health.

Figure 20 Poor air quality and urban heat islands in Plymouth. Data is at the Census Block Level from federal Environmental Protection Agency.



Climate change affects outdoor air quality from warming temperatures increasing air pollutants, drought and wildlife increasing particulate matter, and increased allergens with longer and warmer growing seasons. In Plymouth, the greatest concentration of poor air quality, including ozone, respiratory air toxics, and diesel are located in North Plymouth to Downtown Plymouth (Figure 20). These areas of high concentrations of poor quality also correspond to the Plymouth's urban heat island and low tree canopy cover. There is also a higher concentration of diesel and ozone pollutant in southwest Plymouth. This is also the area with significant cranberry bogs. One indicator of the impact of toxic air exposure is the prevalence of asthma and emergency room visits caused by asthma respiratory distress. Overall, Plymouth is similar to but below the State average for asthma emergency room visits and pediatric incidences of asthma (**Error! Not a valid bookmark self-reference.**). *There is well-established scientific relationship between peak ground ozone levels and high temperatures and scientists project that increasing temperatures with shifting weather patterns may lead to more frequent and higher peak ozone levels, particularly if greenhouse gas*

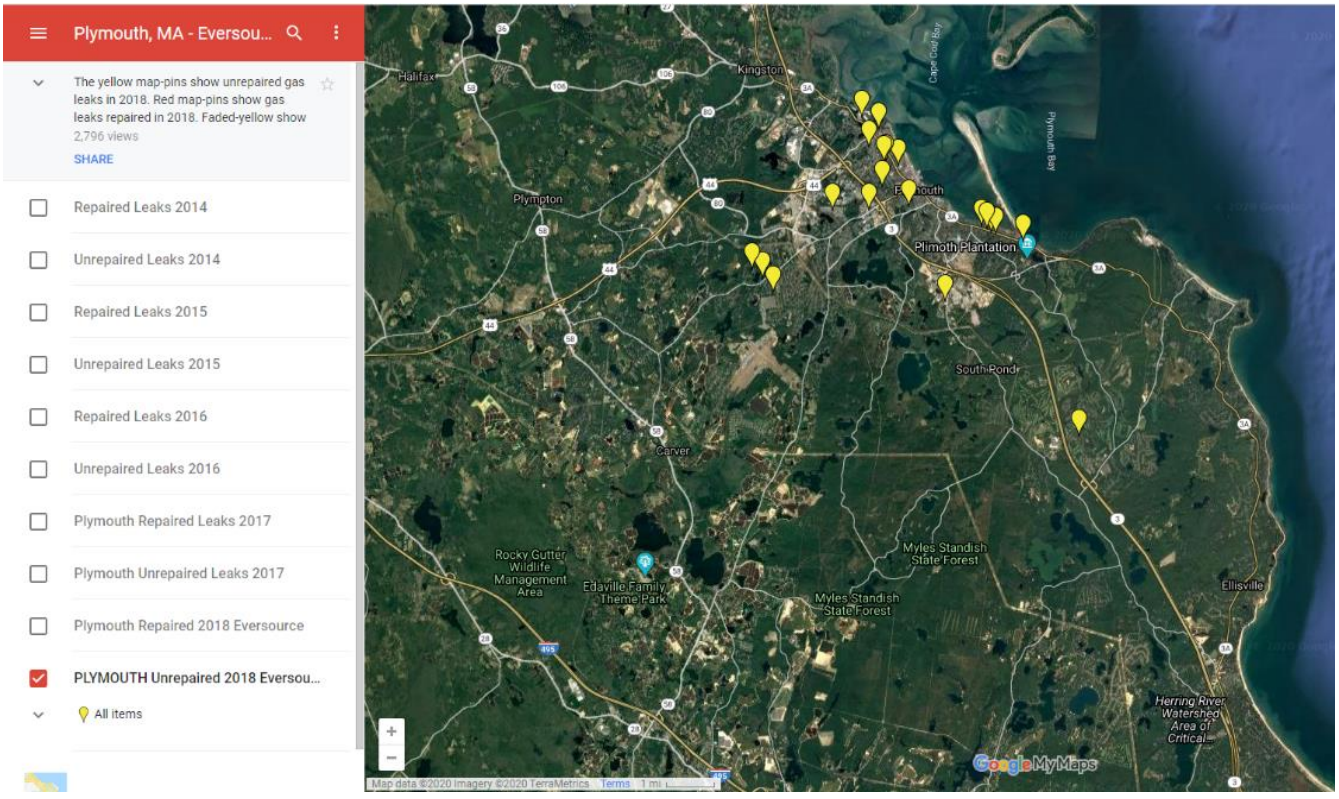
Figure 21 Plymouth's rates of asthma-related emergency department visits and pediatric asthma prevalence in K-8 students. Date from the MA Dept. of Public Health.



emissions are not changed. In addition to the aforementioned public health impacts to toxic air exposure, increases in ground ozone can lead to premature mortality, more frequent hospital visits, and lost school days due to respiratory impacts.[58]

As mentioned, changes in precipitation regimes with increased warming may lead to higher incidence of drought. Drought also raises the risk of the incidence and severity of fire. Because of Plymouth's large expanse of Pine Barren forest, there is a greater risk for widespread and severe impact from these conditions. Wildfires emit fine particles that are ozone precursors. They also release carbon dioxide which, in the event of an extreme wildfire event, could cause premature death, adverse chronic and acute cardiovascular and respiratory health incomes. In addition, wildfire releases significant carbon dioxide into the atmosphere further accelerating climate change. Drought can cause increased dust levels into the air from dried soil, further worsening air quality.[59]

Figure 22 Eversource natural gas leaks as of 2018 in Plymouth. Most gas leaks are congregated in North Plymouth and Downtown Plymouth.



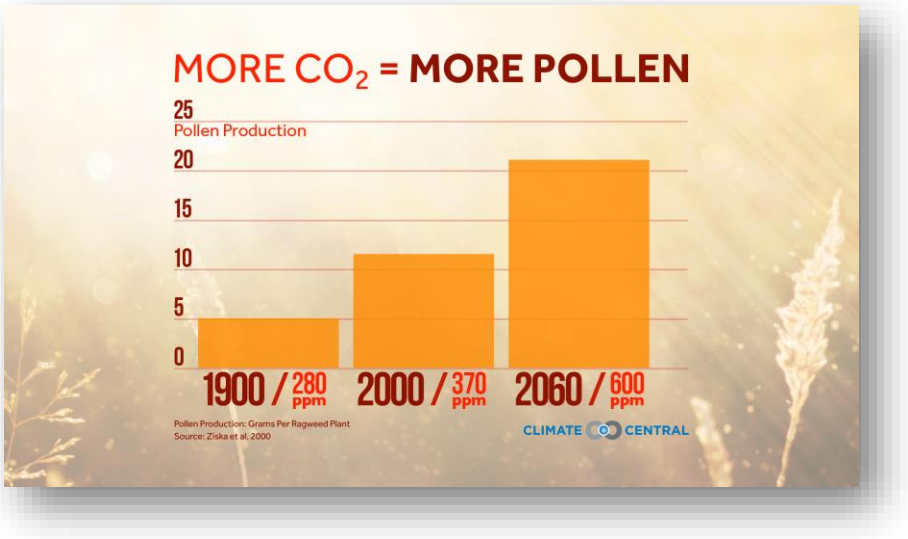
[58] USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. Chapter 13 Air Quality

[59] Rudolph, L., Harrison, C., Buckley, L. & North, S. (2018). Climate Change, Health, and Equity: A Guide for Local Health Departments. Oakland, CA and Washington D.C., Public Health Institute and American Public Health Association. Chapter 13.

Finally, an additional concern for air quality challenges, particularly for North Plymouth, is natural gas leaks through an underground gas pipelines network. Leaked natural gas is mostly methane, which is one of the most powerful greenhouse gases in trapping sunlight and contributing to global warming and climate change. Most gas leaks are relatively harmless to public health. Utilities are required by law to inspect their lines for safety and repair problems within a specified time frame and are immediately responsive to major leaks. However, outdoor methane can contribute

to ground ozone aggravating asthma and other respiratory conditions. More serious concerns with gas leaks is explosions, extensive damage, injury, and loss of life. These have occurred in recent years in Dorchester, Springfield, Winthrop, Gloucester, Hyde Park, and Merrimac Valley. Gas leaks also suffocate trees by replacing life supporting oxygen in the soil with methane. Trees offer tremendous climate resilience benefits and ecosystem services (See 4.2.1 Parks and Forests), hence gas leaks reduce the resiliency of the community. In 2018, there were 21 active gas leaks and 20 repaired gas leaks (Figure 22). These are congregated in North Plymouth, an area already vulnerable to climate impacts such as air toxicity, urban heat island, low tree canopy cover, lower income and greater diversity.

Figure 23 Historic and projected pollen concentrations in the United States. Greater concentrations of carbon dioxide increase the productivity of plants and combined with a longer growing season, create longer and more virile allergens.



Allergies, caused by airborne allergens like pollen and mold, are becoming more prevalent across the United States with an approximate 20% increase in individuals with allergies from 1970-2000. Global warming is extending growing seasons and combined with an increase of carbon dioxide in the atmosphere, plants are more productive increasing the virility of pollen production creating susceptibility and scientists project nearly double the concentration of pollen concentrations by mid-century (Figure 23). Allergens are now more present earlier in the spring

and later in the fall. Boston's growing season has increased by 14.3 days since with spring arriving 4 days earlier since 1981.[60]

4.1.1.4 Vector-Born Disease Exposure

Vector-borne illnesses are those that stem from contact with moving, living, biological sources 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). As climate change is expected to bring heavy precipitation events (which increase areas of standing water) and warmer temperatures, it is expected that mosquito populations will grow, and that the transmission season will extend beyond its traditional late spring through early fall. Warmer temperatures also accelerate a mosquito's lifecycle and increase their biting rates. EEE is already a significant concern to Plymouth residents as expressed through focus group and public forum engagement and one area of vulnerability that was a significant priority.

In late summer of 2019, Massachusetts experienced an outbreak of EEE where 12 individuals were diagnosed, and three individuals died. There were 35 communities at critical risk and 53 and 121 communities at high and moderate risk respectively (Massachusetts conducts regular mosquito control with ground spraying to limit mosquito populations. During periods of increased human risk to EEE, the State performs aerial spraying using Anvil 10+10. This pesticide is determined by the federal Environmental Protection Agency to be generally safe to drinking water, wildlife, and humans when applied properly. The pesticide is harmful to land- and water-based invertebrates and fish. In addition, in 2019, many evening outdoor events such as sports and festivals were cancelled to limit exposure to mosquitos. Many Plymouth residents expressed serious concerns about the health of their families and would not permit their children to play outdoors.

Figure 24). Plymouth had a moderate risk of the disease. EEE was also found in eight horses and one goat.[61] EEE causes brain swelling fever, and coma. Though rare, it is potentially fatal to approximately one-third of individuals who contract it or causes severe neurological disabilities. Individuals over the age of 50 and under 16 are the ones at greatest risk of developing severe symptoms. [62] The virus spreads through an infected mosquito, ones that are found in and around freshwater and hardwood swamps. Outbreaks typically occur every 10-20 years and last about two to three years.[63] Massachusetts is particularly vulnerable due to the large expanse and number of wetlands, including red maple and white cedar swamps, especially in Plymouth County.[64]

There are red maple and white cedar swamps in a very high concentration in Plymouth County, the reason for the significant EEE outbreaks here.

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[60] Climate Central. https://www.climatecentral.org/

[61] Massachusetts Department of Public Health.

[62] http://www.vdci.net/vector-borne-diseases/eastern-equine-encephalitis-virus-education-and-integrated-mosquito-management-to-protect-public-health

[63] Massachusetts Department of Public Health

[64] Dr. Catherine Brown, MA State Epidemiologist, August 2019.

Massachusetts conducts regular mosquito control with ground spraying to limit mosquito populations. During periods of increased human risk to EEE, the State performs aerial spraying using Anvil 10+10. This pesticide is determined by the federal Environmental Protection Agency to be generally safe to drinking water, wildlife, and humans when applied properly. The pesticide is harmful to land- and water-based invertebrates and fish. In addition, in 2019, many evening outdoor events such as sports and festivals were cancelled to limit exposure to mosquitos. Many Plymouth residents expressed serious concerns about the health of their families and would not permit their children to play outdoors.

Figure 24 EEE risk as of August 19, 2019 across Massachusetts.

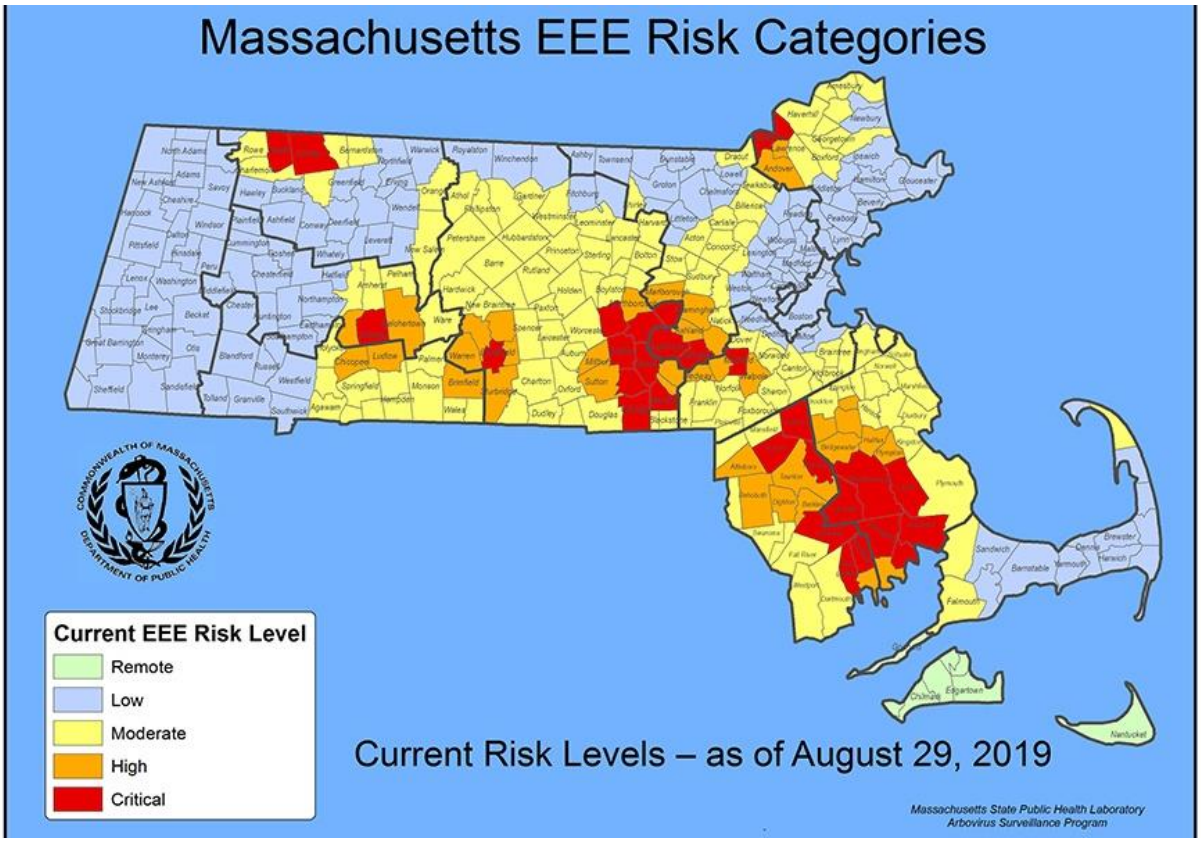
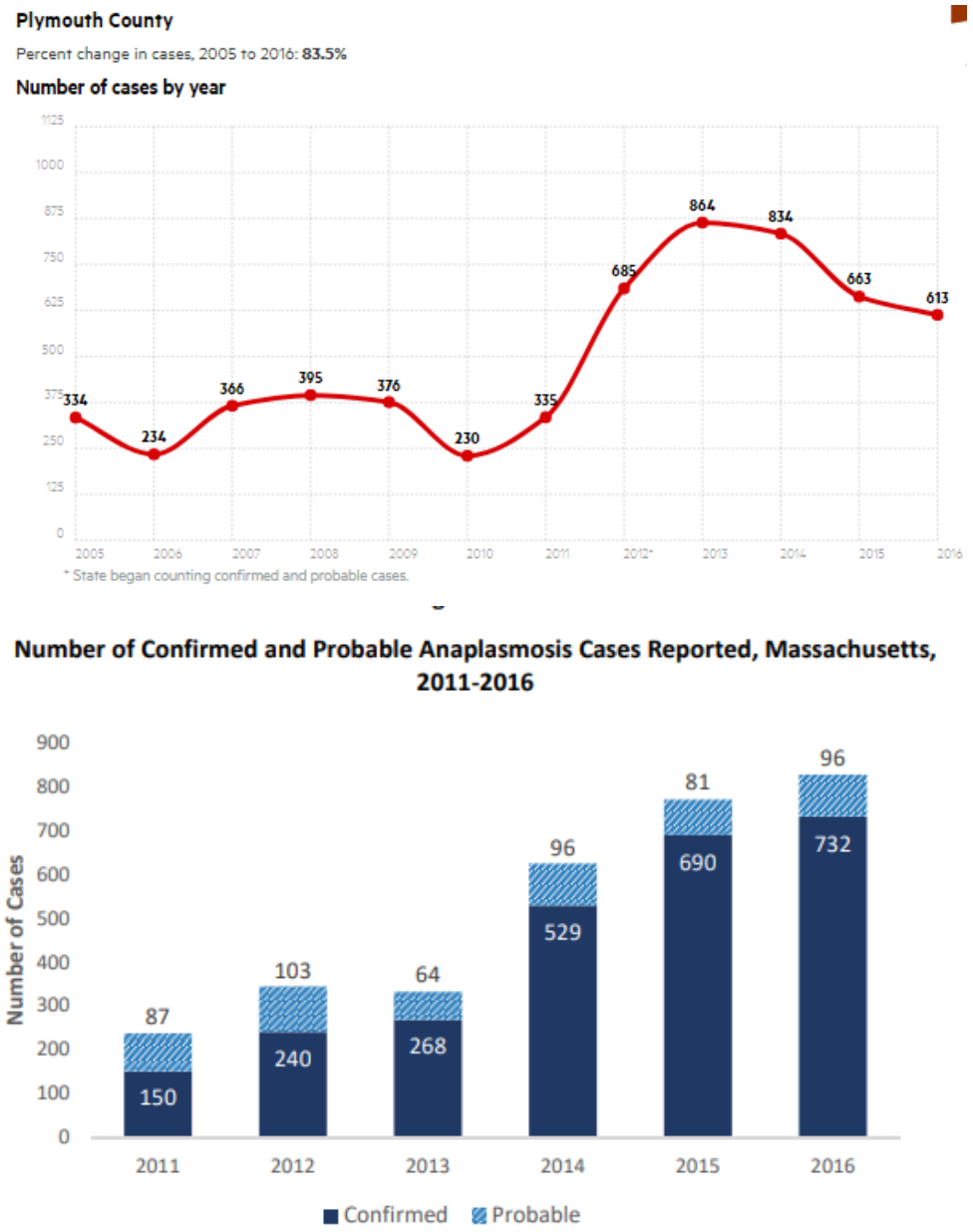


Figure 25 Change in Lyme disease infections 2005-2012 and increasing occurrence of the rare Anaplasmosis cases reported in MA, 2011-2016.



Massachusetts counties with the highest anaplasmosis incidence include the counties of Barnstable, Berkshire, Dukes, Nantucket, and Plymouth.

Source: WBUR "Map: Where Lyme Disease is Worsening in MA."
http://www.wbur.org/commonhealth/2017/07/18/massachusetts-map-lyme-disease;

Tick-borne illnesses, particularly Lyme disease, babesiosis, and anaplasmosis have been on the rise in Massachusetts. From 1991-2014, there has been an average increase of 59 cases of Lyme disease per 100,000 people and from 2005-2012 there was an 83% increase in infections in

Plymouth County.[65] Anaplasmosis cases have increased by 29%, and Plymouth county is one with some of the greatest incidences of this disease (Figure 25).[66] 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-borne disease outbreaks occur globally, residents may import vector-borne illnesses acquired during trips to other countries.

Individuals who spend a lot of time outdoors or live close to vector habitat 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 contact 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.

[65] *Source: WBUR "Map: Where Lyme Disease is Worsening in MA."* *http://www.wbur.org/commonhealth/2017/07/18/massachusetts-map-lyme-disease;*

[66] MA Department of Public Health. 2017. Massachusetts State Health Assessment

4.2 Parks and Natural Areas

Over 40 years of research has indicated the health benefits of parks, open space, and natural areas to communities. These range from active living, to reduced chronic disease (i.e., diabetes, cardiovascular, and respiratory diseases), reduced environmental exposure, mental well-being, greater cognitive function, increased recovery from stress and trauma, reduced crime, greater social cohesion, and increased safety from transportation hazards.[67] Neighborhoods that have been marginalized by disinvestment often have lower access to quality parks and further enhance the health disparities to those already challenged with limited incomes, limited language skills, chronic medical conditions, exclusion and discrimination, or exposure to toxics and climate risks.[68] This section explores the health benefits of natural systems to the community of Plymouth, its vulnerability to climate change stressors and the impact on public health as a result.

4.2.1 Parks and Forests

Parks and natural areas are key components of protecting people, neighborhoods, and infrastructure from the impacts of climate change. "*Nature-based Solutions*" is defined by the International Union of Concerned Scientists (IUCN) as "actions to protect, sustainably manage, and restore *natural* or modified ecosystems, simultaneously providing human well-being and biodiversity benefits."[69] Natural systems lessen climate impacts by absorbing and storing carbon dioxide and by serving vital protective functions. Forests, open space, wetlands, rivers, and streams protect drinking water quality and quantity, provide flood control, and give relief from extreme heat. Healthy ecosystems are more resistant to stresses from a changing climate and better able to protect against heat and flooding. It also achieves multiple benefits of beautification, improvement of air quality and water quality, and community cohesion. Examples of nature-based solutions include green infrastructure as well as protected land/open space, restoring natural areas to improve ecosystem function (forest management, wetland restoration, stream buffers, riverbank stabilization), and reducing and/or greening impervious surfaces.

Nearly 30% of the land area in Plymouth is protected land. Additionally, 86% of residents are within a 10-minute walk of a park, over 30% greater than the national average of 54%. Additionally, parks are equally distributed across income, age, and race (Figure 26). Overall, this data illustrates that park distribution and equity is strong in Plymouth. Parks, open spaces, and natural areas are beloved by residents of Plymouth where every focus group and public forum indicated that what is most important to protect in Plymouth is its natural areas, not only from development but also from climate impacts such as drought, wildfire, and flooding. Many of Plymouth's parks are at risk to climate hazards such as SLR 2050, a 1% or 0.2% Annual Chance Flood, Urban Heat Island or Wildfire (due to historic occurrence). However, these parks at risk are also uniquely located to both withstand or mitigate the impacts to nearby neighborhoods, infrastructure, and amenities with climate change.

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[67] "Green Cities: Good Health" 2018. University of Washington https://depts.washington.edu/hhwb/

[68] Viniece Jennings, Ph.D., Na'Taki Osborne Jelks, Ph.D., MPH, and James Dills, MUP, MPH. 2018. "Parks and Health Equity: An Avenue to Support Health and Wellness for All"

[69] https://www.iucn.org/theme/ecosystem-management/our-work/a-global-standard-nature-based-solutions

Figure 26 ParkServe© park equity analysis for the Town of Plymouth. www.tpl.org/parkserve.

Of the approximate 151 parks in Plymouth, 13 are located in SLR 2050, five are in a 1% or 0.2% Annual Chance Flood, 19 contain urban heat islands >98°, and 36 have experienced wildfire historically (Figure 40). These are listed in Table 11. These parks though exposed are also opportunities to implement nature-based climate resilient solutions to protect ecosystem function, infrastructure, neighborhoods, and businesses.

Table 11 Town of Plymouth's Parks and exposure to climate change hazards. These parks are also opportunities to implement nature-based climate resilient strategies to protect ecosystem function, infrastructure, neighborhoods, and economy. UHI is Urban Heat Island defined by areas that were greater than 98° on a 90° day at Logan Airport in July 2016. "" denotes pockets only of UHI exist in the park but not widespread urban heat.*

Park Name	Owner	SLR2050	FEMA Flood Zone	UHI	Historic Fire Year
Unknown Park Name	Town of Plymouth				
Atlantic Country Club	Sandy Bridge Inc				
Bartlett Pond	Town of Plymouth				
Beaver Dam Pond CR	PACOR Inc				
Benjamin S Harrison Memorial Preserve	Wildlands Trust				
Billington Sea WCE	Town of Plymouth				
Billington St/Town Brook	Town of Plymouth				
Billington Street Water Supply Land	Town of Plymouth				
Bloody Pond Conservation Area	Town of Plymouth				
Boot Pond Conservation Area	Town of Plymouth				May-57
Braley and Caswell Cemetery	Town of Plymouth				
Brewster Gardens Park	Town of Plymouth	Yes		Yes	
Briggs Playground	Town of Plymouth				
Brookfield	Town of Plymouth				
Burial Hill	Town of Plymouth			Yes	
Camp Bournedale	Gerson-Bournedale Trust				
Camp Cachelot WCE	Boy Scouts of America				1963-1966
Camp Clark	YMCA				
Camp Norse	Annawon-Council Inc. BSA				
Camp Squanto	Boy Scouts of America				1963-1966
Camp Wind in The Pines	Girl Scouts of America				
Campgrounds	Carreau Family LT				
Carolyn Drive Conservation Area	Town of Plymouth				
Cedarville Conservation Area	Town of Plymouth				1991-1995
Cedarville Landing	Town of Plymouth	Yes			
Center Hill I CR West	Town of Plymouth				

Park Name	Owner	SLR2050	FEMA Flood Zone	UHI	Historic Fire Year
Center Hill II CR East	Joslin Diabetes Foundation Inc	Yes			
Cleft Rock Park	Town of Plymouth				May-57
Cold Spring School	Town of Plymouth				
Conservation Area	Wildlands Trust				
Cooks Pond WMA	Department of Fish and Game				May-57
Domero Cortelli Preserve	Wildlands Trust				May-57
Dugway Pond Conservation Area	Town of Plymouth				1991-1995
Eel River Headwaters	Town of Plymouth				May-57
Eel River Headwaters Conservation Area	Town of Plymouth				May-57
Eel River Preserve	Wildlands Trust				May-57
Ellisville Harbor State Park	DCR -	Yes			
Emerson Field	Entergy Nuclear Generation Company				
Emery Preserve East	Wildlands Trust				1991-1995
Emery Preserve East	Wildlands Trust				
Emery Preserve West	Wildlands Trust				
Federal Furnace Elem. School	Town of Plymouth				
Finney's Meadow Conservation Area	Town of Plymouth				May-57
Forges Field	Town of Plymouth			Yes	May-57
Fresh Pond Park	Town of Plymouth				
Fresh Pond Park	Town of Plymouth				
Great Herring Pond Conservation Area	Orenda Wildlife Land Trust				
Halfway Pond Conservation Area	Wildlands Trust				1970-1977
Halfway Pond Island	The Nature Conservancy		A		
Halfway Pond WCE	ADM Maple Springs II LLC				
Halfway Pond WCE	ADM Maple Springs II LLC				
Halfway Pond WMA	Department of Fish and Game				
Haskell Field	Town of Plymouth				
Hedge Elementary School	Town of Plymouth				
Hedges Pond Recreation Area and Preserve	Town of Plymouth				
Herries Preserve CR	Town of Plymouth				May-57
Herring Pond Lands Conservation Area	Town of Plymouth				
Holmes Bog Conservation Area	Town of Plymouth				May-57
Holmes Field	The Trustees of Reservations	Yes		Yes	
Hoyts Pond CR	Town of Plymouth				May-57

Park Name	Owner	SLR2050	FEMA Flood Zone	UHI	Historic Fire Year
Indian Brook Conservation Area	Town of Plymouth				
Indian Brook Elem. School	Town of Plymouth				
Jenney Pond Park	Town of Plymouth				
Joe Brown House	Wildlands Trust				
John A Armstrong Memorial Skating Rink	DCR - Division of State Parks and Recreation			Yes	May-57
Keese Bog	Keese Kristine R				
Little Herring Pond Conservation Area	Town of Plymouth				
Little Sandy Pond Road Conservation Area	Town of Plymouth				
Manomet Beach Conservation Area	Town of Plymouth	Yes			
Manomet Bird Observatory	Manomet Bird Observation Trust	Yes			
Manomet Elementary School Playground	Town of Plymouth			Yes	
Manternach Preserve	Wildlands Trust				
Maple Springs WMA	Department of Fish and Game				1963-1966
Massasoit National National Wildlife Refuge	United States Department of the Interior				May-57
Mast Road Conservation Area	Wildlands Trust				
Mayflower Park Preserve	Wildlands Trust				
Morton Park	Town of Plymouth				
Mt. Pleasant School	Town of Plymouth			Yes	
Murdocks Pond	Town of Plymouth				
Myles Standish State Forest	Town of Plymouth				May-57
Myles Standish State Forest*	DCR			*Yes	1957, 1963-1966, and 1970-1977
Myles Standish State Forest	Town of Plymouth				1957, 1970-1977, and 1963-1966
Nelson Memorial Park	Town of Plymouth	Yes	Yes		
Old Field Pond Preserve	Wildlands Trust				
Old Sandwich Golf Club	Pine Hills LLC				May-57
Old Sandwich Road Conservation Area	Town of Plymouth				1991-1995
Parting Ways Cemetery	Town of Plymouth				
Pickerel Pond Preserve	Wildlands Trust				
Pilgrim Memorial State Park	DCR - Division of State Parks and Recreation				
Pine Hill I CR	Pinehills LLC				

Park Name	Owner	SLR2050	FEMA Flood Zone	UHI	Historic Fire Year
Pine Hills Golf Club	Pine Hills Golf Club LLC				May-57
Pine Hills II CR	Pinehills LLC				
Pinewood Lodge Campground	PINEWOOD LODGE				
Pinewoods Camp	PINEWOODS CAMPS INC				
Plimoth Plantation	PLIMOTH PLANTATION INC	Yes	AE	Yes	
Plymouth Airport CR	Town of Plymouth			Yes	
Plymouth Country Club	PLYMOUTH COUNTRY CLUB INC				
Plymouth County Farm CR	COUNTY OF PLYMOUTH			Yes	
Plymouth Fire Tower	DIGITAL EQUIPMENT CORPORATION				May-57
Plymouth Grassy Pond WCR	Pond Parker F. Jr.				
Plymouth Grassy Pond WCR	Warren Ethan				
Plymouth Grassy Pond WMA	Department of Fish and Game				
Plymouth Long Beach	Town of Plymouth	Yes	VE	Yes	
Plymouth Pine Hill WCE	Town of Plymouth				
Plymouth Pinelands	The Nature Conservancy				May-57
Plymouth Rod and Gun Club	PLYMOUTH ROD AND GUN CLUB INC			Yes	
Plymouth South High School Athletic Fields	Town of Plymouth			Yes	May-57
Plymouth Town Forest WCE	Town of Plymouth			*Yes	
Plymouth Water Supply Land	Town of Plymouth				1991-1995
Plymouth Woolen and Cotton Factory Pond Conservation Area	Town of Plymouth				May-57
Plymouth-Carver Hs	Town of Plymouth			Yes	
Raymond Playground	Town of Plymouth				
Red Brook Conservation Area	The Trustees of Reservations	Yes			
Red Brook WMA	Department of Fish and Game				
Reid Pond Preserve	Wildlands Trust				
Richard F Wynn Preserve	Wildlands Trust				1991-1995
Rocky Pond Conservation Area	Town of Plymouth				
Rocky Pond Road Conservation Area	Town of Plymouth				
Russell Mill Pond Conservation Area	Town of Plymouth				May-57
Russell Mills Road	RUSSELL MILLS ROAD RT				May-57
Russell Mills Road CR	Russell Mills Road Realty Trust				May-57
Russell Sawmill Conservation Area	Town of Plymouth				May-57
Russells Mills Pond Conservation Area	Town of Plymouth				May-57
Sacrifice Rock Preserve	Wildlands Trust				

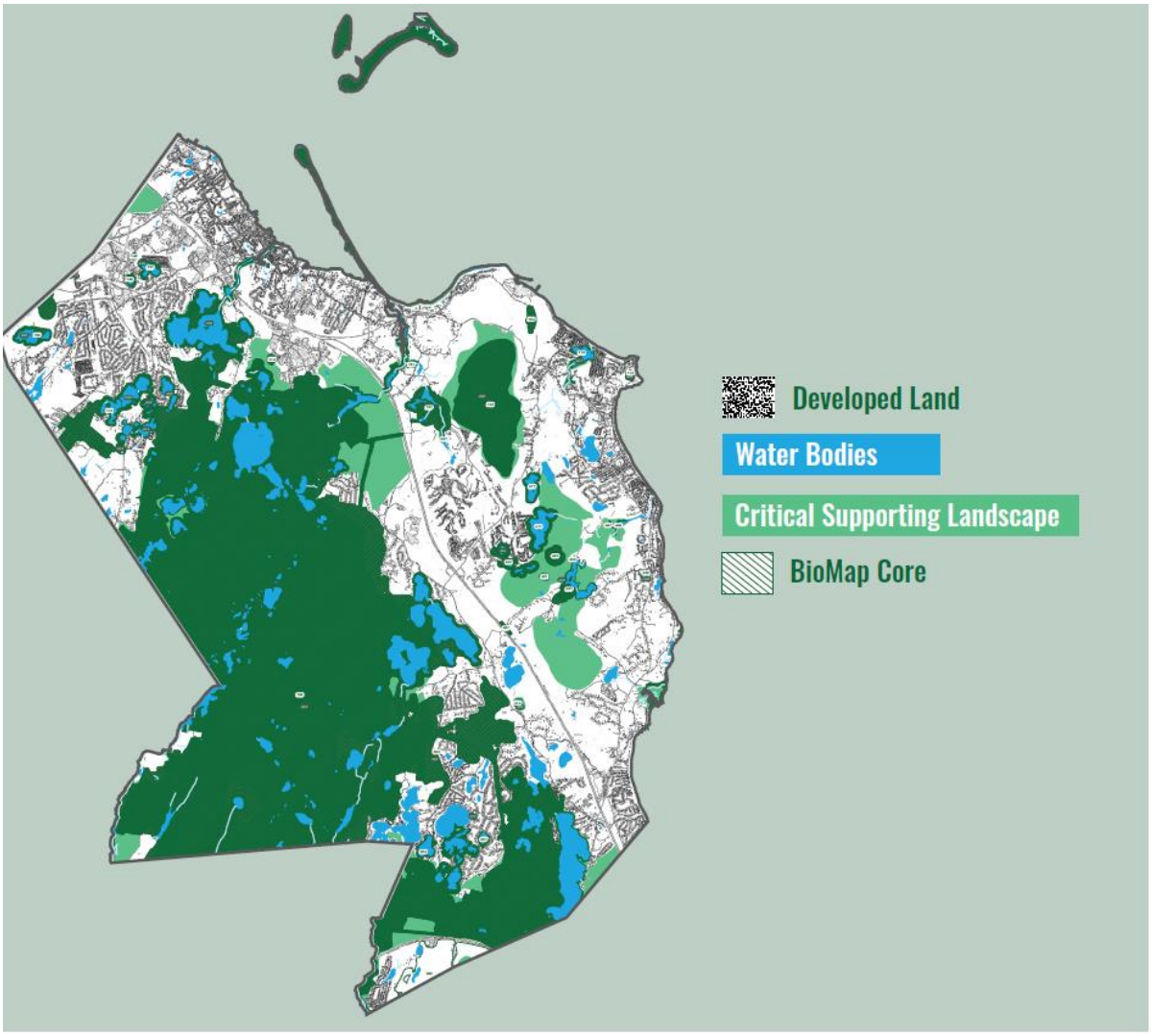
Park Name	Owner	SLR2050	FEMA Flood Zone	UHI	Historic Fire Year
SE Pine Barrens WMA	Department of Fish and Game				
Shallow Pond	Town of Plymouth				
Shifting Lots Preserve	Wildlands Trust	Yes			
Siever Field	Town of Plymouth				
Six Ponds East Preserve	Wildlands Trust				1991-1995
Sly Pond WMA	Department of Fish and Game				
Sol Joseph Road Conservation Area	Town of Plymouth				
South Elem. School	Town of Plymouth				
South Triangle Pond WCE	Wildlands Trust				May-57
South Triangle Pond WMA	Department of Fish and Game				May-57
Southers Marsh Golf Club	Stearns III William B				
Stephens Field	Town of Plymouth	Yes		Yes	
Talcott Conservation Area	Town of Plymouth				1991-1995
Talcott CR	Town of Plymouth				
Taylor Ave. Wetlands	Town of Plymouth				
Thrasherville Preserve	Wildlands Trust				1991-1995
Tidmarsh Farm Conservation Area	Town of Plymouth			Yes	
Tidmarsh Farms Bog	Tidmarsh Farms Inc		A		
Town Brook Park	Town of Plymouth				
Town Forest	Town of Plymouth				May-57
Wannos Pond Water Supply Land	Town of Plymouth				
Watercourse Place Conservation Area	Town of Plymouth				
Waverly Oaks Golf Club	Long Pond Golf Corporation				May-57
West Elem. School	Town of Plymouth			Yes	
West Russell Mills Road Conservation Area	Town of Plymouth				May-57
Whipple APR	Wildlands Trust				May-57
Whipple Farm	Sherman L Whipple Revocable Trust				May-57

Biomap Core Habitat and Critical Natural Landscapes are state-identified intact landscapes, or exemplary natural communities, that are better able to withstand climate stresses and support the long-term viability of biodiversity and ecosystem services. Plymouth contains 30,785 acres of BioMap Core Habitat and 30,839 acres of Critical Natural Landscape, each of which is nearly 50% protected (Figure 27).[70]

[70] http://maps.massgis.state.ma.us/dfg/biomap/pdf/town_core/Plymouth.pdf

In addition to its extensive parks and open space system, Plymouth also has over 54% of its land area covered in tree canopy. These provide important ecological services such as cooling from shade and evapotranspiration, capturing greenhouse gases to reduce emissions contributing to climate change, avoiding stormwater, reducing pollutant loads in stormwater, and improving air quality (Table 12). Plymouth is a Designated Tree City for the 27 years containing a Tree Board or Department, Tree Care Bylaw, and a Community Forestry Program with an annual budget of a least $2 per capita. In addition, Plymouth has a Town Shade Tree Bylaw, established in 2006, contains an inventory of its over 3,000 public trees and routinely cares and manages the Town's trees, some of which are over 300 years old.[71]

Figure 27 BioMap Core Habitat and Critical Supporting Landscape in Plymouth. These areas represent exemplary natural systems that support wildlife habitat and ecosystem function. They are also better able to withstand the impacts of climate change.



[71] Town of Plymouth 2017 Open Space and Recreation Plan.

Table 12 iTree Landscape tree benefit analysis for Plymouth quantifying and monetizing the value of the tree canopy's ecological services and public health benefits to the Town.

Tree Benefit	Amount	Value
Carbon Storage	1,655,600 short ton/yr.	$282,363,912
Carbon Sequestration	22,147 ton/yr.	$3,777,176/yr.
CO2 Equivalent Storage	6,070,536 short ton/yr.	$282,363,912
Co2 Equivalent Sequestration	81,205	$3,777.176/yr.
Total Air Pollution Removal	2,684,546 lbs./yr.	$2,435,078/yr.
Health incidence	433	
Emergency Room Visits	0.02	
Hospital Admissions	0.32	
Acute Respiratory Symptoms	259.36	
Asthma Exacerbation	101.22	
Mortality	0.2	
School Loss Days	60.39	
Cardiovascular and Respiratory Hospital Admissions	0	
Work Loss Days	9.07	
Transpiration	3236.1 MG/yr.	
Rainfall Interception	3,246 MG/yr.	
Avoided Runoff	197.6 MG/yr.	$1,765,472/yr.

*Heath incidence data is yearly averages of avoided cases. The per year average is based upon per county values derived from the Environmental Benefits Mappy and Analysis Program (BenMAP). In some areas, trees increase PM 2.5 concentration which may cause respiratory issues. Those locations may display a negative benefit value.

Much of Plymouth's tree canopy is dominated white pine, pitch pine, red oak, and scrub oak as well as a rare temperate coniferous forest ecoregion, Atlantic Coastal Pine Barrens forest. The Pine Barrens are defined by unique topographical features such as coastal ponds, frost pockets, nutrient-poor and acidic soils, and forest-fire natural disturbance regimes. Plymouth contains one of the largest assemblages across the globe. This forest also includes huckleberry, bracken fern, and bear berry in the understory and is characterized as a fire-dependent forest-type that fosters germination of the pitch pine serotinous cones (though not required). Most of the pine barren forest is protected within the 12,500-acre Myles Standish State Forest. An additional 4,000 acres is protected by the Town and Wildlands Trust.

Because of the serotinous cones and resin-rich needles, the pine barren forest is also very vulnerable to large-scale forest fire disturbance. Indeed, the Town of Plymouth experienced two extreme and large-scale fires. The most severe was in 1958 where 62 communities sent 2,500 volunteers to fight 40-50-foot wall of flames that ultimately burned 15,000 acres, spanning Carver to the Plymouth waterfront (Figure 40). The fire in 1964 consumed 500 acres and 24

structures. [72] With increasing temperatures and changing precipitation regimes, drought could increase the probability of wildfire in Plymouth and damage from a forest fires would likely be more severe due to the extensive and widespread development the Town has experienced over the last half-century. However, prescribed burns are a regular practice at Myles Standish State Park which minimizes the flammability and risk to the community if a fire were to ignite in the forest. Public health risks to wildlife include displacement, financial hardships due to loss of property, stress, anxiety, post-traumatic stress, exposure to fire, debris, or toxics related to the wildfire and exposure to particulate matter (PM) from smoke inhalation. Acute exposure to PM causes wheezing, coughing, sore eyes and throats, and shortness of breath. Prolonged exposure creates more severe health conditions such as asthma-related hospitalizations, chronic and acute respiratory and cardiovascular conditions, and premature death.[73]

Table 13 Tree species adaptive capacity to climate change.

Southern New England Forest

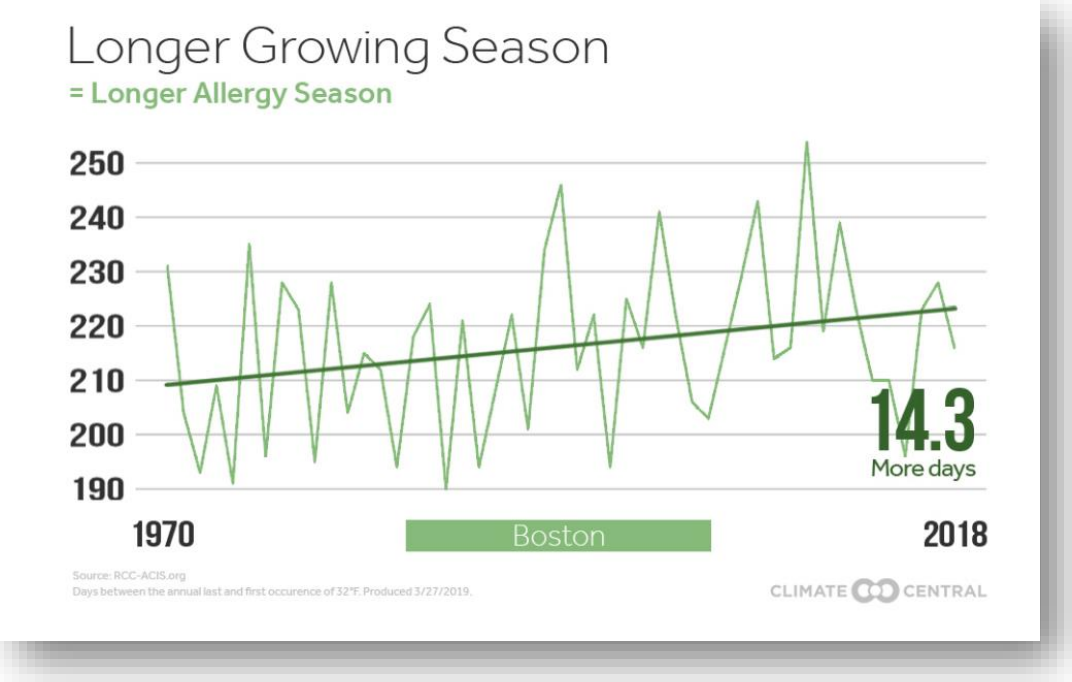
Tree Species	Low Emissions Scenario	High Emissions Scenario
Balsam Fir	--	--
Black Spruce	--	--
Eastern White Pine	--	--
Northern White Cedar	--	--
Paper Birch	--	--
Quaking Aspen	--	--
Red Spruce	--	--
White Spruce	--	--
Tamarack	--	•
American Beech	•	--
Red Maple	•	--
Northern Red Oak	•	--
Bear/Scrub 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	•	•

[72] https://www.massmoments.org/moment-details/fire-rages-at-myles-standish-state-forest.html
[73] http://usclimateandhealthalliance.org/wildfires-public-health-view-front-lines/

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.

Changing climatic conditions will also affect the health of the Pine Barrens and other tree species in Plymouth. Though forest fires enhance regeneration of the Pine Barrens, stress-induced forests are more susceptible to pests and diseases, project to shift in species and abundance with climate change. Non-native species may also benefit from forest disturbance and increasing temperatures with climate change, shifting the composition of this valuable forest. However, the Pine Barren Forest is highly tolerant to extreme heat and drought, making this forest type highly adaptive to climate change. [74] Trees adaptive capacity to climate change is listed in Table 13 which includes other tree types found in Plymouth.

Figure 28 Global warming has caused an increased growing season by 14.3 days since 1970. This translates into greater and longer exposure to pollen and allergies.



Warming temperatures and carbon dioxide are projected to increase productivity of forests and other natural systems. A 2° increase in global temperatures and Massachusetts temperatures has

[74] Wisconsin Department of Natural Resources.
https://www.wicci.wisc.edu/resources/BA_Pine_Barrens_CCVA.pdf

increased our growing season in the Boston area by 14.3 days since 1970. [75] With less freezing temperatures, plants have more time to grow, flower, and produce pollen. In addition, one study on pollen exposure in the United State indicated that plants were producing 42% more pollen in 2000-2010 than the previous decade and that plants were releasing pollen three days earlier. Shifting species and reproductive tree cycles are likely to increase allergy occurrence with climate change. Indeed, in the US, allergies have already increased by 20% between 1970 and 2000.[76]

4.2.2. Coastal Natural Areas

For centuries, Plymouth's coastline has been a prominent resource for its community, from the Wompanoag to its first colonial settlers on the Mayflower and today. Plymouth has 36 miles of coastline with many coastal beaches from Nelson Park in North Plymouth to Ellisville Harbor in South Plymouth. Plymouth Long Beach is a 3-mile barrier beach providing extensive beach recreation access and coastal storm protection to the mainland of Plymouth, Kingston, and Duxbury. Plymouth Harbor at Downtown Plymouth is the center for commercial fishing, shell fishing, and the tourist industry where the historic replica Mayflower is at port.

Warming Oceans

The increasing trend of global warming is affecting ocean surface temperature increasing sea level rise and degrading marine ecosystems. New England oceans have warmed more than 2.5° F since 1901, more than any other coastal area in the U.S. and 40% faster than anticipated.

4.2.2.1 Bays and Ocean

With climate change, an important risk to Plymouth Bay is ocean acidification and warmer temperatures. Oceans capture nearly one-third of our carbon dioxide (CO^2) emissions released into the atmosphere through the burning of fossil fuels. CO_2 forms carbonic acid when dissolved ultimately affecting the typically basic pH levels in the ocean.[77] Future ocean acidification may cause shellfish larvae to create smaller shells or not develop them at all[78] or reduce shellfish reproduction and growth rates.

Increasing ocean temperatures locally can detrimentally affect ecosystem function, causing species migration, potentially introduction of new pathogens, and harmful algal blooms. In the last three decades, sea surface temperatures have been higher on average than over the last century or ever since being recorded.[79] The MA Department of Public Health, in partnership with the Department of Fish and Game and Division of Marine Fisheries (DMF), monitors pathogenic marine micro-organisms related to foodborne illness. There is a reported increase in some naturally

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[75] Climate Central. 2018. POLLEN PROBLEMS: Climate Change, the Growing Season, and America's Allergies.

[76] Climate Central. 2018. POLLEN PROBLEMS: Climate Change, the Growing Season, and America's Allergies.

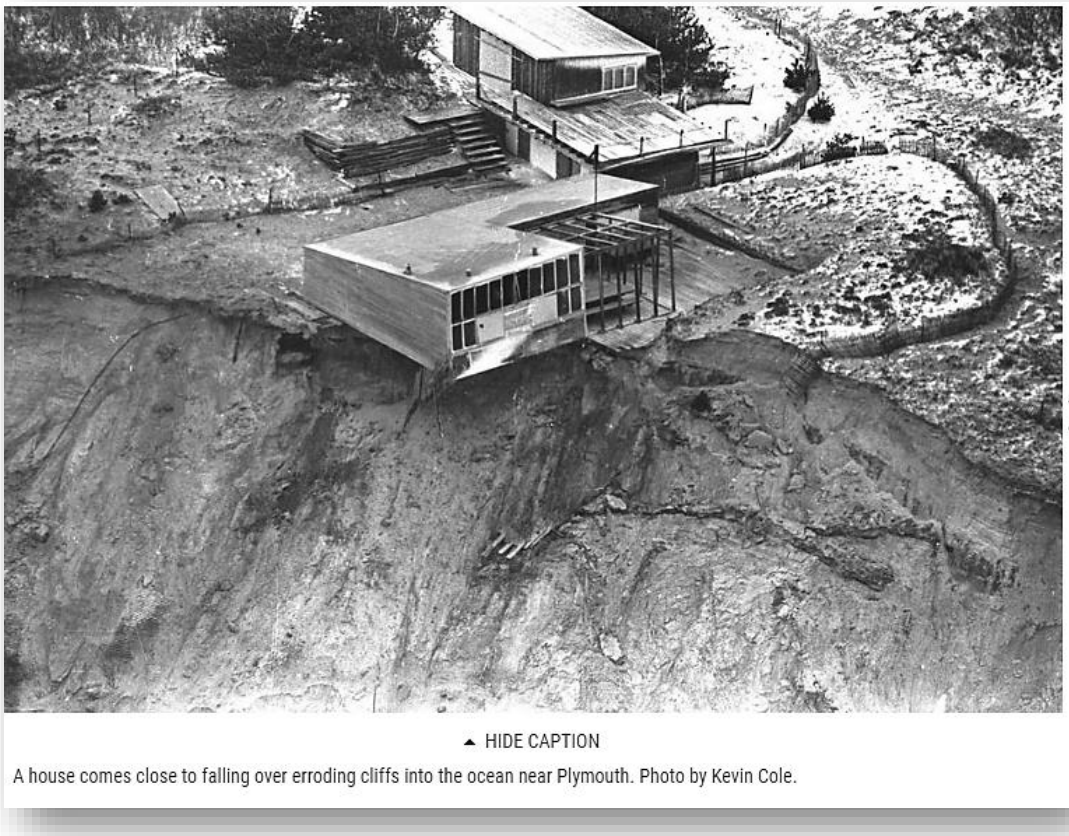
[77] USGCRP, 2017. Climate Science Special Report: Fourth National Climate Assessment, Volume 1[Wuebbles, D.J., D.W. Fahey, K.A Hibbard, D.J. Dokken, B.C. Stewart. And T.K. Maycock (eds.)] U.S. Global Change Research Program, Washington, DC, USA 470 pp doi 10.7930/J0J964J6

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

[79] National Oceanic and Atmospheric Administration. Climate Change Indicators in the United States. 2016 http://www.globalchange.gov/browse/indicators/indicator-sea-surface-temperatures

occurring bacteria found in warm, brackish waters on the Eastern seaboard, such as *Vibrio* spp. [80] and state agencies, local health officials and the shellfish industry carefully monitor for the presence of such organisms. Plymouth Harbor on list for impairments (Table 10). The Town of Plymouth works with the Towns of Kingston and Duxbury collaboratively in reducing pathogens and using Best Management Practices to improve water quality. As a result, Plymouth re-opened its bay for shell fishing in 2014 with over 1,000 acres open for shell fishing. [81]

Figure 29 Blizzard of 1978 coastal storm damage cause severe erosion to Plymouth's coastline.



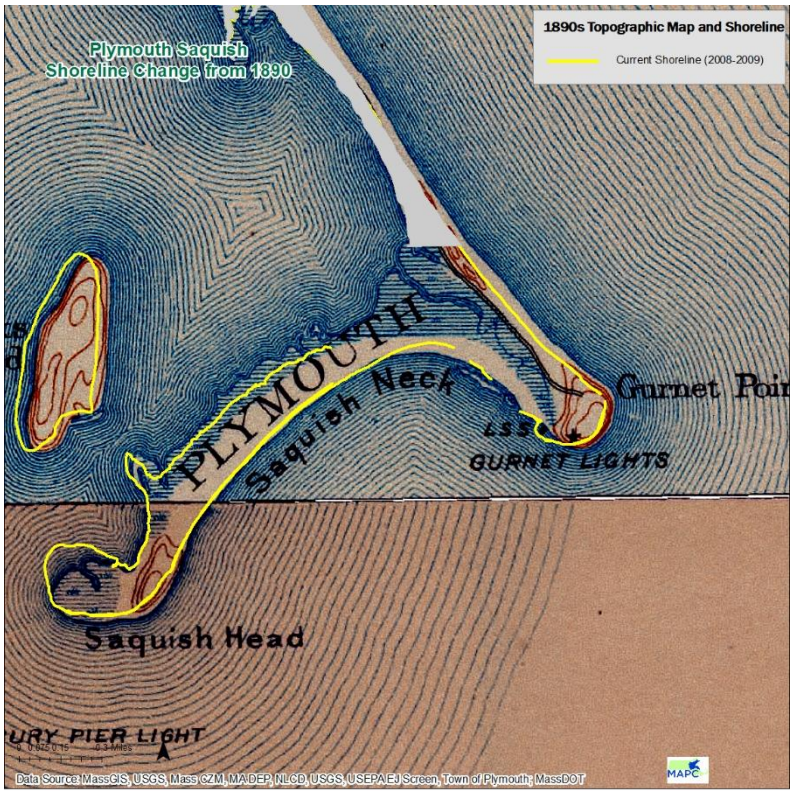
4.2.2.2 Beaches

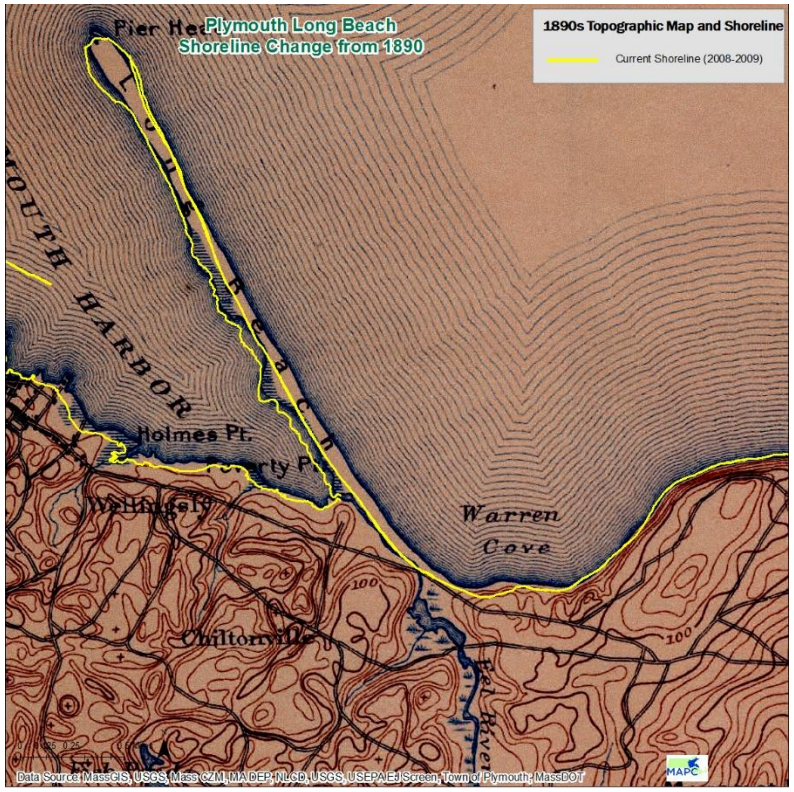
Sea level rise and coastal storms are also having a significant impact on Plymouth's coastline. As mentioned, Boston has experienced over 11 inches of SLR since 1890. The Shoreline Change project sponsored by the MA Office of Coastal Zone Management and performed by Woods Hole Group has sought to understand coastal erosion and accretion processes along the MA coastline and the most erosion-prone areas. The analysis was developed from historical maps, aerial photographs, and LIDAR topographic data an uncertainty level and margin of error due to the source material (i.e., very low-resolution aerial photos, historic maps of the 1800s etc.).

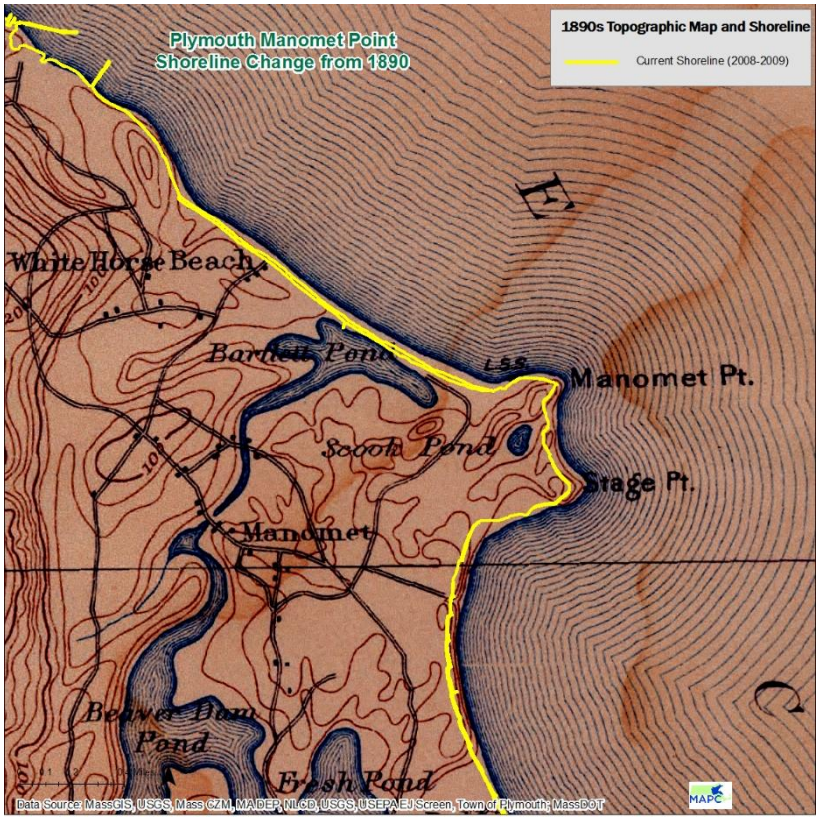
[80] Vezzulli et al. 2016. Climate influence on *Vibrio* and associated human disease during the past half-century in the coastal North Atlantic. PNAS August 23, 2016. 113(34)
[81] Town of Plymouth 2017 Open Space and Recreation Plan

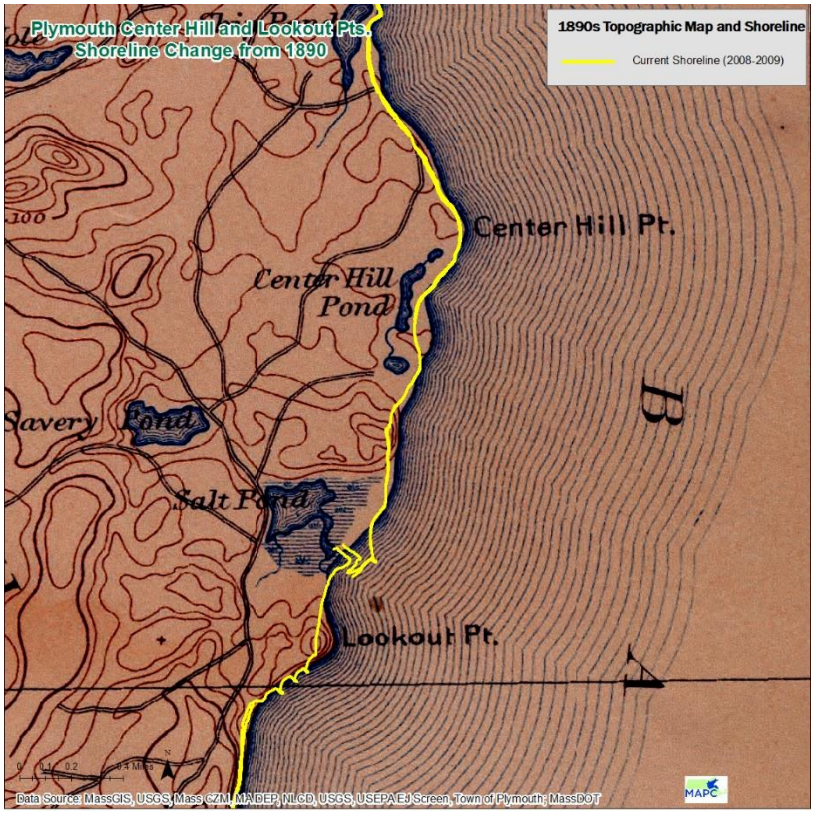
Because most of Plymouth's coastline is sandy, it has a highly dynamic coast susceptible to coastal erosion, further enhanced by the development of hardened shoreline structures which disrupt the natural erosion and accretion processes. However, coastal storms, particularly the Blizzard of 1978 and 2018 Winter Storm Riley, caused severe erosion to some areas of the coast (Figure 29).

Figure 30 Areas in Plymouth with significant shoreline from 1890. Data from Massachusetts Office of Coastal Zone Management Shoreline Change Mapping and Analysis Project.



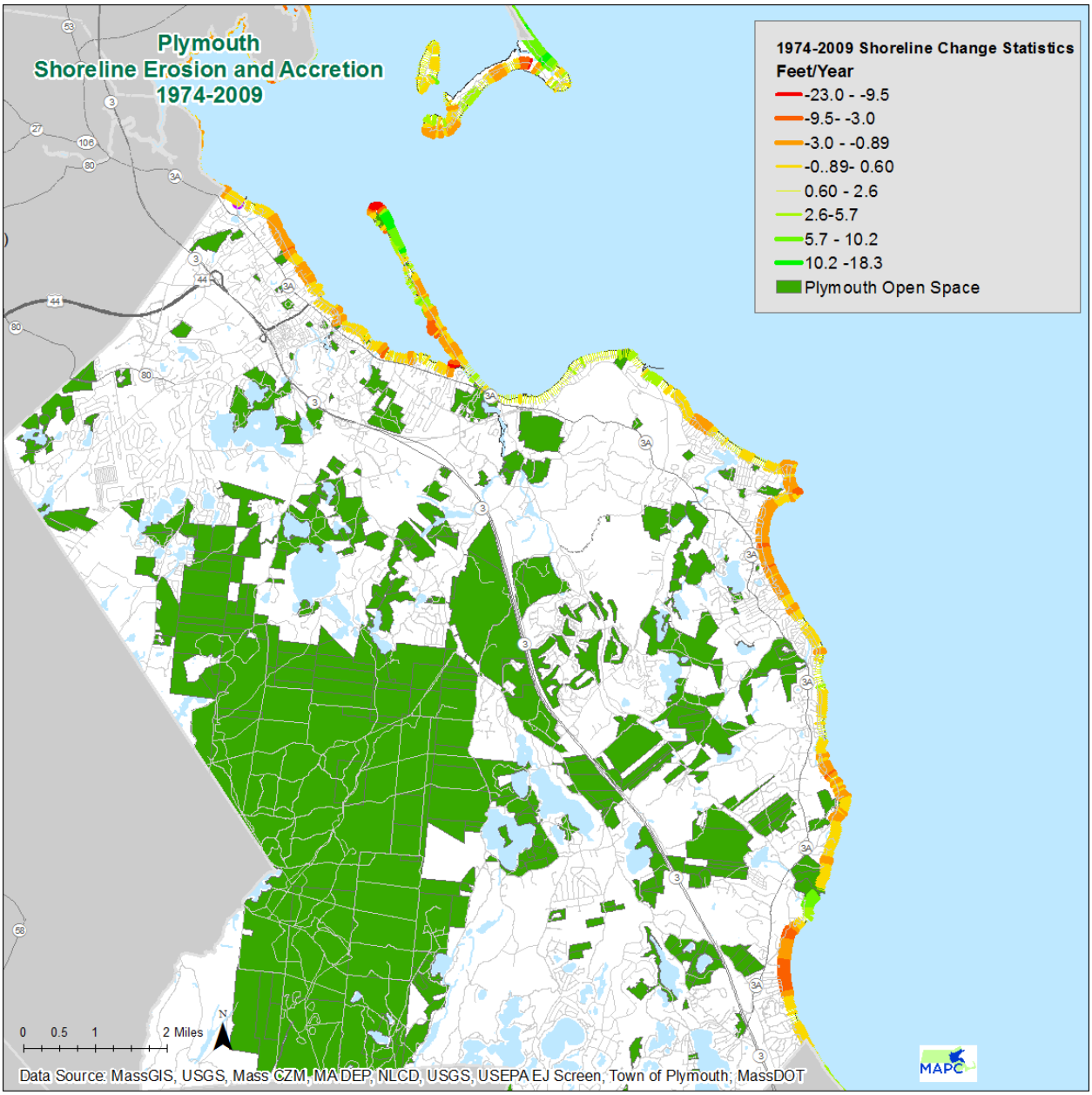



Plymouth Manomet Point
Shoreline Change from 1890
1890s Topographic Map and Shoreline
Current Shoreline (2008-2009)
White Horse Beach
Barnett Pond
Manomet Pt.
Scook Pond
Stage Pt.
Manomet
Beaver Dam
Pond
Fresh Pond
Data Source: MassGIS, USGS, Mass CZM, MADEP, NLCD, USGS, USEPA EJ Screen, Town of Plymouth, MassDOT
MAPC


Plymouth Center Hill and Lookout Pts.
Shoreline Change from 1890
1890s Topographic Map and Shoreline
Current Shoreline (2008-2009)
Center Hill Pt.
Center Hill
Pond
Savery Pond
Salt Pond
Lookout Pt.
Data Source: MassGIS, USGS, Mass CZM, MADEP, NLCD, USGS, USEPA EJ Screen, Town of Plymouth, MassDOT
MAPC

Further, Plymouth Long Beach is barrier beach, a geologic term for long, narrow strips of sand forming islands (or peninsulas) that protect inland areas from ocean wave and storms. They are dynamic land masses subjection to migration from sea level rise and coastal processes causing the

Figure 31 Massachusetts Office of Coastal Zone Management Shoreline Change Mapping and Analysis Project. Using historic maps, aerial photos and LIDAR, the project illustrates MA shifting coastline due to erosion and accretion since the 1800s. Due to the inherent quality of the source data, erosion rates contain a margin of error. However, the most aggressive rate of erosion is often a strong indicator of a major shift in coastal areas.



Coastal Area	Erosion Rate (feet per year)	Margin of Error (feet)
Manomet/Stage Point	-5.47	(+/- 2.75)
Tip of Plymouth Long Beach	-15.6 to -4.36	(+/-21)
Mouth of Eel River	-15.5 to -6.8	(+/- 17.7-6.5)
79 Ellisville Road	-4.36to -3.34	(+/-2.2-1.9)
Plymouth Beach (North)	-7.38 to -3.28	(+/- 25 -1.9)
Holmes Point	-5.08	(+/-37.1
Oak Bluff	-4.33 to -3.31	(+/-2.72-2.82)

landmass to move toward the mainland shoreline.[82] Plymouth Long Beach has experienced significant erosion as well as deposition on the landward side of the peninsula (Figure 30). Manomet/Stage Point experiences the greatest amount of coastal erosion with rates as high as 18 feet a year (±9 feet). Figure 31 illustrates shoreline change rate per year from 1974-2009 for Plymouth's coast.

4.2.2.3 Eelgrass and Marshes

Seagrass meadows such as eelgrass provide important ecological and climate resilience benefits. They capture sediment and take up nutrients ultimately providing better water clarity provide important habitat for fish. Importantly, seagrass meadows will dissipate wave energy and wave height thereby reducing shoreline erosion.[83] Seagrass decline can be attributed to many factors such as pathogens, sea grass is highly vulnerable to environmental stressors as nitrogen loading from stormwater, sewer systems, and fertilizers and warming ocean temperatures.[84] Healthy sea grass beds contribute to the overall water quality in Plymouth and promote healthy commercial fish habitat, both of which provide important industries to the Town through water recreation and fishing. According to the MA Division of Fisheries and Wildlife (DMF), there is evidence of significant decline in the eel grass beds in the Duxbury, Kingston, Plymouth Bay (the DKP), with as much as 71 % loss of eelgrass between 1961 and 2014. Some eelgrass beds in the DKP have disappeared altogether. However, the eelgrass beds in Plymouth Bay specifically has experienced about a 36% loss of seagrass meadows between 2007 and 2016 (Table 14). Eelgrass loss is likely caused by degrading environmental conditions such as reduced water quality from runoff and wastewater exacerbated by an increase in the water temperature overall due to ocean warming.[85]

[82] University of North Carolina Wilmington. Coastal and Barrier Island Ecosystem Factors. https://sites.google.com/site/barrierislandecology2013/coastal-and-barrier-island-ecosystem-factors/barrier-island-migration

[83] 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

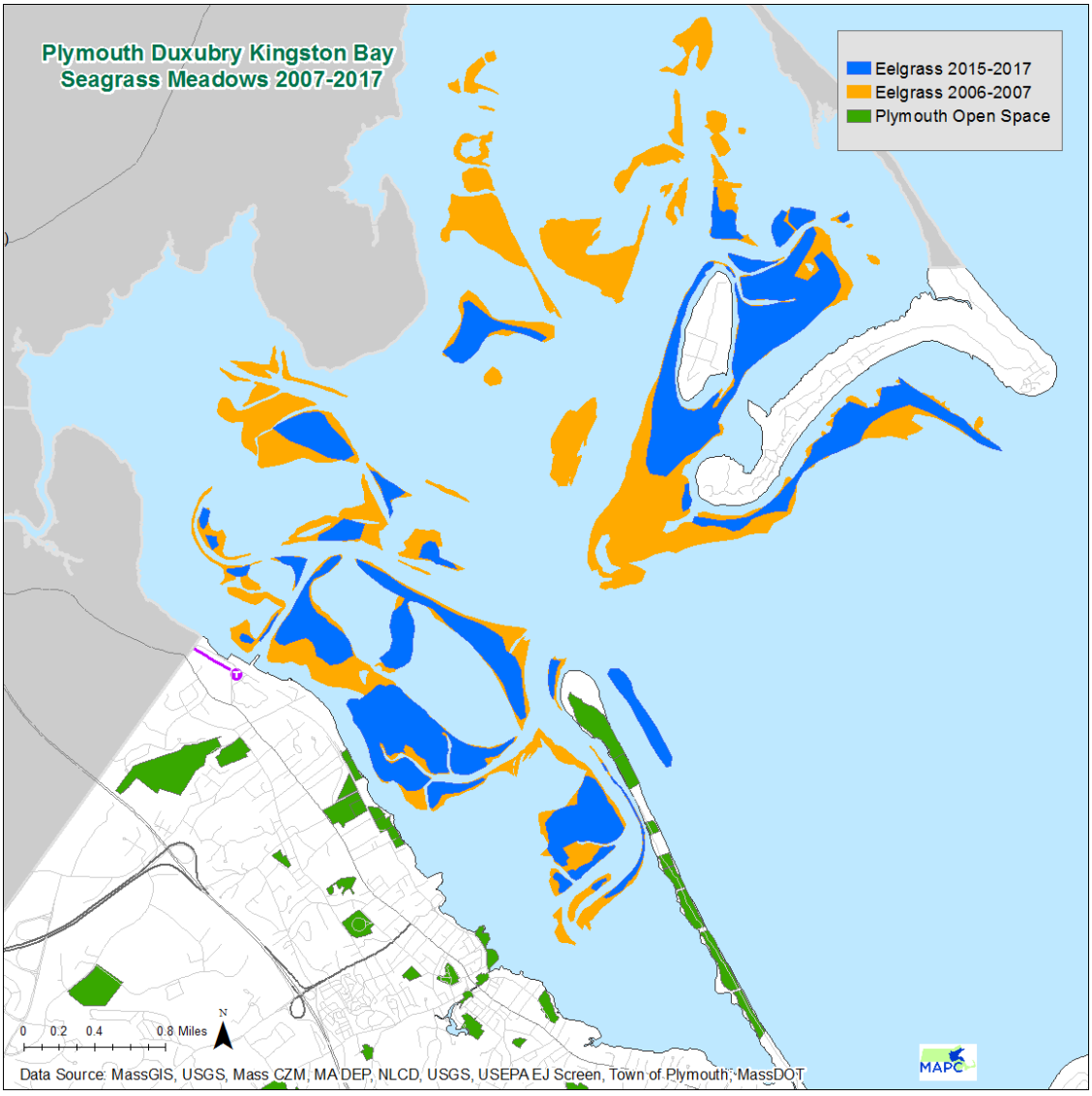
[84] Short, Fred; Klein, Anita; Burdick, David; and Moore, Gregg. 2012. The Eelgrass Resource of Southern New England New York: Science in Support of Management and Restoration Success. NOAA Restoration Center

[85] MA Division of Fisheries and Wildlife. 2016. Eelgrass loss over time in Duxbury, Kingston, and Plymouth Bays, Massachusetts Final Report https://www.mass.gov/files/2017-08/2015%20DuxburyKingstonPlymouth%20Eelgrass.pdf

Table 14 Seagrass beds area in Plymouth as measured by the MA Department of Environmental Protection

Seagrass Meadow Acres	Year Recorded	Percent Change 2007
867.40	2016	-36%
1368.48	2012	+1%
1346.78	2007	--

Figure 32 Plymouth Duxbury Kingston Bay complex seagrass meadows from 2006 to 2017. Plymouth Bay specifically lost approximately 35% of sea grass beds from 2007-2016.



Ellisville Harbor State Park salt marsh, dunes and beach. Photo credit Yelp.com

Salt marshes and estuaries are complex and highly productive ecosystems generally resilient to wide variations in temperature, salinity, and tidal inundation.[86] Ecological and health benefits of salt marshes include floodwater storage, storm surge protection, carbon sequestration, nutrient removal and water quality improvements. Healthy marshes also support important commercial fish and shellfish habitat.[87] 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 inundation but cannot survive if persistently 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 saltwater 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.

Plymouth contains one major, approximately 67 acres, salt marsh at Ellisville Harbor. It is part of a 600-acres State-designated -Area of Critical Environmental Concern which includes a diverse array of ecosystems supporting a wide variety of wildlife habitat. These include a sheltered harbor, sandy beaches, salt marsh, steep bluffs, kettle holes, a small sphagnum bog, and scenic, rural upland sites with woodland and meadow. In addition, the area is an important cultural site of Native American archaeology. Overall, the ACEC illustrates an important natural system providing storm protection for the low-lying inland areas. It is the area most vulnerable to SLR 2050 and 2100 of the entire coast of Plymouth.[88]

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

[87] 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

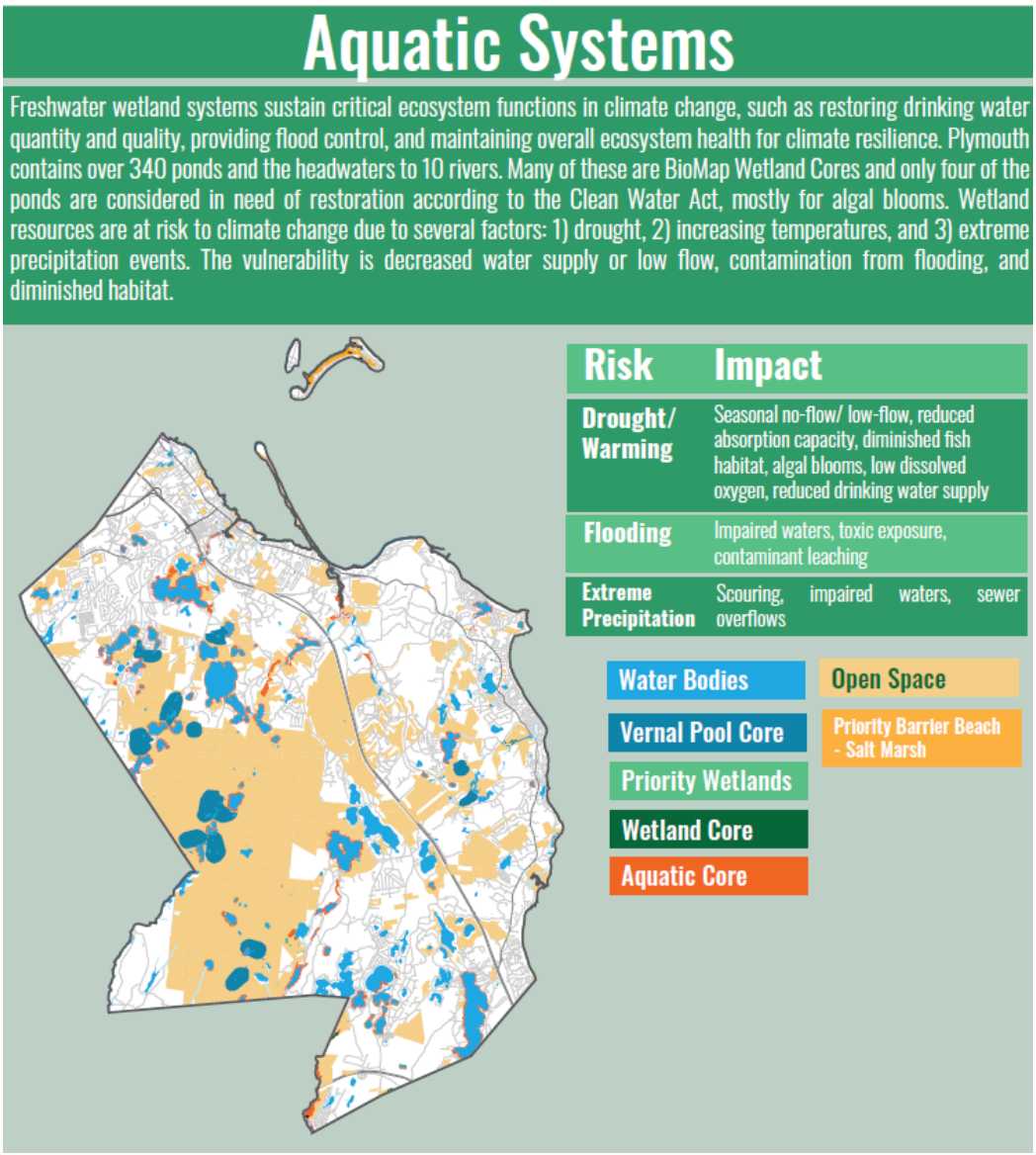
[88] https://www.mass.gov/service-details/ellisville-harbor-acec

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.

4.2.3 Aquatic Natural Areas

Freshwater wetland systems sustain critical ecosystem functions in climate change, such as restoring drinking water quantity and quality, providing flood control, and maintaining overall ecosystem health for climate resilience. Residents of Plymouth repeatedly boasted the unique and abundant ponds in the Town stating, "there is a pond for every day of the year in Plymouth!" Residents and

Figure 33 BioMap2 Aquatic Core Habitat and fresh water exemplary systems in Plymouth and their risks to climate change.



stakeholder expressed strong interest in protecting the quality, integrity and access to Plymouth's ponds. Particularly in the face of climate change and development, residents and stakeholders had significant concerns that shifting weather patterns and increased development that has occurred in the last several years may deplete the water supply, increase vulnerability to pollution from wastewater, and increase the frequency and abundance of harmful algal blooms.

According a study performed by University of Massachusetts, Dartmouth, Plymouth contains 450 ponds encompassing 5,002 acres.[89] Some of these ponds are coastal plain ponds, a globally rare geologic feature that is shallow and influenced by the groundwater table. These unique natural water systems have been recognized as critically important to support wildlife with approximately 6,625 acres of BioMap Aquatic Habitat-intact river corridors where integral physical and ecological process of the water system occur.[90] (Figure 33)

College Pond, a kettle pond in Myles Standish State Forest. Photo credit: SeePlymouth.com

Many of these ponds are kettle ponds, a geologic feature created during the last ice age where melting glaciers left blocks of ice that created depressions in the landscape that filled with water. They are isolated in the landscape and highly influenced by shifting climatic conditions, such as changes in precipitation and temperature.[91] Plymouth's kettle ponds are highly influenced by the aquifer/groundwater table where it is present at the surface, so water levels in the ponds are determined by the amount of

[89] Eichner, E.M., B.L. Howes, and S. Horvet. 2015. Town of Plymouth Pond and Lake Atlas. Town of Plymouth, Massachusetts. Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 137 pp.
[90] Natural Heritage and Endangered Species Program. BioMap2. Conserving the Biodiversity of Massachusetts. Plymouth Town Report.
[91] Smith, Stephen. 2017. "Cape Cod's Kettle Ponds are showing signs of Climate Change"

groundwater.[92] Because the groundwater exists at the surface, residents expressed concern about nitrification of the groundwater from runoff and ineffective OSWS at or near the ponds. Finally, Kettle ponds are susceptible to warming and recent years have indicated a disparity in the surface temperature of the pond to the bottom temperature.[93]This phenomena affects all the naturally occurring biogeochemical reactions and ecological processes in the bottom waters as well as influence greater amounts of algal blooms at the surface.[94]

In addition, Plymouth is the headwaters and/or contains 10 different rivers. These include the Eel River, Beaver Dam Brook, Indian Brook, Town Brook, Herring River, Agaway River, Wankinco River, RedBrook and the Crane Brook portion of the Weweantic River. Healthy riverine ecosystems support the overall water system in the Town which includes the sole-source aquifer providing drinking water to three towns.

The Town in cooperation with federal, State and private partners have taken significant measures to restore and preserve these water systems. For example, in the last several years, nine dams have been removed in Plymouth.

Holmes dam removal (top) and Plymouth's Town Brook today as part of the Town Brook restoration project. Photo credit: NOAA (top) and Matt Noyes (bottom).

[92] Town of Plymouth. 2017. Plymouth Open Space and Recreation Plan

[93] Eichner, E.M., B.L. Howes, and S. Horvet. 2015. Town of Plymouth Pond and Lake Atlas. Town of Plymouth, Massachusetts. Coastal Systems Program, School for Marine Science and Technology, University of Massachusetts Dartmouth. New Bedford, MA. 137 pp.

[94] [94] Smith, Stephen. 2017. "Cape Cod's Kettle Ponds are showing signs of Climate Change"

Dam removal is an important climate resilience strategy for several reasons. First, it restores streamflow to its more natural state which also restores the riverine ecosystems associated with the river. Dam removal assists in minimizing flooding and flood storage during extreme weather events, it minimizes riverbank scouring during high streamflows, and it enables fish passage which is a critical component of the overall riverine ecosystem.

A recent and critically important riverine restoration project occurred at Town Brook. This is 1st order stream from Billington Sea to Plymouth Harbor. The restoration project removed four dams, completed in 2014, renovated Brewster Gardens, and restored with anadromous fish run and passage. 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. Another important climate resilience project is the 250-acre Beaver Dam Brook restoration project, the largest wetland restoration project in Massachusetts. This restored 3.5 miles of high-quality cold-water stream and wetland habitat. A similar project occurred at the Eel Brook watershed area. The Town and other partners have protected significant land within the watersheds of Indian Brook, Agawam River, and Red Brook.

As a result of these efforts, a small percentage of Plymouth's total water resources are in the 2014 "Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act," as Category Five, requiring Total Maximum Daily Loads (TMDL) in 2014.[95]

Table 15 Town of Plymouth's 2014 and 2016 List of Integrated Waters regulated by the Clean Water Act.

Water Body	TMDL	Reason
Plymouth Harbor	*5*	Fecal coliform, nutrient eutrophication, biological indicators.
Russel Millpond	*5*	Not supporting aesthetic fish consumption, fish, primary contact recreation. Excess algal growth, fish passage barrier.
Ellisville Harbor	*5*	Fully supporting primary and secondary contact recreation. Not supporting shellfish consumption due to fecal coliform
Billington Sea	*5*	Turbidity, excess algal growth. Not supporting primary contact recreation.
Halfway Pond	*5*	Harmful algal bloom
Savery Pond	*5*	Harmful Algal Blooms

[95] http://maps.massgis.state.ma.us/images/dep/omv/il2014viewer.htm

4.3 Housing

Housing is an important component of understanding public health risks and vulnerabilities to climate change. First, long distances between housing, transit hubs, and employment centers and insufficient affordable housing near employment centers is a major contributor to greenhouse gas emissions due to increased car-dependent transportation. Housing indicators of climate risk include age and condition of housing stock and proximity to heat and flood risks. Older housing often has poor insulation and ventilation and is rarely equipped with central air conditioning. Combined with insufficient maintenance, these older homes can increase exposure to extreme temperatures, mold, pests, and other allergens. Low-income households also face greater utility cost-burdens and are less able to afford air conditioning. If these households live in an older, poorly insulated home, they are more vulnerable to extreme heat. Discriminatory housing practices also increase vulnerability to climate impacts and impair households' ability to adapt to and recover from those impacts. For example, communities of color often live in neighborhoods with fewer trees, greater heat-trapping impervious surface, and consequently, greater exposure to poor indoor air quality and extreme heat. This can cause or exacerbate renal, cardiovascular, and respiratory conditions, such as asthma. Finally, housing cost-burdened[96] households, especially renters, have fewer resources with which to make repairs or access to temporary housing. They may face greater housing instability and displacement if their homes are damaged or destroyed due to extreme weather events. This section will evaluate the state of housing in Plymouth, its vulnerability to climate impacts, and the public health implications.

4.3.1 Housing Stock

Plymouth has seen an influx of new development in the last two decades. Between 2000-2016, there was a 21% increase in housing stock. In addition, there are 47 new residential and mixed-use developments that are under construction, approved, or recently completed. These include approximately 3,400 new units of which 304 are classified as Deed-restricted, Affordable Housing.[97] As of 2019, there was a 1.2% homeowner vacancy rate and 6.5% rental vacancy rate.

According to a study performed by the Metropolitan Area Planning Council in 2014, Plymouth households and housing units are projected to increase by 11% and 10% respectively (Table 16). Thus, the housing demand in Plymouth is projected at 3,817 units by 2020 and 6,665 units by 2030 with a stronger population and economic growth scenario.[98] Importantly, not only is there a projected increase in housing demand, the number of households over the age of 65 will increase by 38% between 2020 and 2030.

[96] Housing cost-burdened households pay 30% or more of their income on housing.
[97] Town of Plymouth Planning and Community Development. September 2019.
[98] Metropolitan Area Planning Council Regional Growth Projections. January 2014. https://www.mapc.org/learn/projections/

Table 16 Stronger region scenario for housing and housing demand, 2000-2030. Scenario projections are based upon age-specific headship rates and municipal-specific housing occupancy patterns and vacancy rates.

	2000	2010	2020	2030
Households	18,423	21,269	25,152	27,931
Housing Units	21,250	24,800	28,617	31,465

Despite Plymouth being "America's Hometown" celebrating its 400th Anniversary with rich historic assets and buildings, the housing stock is relatively young with 54% of housing being built after 1969 and 29.6% built between 1980-2009.[99] As of 2018, 78% of Plymouth residences were owner-occupied and 72% are single-family homes. In addition, Plymouth has five mobile-home housing communities totaling 649 mobile homes or 2.5% of housing stock. In addition, there is an increasing demand for mobile homes based upon the number of permits approved between 2010-2018.[100]

4.3.2 Housing Affordability

The Town of Plymouth has prioritized housing affordability and production for its residents, having completed three housing production plans since 2007. This is approach is an important strategy for a planned community development while meeting the State's requirements of 10% of its housing stock being affordable. [101] As of December 2018, Plymouth had 732 units or 3.28% are on the subsidized housing inventory. Once the proposed new development is complete, that will increase to 7.17%. Senior households account for nearly 50% of the affordable units in Plymouth.

[99] Old Colony Planning Council. "Plymouth Housing Production Plan" January 2019. Pp. 10-21
[100] Old Colony Planning Council. "Plymouth Housing Production Plan" January 2019. Pp. 10-21
[101] Old Colony Planning Council. "Plymouth Housing Production Plan" January 2019. Pp. 10-21

In addition, persons with disabilities or mental health account for 82 units of all of Plymouth housing units.

In addition to affordable housing options, cost-burdened households are another indicator of the housing affordability gap in a community. According the federal Department of Housing and Urban Development, a household that is cost-burdened pays more than 30% of their income for housing and may have difficulty with other necessary expenses such as food, clothing, transportation and medical care. Severe cost-burdened is where households are paying more than 50% of their income on housing.

As of March 2020, the median sale price for a two-bedroom home is $345,000.[102] The average rent of a two-bedroom apartment is $2,043 and $1,986 for a one-bedroom apartment.[103] Many renter-occupied households in Plymouth are cost burdened with 3,715 of households (spending more than 30 percent of their gross income on housing) and 1,350 of those households are severely cost burdened (spending more than 50 percent of their gross income on housing). As of 2019, 31% of owner-occupied households were cost-burdened and 11.0% are severely cost-burdened. Fifty-one percent of renters are cost-burdened as of 2016 which is the highest in Plymouth County and higher than Massachusetts overall.[104] However, Plymouth has set the goal to meet and maintain the 10% state standard for affordable housing for year-round housing units that include both low-income and moderate-income units.

4.3.3 Housing Vulnerability

Plymouth's housing is vulnerable to inland flooding, coastal flooding from storm surge, sea level rise, extreme heat, and wildfire.

Affordable housing that is vulnerable to the urban heat island effect include Harborwalk (an inclusionary housing development with affordable units and units for persons with disabilities), Spring Hill, and Algonquin Terrace. As discussed in Section III, low-income individuals are disproportionately vulnerable to the impacts of climate change f limited resources and lower adaptive capacity. Because of these conditions, lower income individuals are more exposed and at higher risk to the health impacts of climate change. Seniors with fixed incomes are also even greater risk if living in low-income housing. [105] MA Department of Public Health indicates that people of color are also disproportionately affected by higher rates of asthma. The abovementioned low-income housing units are not only in areas of high heat but also areas with greater concentrations of poor air quality (4.1.4.3 Air Toxic Exposure). There is a greater concentration of people of color located in North Plymouth thereby creating significant disparities in climate vulnerability to the remainder of the Town. Additionally, there are four long-term care facilities vulnerable to urban heat island, Chilton House Rest Home, Radius Health Care and Pediatric Center, Plymouth Crossing, and Life Care Center of Plymouth. These centers are more

[102] Trulia.com March 2020
[103] Apartments.com March 2020
[104] Old Colony Planning Council. "Plymouth Housing Production Plan" January 2019. Pp. 10-21
[105] Rosenthal, J.K. 2010. Evaluating the impact of the urban heat island on public health: Spatial and social determinants of heat-related mortality in New York City. Columbia University.

likely to have air conditioning resources thereby reducing the vulnerability of patients receiving care.

4.3.4 Housing Coastal Zone Vulnerability Matrix

As part of the expanded scope of the Municipal Vulnerability Preparedness, Plymouth sought to consider the implication of residences in high risk coastal areas, such as those vulnerable to existing coastal erosion, sea level rise, and storm surge. The scope of work included creating a coastal zone vulnerability matrix (CZVM) that considers the following factors:

- Vulnerable infrastructure
- Near shore bathymetry
- Shoreline and near shore topography
- Fresh ground water elevation
- Shore line soils
- Coastal armoring
- Embayments and near shore freshwater ponds
- Groundwater interface.

The coastal zone vulnerability matrix would be a platform for identifying and prioritizing housing and infrastructure that may require landward relocation or retreat.

The CZVM analysis was completed using the following methodology:

1. Spatial analysis of the risk of all buildings by footprint in a FEMA flood zone and at SLR 2050, or approximately 4.0 feet of sea level rise;
2. Categorization of buildings in flood zones into geographic areas or "risk neighborhoods;"
3. Evaluation of municipal services risks such as sewer and transportation in the risk neighborhoods;
4. Identification of shoreline protection infrastructure. Shoreline protection was measured at each risk neighborhood; Coastal armoring or hard shoreline infrastructure was mapped from aerials photos and local knowledge and included stone revetments, sea walls, groins, and engineered dunes. Natural shoreline protection systems, living shorelines, wetlands, and BioMap Aquatic Core and Critical Natural Landscape;
5. Evaluation of topography to ascertain the potential extent of flooding;
6. Spatial analysis of coastal erosion greater than three feet since 1974; and
7. Risk neighborhood determination of resilience using a resilience score of 0-10. A resilience score of 0 represents an area that is extremely high risk with virtually no resilience present. A resilience score of 10 represents an area that has some risk to few buildings but with a few modifications at the building level, the neighborhood is viable with current and future flooding.

Because this evaluation is particularly related to discussions of potential retreat or landward migration, the CZVM analysis considers the matrix from the perspective of housing vulnerability to flooding, inland and coastal, and coastal erosion. The score represents the risk in providing municipal services such as emergency response during an extreme weather event. For example, if the risk neighborhoods have roads that flood, then the neighborhood could be effectively disconnected to emergency response. It also considers the public health challenges imposed by

neighborhoods remaining in high-risk flood area. For example, if a risk neighborhood has private septic and repeated floods, this creates public health exposure to wastewater. If a risk neighborhood is within a FEMA VE: High Risk Zone and exposed to

Table 17 Coastal Zone Vulnerability Matrix illustrating neighborhoods and housing at risk to coastal and inland flooding.

Neighborhood	Total	1% Annual Chance Flood	VE:High Risk Zone	SLR 2050	Municipal Sewer	Road in Flood Zone	> 3 feet coastal erosion 1974-2009	Topography	Living Shorelines and Wetlands	Hard Shoreline Protection	Resilience Score
Saquish and Clark Island	288	18	201	69	No	Yes	Yes	Low to Mid-Lying	Salt Marsh	Three private rock revetments	0
White Horse Manomet Point	280	95	185		No	Yes	Manomet	Low lying and steep dune cliffs	Barrier Beach System, Intertidal, Aquatic Core	Rock Revetments, Two Groins at Manomet Point	4
Downtown Plymouth	36	22	7	7	Yes	Water Street	Yes	Low to Mid-Lying	Barrier Beach, Aquatic Core	Seawalls, rock revetments	8
Plymouth Long Beach	22	2	20		No		Yes	Low lying	Barrier Beach-Coastal Beach	Seawall, rock revetments	4
Buttermilk Bay South Plymouth	11	11	---	---	No	No	__	Low and mid-lying	Wooded Swamp coniferous and trees, Aquatic Core	__	5
North Plymouth	10	8	2	---	Yes	No	Yes	Low Lying	Barrier beach system, coastal beach, intertidal	Seawalls at Cordage, Engineered dune	9
Manomet Cedarville	8	2	6	---	No	Yes	Yes	Low lying and steep dune cliffs	Coastal Bank, Barrier Beach Dune, Coastal Dune	Rock revetments at coastal bank and dune	5
Kings Pond	13	13	---	---	No	No, but local reports of flooding	---	Low lying	Shrub swamp	---	8

Neighborhood	Total	1% Annual Chance Flood	VE:High Risk Zone	SLR 2050	Municipal Sewer	Road in Flood Zone	> 3 feet coastal erosion 1974-2009	Topography	Living Shorelines and Wetlands	Hard Shoreline Protection	Resilience Score
Billington Sea	1	1	---	---	No	Yes, minimal	----	Low lying	Cranberry Bog, Aquatic Core	----	8
Neighborhood	**Total**	**1% Annual Chance Flood**	**VE:High Risk Zone**	**SLR 2050**	**Municipal Sewer**	**Road in Flood Zone**	**> 3 feet coastal erosion 1974-2009**	**Topography**	**Living Shorelines and Wetlands**	**Hard Shoreline Protection**	**Resilience Score**
Accessory Buildings/Various	175	130	30	15							
Grand Total	**380**	**153**	**220**	***7***							

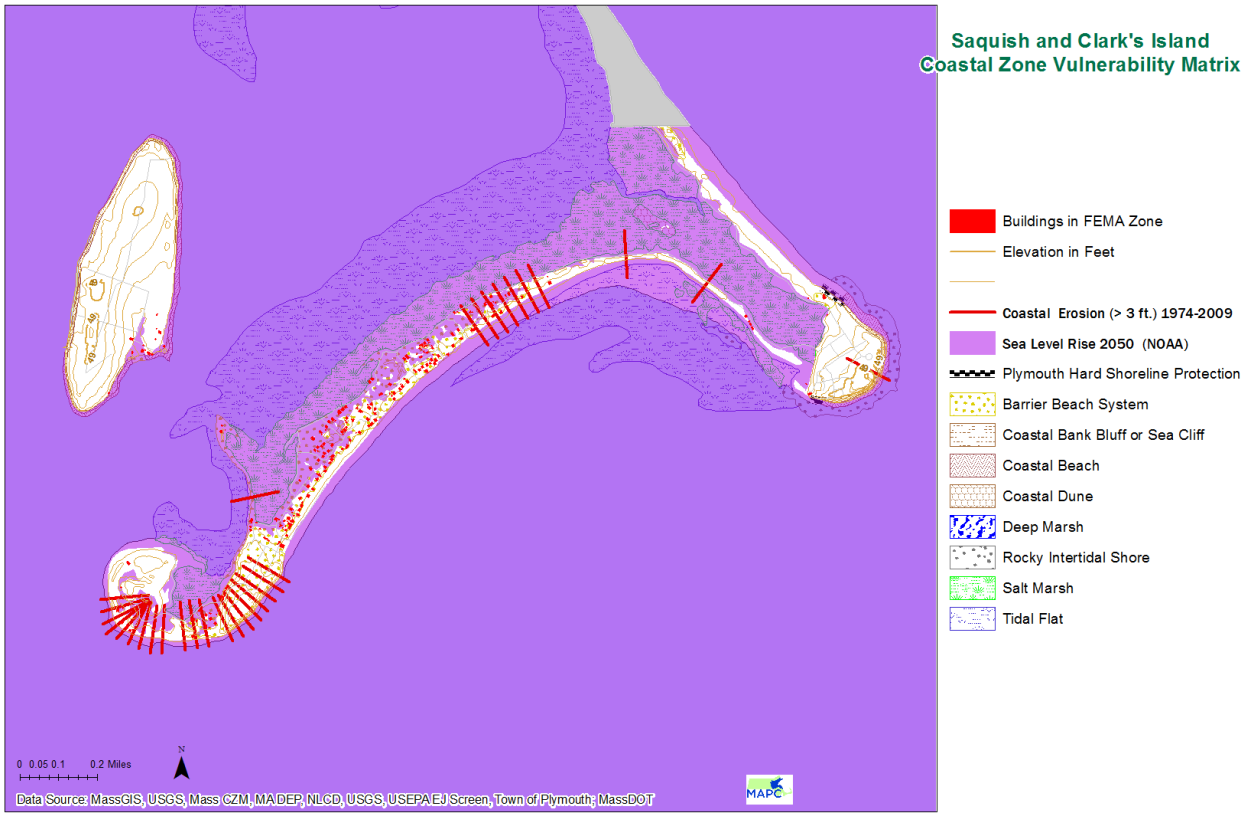
flooding at SLR 2050 with little to armoring, then the risk neighborhood is deemed to have little to no resilience. Resilience scores are increased if natural or hardened infrastructure improvements exist in the neighborhood or if the probability of flooding is less likely but resilience scores decrease if severe coastal erosion exists in the risk neighborhood. The Coastal Zone Vulnerability Matrix and resilience scores are summarized in Table 17.

4.3.4.1. Resilience Score Results

There are 669 houses located in a flood zone including the 1% Annual Chance, VE: High Risk and SLR 2050 floodplains. This represents approximately 3% of all the buildings in the Town of Plymouth. In addition, there are 236 accessory structures such as garages, sheds, or warehouses. Most at-risk buildings, 438, are in a VE: High Risk Zone, and 86 buildings are within SLR 2050.

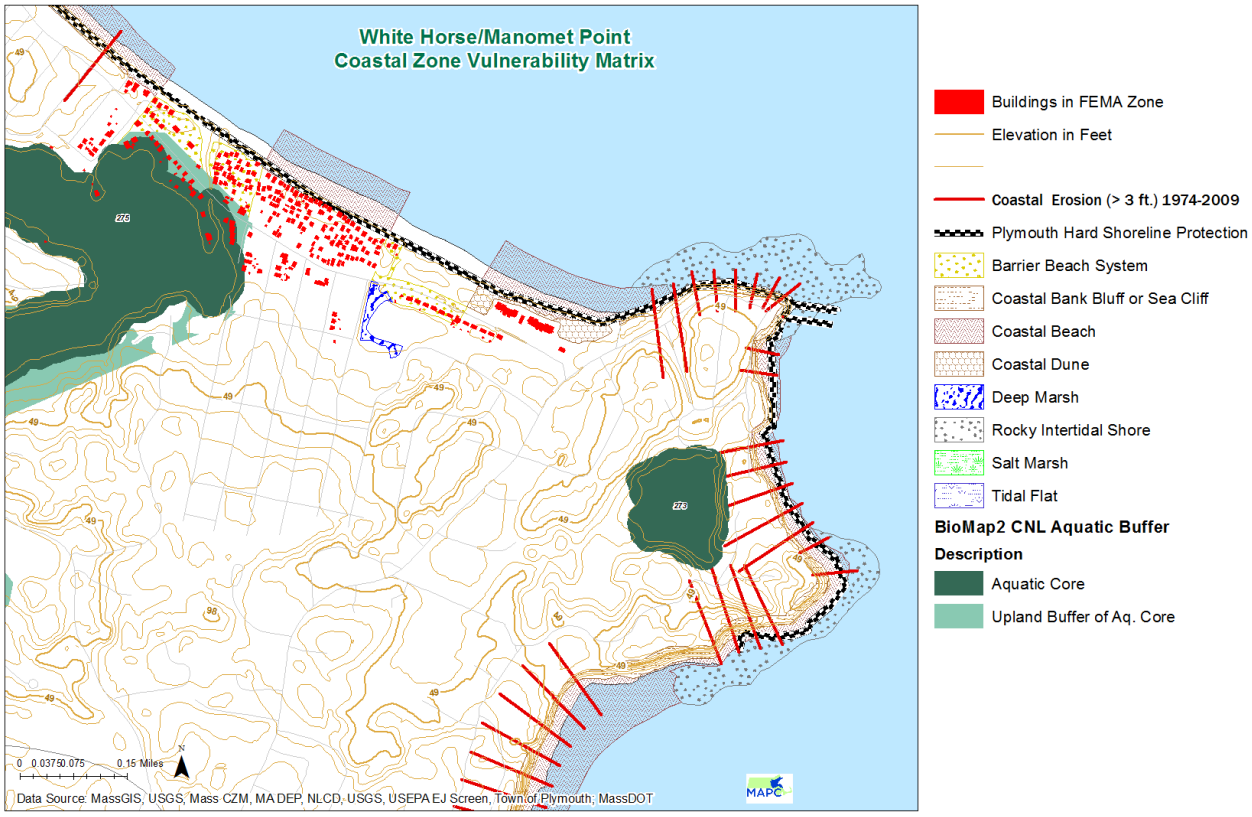
Saquish is the neighborhood at greatest risks to flooding with 288 houses, 201 in a VE and 69 in SLR 2050 Zone. The area has significant coastal erosion, limited shoreline protection on only two residences, and high flood risk access road. Saquish is relatively low-lying except Gurnet Point where significant coastal erosion is occurring (Figure 34). Access to Saquish is through Duxbury on a private dirt road owned by the Duxbury Beach Reservation, Inc. This road is known to flood on windy days with lunar high-tides in addition to coastal storms. Additionally, all wastewater is treated onsite, making the vulnerability of untreated wastewater entering into the ocean and bay during flooding and storms very high. Saquish received a resilience score of 0. Discussions of relocation are recommended for this high-risk neighborhood.

Figure 34 Saquish and Clark's Island Coastal Zone Vulnerability spatial analysis. 317 buildings are in SLR 2050 and/or FEMA Flood Zone



White Horse and Manomet is the second highest risk to flooding with less resilience with 280 structures in a flood zone. This includes the area from the beginning of White Horse Beach to Manomet point. Most of the buildings at risk, 185, are in a VE: High Risk Zone. The area is relatively low-lying with high exposure with both hard and natural shoreline protection structures in place. None of the houses are located within SLR 2050. All residences have onsite wastewater creating a public health risk during coastal storm events. This area received a resilience score of 4. The areas where relocation may be most practical include Manomet Pont where there is extreme coastal erosion and the front line of residences at White Horse Beach. However, there are near team measures that could increase the resilience at White Horse Beach. These are discussed in Section VI. Climate Ready Healthy Plymouth Action Plan.

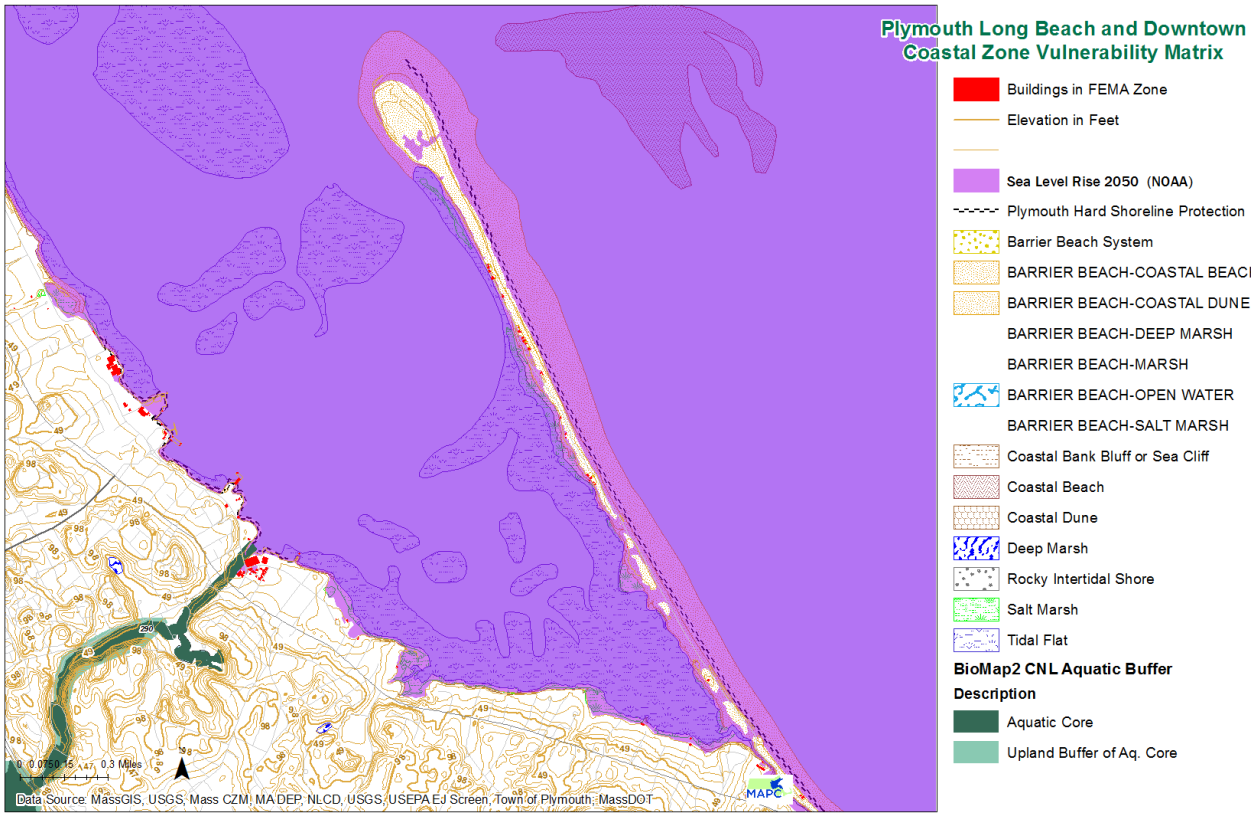
Figure 35 Coastal Zone Vulnerability Matrix spatial analysis for White Horse Beach to Manomet Point.



The third highest risk neighborhood in the Coastal Zone Vulnerability Matrix is Downtown Plymouth/Plymouth Long Beach. There are 36 structures at risk; 22 are in a 1% Annual Chance Flood, 7 in a VE: High Risk flood zone, and 7 in SLR 2050. There is significant coastal erosion at Plymouth Long Beach though there is a rock revetment along most of the barrier beach and a sea wall at the entrance. These structures were recently damaged in Winter Storm Riley in March 2018 and require repeated maintenance, repair, and reconstruction. In Downtown Plymouth, most of the shoreline is protected with sea walls and revetments and the area is sheltered from intense wave energy by Plymouth Long Beach and the jetty in Plymouth Harbor. Discussions for relocation may be considered for residences at Plymouth Long Beach where the costs of repair and reconstruction to serve the neighborhood exceed the financially ability of the Town or willingness of the public for repeated investments. Plymouth has already acquired with Community

Preservation Act funds a few houses here and created more public natural space along the barrier beach and these discussions are worthwhile for the remaining. Additionally, Plymouth is reconstructing the Harbormaster building raised to accommodate flood waters. Due to the presence of municipal sewer, center of economy, and existing armoring, Downtown Plymouth could increase its resilience score with some accommodations at the parcel level that limit water entry during storms and minimize risk of damage with flood proof buildings. These are discussed in Section VI. Climate Ready Healthy Plymouth Action Plan.

Figure 36 Coastal Zone Vulnerability Matrix spatial analysis of Downtown Plymouth/Plymouth Long Beach.



The remaining risk neighborhoods in the CZVM may increase their resilience scores with resilience improvements at the parcel level. The most significant concern in these neighborhoods is onsite wastewater treatment, flood risk, and public health exposure. These concerns are addressed in Section VI. Climate Ready Healthy Plymouth Action Plan.

4.4 Economy and Employment

Climate change and the uncertainty it creates provides important implications to local, state, federal and global economies, and the interconnected nature of public health, climate change, and economy critically important to evaluate for the long-term well-being of a community. There is evidence that climate change can spur entrepreneurship. For example, advocacy and political action in the last decade on reducing greenhouse gas emissions prompted significant growth in the clean energy sector with new technologies, scaling of renewable energy infrastructure and use, and clean energy sector jobs. In Massachusetts, the clean energy industry employs more than 110,000 employees consisting of 30% of the workforce contributing $13.2 billion to the gross

state product.[106] In 2018, Massachusetts secured the Environmental Bond Bill enabling $2.4 billion in capital allocations for investments in climate change resilience, adaptation, and natural resource protection. These funds will have a direct and indirect impact on many industries related to conservation, design, engineering, development, and others across the Commonwealth.

Reducing or eliminating greenhouse gas emissions has a direct correlation in poverty reduction, global economic growth, and mitigating economic loss due to climate change. Scientists project that GHG reduction could prevent the loss of thousands of American lives and hundreds of billions of dollars in health-related economic benefits. Under a low-emission scenario. For example, under a scenario where GHG concentrations peak at 2040 and then decline, annual health impacts and health-related costs are projected to be approximately 50% lower than an emission scenario that peaks at 2080 or continues its current trajectory of GHG emissions. This estimate does not include the economic health benefits of reducing climate change health scenarios such as reduction in mental illness or chronic conditions, [107]so the economic and health benefits stand to be far greater if communities take collective action not only on reducing GHG gas emissions but also through health adaptation strategies.

However, the widespread impacts (i.e., geographic, demographic, and sectoral) of global warming and climate change are likely to create more negative impacts on the economy due to the potential for damage to infrastructure (buildings, residences, roads, bridges, etc.) and public health (cardiovascular and respiratory diseases, mental health challenges, vector-borne and infectious diseases, etc.). In addition, climate change with extreme weather events and economic burdens could expand populations in poverty. [108] Furthermore, there is long-standing evidence on the interrelationship between wealth or economic status and health outcomes. Lower income individuals or lower socioeconomic status poses greater risk to both physical and psychological health problems. The lower your socioeconomic status, the greater your risk of both physical and psychological health problems[109] further reducing adaptive capacity and recovery from extreme weather events, residence damage/displacement, and health-care costs related to long-term health impacts and conditions.

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[106] Massachusetts Clean Energy Center. 2018. Massachusetts Clean Energy Industry Report.

[107] Ebi, K.L., J.M. Balbus, G. Luber, A. Bole, A. Crimmins, G. Glass, S. Saha, M.M. Shimamoto, J. Trtanj, and J.L. White-Newsome, 2018: Human Health. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 539–571. doi: 10.7930/NCA4.2018.CH14

[108] Richard, S.J. Tol. The Economic Impacts of Climate Change. Review of Environmental Economics and Policy, Volume 12, Issue 1, Winter 2018, Pages 4–25, https://doi.org/10.1093/reep/rex027
Published: 12 January 2018

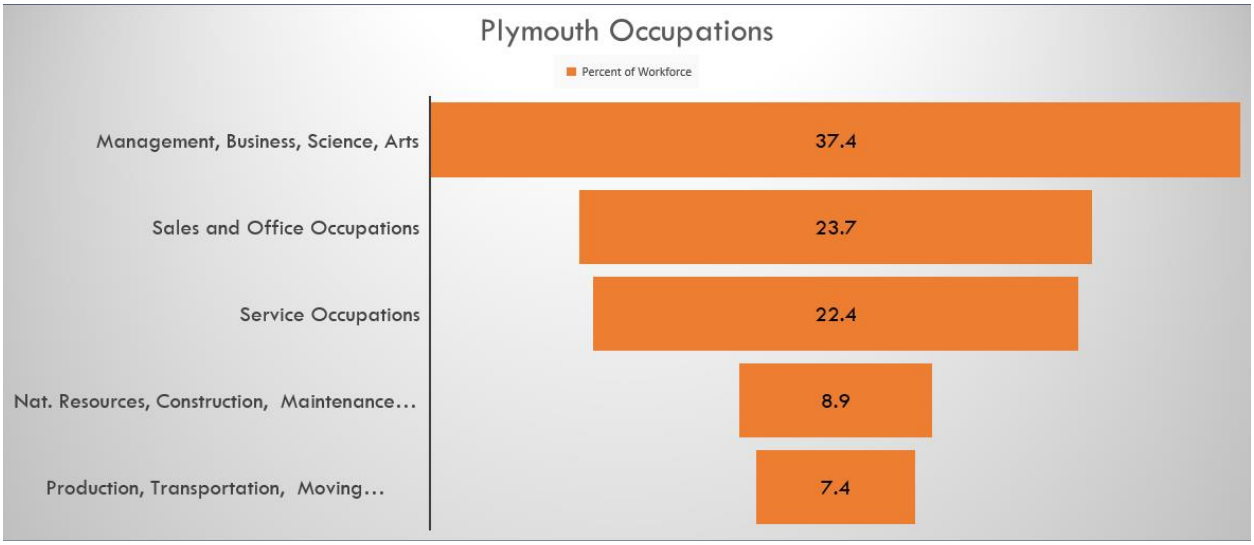
[109] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017.

Plymouth and the Commonwealth have already invested in "health adaptation measures" actions that reduce or aid in mitigating the additional impacts arising as a result of climate change. [110] Some examples of health adaptation include minimizing the impact of vector-borne disease (i.e., Lyme Disease, EEE, West Nile Virus), waterborne disease (i.e., Vp, fecal coliform), and malnutrition (i.e., free and reduced breakfast and lunch in schools). This section will evaluate Plymouth's economy and employment and the implications of the economy from climate change and public health impacts.

4.4.1 Employment

Employment is one of the most important social determinants of health because the way it affects multiple components of how people live. Employment provides income, health care, parental leave, child and elder services, wellness programs and overall stability. It also provides a social network for individuals. Employment can also provide unhealthy conditions such as long hours, increased stress and anxiety, poor eating and exercise habits, loss of sleep, and limited family/leisure time. In addition, the physical workplace can contribute to poor health creating injuries, illness, and potentially death.[111]

Figure 37 Plymouth occupations by percent of total workforce over the age of 16. Data from American Community Survey 2017.



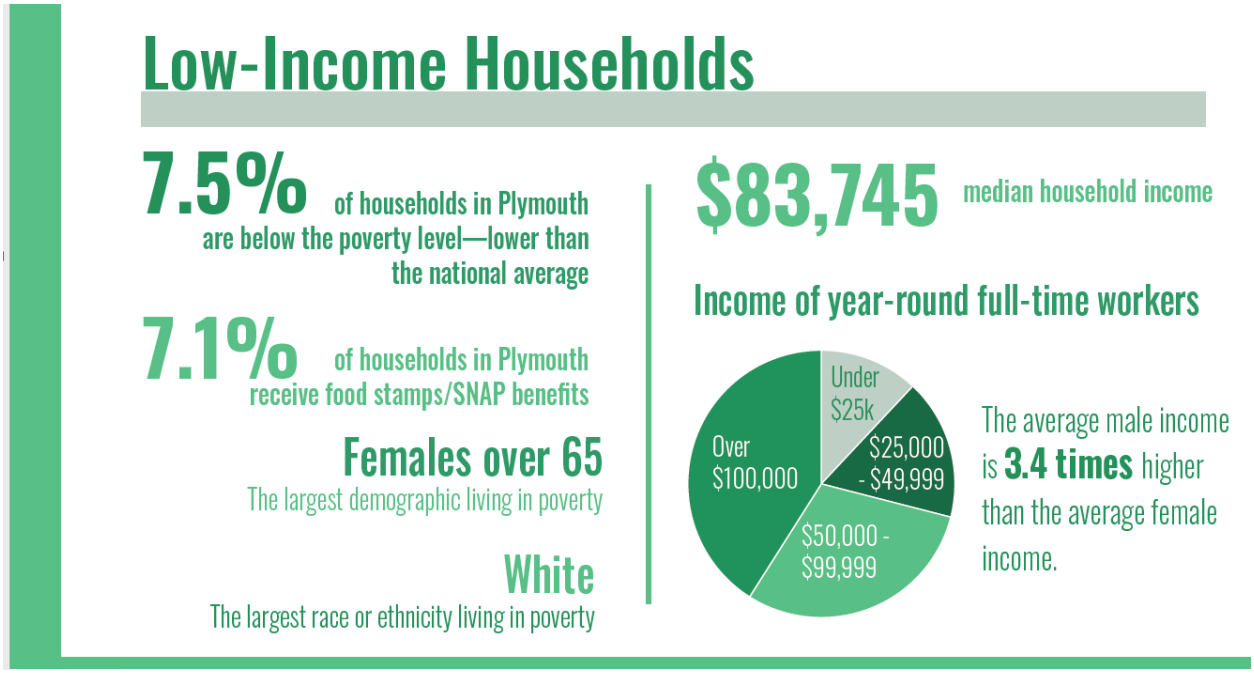
Unemployment and underemployment are directly correlated with poor health outcomes. Low-paying and/or unstable jobs are linked to chronic disease, stress, hypertension, heart disease, stroke, substance abuse, low self-esteem, and depression. These conditions can also create

[110] World Health Organization.2013. Climate Change and Health: A Tool to Estimate Health and Adaptation Costs. 44pp.

[111] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017.

adverse childhood experiences that implicate the long-term health of the future workforce. These include exposure to violence in the community, homelessness, or incarceration of a parent, behavioral issues in school and beyond, substance use disorders, as well as mental health disorders.[112] Lower income or service jobs may also be lacking in additive health benefits like parental leave or wellness programs. Discriminatory practices in hiring have led limited certain protected classes of individuals (women, people of color, LGBQT, etc.) toward poverty and/or underemployment and the corresponding poor health outcomes.[113] Financial stresses can lead to displacement or homelessness creating further negative health outcomes. Climate change and its corresponding extreme weather events as well as environmental exposure risks (4.1.4 Environmental Exposure) can exacerbate the challenges with unemployment and underemployment. Low-income individuals are often more susceptible to financial shocks which occur after extreme weather events or chronic medical conditions as a result of long-term environmental exposure.

Figure 38 Income statistics for the Town of Plymouth. Data source American Community Survey 2017.



Plymouth is one of the major employment centers for the South Shore and Old Colony Planning Council region. The majority of Plymouth's workforce is in management, business, science, and arts

[112] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017.
[113] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017.

occupations at 37.4% ±2.2% with Sales and Office Occupations as the second most frequent occupation (23.7%±1.8%) (Figure 37). As of 2020, Plymouth provided more than 32,000 jobs and over 30,000 individuals over the age of 16 were employed. The median household income for Plymouth is $83,746 and the mean household income is $104,522. This is higher than the median and mean for Plymouth County but lower than surrounding towns like Kingston, Duxbury, Scituate and Marshfield.

Unemployment has declined from the 2008 recession by to 3.4% in 2018.[114] Although, according to the regional Comprehensive Economic Development Strategy report of 2018, Plymouth and the OCPC region had not yet fully recovered from the recession. In Plymouth, 7.5% of residents live below the poverty level with a four-person household income of $24,000 or less. Further, males in Plymouth had wages that were 3.4 times more than the female incomes and females over the age of 65 were the largest demographic living in poverty (Figure 38).

4.4.2 Community Economy

Local economic systems represent community values, connectedness, distribution of resources, and exchange of goods and services. Local economies can also play a role in access to wealth and resources, foster or alleviate wealth inequities, or promote or limit access to livelihoods and employment. [115] For example, Plymouth residents and stakeholders through various public engagement strategies indicate a very high value toward the historical culture of the town and the natural and historic resources that it promotes. Indeed, Plymouth400 is regional effort to promote the 400th Anniversary of the Town's colonization by the Pilgrims in 1620. Over many years, local businesses, organizations, community members, Native Americans, global partners (the Netherlands and the United Kingdom) and municipal officials collaborated to create a year-long series of events to enhance the awareness and attraction of America's Hometown. The goals of this effort include (i) Tourism and Economic Development, (ii) National and International recognition, (iii) Cultural and Civic Engagement highlighting the multi-cultural roots of America-English, Dutch, and Native Americans, and (iv) Commemoration Legacies to leave lasting positive and meaningful legacies through events, education, tourist attractions, exhibits, and revitalization of historic assets.[116] This monumental effort is indicative of a strong local economy that supports the fabric of its community.

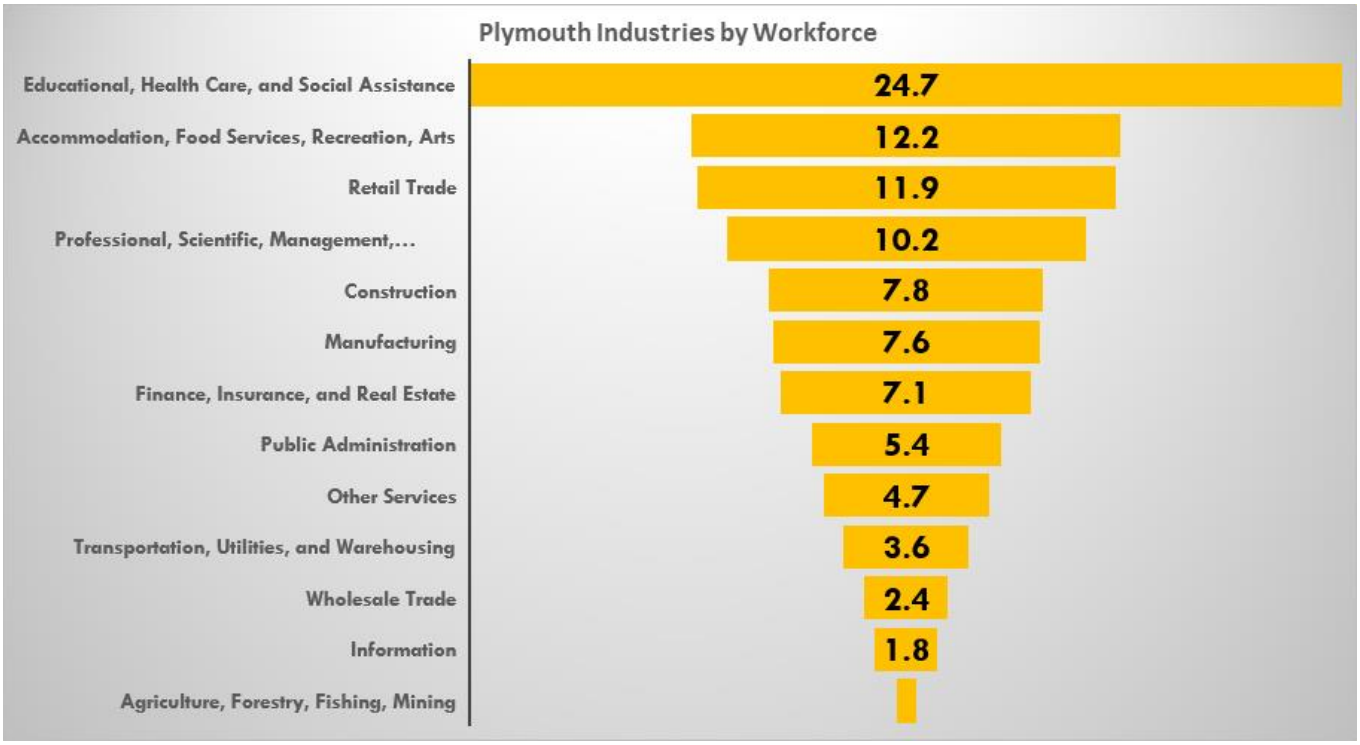
Major employers driving Plymouth's economy include Beth Israel Deaconess Hospital, Plymouth County Correction Facility, and the Plymouth County Sheriff's Department. The Pilgrim Nuclear Power Plant was once the largest employer with a positive economic stabilizing effect for the Town until its closure in 2019. The closure has created a loss of 190 jobs and $17.8 million in wages, and $14 million in municipal taxes in Plymouth alone.[117] The most frequent industry represented by the Plymouth workforce is educational, health care, and social assistance industries (24.7% ±1.8%) with the service industry (arts, entertainment, recreation,

[114] Old Colony Planning Council. 2019. Town of Plymouth Housing Production Plan.
[115] American Public Health Association. 2019. Climate Change, Health, and Equity: A Guide for Local Health Departments.
[116] Plymouth 400, Inc. https://www.plymouth400inc.org/about-us/mission/
[117] Cooper, Johnathon. 2015. The Pilgrim Nuclear Power Station Study A SOCIO-ECONOMIC ANALYSIS AND CLOSURE TRANSITION GUIDE BOOK. University of Massachusetts Amherst Center for Economic Development.

accommodation and food service) as the second most frequent industry (12.2% ±1.6%) followed closely by retail trade (11.9% ±1.6%) (Figure 39)

The high frequency of service and retail industries illustrate the importance of tourism in Plymouth. A member-based organization, Destination Plymouth, was created to promote the awareness and growth of the hospitality and tourism industry in the greater Plymouth area by marketing its

Figure 39 Employment industries in Plymouth by percent of the Town's workforce. Data source American Community Survey 2017.



destination assets and ensure easy accessibility and high-quality visitor services.[118] Tourism in Plymouth is one of its greatest strengths but also a point of high vulnerability to climate change and the associated public health challenges related to disruptions to employment or underemployment. Tourist economies thrive seasonally but also may require employees to seek alternative employment strategies during the off-season. Additionally, tourism may strain local resources such as municipal services during a temporary period of population growth.[119]

[118] SeePlymouth.com

[119] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017.

Extreme weather events from climate change can cause serious and sometimes debilitating disruption and discontinuity to local businesses and municipal budgets. For example, in 2015 Massachusetts, particularly Boston had record-breaking snowfall of over 107 inches between late January and early March. 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, such as frozen pipes and heating systems, and delayed or cancelled transportation, such as airlines.[120,121] Further, the COVID-19 pandemic is an example of how societal shutdown has affected economic systems and small businesses and restaurants in the Town are not immune. As of March 26, 2020, there were over 3 million unemployment claims due to COVID-19 and societal shutdown.

Small businesses are the critical component of the OCPC region's economy.[122] They represent an important cultural and community asset that supports a unique culture in the Town of Plymouth. There are many entities supporting their growth and development including Plymouth Area Chamber of Commerce, Plymouth County Development Council, Plymouth Promotion Fund, Plymouth Growth and Development Corporation, and Plymouth Regional Economic Development Foundation. In addition, small businesses can secure business interruption insurance to minimize the losses associated with severe weather events and climate change. Finally, the Microenterprise Assistance Program provides low-interest loans with flexible repayment terms for acquisition, renovation, working capital, furniture, equipment and any other justifiable need.[123]

4.4.3 Municipal Economy

Plymouth municipal economy is comprised of the revenues derived from real estate and personal property taxes, utility revenue and enterprise funds, local receipts, and state aid. Revenues received by the Town enable functionality of a multitude of services including planning and development, public health, local education, natural resource protection and management, parks and recreation, water and sewer delivery and management, as a few examples. These are critical services that enable a healthy and thriving community. In fiscal year 2020, the total anticipated revenue for the Town was approximately $253 million. The majority, 72%, of municipal tax revenue is from property taxes at $182 million in fiscal year 2020.

The health of the municipal economy is directly dependent on real estate property taxes. These can fluctuate between housing markets, recessions, and severe events both weather and pandemic where there is a decline in the value of housing or a decline in the collection of property taxes from resident's inability to pay. Climate change exposure to the municipal economy is significant. If properties are damaged or destroyed from acute impacts like fire and severe coastal storms, properties and resident's may have the ability to recover their loss. However, sea level rise and accelerated coastal erosion poses a significant risk in the long-term to the municipal economy where land is lost. This analysis reviews climate change impacts on municipal economy by evaluating parcels and their value with climate change hazards.

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[120] http://money.cnn.com/2014/10/30/news/economy/us-gdp-3-and-half-percent-beats-expectations/?iid=EL

[121] https://www.cbsnews.com/news/economic-impact-of-polar-vortex-could-reach-5b/

[122] Old Colony Planning Council. 2018. Comprehensive Economic Development Strategy.

[123] Town of Plymouth Community Development

There over 29,000 parcels worth over $11 billion in Plymouth. The most widespread climate change risk to structures in Plymouth, most residences and housing, is wildfire, based upon historic occurrence. This analysis compares the path of historic wildfires from 1957 to present where only 24 structures were damaged. Today, population growth and development increase the vulnerability of neighborhoods where if the historic paths of wildfire in Plymouth were to occur today, 3,372 buildings $870 million are at risk to wildfire based upon the historic paths (Table 18 and Figure 40).

The second most significant hazard to Plymouth's residences is SLR 2050 where 1,025 parcels with 871 buildings worth $400 million are at risk. Most important is the 492 parcels with buildings located in a VE 1% Annual Chance Flood zone, which is a significant current risk to the Town. VE Zones are known as the coastal high hazard zone or high wave-energy zones. They are influenced by high velocity water and waves and wave effects three feet or more. Though considered a 1% Annual Chance flood, buildings in VE zones are likely to have at least one flood within the life of a 30-year mortgage.

Table 18 Plymouth parcels and buildings that are vulnerable to sea level rise and coastal and inland flooding. In addition, parcels that are located within the areas of historic fires are also included as these have a higher risk of recurrence.

	SLR 2050	1% Annual Chance Flood	VE 1% Annual Chance Flood	0.2% Annual Chance Flood	Historic Fire
Parcels	1025	201	492	8	4,410
Parcel Value	*$406,793,472	$231,535,676	$78,750,795	$792,200	$1,593,153,306
Buildings	871	0	492	3	3,722
Building Value	$226,662,800	$0	$33,346,100	$171,200	$869,218,388

* Includes the value of the Entergy Pilgrim Nuclear Power Station

In addition to these historic, potential, and project climate change risks to residences, Plymouth contains approximately 464 repetitive loss properties with $8,460,374 in total losses paid for flood damage since 1978.[124] A Repetitive Loss property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program within any rolling ten-year period, since 1978. A repetitive loss property may or may not be currently insured by the NFIP. The areas in Town with the most frequent repetitive loss claims include Plymouth Long Beach, Saquish, and White Horse Beach. However, Plymouth has been proactive in Land Use regulations that minimize loss and impact from coastal and inland flooding.

Since 1986, Plymouth has participated in the Community Rating System as part of the National Flood Insurance Program. This is a voluntary incentive program that approaches floodplain management from a comprehensive approach. The goals are to reduce flood damage to insurable property, strengthen and support insurance aspects of the National Flood Insurance

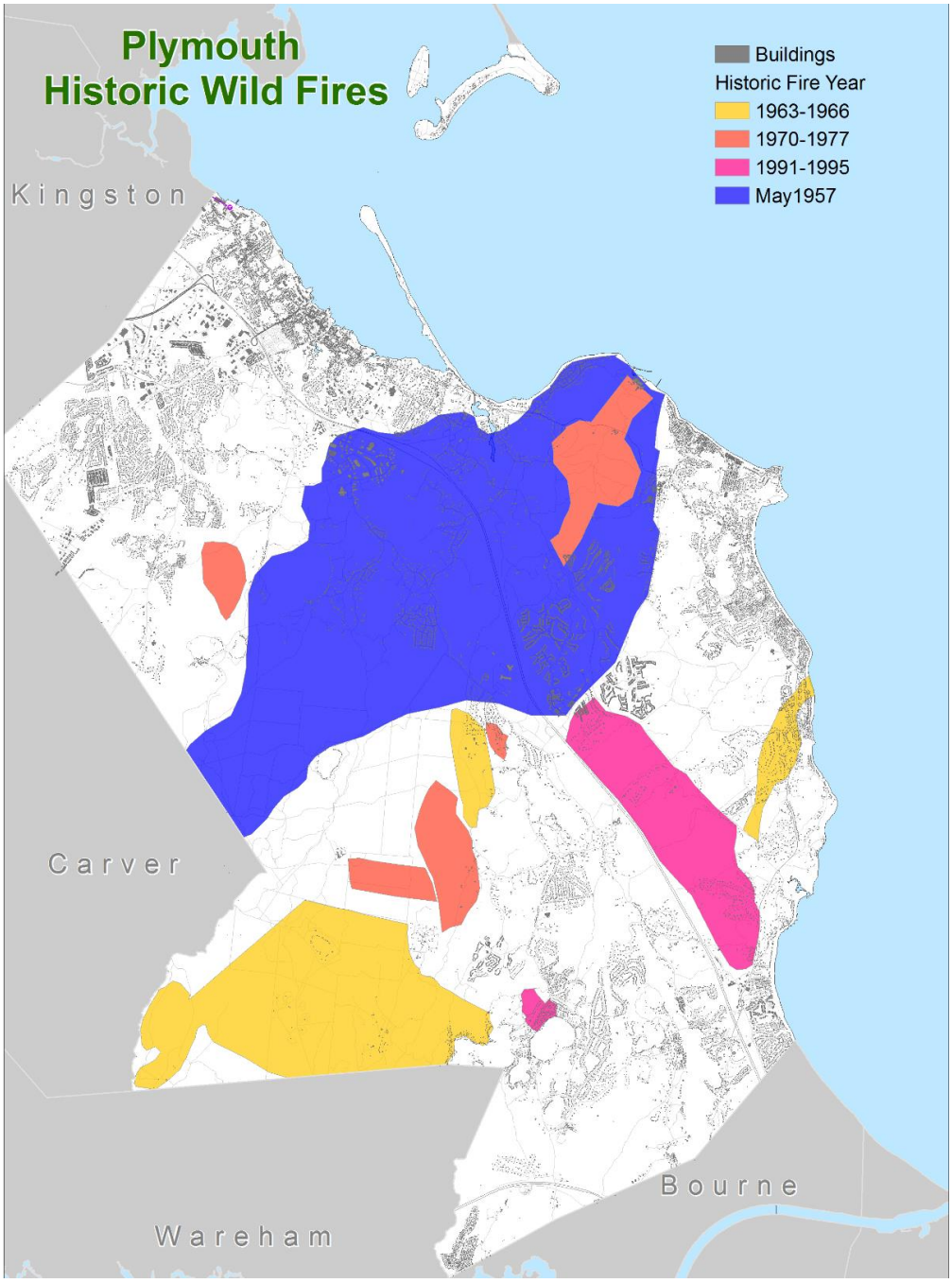
[124] Federal Emergency Management Agency. Hudex Report, Policy and Loss Data by Community. July 2019.

Program and encourage a multi-faceted and comprehensive approach to managing flood waters at the localized and watershed level. In return, residents of Plymouth have a 5% reduction in their flood insurance.

The Town has also implemented important zoning and regulations that minimize loss to residences homes. These include :

- *Floodplain District Zoning Bylaw*-all new construction located landward of the reach of mean high tide the 1% Annual Chance Flood plain. Placement of mobile home in a floodplain district is prohibited.
- C*oastal Flood Management Plan*-focuses on repetitive loss areas such as Saquish, Plymouth Long Beach and White Horse Beach. Seeks to include erosion-prone coastal bluffs into the analysis.

Figure 40 Path and location of historic wildfires in Plymouth and existing building footprints. Wildfire is the most widespread climate risk to residents and housing in Plymouth.



- *Wetlands Bylaw #27*-Enforced by the Conservation Commission, this bylaw regulates development within the 1% Annual Chance Flood plain, wetland resource areas, and 100-feet from any wetland resource area. Proposals are being discussed for 50-foot setbacks on coastal bluffs for development.[125]

[125] Town of Plymouth Coastal Flood Management Plan. 2009.

Furthermore, the Town has discouraged the expansion of existing structures in the repetitive loss areas and has acquired some houses on Plymouth Long Beach with Community Preservation Act Funds to restore the area to its natural state. Finally, the Town sends mailings to residences where repetitive loss has occurred. These are all important measures that protect people's homes and livelihoods as well as the municipal economy. However, zoning bylaws and regulations should be updated to reflect the risk of sea level rise to 2050.

4.5 Education

As a social determinant of health, education includes formal education in schools, educational activities in community groups or organizations and informal education through interaction. According to MA Department of Public Health, education is one of the strongest influences for positive health outcomes. For example, schools often provide resources that have a positive influence on overall health, such as healthy food options, recreational activities, social engagement, counseling, mentoring, and community engagement activities. Additionally, education attainment has a direct correlation on health by providing better jobs, higher incomes, and economic stability.[126]

Rising Tide Public Charter School, Plymouth, MA

Individuals without a high-school diploma have higher rates of unemployment, by 4%, than the national average, and 80% of incarcerated individuals did not achieve a high school diploma; 22% of people jailed in the United States are black males without a high school diploma. Young women who leave high school without graduation are nine times more likely to be or become young single mothers. Data indicates that high school graduates obtain higher employment and earnings and increased education improves skill levels and healthier more productive lives. [127] Income has a very strong correlation between education achievement as well. Low-income students are more likely to leave school without graduation by 2.4 times than middle-income students and 10 times more likely than high-income

Table 19 Schools, colleges, and education organizations in the Town of Plymouth.

School	Grades	Affiliation

[126] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017

[127] Levin, H.M. Columbia University and Rouse, C.E, Princeton University. 2012. The True Cost of High School Droupout" The New York Times, January 25, 2012.

Woodside School and Community Center	Early Childhood	Private
Plymouth Early Childhood Center	Early Childhood	Plymouth Public
Garden of Knowledge	Early Childhood	Private
Plymouth Kinder Care	Early Childhood	Private
New Testament Church and Christian School	Early to High School	Private/Religious
Southeast Campus School	Early to High School	Private
Hedge Elementary School	Elementary	Plymouth Public
Nathaniel Morton Elementary School	Elementary	Plymouth Public
Indian Brook Elementary School	Elementary	Plymouth Public
Federal Furnace Elementary School	Elementary	Plymouth Public
Cold Spring Elementary	Elementary	Plymouth Public
Manomet Elementary	Elementary	Plymouth Public
Nathaniel Morton Elementary	Elementary	Plymouth Public
South Elementary	Elementary	Plymouth Public
West Elementary	Elementary	Plymouth Public
Bridgeview Montessori School	Elementary	Private
Rising Tide Charter School-Grades 5-12	Middle/High School	Public Charter
Pilgrim Academy-Special Education School	Middle/High School	Public Charter
Plymouth Community Intermediate School	Middle School	Plymouth Public
Plymouth South Middle School	Middle School	Plymouth Public
Plymouth North High School	High School	Plymouth Public
Plymouth South High School	High School	Plymouth Public
Plymouth Harbor Academy	High School	Plymouth Public
The Map Academy	High School	Public Charter
Charis Bible School	Undergraduate	Private/Religious
Curry College	Graduate/Undergraduate/Certification	Private

School	Grades	Affiliation
University of Massachusetts-Boston	Undergraduate	Public Charter
Quincy College at Plymouth	Undergraduate/Certification	Private

students. Students with learning or physical disabilities are also highly like to leave school without graduation, at a rate of 36%.[128]

The population of Plymouth is overall well-educated. For adults 25 years and older in 2018, 36.4% had a bachelor's degree or higher, 95.2% had a high school degree or higher, and 13% had a graduate or professional degree. Approximately 4.8% had less than a high school degree. Additionally, there are a diverse array of strong and well-rated school in Plymouth, designed to serve a diversity of students needs and strengths.

There are 28 schools in Plymouth from early childhood education to college (Table 19). Rising Tide Charter Upper School and Plymouth North High School received notable ratings142 and 151 in Massachusetts and 3,569 and 3,870 in the U.S. respectively by the U.S. News and World Report, 2018. Plymouth South High School had lower ratings, 5,634 nationally and 200 in Massachusetts.[129] South Elementary, Indian Brook, Rising Tide Public Charter School, and Manomet Elementary all rate above average on Great Schools. [130] Overall, enrollment at Plymouth's Public Schools is decreasing annually, by approximately by 16 percent over the last 15 years. This data correlates with the population projections of a declining population in youth.

There are three alternative high schools in Plymouth, designed support non-traditional students or students at risk of leaving school without a diploma. Plymouth HARBOR Academy is a Plymouth Public School providing an alternative education diploma for Plymouth Public Schools for those who struggle with mainstream settings. HARBOR is an acronym for their mission: Hope Accountability Resilience Balance Opportunity Respect. Map Academy -is a regional charter school designed to serve students who have had trouble connecting, engaging, and attending school. It provides a tailored education system with high levels of support, particularly for students social-emotional needs. The Southeast Campus School is an integrated, co-ed residential treatment program that in grades 2-12 and part of Plymouth's Home for Little Wanderers. Home for Little Wanderers-provides vital programs and services to strengthen vulnerable families and keep children safe in their own communities. Includes behavioral health, therapeutic residential and special education, adoption and foster care.

Overall, Plymouth has a diverse array of education opportunities to support the traditional and non-traditional learning. Residents are highly educated and are afforded many opportunities to thrive in the education systems. Furthermore, there are a diverse array of recreation and social services with the Plymouth Public School system to enrich the lives of the students and promote greater health and well-being in the long-term.

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[128] Sum, Andrew, Khatiwada, I. and McLaughlin, J. 2009. *The Consequences of Dropping out of High School. Joblessness and Jailing for High School Dropouts and the High Cost for Taxpayers*. Northeastern University.
[129] https://www.usnews.com/education/best-high-schools/rankings-overview
[130] https://www.greatschools.org/massachusetts/plymouth/

4.6 Safety

The MA Department of Public Health identifies violence as a specific category of social determinants of health. However, safety is a better approach in addressing climate change and public health vulnerabilities, strengths, and actions. Threats to safety include self-harm, interpersonal violence between family members, peers, community members, classmates, etc., and collective violence, such as like gang violence or war. Less prominent though as significant threats to safety include repression and neglect and unequal access to power through discrimination and racism. Much research has indicated that threats to safety increase mental illness, substance use disorders, poor academic performance, involvement in the criminal justice system and greater risks to chronic conditions such as heart disease, lung disease, injury (and associated disorders such as bladder and kidney infection, circulatory conditions, central nervous system disorders, joint disease, eating disorders and more), and disabilities.[131]

Threats to safety are not distributed equally among all residents locally, statewide, nationally, or globally. Data indicates that individuals with low incomes, communities of color, LGBQT, people with disabilities, children and seniors are at a greater risk of compromised safety. Climate change is one of the most significant threats to public health, particularly where health disparities already exist. Climate change brings extreme weather events that increase exposure to communities. Climate related disasters such as nor'easters, coastal and inland flooding, drought, wildfire, extreme heat, and vector-borne that may cause conditions that increase the threat to safety. Extreme weather events may increase stress or agitation prompting greater prevalence of interpersonal violence, collective violence, and self-harm. For example, the World Health Organization projected that 20%-50% of victims of natural disasters will experience mild to severe psychological distress.[132] Research on survivors of Hurricane Katrina in New Orleans indicated that there 49% developed anxiety or mood disorder, 17% developed Post traumatic Stress Disorder, and suicide and suicide ideation doubled. Further, these outcomes were distributed widely affecting ALL people and the effects lasted almost two years after the event.[133]

A safer community is one that has prepared for and built resilience to climate change impacts and minimizes the threat to violence. A safer community contributes to better health outcomes overall. This section evaluates safety relevant to Plymouth and how the impacts of climate change can increase or exacerbate existing public health challenges.

4.6.1 Climate Change and Violence

As described in 3.2 Public Health Strengths, Plymouth has lower incidences of violent crimes than other major cities across the Commonwealth and the United States. There are approximately 283

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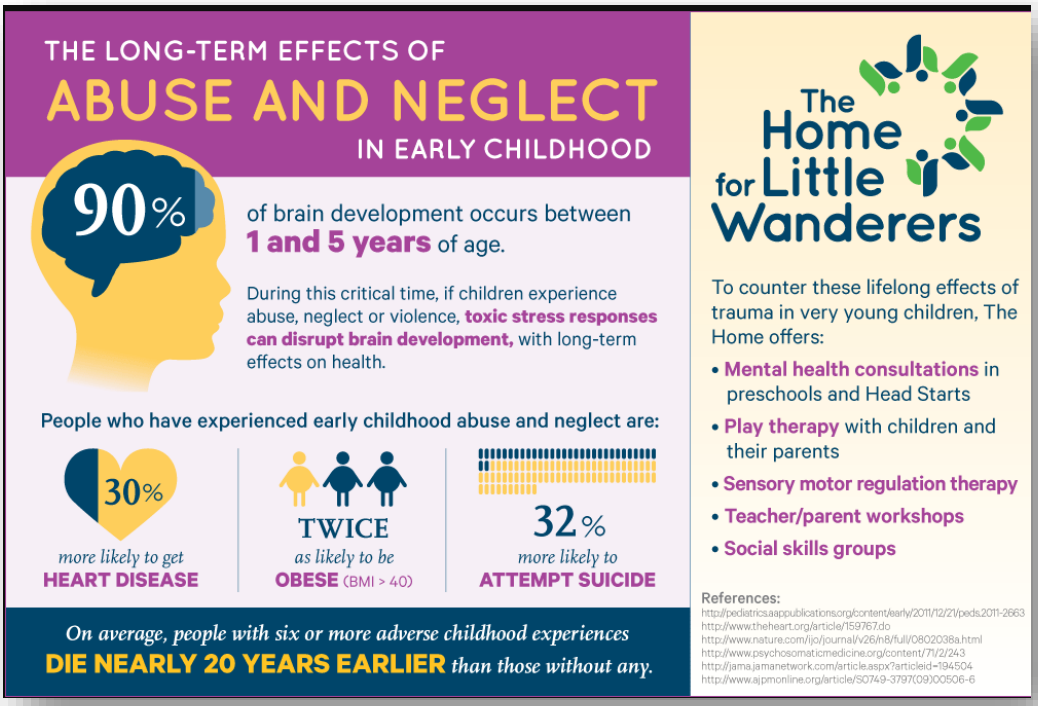
[131] Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017, pp 12-13

[132] World Health Organization Country Office for Bangladesh. Disasters and mental health. Available at: http://www.searo.who.int. Accessed December 27, 2019.

[133] Kessler RC, Galea S, Gruber MJ, Sampson NA, Ursano RJ, Wessely S. Trends in mental illness and suicidality after Hurricane Katrina. Molecular Psychiatry. 2008;13:374–384.

aggravated assault crimes per 100,000 people in 2018 but this is a slight increase from 2017of 252 per 100,000 and property theft was the most prevalent form of violence in the community whereas arson, rape, and murder/manslaughter were the most infrequent crimes.[134] This is an important strength of the community that should be supported to further enhance the safety from increased stressors from climate change.



Some research indicates that exposing individuals to high uncomfortable temperatures increases aggressive thinking, perceived aggression in others, hostile feelings and violent behavior. This violence may also be exacerbated by underlying poverty and resource scarcity. A study on the influence climate change global temperature increase and interpersonal violence indicated a statistically significant relationship where warmer average temperatures were associated with a nearly 6% average increase in homicides.[135] One single standard-deviation increase in temperature elevates the risk of person to person violence by 2.4% and the risk of group to group violence by 11.%.[136] A study on heat and violence in Dallas, Texas indicated that long-term warming as a result of climate change would not likely have associated higher rates of violent crime, injury, and death however spikes in daily ambient temperatures do create higher incidences of violent crimes in the short term. Additionally, the researchers postulated that during

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[134] 2018 Federal Bureau of Investigation Crime Data. Socrata. Open Data Network. https://www.opendatanetwork.com/entity/1600000US2554275/Plymouth_MA/crime.fbi_ucr.count?crime_type=Aggravated%20assault&year=2018

[135] Dennis Mares & Kenneth Moffett, 2016. "**Climate change and interpersonal violence: a "global" estimate and regional inequities**," Climatic Change, Springer, vol. 135(2), pages 297-310, March

[136] CDC, "Heat-Related Deaths Among Crop Workers --- United States, 1992--2006," Morbidity and Mortality Weekly Report (US Centers for Disease Control and Prevention, June 20, 2008), https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5724a1.htm.

extreme heat, individuals were more likely to shelter inside for cooling, reducing crime outside of the home. [137]

If the latter is true, increase frequency of domestic violence is also a potential issue. Because domestic assaults may or may not be reported to authorities, this is particularly difficult to measure. Domestic violence is a public health issue due to its immediate debilitating harm and gives rise to chronic illness, mental health issues, homelessness, and diminished social function in society.[138] There is evidence that climate-related disasters or weather events have caused an increase in domestic violence. A study in rural Australia during a time of declining water supply indicated significant levels of family disruption and violence against women associated with drought and income-related stress.[139] In Massachusetts, one out of three women and one out of four men experience domestic violence in their lifetime and in recent MA history, there are on average 15 domestic violence related homicides per year.[140] Data indicates that a woman takes an average of seven attempts to leave and stay separated from her abuser. There was no immediate data on domestic violence occurrences in Plymouth, however the many social service organizations for supporting domestic and sexual violence in the immediate area are an indicator that domestic violence occurs frequently and regularly requiring demand for services.

4.6.2 Climate Change and Repression

Repression and neglect or unequaled access to power become critically important during times of crisis and extreme weather events. This is particularly relevant for low-income individuals and families, people of color and the LGBQT community.

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[137] Gamble, Janet L. and Hess, J'eremy, J. "Temperature and Violent Crime in Dallas, Texas: Relationships and Implications of Climate Change. West J Emerg Med 2012.13 (3): 239-246

[138] https://www.masslive.com/politics/2017/10/massachusetts_lawmakers_addres.html

[139] Whittenbury, Kerri. "Climate Change, Women's Health, Wellbeing and Experiences of Gender Based Violence in Australia. In *Research, Action, and Policy: Addressing the Gendered Impacts of Climate Change*.

[140] https://www.respondinc.org/dv-facts-stats/

The LGBQT community in Massachusetts and Plymouth is a growing population. According to the Massachusetts Department of Elementary and Secondary Education analysis of the 2011-2015 Massachusetts Youth Risk Behavior Survey, 14.8% of Massachusetts youth identified as Sexual and/or Gender minority. Due to data limitations, MA Dept. of Public Health believes that this is an undercount of actual rates. Among sexual/gender youth, 63% are white, 20%are Hispanic, 9% are Black, 5% are Asian, and 3% are Multi-Ethnic.[141]

In disaster preparedness, the LGBQT community is 120 time more likely to report homelessness than heterosexual and cisgender. Homelessness presents an even greater risk to heat illness, injury and displacement during emergencies. Data indicates that the LGBQT community is more socially isolated than seniors, increasing risk of illness or death in an emergency. Furthermore, the LGBQT are more likely to formulate their own community, living in closer proximity to each other building a strong community support system. If extreme weather events cause destruction or displacement of their safe community, LGBQT at greater risk of harassment, including shelters. Finally, LGBQT are at greater risk of discrimination and marginalization during emergency protocols that are cisgender (male and female divisions in emergency housing and sanitary facilities, problematic, denial of services, discrimination, and violence.[142]

These issues are problematic to low income individuals, communities of color, recent immigrants, or others experienced repression, neglect, or unequaled access to power. However, Plymouth Pride, Inc. was recently established celebrating the diversity and inclusion of the LGBQT community. This is an invaluable resource to build better social cohesion, community support, and greater access to power and services, particularly in the face of climate change.

4.6.3 Climate Change and Mental Health

Climate change can affect mental health in three ways, Immediate Impacts, Gradual Impacts, and Indirect Impacts. Immediate Impacts are acute response or sudden onset from destructive storms or emergency response to disaster. This can cause post-traumatic stress disorder (PTSD), anxiety, stress, and depression. The self-harm response can include substance abuse and suicidal ideation. First responders of professionals engaged in the front-line of the acute event are highly vulnerable to the Immediate Impacts. These include first responders, journalists, health care workers, and medical professionals.[143] Gradual Impacts of climate change on mental health are defined by a slowly progressing long-term conditions associated with climate change impacts like rising temperatures, rising sea levels and changing precipitation patterns. Chronic stress is a result. Though this category may or may not lead to self-harm, the long- term implications elevate risk of nutritional deficiencies, diabetes, and chronic diseases for example. The Indirect Impacts of

[141]Massachusetts Department of Public Health. Massachusetts State Health Assessment. Boston, MA; October 2017.Chapter 2

[142] American Public Health Association. 2018. *Climate Change, Health, and Equity: A Guide for Local Health Departments*.

[143] American Public Health Association. 2019. *Addressing the Impacts of Climate Change on Mental Health Well-Being*. Policy Report Number 20196

climate change on mental health include how climate change affects how a person believes in themselves, their community, humanity, and the world. The implications of Indirect can be severe with long-term implications.[144]

Indirect Impacts of climate change can create a diminished sense of self, difficulty in relating to others, loss of sense of place or one's physical environment which ultimately can lead to domestic violence, child abuse, assault and community violence. [145] Men and women experience Indirect Impacts differently. Date has indicated that women and widows demonstrate a more immediate emotional response after a climate change event and may be disproportionately affected by the disaster in comparison to men. For example, women may have increased stress due to new and greater responsibilities for caregiving for children and elderly parents, financial hardships, and defending against violence.[146] Men may have a long term depression with Indirect Impacts such associate with feelings of guilt, inadequacy, and stigma associated with their inability to work or provide for their family after a climate-related event.[147]

Self-harm in the form of addiction can be a serious public health crisis in response to climate change impacts and mental health, particularly for Plymouth. According to the Bureau of Substance Addiction Services in MA, 52.3% of patient treated for addiction in 2018 had received prior mental health treatment. Furthermore, treatment for addictions in Plymouth have significantly increased to Heroin treatment from 24% in 2008 to 49% in 2017. [148]

Understanding these safety challenges in Plymouth provides a robust opportunity to expand priorities and care to support communities to prepare for and recover from Direct, Gradual, and Indirect impacts of climate change on mental health and safety. Climate Change adaptation measures should inform a robust cognitive approach that supports preparation and recovery of climate change from first responders to families.

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[144] American Public Health Association. 2018. *Climate Change, Health, and Equity: A Guide for Local Health Departments*.. p 157

[145] American Public Health Association. 2018. *Climate Change, Health, and Equity: A Guide for Local Health Departments.*. p 157

[146] Dodgen D, Donato D, Kelly N, et al. Mental health and well-being. In: Crimmins AJ, Balbus J, Gamble JL, et al., eds. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Washington, D.C.: U.S. Global Change Research Project; 2016.

[147] Dodgen D, Donato D, Kelly N, et al. Mental health and well-being. In: Crimmins AJ, Balbus J, Gamble JL, et al., eds. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Washington, D.C.: U.S. Global Change Research Project; 2016.

[148] https://www.mass.gov/doc/admissions-statistics-by-city-and-town/download

4.7 Community Cohesion

Community cohesion refers to the strength of relationships and sense of connectedness and solidary across a community. Strong social cohesion enables communities to develop and enforce social norms (e.g. appreciation for nature, respect for elders), connects people to information and resources across social networks (i.e. social capital), and facilitates collective action. These factors are critical to our response to and recovery from weather-related disasters and other moments of crisis. Researchers have demonstrated that community cohesion saved lives during the Chicago heat wave of 1995, and positively influenced recovery following Superstorms Sandy and Katrina.[149] A more than decade long longitudinal study of Hurricane Katrina survivors, the RISK Project, has even demonstrated that social supports can promote post-traumatic growth, or thriving following adversity, among survivors.[150] More recently and closer to Plymouth, the COVID-19 public health crisis has heightened awareness of the importance of community cohesion as public agencies, community-based organizations, and neighbors have mobilized to establish and enhance mutual support networks.

Figure 41 The Plymouth Public Library offers free classes and online resources for Plymouth residents trying to learn English as a second language.

Conversely, social isolation is among the strongest indicators of vulnerability to climate change. Social isolation limits our access to information, resources, and social and emotional support systems. People experiencing social isolation are at higher risk for heat-related illness, injury and

[149] American Public Health Association. 2018. *Climate Change, Health, and Equity: A Guide for Local Health Departments*.

[150] Manove, E. E., Lowe, S. R., Bonumwezi, J., Preston, J., Waters, M. C. & Rhodes, J. E. (2019). Posttraumatic growth in low-income Black mothers who survived Hurricane Katrina. *American Journal of Orthopsychiatry.* Advance online publication. doi:10.1037/ort0000398.

poor mental health outcomes during and after a weather-related disaster. People living in social isolation also experience higher rates of stress, anxiety, depression, and a wide range of physical health conditions.[151] Climate impacts can worsen these associated health conditions. A risk factor for social isolation is living alone; 23% of Plymouth households consist of a single person living alone. The impact of social isolation on health and climate vulnerability is worse for people experiencing other forms of marginalization, including people experiencing homelessness, low-income individuals, older adults, people with disabilities, and people with low levels of English proficiency.[152] Nearly 8% of Plymouth residents speak a language other than English; of those, 30% speak English less than very well.

A climate resilient community fosters social cohesion and builds social capital across diverse segments of the community. Focus group and public forum participants identified strong social bonds and a spirit of civic engagement as areas of strength for the Town of Plymouth. They also expressed strong support for increased levels of public outreach and engagement around climate issues and for climate action in close collaboration with neighborhood groups, community-based organizations and civic associations. Engagement participants most strongly supported the idea of Plymouth leveraging the social capital of these groups to build political will for action on climate change. The Climate-Ready, Healthy Plymouth project team did a survey of these types of groups during the development of the community engagement strategy and more groups emerged through the engagement activities. The list of organizations is included in the Engagement Strategy in

[151] Kafeety, A., Henderson, S.B., Lubik, A., Kancir, J., Kosatsky, T., Schwandt, M., (2020). Social connection as a public health adaptation to extreme heat events. Canadian Journal of Public Health.
[152] Ibid.

Appendix C Public Engagement and Presentation Materials. Many of these organizations have a specific mission of serving the needs of people at greatest risk for isolation and promoting their inclusion in Plymouth society.

V. Public Engagement Analysis and Summary

Throughout winter and spring 2020, the project team organized various engagement activities to learn about Plymouth residents' experiences with and views on public health and climate issues and to gather their ideas for action. MAPC staff, Town of Plymouth staff, and the Core Team worked together to develop a community engagement strategy for Climate Ready, Healthy Plymouth. The purpose of the community engagement for this assessment and action plan was threefold:

- Exchange information and knowledge between Plymouth's residents, businesses, community-based organizations and other stakeholders and MAPC and town planning staff about the challenges facing Plymouth and potential resilience actions.
- Engage stakeholders in crafting a vision for a healthy, climate resilient Plymouth by exploring common challenges, identifying shared values, and contending with potential trade-offs.
- Empower stakeholders with the tools necessary to act on the plan's recommendations.

In addition, the project team developed several goals for the engagement process:

- Stakeholders develop a deep understanding of Plymouth's current and future challenges so that they can provide meaningful feedback about what actions they want to prioritize.
- Planning staff and other core team members develop a rich understanding of the nature of the relationship stakeholders have with Plymouth and with populations within Plymouth most likely to experience health impacts from climate change.
- Craft a comprehensive climate change vulnerability assessment and action plan that prepares Plymouth to implement solutions for future resiliency-related challenges, while equitably protecting and promoting the public's health, environment, and economic prosperity.
- Achieve MVP designation to quality for state grants for implementation.

A full description of this project's Engagement Strategy can be found in Appendix C Public Engagement and Presentation Materials.

Engagement Activities and Outreach

The project team designed and facilitated several different engagement activities in support of the purpose and goals outlined above. These included a public meeting, focus groups, and a project webpage hosted on the Town's website.

Project staff and Core Team members contacted potential stakeholders and members of the public using a variety of engagement methods, depending on the engagement activity. The project team worked together to include an extensive and diverse list of stakeholders in the Engagement Strategy. Everyone worked collaboratively to contact organizations and individuals using flyers, the Town website, organizational newsletters, social media, email, and phone calls to individuals. The project also received news media attention, including coverage in an episode of PACTV's Town Talk. Members of the public continue to have access to the episode on PACTV's website and to other project content on the Climate Ready, Healthy Plymouth webpage.

Public Forum

Photo Credit: Wicked Local/Emily Clark

MAPC staff facilitated a public forum in January 2020 at the Plymouth North High School, which had approximately 60-80 participants. Outreach for the public forum included flyers shared by Town staff and Core Team members, traditional public notice, press releases sent to local media outlets, and emails sent to all the stakeholders listed in the project Engagement Strategy. The forum began with an informal open house, where attendees were able to engage with informational and interactive boards covering different Climate Ready, Healthy Plymouth topics. Attendees were then given an overview of the project and a summary of Plymouth public health issues and climate impacts. During the presentation, participant feedback was solicited via Poll Everywhere, an online tool that enables participants to text responses to questions live during a presentation. Paper copies of the in-presentation questions were distributed as well. After the presentation, attendees broke into small groups facilitated by Core Team members and asked to discuss their responses to a series of questions related climate impacts and potential solutions. This activity was designed to guide the assessment and future engagement.

Focus Groups

MAPC and OCPC staff conducted focus groups within five Plymouth neighborhoods – Manomet, Plymouth Center, North Plymouth, West Plymouth, and South Plymouth. Each neighborhood, with exception of South Plymouth, has a Steering Committee consisting of resident volunteers who meet regularly and are charged with implementation of the neighborhood's Master Plan. The focus group were conducted with members of these steering committees, as well as representatives from local organizations and the business community. Once focus group participants were identified, the project team recruited them through an email invitation and one-on-one conversations.

At each focus group, participants were first given a project overview as well as an introduction to the public health issues currently facing Plymouth and an overview of the current research regarding heat, sea level rise, coastal erosion, and severe storms. MAPC and OCPC staff then led participants through a series of facilitated exercises aimed at gathering their experiences and concerns related to climate change, defining the problem, framing solutions, and generating ideas for discussion. The Focus Group presentation is attached in

Focus Group Location	Date	# of Participants
Manomet	1.30.20	9
Plymouth Center	2.5.20	8
North Plymouth	2.13.20	8
South Plymouth	2.19.20	4
West Plymouth	2.19.20	7
Total Focus Group Participants		**36**

Public Forum and Focus Group Findings

Top Strengths

- Natural and Recreational Areas
- History
- Sense of Community and Civic Engagement
- Downtown

Top Climate and Pubic Health Challenges

- Coastal Erosion
- Flooding Threats to Roads, Public Facilities, and Homes
- Water Contamination in Ponds
- Vector-borne Illness from Mosquitos and Ticks
- Power Outages
- Habitat Loss

Top Climate Actions

- Clean Energy Investments
- Shoreline Protection
- Open Space Conservation and Development Regulations
- Climate Change Outreach and Education
- Water Resources Conservation and Quality Improvement

Plymouth Strengths

Public Forum and Focus Group participants were asked to identify Plymouth strengths and features of the community they thought important to preserve as the town continues to experience climate-related changes. Residents most frequently mentioned natural and recreational resources as Plymouth's greatest strength, particularly the shoreline, ponds, and forests. The shoreline was overwhelmingly the most frequently mentioned community asset when combining word counts of terms like "ocean," "coast," "beach," and "shoreline." Residents also spoke repeatedly about passive and active recreational opportunities at the beach, ponds, and on paths and trails throughout the town. North Plymouth, Plymouth Center, and Manomet residents spoke most

extensively about the coastal features, trails, and parks, while West Plymouth and Manomet residents spoke most extensively about forested walking paths.

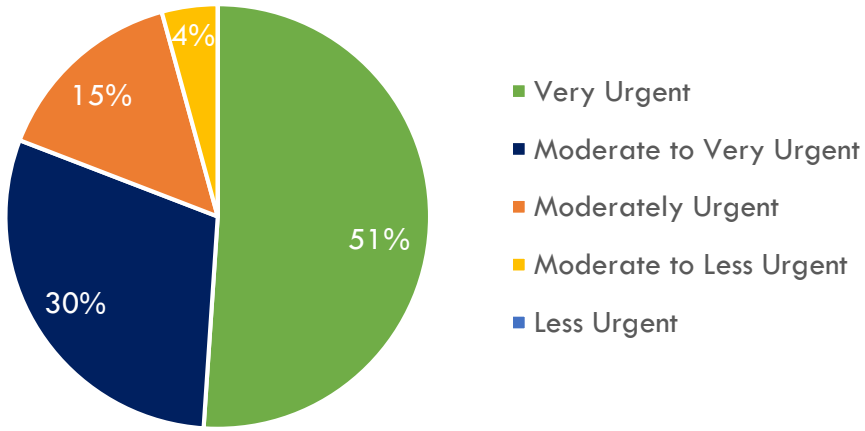
Residents also expressed appreciation for Plymouth's "complete community" character and a sense that the town "fulfills all [their] needs." Beyond access to natural resources, it has a "walkable downtown" bustling with "small business" activity, "convenient proximity to Boston and the Cape", "good schools", a "tight-knit and civically engaged community", and a deep sense of "history". Plymouth's history was the second most frequently mentioned asset after natural resources. Residents spoke about both historic landmarks, architecture and events, as well as summer community traditions. Several participants visited Plymouth during summers as children or young adults and then decided to make a permanent move to the community. Despite their appreciation for these features, residents acknowledged the pressures that come with the community's attractiveness as a summer destination and residential community (e.g. sprawl from new development, traffic, and littering). Residents cautioned against the risk of losing natural resources and some of the rural quality of the community to these pressures.

"We are so close to water, so many trees, fresh and salt water access, and great air quality. Most people don't know what it is like to live in a place like this. They come from all over to experience this, and we live it. We take it for granted."

"Plymouth is the only place in the South Shore that fits all your needs. We have a lot of friends who are trying to buy houses in Plymouth because of the downtown and open spaces, but there's issues when you attract more people; you're going to bring more traffic."

Figure 42. Out of 47 responses, most participants supported the idea that climate change is an urgent issue for Plymouth, but a higher share of Public Forum participants expressed greater urgency on the issue of climate change.

Participant Responses to the Question:
How urgent of an issue do you think climate change is for Plymouth?



	Very Urgent	Moderate to Very Urgent	Moderately Urgent	Moderate to Less Urgent	Less Urgent
Focus Group	11 (41%)	9 (33%)	5 (19%)	2 (7%)	0

(27 Votes)					
Public Forum (20 Votes)	13 (65%)	5 (25%)	2 (10%)	0	0
Total	24 (51%)	14 (30%)	7 (15%)	2 (4%)	0

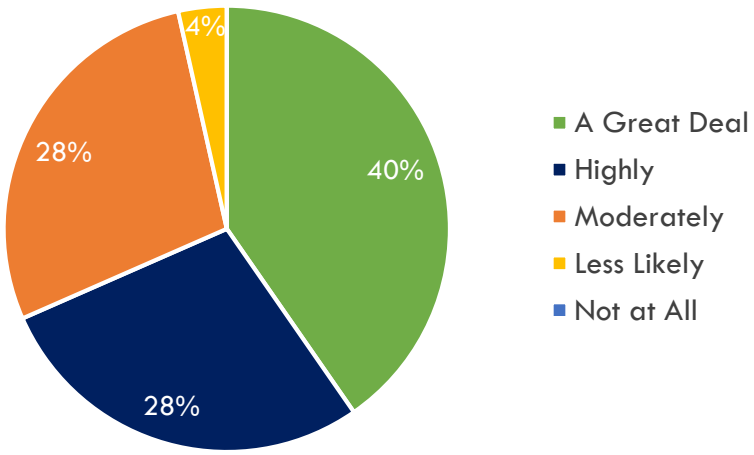
Additionally, residents referenced the town's record of grassroots driven environmental stewardship and Town planning as strengths and drivers of climate action. Focus group and public forum discussions suggested ongoing organizing related to plastic waste reduction, conservation and trails development, and water system planning.

Plymouth Challenges

Most Plymouth residents supported the idea that climate change is an urgent issue for the Town of Plymouth. Most residents also believe that climate change will impact them "moderately" to "a great deal". Forum and focus group facilitators asked participants what experiences or concerns factored into their sense of urgency and personal vulnerability. In response, residents highlighted various climate and health-related challenges facing the Town. MAPC staff analyzed and categorized these responses according to their relationship to Plymouth's infrastructure, society and public health, and environment (Figure 42zzzzz0

Figure 43 Most participants expect they will be impacted by climate change moderately to a great deal.

Participant Responses to the Question:
How much do you think future climate change will affect you or your family?



	A Great Deal	Highly	Moderately	Less Likely	Unlikely
Focus Group (27 Votes)	11 (41%)	5 (19%)	9 (33%)	2 (7%)	0
Public Forum (30 Votes)	12 (40%)	11 (37%)	7 (23%)	0	0
Total	23 (40%)	16 (28%)	16 (28%)	2 (4%)	0

Infrastructure Challenges

The challenges that Plymouth residents mentioned most frequently when discussing climate-related challenges to infrastructure were flooding, severe storms, and coastal erosion.

The type of infrastructure thought to be most vulnerable to flooding included roads, coastal parks, homes, town facilities, and downtown businesses (listed by frequency of mentions). Residents acknowledged some of the work the Town and local stewardship organizations have recently completed to protect roads and town facilities from flooding, including the planned conversion of Stevens Field into a climate smart park. Even so, residents discussed how flooding has occurred and continues to be a risk to roads and Town facilities, requiring expensive and recurring repair.

Residents also described coastal erosion and storms as significant threats to homes and roadways. Coastal homes are damaged by erosion and storms, yet people continue to build new homes and renovate existing homes along the coast. Some homeowners have resorted to "armoring" their properties to protect them from damage, but residents suggested that this technique places neighboring properties at greater risk. Most residents expressed support for the Town's work on the seawall but recognized that needed upgrading and recurring maintenance represent a significant expense to the town.

"Road repairs are costly; do we keep repairing things or do we rethink due to the frequency of storms?"

"I live in a historic coastal district. New FEMA maps placed my home directly within the flood plain. My personal impact from climate change is high."

"After a storm more money is invested into a property that should retreat rather than rebuild; at what point can a town step in?"

The need to weigh the "pros and cons of rebuilding" vulnerable infrastructure and of investing even more public funds into a seawall came up repeatedly across focus groups. Residents described Town Meeting deliberations on these investments, and some even debated the merits of the investments with other focus group members. However, most participants commenting on the issue questioned the wisdom of continuing to spend public resources on infrastructure that will become increasingly vulnerable to climate impacts.

Other infrastructure challenges discussed by residents included the poor condition of some fire stations and impact to emergency response, heat island effects created by shopping centers and other highly paved areas of town, and the impact of development patterns and activity on fire response capacity. On the latter point, some residents expressed concern that combined impact of developing natural areas, cottage conversions, and narrow roads are impede response times to fire threats.

Society and Public Health

The challenges that residents mentioned most frequently when discussing climate-related impacts to society and public health were vector-borne illness, urban heat islands and exposure to extreme heat, contamination of local ponds, and power outages.

Often, residents made linkages between several of these hazards and the general trend of rising temperatures. While several residents shared their pleasure with the warmer winter (e.g. "less snow removal"), most expressed concern for the implications on the coming mosquito and tick seasons. Residents recalled past summer and fall experiences related to the rise of Eastern Equine Encephalitis (EEE), which led some people to limit their and their children's time outdoors. Residents also discussed possible exposure to West Nile virus and Lyme disease.

Residents discussed impacts of warming temperatures and stormwater runoff (e.g. "pet and septic waste, fertilizers") on pond water quality, which poses a potential threat to the health of people using the ponds for recreation (e.g. "cyanobacteria:"). Other threats to water quality and water supply included sea water intrusion, drought, and over-consumption.

Concerns about extreme heat featured most prominently in North and West Plymouth, where large areas of impervious surface and reduced tree canopy contribute to urban heat island effect. Residents noted large temperature differences across parts of town with different levels of tree canopy and lamented a recent loss of older trees in North Plymouth. People living in homes without AC are more vulnerable to heat-related illness, especially isolated older adults. Shopping areas, such as Colony Place, are advertised for walking but "lack adequate shade and get too hot."

> "What about ticks, mosquitos? People refuse to be active, but it's hard to keep kids inside. Because we're such a tourist area, people bring pets - could bring in different breeds of ticks."
>
> "There is a lot of money and talk about seawalls, but I think the biggest impact is the loss of electricity for elderly or in the winter when we are freezing cold - immediate health crisis. I was concerned about my elderly father who was boiling water (to keep warm). If you are looking for impact on people, electricity has to be part of the discussion."

Most focus group participants described some experience with power outages, mostly credited to downed trees during storms; this was a deep concern for a few individuals. Power outages expose people to extreme cold, extreme heat, loss of power to medical devices, and refrigeration for food and medications, etc. Older adults are more likely to be socially isolated during a severe storm and require more assistance, especially during an outage.

Residents also often discussed access to and condition of recreational facilities across town, which enhance overall quality of life but also provide residents with opportunities for physical activity. Residents credited beach erosion, storm damage, and overuse for the poor condition of some facilities, but noted planning that is underway to improve them (e.g. Stevens Field). Another barrier often noted was inadequate bike and pedestrian access to recreational areas. Residents also described poor transit and commuter rail access.

Environment

The challenges that residents mentioned most frequently when discussing climate-related impacts to the environment were habitat loss, water contamination, and declining forest health. Again, residents made linkages between several of these challenges and trends in rising temperatures (e.g. impacts to cranberry production from fewer frosts).

"There's a new 15-acre solar array in West Plymouth. They're just clear-cutting forest. Does the benefit outweigh the cost?"

"Plymouth is putting cart before the horse. Building is out of control. We got forest animals walking on the streets."

Warming water temperatures and stormwater runoff (e.g. "pet and septic waste, fertilizers") contribute to blooms of cyanobacteria. Warming bog water is also a challenge for local cranberry farmers. Dam removal and land conservation has helped mitigate temperature increases on local waterways, but residents agreed that more needed to be done to prevent runoff to ponds.

One reason described for the frequency of power outages is the poor health of local forests resulting in more tree falls during heavy winds and precipitation. Residents described several threats to local forests, including habitat loss resulting from development and clearings for installation of large solar arrays. Warming temperatures are also attracting invasive species and promoting the growth of local, but opportunistic species that contribute to worsening forest health. One resident also suggested that poor forest health can also contribute to wildfire threat.

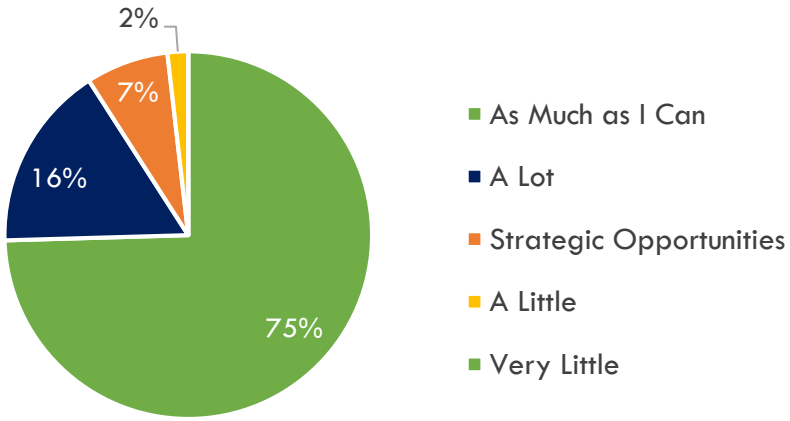
Other mentioned challenges relevant to environment include coastal erosion, seawater intrusion, and plastic waste pollution, especially along roadways and in areas with high tourist traffic.

Plymouth Climate Action

A majority of focus group and public forum participants expressed strong support for climate action by the Town of Plymouth. Forum and focus group facilitators asked residents to suggest types of actions individual residents, community groups, or the Town could take to lessen or prevent the impacts of climate change. Residents identified a range of possible actions from clean energy investments to land use policies to climate-related outreach and education. MAPC staff analyzed and categorized these responses according to their relationship to Plymouth's infrastructure, society and public health, and environment.

Figure 44 Three quarters of focus group and public forum participants support action on climate change by the Town of Plymouth.

Participant Responses to the Question:
How much would you support climate action by the Town of Plymouth?



	As Much as I Can	A Lot	Strategic Opportunities	A Little	Very Little
Focus Group (27 Votes)	17 (65%)	5 (19%)	3 (12%)	1 (4%)	0
Public Forum (30 Votes)	24 (83%)	4 (14%)	1 (3%)	0	0
Total	41 (75%)	9 (16%)	4 (7%)	1 (2%)	0

Infrastructure

The actions residents mentioned most frequently relating to infrastructure included energy efficiency and clean energy, shoreline protection, development regulations, and land and water conservation.

> "If you believe solar is part of the answer to where we are, allowing development of solar on agricultural land can help keep the farm viable. The 5-acre limit is a barrier in Plymouth."

Residents most consistently recommended energy efficiency and clean energy measures across the public forum and focus groups, and even noted Plymouth's progress towards Green Communities designation. Residents articulated support for "green buildings," "electrification of municipal and transit vehicle fleets," "community solar," "solar on rooftops, carports, cranberry bogs", and "micro-grids." Individuals described micro-grids to ensure consistent power to water treatment plants and other facilities in emergencies and community solar as an option to expand solar to renters and homeowners without the appropriate roofing. Individuals in different focus groups also discussed the pros and cons of solar infrastructure. Clear-cutting forest for large arrays was perceived as undesirable, but a representative for cranberry farmers suggested that the economic and resilience benefit to farmers should outweigh aesthetics-based opposition to on-farm solar.

Residents promoted shoreline protections, open space conservation, and development regulations as a response to coastal storm and erosion-driven damage to public facilities and private property. Shoreline protection recommendations included both structural and natural approaches (e.g. sea wall maintenance, dune nourishment, rigid revetments, re-routing of the Eel River, climate smart parks). However, support for natural approaches was more common, and even though residents voiced support for some continued investment in sea walls, several expressed apprehensions about the costs associated with emphasizing sea wall-focused strategies. Some residents encouraged consideration of managed retreat through buyouts and conservation of coastal land as an alternative to recurring repair or rebuilding of sea walls, coastal roads, and coastal residences.

Residents also suggested avoiding locating critical facilities in wetland areas, elevating roads (when feasible), and integrating low impact development features into new facilities to prevent damage from inland flooding. Cluster developments, regulation of cottage conversions, and permanent protection of open space were also suggested strategies to protect forest lands and lower fire risks.

Another infrastructure-related action recommended by residents was improvement of non-vehicular transportation options in the community, including commuter rail and water transit.

Public Health and Society

The actions residents mentioned most frequently relating to society and public health included protection of water quality and water supply, climate-health outreach and education, shading and cooling, and improved access to and protection of open spaces.

> "We are swimming in the summer time. Others would do so if they had access to water and were confident in the quality of those ponds. Clean the ponds so we can recreate in them."

In order to protect the health of people visiting local ponds, residents recommended increased water quality testing and stormwater pollution control. Control measures include maintaining buffer areas, limiting fertilizer use, upgrading cesspools, pumping septic tanks, controlling dog waste, and regulating development near water ways. The ongoing Water Master Plan process also featured prominently in discussion, with many residents suggesting water conservation measures to protect drinking water supply.

Residents also supported various approaches to improve outreach to older adults and hard to reach populations about weather-related emergencies and exposures to vector-borne disease and other climate-health risks. Residents suggested leveraging community groups and associations, school curriculum, local and social media to share these messages.

Recommendations to protect residents from exposure to extreme heat including green building design, ensuring access to AC in affordable housing, preserving forest lands, tree planting and maintenance, developing walking trails with permeable surfaces in shaded areas, and improving pedestrian and bicycle access to recreational areas and ponds. Improved forest management could also help reduce the likelihood of power outages. Although, one person additionally suggested burying power lines.

Environment

The actions residents mentioned most frequently relating to environment included protection of water quality and water supply, conservation and restoration of natural areas, and plastic waste reduction.

The recommendations for protecting water quality and supply are consistent with those identified under society and environment, which includes water conservation, water quality testing, and controlling sources of stormwater runoff. Residents noted many recent and ongoing conservation efforts to restore habitat and improve water quality, including dam removal projects. One resident suggested finding ways to celebrate and share these efforts to build more support for climate action.

> "Dam removal has quietly made Plymouth more resilient. We need a way to recognize and celebrate the actions people have done. People are interested in what has happened in Tidmarsh and there are people here who would support open space conservation."

Residents strongly emphasized the value of protecting natural areas from development. Some individuals also suggested developing a forest management plan and increasing staffing for forest management as an additional way to improve the health of local forests.

Another action area that received strong support from residents was plastic waste reduction, which includes actions such as banning single-use plastics and installing water-refill stations in schools and areas of town with heavy tourist traffic.

Context for Action and Future Engagement

The project team also learned two important lessons through the engagement activities that broadly apply across infrastructure, society and public health, and environment: 1) residents are acutely aware of need to balance the cost of climate action and inaction, and 2) people's perceptions of their own vulnerability to climate change sometimes boils down to their perceived risk to a single or small set of potential climate impacts.

Residents suggested that several large cost items have come to Town Meeting in recent years (e.g. two high schools, sea wall improvements, a promenade project) and that appetite for more spending is low. While most support town action on climate change, they recognized other competing and urgent demands (e.g. road maintenance, fire stations). Most focus group participants expressed a desire to better understand the range of costs associated with climate action and climate inaction (e.g. "what is the cost of not investing in stormwater infrastructure now?").

Factors that might make someone ***less likely*** to be impacted by climate change:

Factor/Question	# of Yes Responses
Does someone in your household have a car?	49
Do you know your neighbors well enough to help each other out if needed?	38
In case of a flood or other disaster do you have someplace to stay outside of your neighborhood?	33
Do you have enough money saved to draw upon if you missed a paycheck?	42

Factors that might make someone ***less likely*** to be impacted by climate change:

Factor/Question	# of Yes Responses
Do you - or someone in your household - have allergies or asthma?	27
Does someone in your household have limited mobility?	3
Does your electricity sometimes shut off in a storm?	30
Is there someone in your household who would be afraid to call for help in an emergency?	2

Second, most residents indicated that they anticipated they or their families being personally impacted by climate change, but there was more variability in responses on this poll question than

on the question related to the urgency of climate change and support for climate action. That pattern is not unique to Plymouth and reflects national attitudes on climate change. More Americans report being worried about climate change than think climate change will personally impact them. Across several focus groups, residents explained that they voted according to the level of exposure their home has to potential flooding. Those with homes at higher elevations described their anticipated personal impact as low or moderate.

Flood risk alone does not determine people's vulnerability to climate impacts. People's vulnerability to climate change depends on many different factors. To illustrate this fact, public forum and focus group participants were provided with a Climate Justice Activity. The Activity, which looks like a bingo board, asks residents to indicate with a sticker dot whether a factor influencing climate vulnerability applies to them. The Climate Justice Activity poster and full responses can be found in **Error! Reference source not found.**.

Community Resilience Building Workshop and Listening Session

In April 2020, the project team launched a virtual Community Resilience Building (CRB) Workshop. The workshop is a critical step to achieving Municipal Vulnerability Preparedness designation and is intended to gather information from representatives across diverse segments of the public on Plymouth's climate strengths, vulnerabilities, and potential resilience actions. These forums typically bring representatives together from across businesses, education, housing, social services, emergency preparedness, environmental stewardship, etc. Plymouth's CRB Workshop represented the first time this forum has been conducted entirely online. The project team integrated videos, printable materials, virtual office hours, and a survey to facilitate online engagement and data collection. The project team will hold a Listening Session in summer 2020 to share findings from the workshop and engage the public in prioritization of resilience actions.

VI. Climate Ready Healthy Plymouth Action Plan

Based upon extensive public engagement and responses from the Community Resilience Building workshop, the following are a summary of the Plymouth residents', stakeholders', and businesses' recommendations for acting on climate and public health. Participants voted for their top priority actions via poll at the Final Public Forum on May 26, 2020.

5.1 Plymouth Top Priority Actions

Increase Access to Recreation opportunities for residents in every neighborhood by improving existing facilities and expanding walking and bicycling paths so that people have safe, non-vehicle alternatives to access open space amenities.
Prepare for Emergencies using an integrated preparedness and communications plan that leverages diverse media, social networks, and neighborhood response teams to prioritize the wellbeing of vulnerable residents.

Conserve Natural Areas and Prevent Sprawl by encouraging adaptive reuse of older buildings, incentivizing cluster developments, and acquiring and permanently conserving properties in ecologically sensitive areas, especially along coastlines and wetlands.
Manage and Protect Water Resources through frequent water quality testing, water conservation measures, regulating sources of pollution (e.g. pesticide and fertilizer use), and by completing and implementing the Town's Water Master Plan.

Upgrade Residential Wastewater Systems by providing incentives and assistance to homeowners, so they can inspect and upgrade cesspools and septic system or connect to town sewer.

Promote Renewable Power and Energy Efficiency by securing Green Communities designation, supporting adoption of electric vehicles, reducing municipal energy use, encouraging residential and commercial energy efficiency, and facilitating solar power generation on roofs, parking lots, and farms.

5.2 MVP Society and Public Health

Enhance Health System Capacity by hiring and training qualified public health staff, enhancing disease surveillance systems (e.g. heat-related illness, vector-born disease), supporting enforcement action by the Board of Health, and developing multi-platform climate health education and prevention campaigns.

Promote Climate and Health Education to both improve public health literacy and awareness of climate and health impacts, including to support individual-level actions (e.g. protection from vector-borne illness).

Help Residents Keep Cool as temperatures get hotter by helping older adult and low-income households access home weatherization and energy efficient cooling, planting trees, installing shade structures, and reducing impervious surface in heat islands, and by deploying cooling and emergency shelters.

5.3 MVP Environment Actions

Protect the Shoreline using both structural and natural approaches, including sea wall maintenance, rigid revetments, dune nourishment, habitat restoration, and flood parks. Specific shoreline protection projects include:

Plymouth Long Beach

- Beach nourishment seaward of the dike from the main beach to the Crossover
- Nourishment/create cobble berm on harborside north of Crossover
- Mixed sediment nourishment at Warren's Cove
- Nourishment/stabilization of shoreline day parking to Crossover
- Nourishment/stabilization at point
- Marsh restoration on the harborside

White Horse Beach

- Dune and beach nourishment

Manomet Point

- Maintain coastal structure

Ellisville Harbor

- Coastal shoreline and inlet protection at Ellisville Marsh

Plymouth Harbor

- Reconstruct bulkhead at harbor between Wood's Seafood and Lobster Hut
- Reconstruct seawalls and revetments along Water Street – Plymouth Harbor

Increase Forest Management by developing a forest management plan and increasing staffing to maintain healthy forests and mitigate fire risks (e.g. thinning forests mechanically and with prescribed burns).

Continue Restoration Efforts focused on dam removal, flood mitigation, wetland and forest habitat expansion, while also monitoring and celebrating conservation successes (e.g. Living Observatory). Specific projects include:

Jenney Pond Dam

- Repairs to Jenney Pond Dam
- Dredging of Jenney Pond
- Construction of bypass at Jenney Pond Dam

Cranberry Bog Natural Restoration

- Restore decommissioned cranberry bogs back to natural wetlands – town wide

5.4 MVP Infrastructure Actions

Mitigate Stormwater Runoff and Heat Islands from impervious surfaces by redesigning areas with excess pavement (e.g. install rain gardens), encouraging cluster development, and integrating stormwater management measures into new developments.

Safely Store Fuel Rods from the Pilgrim Energy Plant.

Prevent Power Outages to critical facilities during and following emergencies by burying power lines, equipping facilities with back-up generators, and developing micro-grid and energy storage systems.

Prevent Repeated Damage to Homes using regulations to prevent damage to homes and public infrastructure, promoting landward migration and by gradually buying and removing homes at highest risk for coastal storms and erosion.

5.5 Other Recommended Actions

Onsite Wastewater Systems

- Hire an engineer to fully assess the vulnerability of to flooding and exposure to ponds and other water bodies. Investigate options to optimize function and minimize contamination with high water table and coastal and inland flooding.

Heat Preparedness

- Create and implement a plan to increase tree canopy cover in North Plymouth to reduce the urban heat island effect. Install trees in the public realm as well as require greater tree canopy cover in new and redevelopment.
- Help older adult and low-income households access home weatherization and energy efficient cooling,
- Install shade structures in areas where increasing tree canopy is not feasible.

Energy Efficiency and Greenhouse Gas Emission Reductions:

- Secure Green Communities designation to unlock funding and technical assistance to help the town cut its energy consumption
- Support adoption of electric vehicles (EVs): Electrify transit and municipal fleets, require charging stations in new developments, and install charging stations in other parts of town
- Reduce municipal energy use: transition public lighting to LED lights, conduct energy retrofits of public facilities (esp. safety buildings).
- Create a Net Zero by 2050 plan and work towards implementation.
- Encourage local solar energy production on roofs and parking lots: provide information to residents on home solar and incentives, help residents overcome HOA barriers to roof-top solar (and outdoor clothes lines), and facilitate development of community solar.

- Reduce barriers to on-farm solar and help farmers access grants for solar projects. Install solar canopies at large commercial/retail parking lots like Colony Place to reduce urban heat island and improve access to clean energy.

Landward migration, Coastal Buybacks and Climate Migration

- Hire a third-party consensus building organization to facilitate discussions on coastal buybacks, climate migration, and/or retreat for the neighborhoods of Saquish, Plymouth Long Beach, White Horse Beach and Manomet.
- Continue to increase coastal public space with coastal buybacks in critical areas using Community Preservation Act funds.

Public Health Data Gap Reduction

Enhance capacity to collect and spatially analyze data on socioeconomic indicators of climate vulnerability, climate-health behaviors, and health outcomes to guide location-specific opportunities to advance health equity through climate action. With coordination and adequate resources, local health departments and hospital systems can leveraged their experience with disease surveillance, vital statistics, and community health assessments to integrate climate relevant indicators into these tools. Potential indicators include: respiratory and cardiovascular conditions, incidence of vector borne diseases such as Lyme disease, EEE, Anaplasmosis, WNV, heat-related illnesses, incidences of domestic violence by location, free and reduced lunch by school, access to air conditioning, demand for affordable housing, etc.

Shoreline Protection

Perform a research and planning effort on the Duxbury, Kingston, Plymouth Harbor (the DKP) for a more collaborative approach to shoreline protection. Identify coastal wave pathways and energy as well as inland/coastal hydrogeologic flows to minimize stress on coastal and stormwater infrastructure. Identify key nature-based solutions that mitigate wave energy and protect the Long Beach barrier beach and infiltrate stormwater to minimize entry into the infrastructure.

Zoning and Land Use Regulation

- Evaluate building requirements in flood zones. Incorporate language that improves resilience at the building level such as increase free board requirements for redevelopment that incorporates depths and extent of sea level rise in 2050, approximately 4.6 feet.
- Ensure all capital improvements, from roads, buildings, sewer, stormwater, etc. utilize design guidelines that account for increased precipitation and SLR 2050.
- Evaluate coastal wetlands protection bylaws to maximize natural shoreline protection on coasts and ponds. Increase buffer zones to extend beyond current FEMA flood zones.

Public Recommendation: Craft a comprehensive climate change vulnerability assessment and action plan that prepares Plymouth to implement solutions for future resiliency-related

challenges, while equitably protecting and promoting the public's health, environment, and economic prosperity.

Appendix A Stormwater and Sewer Infrastructure Vulnerability

* This includes the general location of sewer pipes at risk. Some sewer pipes are already submerged or located in a wetland by design. Pipes in this table are ones that will be flooded with either a storm or Sea Level Rise by 2050.

Critical Facilities	Urban Heat Island	Sea Level Rise 2050	FEMA 1% Annual Chance Flood	FEMA 0.2% Annual Chance Flood
Catch Basins				
Ryder Way-536	N/A			
Water St -1359	N/A			
Water St-1464	N/A			
Town Wharf-1466	N/A			
Town Wharf-1467	N/A			
Town Wharf-1468	N/A			
Town Wharf-1469	N/A			
Water St-1516	N/A			
Water St-1534	N/A			
Water St-1535	N/A			
Water St-1536	N/A			
Water St-1538	N/A			
Union St-1539	N/A			
Water St-11607	N/A			
Water St-11618	N/A			
Nelson St-11628	N/A			
Stormwater Outfalls				
35	N/A	X		
36	N/A	X		
192	N/A	X		
193	N/A	X		
1	N/A	X		
2	N/A	X		
3	N/A	X		
4	N/A	X		
5	N/A	X		
6	N/A	X		

Critical Facilities	Urban Heat Island	Sea Level Rise 2050	FEMA 1% Annual Chance Flood	FEMA 0.2% Annual Chance Flood
7	N/A	X		
8	N/A	X		
9	N/A	X		
10	N/A	X		
11	N/A	X		
12	N/A	X		
17	N/A	X		
18	N/A	X		
20	N/A	X		
21	N/A	X		
21	N/A	X		
22	N/A	X		
25	N/A	X		
28	N/A	X		
27	N/A	X		
26	N/A	X		
33	N/A	X		
32	N/A	X		
34	N/A	X		
195	N/A	X		
196	N/A	X		
197	N/A	X		
198	N/A	X		
199	N/A	X		
43	N/A	X		
46	N/A	X		
48	N/A	X		
51	N/A	X		
55	N/A	X		
58	N/A	X		
58	N/A	X		
59	N/A	X		
60	N/A	X		

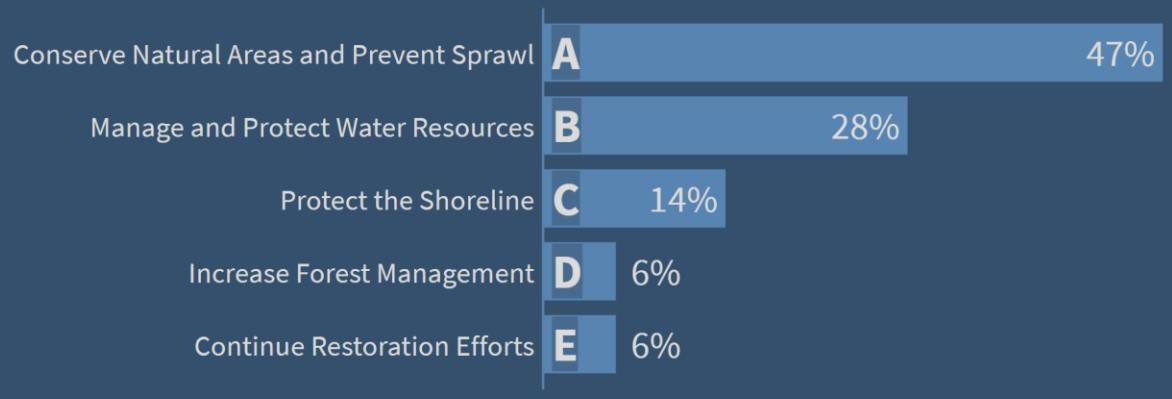
Critical Facilities	Urban Heat Island	Sea Level Rise 2050	FEMA 1% Annual Chance Flood	FEMA 0.2% Annual Chance Flood
61	N/A	X		
62	N/A	X		
24	N/A	X		
1004	N/A	X		
53	N/A	X		
63	N/A	X		
64	N/A	X		
65	N/A	X		
66	N/A	X		
66	N/A	X		
67	N/A	X		
72	N/A	X		
72	N/A	X		
25	N/A	X		
50	N/A	X		
100	N/A	X		
101	N/A	X		
102	N/A	X		
106	N/A	X		
107	N/A	X		
28	N/A	X		
57	N/A	X		
0	N/A	X		
923	N/A	X		
1005	N/A	X		
14	N/A	X		
15	N/A	X		
*Sewer Pipes**				
Cordage Park	N/A	X	X	X
Nelson Park	N/A	X	X	X
Downtown Plymouth	N/A	X	X	X
Town Brook	N/A	X	X	X
Stephens Field	N/A	X	X	X

Appendix B MVP Workshop Summary of Findings

Appendix C Public Engagement and Presentation Materials

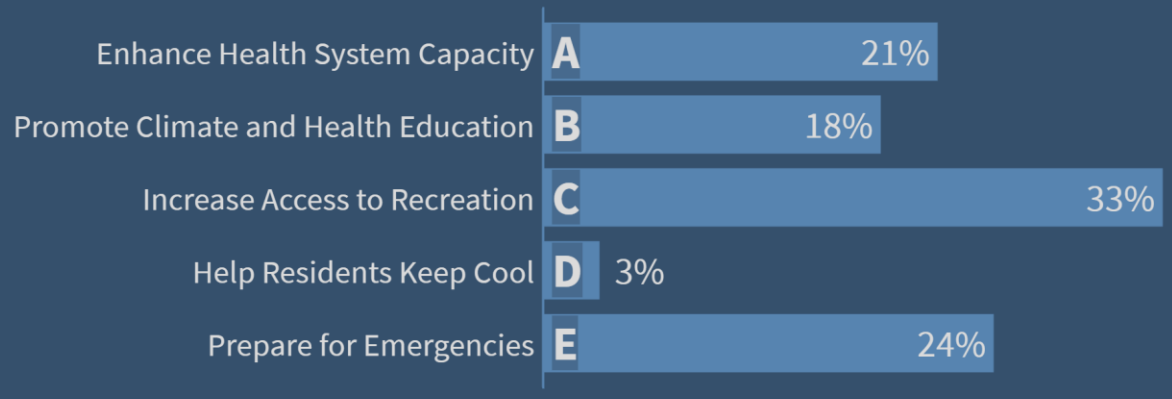
Respond at **PollEv.com/mapcpoll**
Text **MAPCPOLL** to **22333** once to join, then **A, B, C, D, or E**

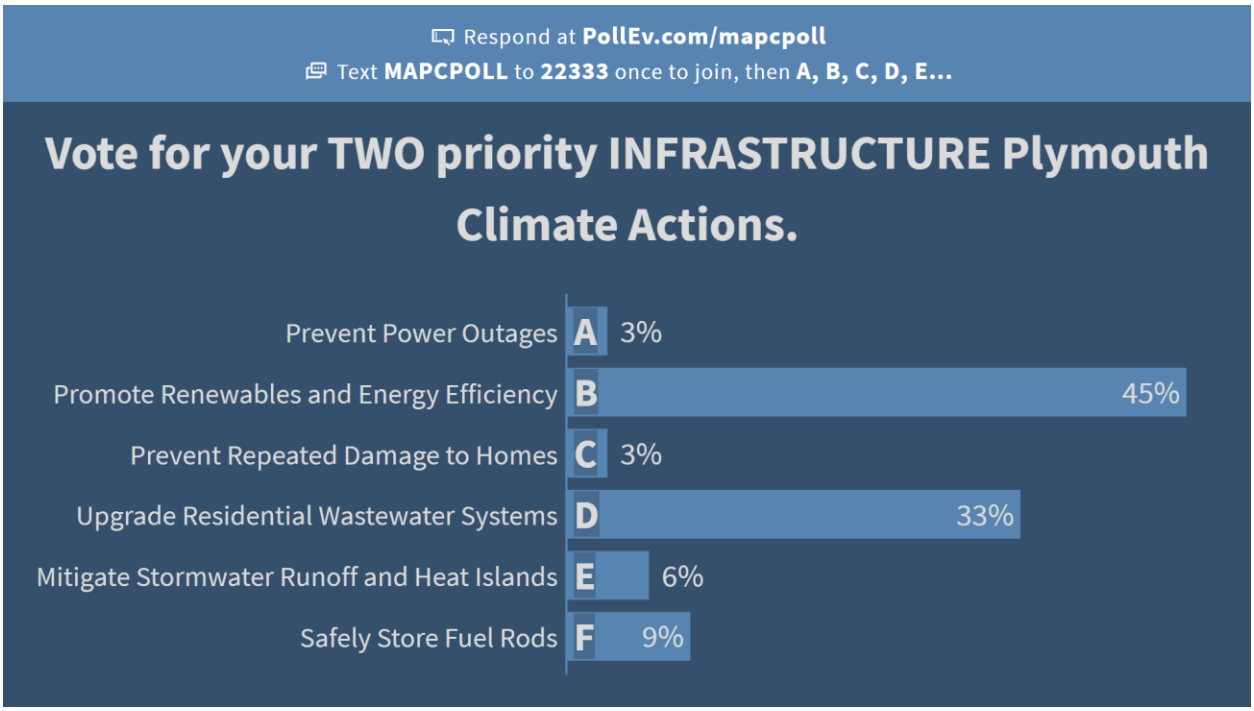
Vote for your TWO priority ENVIRONMENT Plymouth Climate Actions



Respond at **PollEv.com/mapcpoll**
Text **MAPCPOLL** to **22333** once to join, then **A, B, C, D, or E**

Vote for your TWO priority SOCIETY AND PUBLIC HEALTH Plymouth Climate Actions.




Respond at PollEv.com/mapcpoll
Text MAPCPOLL to 22333 once to join, then A, B, C, D, E...
Vote for your TWO priority INFRASTRUCTURE Plymouth Climate Actions.
Prevent Power Outages
A
3%
Promote Renewables and Energy Efficiency
B
45%
Prevent Repeated Damage to Homes
C
3%
Upgrade Residential Wastewater Systems
D
33%
Mitigate Stormwater Runoff and Heat Islands
E
6%
Safely Store Fuel Rods
F
9%

Appendix D Core Team Meeting Documentation

Plymouth Climate Vulnerability Assessment and Municipal Vulnerability Preparpedness

Task Force Meeting #1
September 20, 2019
Cranberry Room, Plymouth Town Hall
Join by phone
+1-415-655-0002 US Toll
Access code: 859 766 704

Agenda

Introductions (10 minutes)
Overall Project Introduction (10 minutes)

- Scope of Work
- Schedule

Climate Vulnerability Assessment (20 Minutes)

- DRAFT Outline
- Preliminary Analysis Examples

Municipal Vulnerability Preparedness (20 minutes)

- About MVP
- Community Resiliency Building Workshop Overview

Core Team Engagement (20 minutes)

- What is your most significant concern about climate change in Plymouth?
- What are Plymouth's greatest strengths?
- What additional analysis is needed for this climate vulnerability assessment?
- What do you hope to achieve with the MVP community-based planning process?

Intro to Community Engagement Plan (5 minutes)

- Stakeholder outreach/engagement
- Focus Groups
- Public Forums
- Communication Strategies (mailings, social media, etc.)

Task Force Role and Meetings (5minutes)

- Plan Ambassadors
- Engage and support
- 8 meetings (no more than 1 per month)

Next steps

- Existing conditions and Climate Vulnerability Assessment
- Collect Needed Spatial Data
- Set Date for October Task Force Meeting
- Set Date for First Public Forum

Plymouth Climate Vulnerability Assessment and Municipal Vulnerability Preparpedness

Task Force Meeting #
December 11, 2019
Cranberry Room, Plymouth Town Hall

Wednesday, Dec 11, 2019 2:00 pm | 2 hours | (UTC-05:00) Eastern Time (US & Canada)
Meeting number: 730 874 191
https://mapc.webex.com/mapc/j.php?MTID=m29e34b843a61d89acc32607e1ba6f678

Join by phone
+1-415-655-0002 US Toll
Access code: 730 874 191

Agenda

Introductions/Review (5 minutes)

Focus Groups (35 minutes)
- Presentation and Materials
- Review of data we will be collecting
- Set Dates and Tentative Locations

Community Engagement Strategy-Focus Groups Only
- Task Force Assignments
- Email, Posters, Webpage

Public Forum
- Set Date (January/February)
- Set Location
- Discuss Format

MVP Workshop
- Review of MVP Agenda
- Review of Sample Materials
- Determine Date, Format, and Location

Next Steps
- Set Date for January Task Force Meeting

Plymouth Climate Vulnerability Assessment and Municipal Vulnerability Preparpedness

Task Force Meeting #
December 11, 2019
Cranberry Room, Plymouth Town Hall

Wednesday, Dec 11, 2019 2:00 pm | 2 hours | (UTC-05:00) Eastern Time (US & Canada)
Meeting number: 730 874 191
https://mapc.webex.com/mapc/j.php?MTID=m29e34b843a61d89acc32607e1ba6f678

Join by phone
+1-415-655-0002 US Toll
Access code: 730 874 191

Agenda

Introductions/Review (5 minutes)

Focus Groups (35 minutes)
- Presentation and Materials
- Review of data we will be collecting
- Set Dates and Tentative Locations

Community Engagement Strategy-Focus Groups Only (15 minutes)
- Task Force Assignments
- Email, Posters, Webpage

Public Forum (20 minutes)
- Set Date (January/February)
- Set Location
- Discuss Format

MVP Workshop (10 minutes)
- Sample Materials
- PPT Presentation or Musical Boards

[Deep Dive into Workshop at January Task Force Meeting]

N**ext Steps**
- Schedule January Task Force Meeting

Plymouth Climate Vulnerability Assessment and Municipal Vulnerability Preparpedness

Task Force Meeting #4
January 7, 2020
Cranberry Room, Plymouth Town Hall

Plymouth MVP Core Team Meeting #4

Meeting number: 730 885 909
https://mapc.webex.com/mapc/j.php?MTID=md3d48ee3c170e1605fc4d335417acecf

Join by phone
+1-415-655-0002 US Toll
Access code: 730 885 909

Agenda

Introductions/Review (5 minutes)

MVP Workshop (45 minutes)
- Review of Community Resilience Building Workshop
- Format (PPT and/or Musical Boards)
- Review of CRB Matrix
- Identification of Top Climate Hazards
- Sample Materials
- Set Date and Location
- Identify Participants
- Designing Invitations

Focus Groups (20 Minutes)
- Review of revised power point
- Scheduling update
- Outreach Update

Public Forum (10 minutes)
- January 28, 2019 at Plymouth North Hight School
- Outreach and Publication

N**ext Steps**
- Schedule Next Task Force Meeting
- Outreach assignments for Focus Groups
- Outreach assignments for Core Team

Plymouth Climate Vulnerability Assessment and Municipal Vulnerability Preparpedness

Task Force Meeting #5
February 11, 2020
Cranberry Room, Plymouth Town Hall

Join by video system
https://mapc.webex.com/mapc/j.php?MTID=m8024bc652cd9c35fd7a6df9487dd4004
Meeting number: 731 242 081
Password: e9g3UV3M

Join by phone
+1-415-655-0002 US Toll
Access code: 731 242 081

Agenda

Public Forum debrief (Core Team)

Report on summary of community response (Jeanette Pantoja)

MVP Workshop

Review Posters and Presentation -View on the Plymouth Website!
https://www.plymouth-ma.gov/planning-development/pages/climate-change-municipal-vulnerability-preparedness
Review invitation List to CRB Workshop-designate contacts
Discuss outreach to invitees.

N**ext Steps**

Attend the MVP Workshop on March 18!
Outreach assignments for MVP Workshop
Schedule April Core Team Meeting and May Public Forum

Schofield, Darci

Subject: Plymouth Core Team Meeting
Location: Zoom-see link

Start: Tue 4/7/2020 2:00 PM
End: Tue 4/7/2020 3:00 PM

Recurrence: (none)

Meeting Status: Meeting organizer

Organizer: Schofield, Darci
Required Attendees: Schofield, Darci; Pantoja, Jeanette

Hi all,

I hope this email finds you and your family healthy during this difficult time. Two months ago, we scheduled a Core Team meeting for Tuesday, April 7 at 2 PM. We would like to keep that meeting and meet online via Zoom.

MAPC, the Town, and OCPC have been deliberating at length together and with the Executive Office of Energy and Environmental Affairs on how to proceed with Climate-Ready Healthy Plymouth given these unprecedented circumstances.

We will relay that information to you, provide an update on the MVP workshop, the public forum, and next steps for Climate-Ready Healthy Plymouth in consideration for the momentum we have built, social distancing requirements, and the need to respect various commitments of our community in responding to COVID-19.

We very much look forward to seeing you and answering any questions you may have on this process on April 7, 2020.

Join Zoom Meeting on April 7th at 2:00 p.m. by clicking on this link:
https://zoom.us/j/240272195
Meeting ID: 240 272 195
Dial by phone (Voice only)
+1 929 205 6099 US
Download the Zoom app at https://zoom.us/download

Lee Hartmann, AICP
Director of Planning and Development
Town Hall

1

Plymouth Municipal Vulnerability Preparpedness
And Climate-Ready Healthy Plymouth

Task Force Meeting #7
May 12, 2020
Remote Meeting via Zoom

Join by video

https://zoom.us/j/97776610769?pwd=RlB1NDZaMnJNR3cwVzhPRnRjOGpBZz09

Meeting ID: 977 7661 0769
Password: 197722

Join by phone

+1 646 876 9923 US
Meeting ID: 977 7661 0769

Agenda

MVP Workshop summary of response (Jeanette Pantoja)

Final Public Forum-Online Details and Outreach (Darci Schofield and Jeanette Pantoja)

Review and Feedback of Climate-Ready Healthy Plymouth report (Core Team)

Next Steps

Appendix E Public Comment on final Climate-Ready Healthy Plymouth Report

Date: June 12, 2020

To: Jeanette Pantoja, Metropolitan Area Planning Council

From: Sharl Heller, Plymouth Resident

Re: Comments regarding the Climate-Ready Healthy Plymouth Report

Dear Ms. Pantoja and Members of the Municipal Vulnerability Preparedness Planning Steering Committee:

Thank you for the opportunity to submit comments on the Climate-Ready Healthy Plymouth Report. I am very grateful to you for undertaking this important project for the Town of Plymouth. You have made it possible for Plymouth to qualify for grants that will enable the town to complete projects necessary for building resiliency against climate change while considering how climate change may impact the health and well-being of Plymouth's citizens. This is a very creative and thoughtful approach and you are all to be commended for your efforts. I do have some concerns, however, and would like to submit the following comments for your review and consideration. Thank you.

Sincerely,

Sharl Heller

Sharl Heller

Section I Introduction

Paragraph 1, page 6

While I understand why the committee may have wanted to place the MVP process in an historical context, given the recent pandemic, I find the first paragraph distracting and the historical references subjective and largely irrelevant to the planning process.

Many in the community wanted the Town of Plymouth to engage in the MVP program because we understand that climate change is an emergency that too few residents and some officials realize is upon us. My suggestion is that this report begin with the second paragraph or start with a paragraph that includes the impetus behind why the community wanted to engage in an MVP program that considers public health in a climate change vulnerability assessment and action plan.

Paragraph 2, page 6

Climate Change is more than a "compelling," issue, as described here. Climate change is a global emergency that will surely make the current pandemic seem like a minor occurrence, a blip on the screen in comparison. Describing climate change as a "compelling issue," rather than as a potentially terrifying consequence of inaction, is a failure to state what the residents of Plymouth are facing. In my opinion, this report does not express the urgency behind the need to create a climate action plan.

I am glad to see that this report includes a reference to the region's unique ecosystem: "…globally rare Atlantic Coastal Pine Barren forest and contains some of the most endangered species in Massachusetts." Please note that "Atlantic Coastal Pine Barrens" refers to the ecoregion. The forest type most common and most significant to the ecoregion is the Pitch Pine-Scrub Oak forest, often referred to as a "pine barrens." Notice that there is always an "s" in barrens.

This sentence needs further consideration: "The Town through time has had the foresight to protect and promote these assets to uphold its cultural character and healthy, livable community."

I would argue that the Town has done little to protect forest lands, outside of the great work of the Community Preservation Committee and the Department of Marine and Environmental Affairs. Give credit where it is due. The Town Department of Planning, the Planning Board and the Planning Board of Appeals have, in my opinion, failed the Town by their purposeful failure to implement the Town of Plymouth Master Plan 2004-2024, and the Strategic Plan developed immediately after to carry out the Master Plan. If the Town officials and boards had followed these two plans, Plymouth would have already built a strong foundation for a healthier Plymouth and be in a better position to incorporate climate resiliency here in 2020.

Sections 2, 3, 4

I commend the Metropolitan Area Planning Council for their excellent work compiling and presenting data regarding Plymouth's challenges in relation to climate change.

Section V. Public Engagement Analysis and Summary

Paragraph 2, page 117

> Goal: Craft a comprehensive climate change vulnerability assessment and action plan that prepares Plymouth to implement solutions for future resiliency-related challenges, while equitably protecting and promoting the public's health, environment, and economic prosperity.

The MVP effort to engage the citizens of Plymouth is to be commended. This study does a good job in assessing how Plymouth residents view climate change and shows that their interests are largely influenced by how they perceive climate change will affect them personally.

The "Top Priority Actions" list contains some excellent and valuable suggestions. However, identifying priorities for resiliency-related projects is too important for the Town of Plymouth to rely on public opinion.

For example, the top priority on the Climate and Public Health Resilience Actions list is, "Increase Access to Recreation." Increasing recreational opportunity, most people would agree, makes for a healthier community. But how effective are additional recreational opportunities in building resiliency? Climate action needs to be prioritized on the most current scientific understanding, not on majority opinion.

Instead, Plymouth should engage Manomet, Inc., or another scientific organization involved in climate change and resiliency research, to evaluate the action priorities identified in this report. A scientific evaluation will enable the Town of Plymouth to determine which of these priorities is most urgent and

what other actions should be added to this list that the public surveys may have missed. Only then will the Town of Plymouth be able to craft an effective response to climate change.

While this report is very thorough and useful, without a science-based evaluation of the Top Priority Actions, this report has failed to meet its goal to produce a comprehensive climate change vulnerability assessment and action plan.

From: Frank Mand <dogd@aol.com>
Sent: Saturday, June 13, 2020 10:08 AM
To: Pantoja, Jeanette <jpantoja@mapc.org>
Subject: Climate Ready Plymouth comments

Jeanette:

Here a few comments on the CRHP report. Overall I am very impressed by the comprehensive nature of this report, but...

The opening is distracting. I certainly understand the irony of finding ourselves shut down because of a pandemic when we are about to celebrate the 400th anniversary of an event that, in part, only happened because native peoples were decimated by disease BUT – I'd advise getting to the point earlier, starting perhaps with the second paragraph.

I think that many people would disagree with the assertion that the government in Plymouth should be automatically put in the positive column. There may be intellectual support for the MPV process, but there has not been either vocal support from the town leaders or sufficient regulatory changes to meet the challenges outlined in this report.

I may have missed it, but I didn't see reference to unnecessary expenditures that are made annually, and look to be ongoing for the foreseeable future, to armor our coastline – as oppose to using more cost effective, climate-resiliency approaches. I think that it is just as important to stop doing things in certain ways, as to plan to do things differently in the future.

-in fact your 'resliiency actions' include a call to continue structural approaches including seawalls. What are we protecting? Beach stickers? Homes on a barrier beach? In a serious approach to climate resiliency we need to abandon these costly systems, remove homes from that beach, allow for nature to take back the shoreline and, instead of walls, build 'flood parks' and such. That is an argument, I believe, that can be made from a strictly economic perspective as well.

Frank Mand

(774) 454-0856

From: Eric Cody <eric@ellisvillemarsh.org>
Sent: Thursday, June 4, 2020 1:36 PM
To: Lee Hartmann <LHartmann@townhall.plymouth.ma.us>
Subject: Fwd: Climate-Ready Healthy Plymouth Report

Very comprehensive report, Lee. Hopefully it'll provide lubrication for Plymouth's grant-funding wheel.

One error on p. 76, under sec. 4.2.2 that should probably be fixed: Ellisville Harbor is not "at the Town's southern boundary."

Best,

Eric