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Chapter 11

CLIMATE CHANGE & RESILIENCE

A climate change and resilience element is not a required master plan chapter per Massachusetts law; however, in an age of a changing climate, failing to plan for climate changes' multiple impacts is planning to fail. Dartmouth has already seen the impacts of climate change, from sea level rise, more frequent droughts, more significant flooding, increased extreme storm events, and rising temperatures. As climate change progresses, the town can expect to see more impacts with regards to high heat levels, dangerous sea level rise and storm surge, flooding, erosion, drought and pest emergence. While Dartmouth has already started to experience the effects of climate change, it has also started to take steps to become more resilient, mitigating negative impacts through planning efforts such as the 2020 Municipal Vulnerability Preparedness (MVP) Program process and hazard mitigation planning. These efforts serve as a starting point for Dartmouth to increase its resilience, responding to and minimizing its climate vulnerability profile. Planning for these impacts today will position Dartmouth for a stronger position in the future. Resilience has also taken another meaning for towns like Dartmouth over the past couple of years. Resilience quite simply may mean surviving a world health even such as a global pandemic.

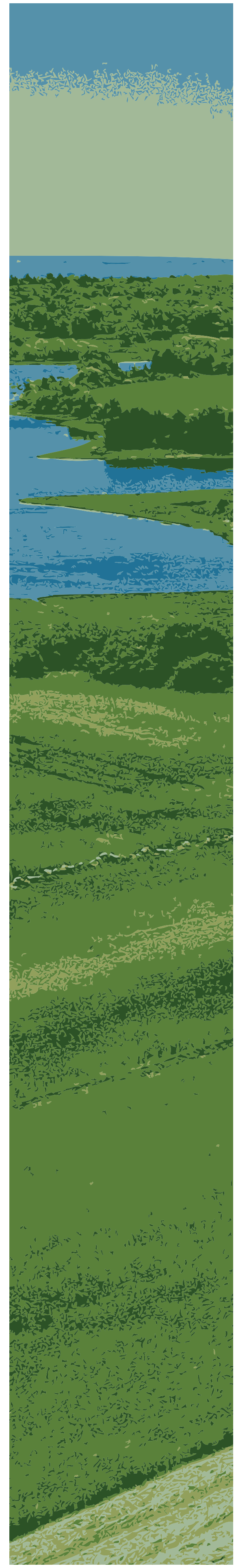
Defining Terms and Definitional Concepts

The development of climate change science has generated a 'climate change lexicon' filled with specialized terms, phrases, and concepts. Some terms, such as greenhouse gas or fossil fuel, may already be familiar. Other terms for more nebulous concepts, such as resilience or adaptation, which have specific meanings but are sometimes used interchangeably, may benefit from up-front definition to ensure that they are interpreted consistently. The following paragraphs establish these baseline definitions in preparation for their application to Dartmouth's specific context.

Climate Change: "Weather is what you get. Climate is what you expect."

Much different from the concept of **weather**, which is the atmospheric conditions that manifest on a given day, **climate** refers to overall trends in atmospheric conditions for a give region at a given time of year. Climate determines the range of weather possibilities. Imagine a typical statistical bell curve – there are extremes of temperature on either end of the spectrum for a given season that will occur, but on most days weather conditions fall in an expected middle range. **Climate change** is the shift in a region's climate (particularly its temperature and precipitation) over time. Rather than a shift along the bell curve, it represents a shift *of* the bell curve itself in a given direction, changing both the range of possible extreme events and the character of typical weather conditions.

Climate scientists measure climate in 30-year **'climatological intervals.'** Historical records from sediment samples, fossils, ice cores, and other



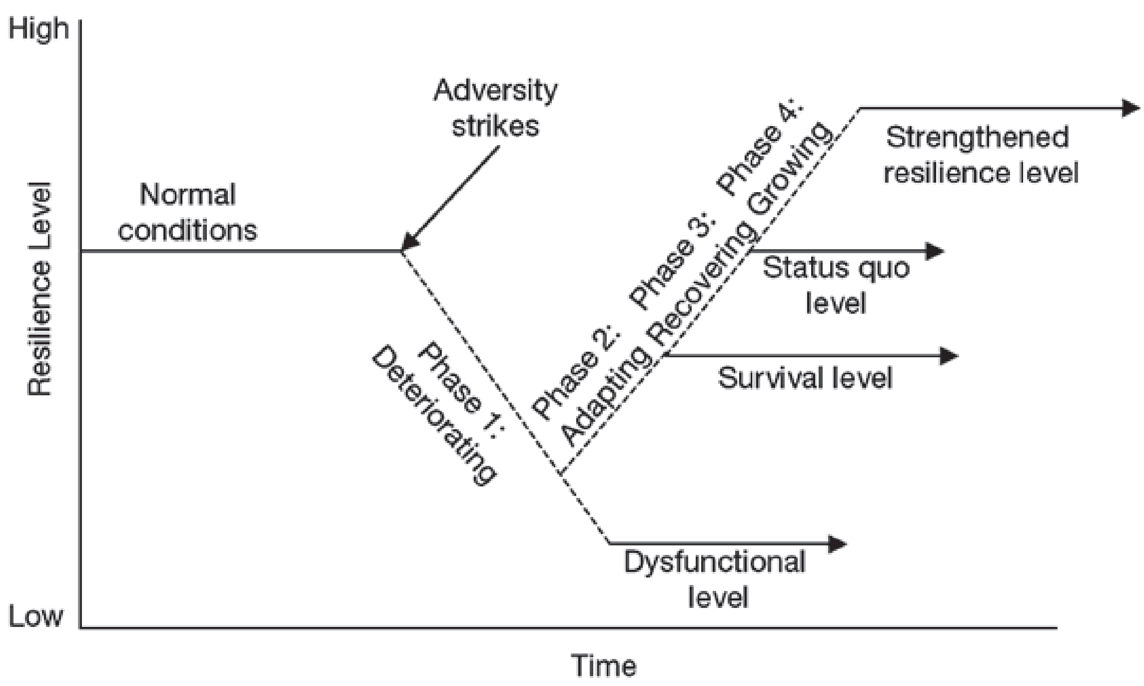
geologic sources allow climate scientists to establish the climactic conditions of these intervals far into the past, up through the present, and to use observed rates of change to model the future. In the long scale of geological time, climate change has been caused by natural events such as the planet's tilt or the rotation of its orbit. These natural shifts typically occur over the span of hundreds of thousands of years.

However, since the dawn of the industrial revolution, the rate of Carbon Dioxide (CO_2) – a so called **'Greenhouse Gas or GHG'** – in the atmosphere has increased exponentially. The global release of CO_2 is occurring at rates nearly nine times greater than in the hottest period of the past 800,000 years and has created an environment fruitful for trapping thermal energy from sunlight within the earth's atmospheric system. Some known impacts of climate change-induced warming include sea level rise, intense flood, ocean acidification (creating inhospitable living conditions for marine life), species migration, shoreline erosion, saltwater intrusion into wells, illness induced from extreme heat (especially a concern for vulnerable populations and those who work outdoors), earlier pest emergence and spread of vector borne disease, and mental health issues associated with climate-hazard-induced loss.

Resilience: the ability of infrastructure, environment, and community to bounce back

Any one of the climate change-induced impacts described above can be disruptive. **Resilience** is the ability of social, environmental, and economic systems to return to their original form and integrity after enduring stress or disruption.

Communities that exhibit high resilience will be able to withstand with many impacts of climate change and return to their regular process and operations after a hazardous event or prolonged disruption. Resilience can look like the ability to return people to work after a pandemic, the reconstruction of a flood-prone roadway to withstand more intense storms, or the preservation of environmental features that perform essential functions like absorbing and infiltrating floodwaters.



A representation of the concept of resilience, Patterson & Kelleher, 2005

A Paradigm Shift: Stationarity to Non-stationarity

Traditionally, our society has been able to look to the past to inform the future. Scientists, farmers, engineers, planners, administrators, and many other professions have been able to rely on past trends to anticipate the weather conditions expected for a given place as they make decisions. Climate trends influence everything from what agricultural products can be expected to thrive in a region, to what water levels can be relied upon in reservoirs and personal wells for maintaining potable water supply. Professionals have used these past-based predictions to plan projects, such as the requirements for a road to withstand a "hundred-year storm," as defined by FEMA, which represents the intense weather conditions that have a probability of occurrence just once in a one-hundred-year period (the 1-percent annual chance flood). The ability to draw on prior conditions to inform our expectations of the future is referred to as **'stationarity.'**

Climate change, however, is shifting weather events and climate conditions outside of the boundaries of the historical record. The impact of this is that we are no longer able to rely as heavily on the past to inform our understanding of the future. This reality is a complete rupture to many "business as usual" processes, causing a paradigm shift from a condition of stationarity to **'non-stationarity,'** where weather events into the future are unlike weather events in the past. For example, what previously used to be the 1-percent annual chance flood event may become a much more likely and frequent occurrence; it may become the 5- or even 10-percent annual chance flood event. Current regulatory mechanisms, such as Federal Emergency Management Agency's (FEMA) mapped floodplain extents, or state-mandated engineering design standards, may struggle to keep pace with these changes. Everything from emergency response plans, to siting community facilities, to designing roadways to determining flood insurance rates, to the advisability of new home construction in a given location, will continually evolve going forward. Without the ability to draw on historical records, planning efforts and public policies need to be flexible, nimble and work with the latest science and projections.

Resilience Strategies: Mitigation and Adaptation

The uncertainty associated with non-stationarity means that communities must take the long view and build some of this uncertainty into their decision-making structures with strategies that can adapt to and mitigate the effects of climate change.

Mitigation refers to reducing the overall amount of climate change caused by human-released GHGs (via a reduction in the amount of GHGs that an individual, city, or country emits in the first place, or the establishment of mechanisms that draw carbon and other GHGs out of the atmosphere). By mitigating carbon emissions, we can help slow down the rate of human-caused climate change, lengthen stationarity, and reduce the uncertainty caused by climate change. Mitigation in a global, national, regional, or local health event might be the addition of services like vaccine clinics.

Adaptation refers to implementing changes in our built or natural environment to reduce our societal and individual vulnerability to the negative impacts of climate change, or to take advantage of any new positive opportunities that climate change creates. Adaptation strategies can cut across all sectors of our life, including our behaviors, building techniques, and where we live. In many instances, Nature Based Solutions (NBS) – projects that restore, protect, and/or manage natural systems and/or mimic natural processes to address hazards like flooding, erosion, drought, and heat islands – are often the most cost-effective, low-maintenance, and multi-beneficial mitigative or adaptive proposals for enhancing local resilience and public health, safety, and well-being. Other situations will call for "grey infrastructure" or built projects such as armoring, building or roadway elevation, or drainage improvements. Adaptation during pandemic style events might be changing governmental and community services such as more outdoor amenities along with more localized goods and services. These changes would involve community resilience planning and the ability to mobilize the government.

The Three S's of Climate Change and Resilience

Building from these definitional concepts, the key elements of the climate change threat can be communicated by answering three basic questions with the "3S's" of climate change (3S framework developed by Scott Denning of Colorado State University):

Q1: How do we know climate change is occurring?

Answer: It's <u>simple</u>, shown in data.

Data proves that climate change is currently occurring at an unprecedented rate because our human actions are forcing the earth's system to retain more heat than is emitted back into space.

When thermal energy in the form of sunlight reaches earth, two things can happen; either it is absorbed into the Earth's atmospheric system or it is reflected and able to emit back into space and dissipate. We can conceive of these phenomena as Earth's "energy budget." If the energy that is reflected and emitted back to space equals the energy that is absorbed into the Earth's system, the energy budget is in balance. If more energy is emitted than absorbed, the Earth's system cools. If more energy is absorbed than emitted, the Earth's system warms. GHGs, including Carbon Dioxide/ CO_2, methane, and others, increase the trapping capacity of the atmosphere, causing thermal energy to remain in the system, which causes the world to warm.

The changing concentrations of these gases are measurable over time, and climatologists worldwide examining all available data have concluded that the rate of warming we are experiencing today cannot be explained solely by natural causes – it is a human-made phenomenon (4th National Climate Assessment, 2018). Since 1901, the global temperature has increased 1.8 degrees Fahrenheit. Due to global differences in topography, wind patterns, and ocean circulation, this temperature increase is not felt evenly; in Massachusetts, the temperature change has been even greater, with an increase of 2.9 degrees Fahrenheit since 1895. There is also a large difference between the warming felt on land and in water. In fact, an astounding 90% of the excess thermal energy that has entered the Earth's system has sunk into the deep ocean. While this has kept us cooler on land, it is extremely problematic for the ocean – higher sea surface temperatures and climate-driven acidification make it impossible for marine animal and plant species to survive or thrive and cause their migration out of traditional habitat ranges potentially leading to serious implications for marine-based economic industries and cultural heritage.

Q2: What harm will climate change cause?

Answer: It's <u>serious,</u> and we are seeing the impacts already.

As of this writing, the most locationally-specific climate change modelling available to municipalities in Massachusetts is provided at the major watershed scale. The State of Massachusetts has made this modelling available through its online climate change data clearing house, called ResilientMA. Dartmouth is located in the Buzzards Bay watershed, and thus, the figures referenced in this chapter are from the Buzzards Bay predictions issued by ResilientMA.

Detailed further below, in high-level summary, by 2050, the annual average temperature in the Buzzards Bay Watershed is expected to increase by 5.1 degrees Fahrenheit under a business-as-usual GHG emissions scenario. Dartmouth is a coastal town with more than 47 miles of exposure to Buzzards Bay, which has experienced nearly 10 inches of sea level rise since 1932. The rate of sea level rise is going to increase as thermal expansion and icesheet melt become even greater. Under a business-as-usual GHG emissions scenario, Dartmouth is expected to receive an additional 2.4 feet of sea level rise by 2050. By 2100, Buzzards Bay sea levels are anticipated to rise 7.7ft.

Q3: What can we do?

Answer: It's solvable if we work together to change course.

We are looking at an extremely different world by the end of this century if our high rate of CO_2 emissions continues unabated. However, there is some possibility for humans to change this harsh trajectory. Future emissions upon which various climate change scenarios are based have not yet occurred and are not set in stone. Climate scientists use a range of GHG emissions scenarios - called Representative Concentration Pathways (or RCP's) - as a basis to predict how temperature and precipitation might change in the future based on different levels of CO_2 emissions. Under lower emissions scenarios called RCP 2.6 and RCP 4.5, humans would decrease our overall emissions to limit global temperature increases between 2 – 6 degrees Fahrenheit. This shift to meeting lower emissions scenarios, however, will take material changes to the way that we live, plan our communities, and consume.

This Master Plan chapter takes the hopeful and impassioned outlook that comes from the final "S" and provides information on how Dartmouth can contribute toward solutions for mitigating and adapting to climate change challenges. It is designed to serve as an introduction to the fundamentals of climate change and its likely impacts on Dartmouth and the surrounding region. This chapter first provides the reader with a baseline level of data that the Town may use going forward to increase its resilience to climate change. This chapter will then integrate previous planning efforts into a single comprehensive framework and establish additional actions for enhancing the town's resilience and ability to withstand climate shocks in the future.

KEY CLIMATE CHANGE AND RESILIENCE DATA

Anticipated Climate Change in Dartmouth

Climate change models have advanced significantly in their accuracy and scope since the international community came together to form the United Nations Intergovernmental Panel on Climate Change (IPCC) in 1988 to establish a baseline related to climate change data, and since the creation of the UN Framework Convention on Climate Change (UNFCCC) in 1990, which established a country-by-country benchmark of GHG emissions levels. Since these early advances, efforts at "down-sampling," whereby global or regional climate change models are applied to

resilient MA
Climate Change Clearinghouse for the Commonwealth

increasingly smaller-scale entities, like states, counties, or municipalities, is a challenge as it introduces more potential for variability in climate change outcomes by specific locational attributes (topography, proximity to coastal influences, micro-climate effects, etc).

Like all climate change models, ResilientMA presents climate predictions for a number of potential future scenarios. The largest variable in our climate future is the amount of GHGs that society puts into the atmosphere, which will cause more or less warming, depending on our actions. The models imaging a few distinct emissions scenarios: a future where society rapidly reverses and emits less GHG than in previous decades; a future where society eventually cuts down on emissions, but emits at current levels for many more decades before making this shift; and a "business as usual" scenario where emissions continue to increase at their current rate. Several emissions scenarios, called Representative Concentration Pathways (RCPs) have been standardized across the international community for the purpose of comparing future outcomes. ResilientMA uses these consistent RCPs.

The data presented below are for a medium emissions scenario (RCP4.5), whereby global emissions peak in 2030 and then decrease over time, and for a high emissions scenario (RCP8.5), whereby global emissions continue to increase through 2100. The predictions for these scenarios by decade are presented as a range of likely future values, with the midpoints of these ranges in the tables below.

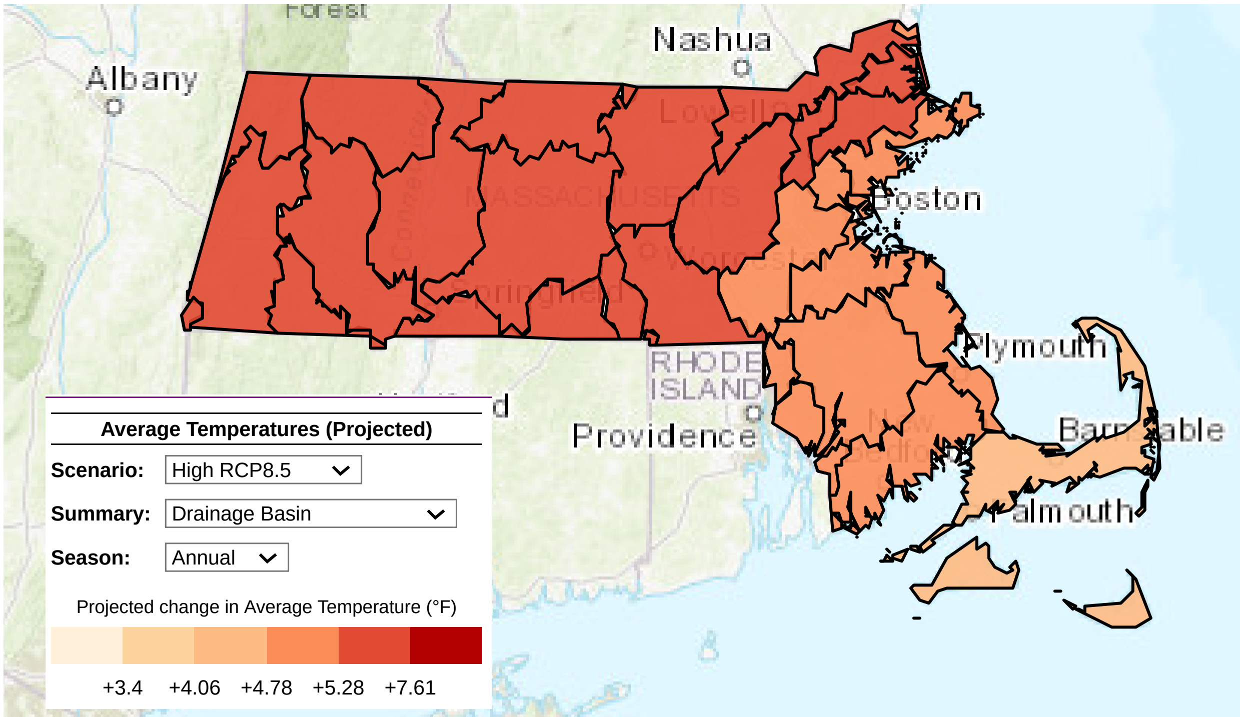
Increasing Temperatures

Annual Averages

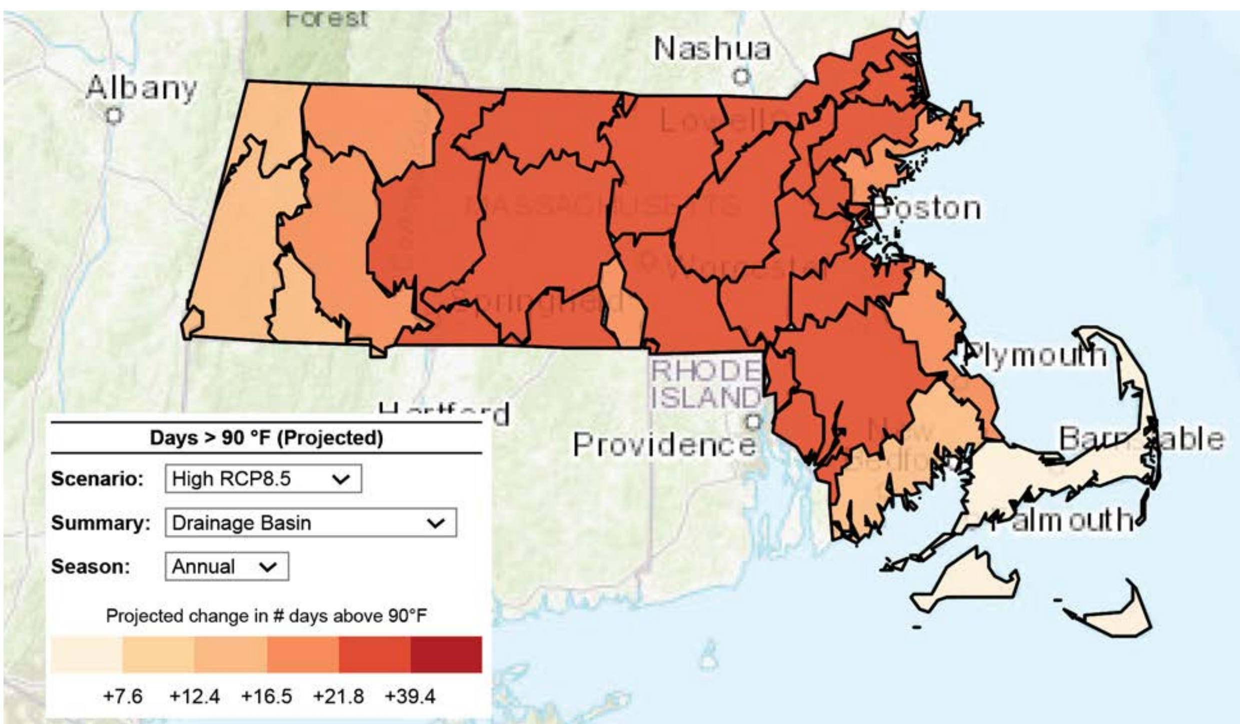
Between 1901 and 2016, there has been a 1.8-degree Fahrenheit increase in the global annual average temperature. The annual average temperature change in Massachusetts over roughly the same period has been much higher, at an increase of 2.9 degrees Fahrenheit. Much of this temperature increase has been concentrated in the last 50 years, indicating that temperature increases have been occurring at an accelerated rate through time as society continues to expel CO_2 into the atmosphere. By 2050, the annual average temperature in the Buzzards Bay Watershed is expected to increase by 5.1 degrees Fahrenheit under a business-as-usual scenario.

Figure 11.1: Predicted Changes in Annual Average Temperature for the Buzzards Bay Watershed

	Baseline	2050	2090
Medium Emissions Scenario (RCP 4.6)	50.7°F	+3.7°F	+4.9°F
High Emissions Scenario (RCP 8.5)		+5.1°F	+8.8°F



This map shows the increase in annual average temperature across Massachusetts by 2050 under a high carbon emissions scenario. The Buzzards Bay watershed is projected to experience a lesser degree of warming than other areas of Massachusetts, with the exception of the Cape Cod Basin.



This map shows the increase in the number of days above 90 degrees Fahrenheit across Massachusetts by 2050 under a high carbon emissions scenario. The Buzzards Bay watershed is projected to experience a lesser number of additional heat days than its immediate region, and the western half of the state.

Seasonal Differences

While the climate is warming as a whole, this warming is often unequally distributed throughout the year. Winter months are expected to warm three times faster than summer months. In Dartmouth, summer temperatures are projected to increase 2.8°F under RCP8.5, compared with a greater winter time increase of 3.5°F.

Though summer temperature increases are smaller in magnitude than winter changes, summer increases have a greater bearing on human health risk, creating the potential for heat stroke, especially for vulnerable populations and those who work outside. By 2050, Dartmouth is predicted to experience an additional 5.7 days with temperatures above 90°F. In winter, there is anticipated to be 9.5 fewer days below freezing (32°F).

Figure 11.2: Seasonal changes in average temperature, heat waves, and cold spells by 2050 under a 'Business-as-usual' emissions scenario (RCP8.5)

	Baseline	Seasonal Average Temperature Change	Change in Days with Temperatures above 90°F	Change in Days with Temperatures below 32°F
Winter	31.3°F	+3.5°F	-	-9.5 days
Summer	70.1°F	+2.8°F	+5.7 Days	-

Altered Precipitation Patterns

Annual Averages

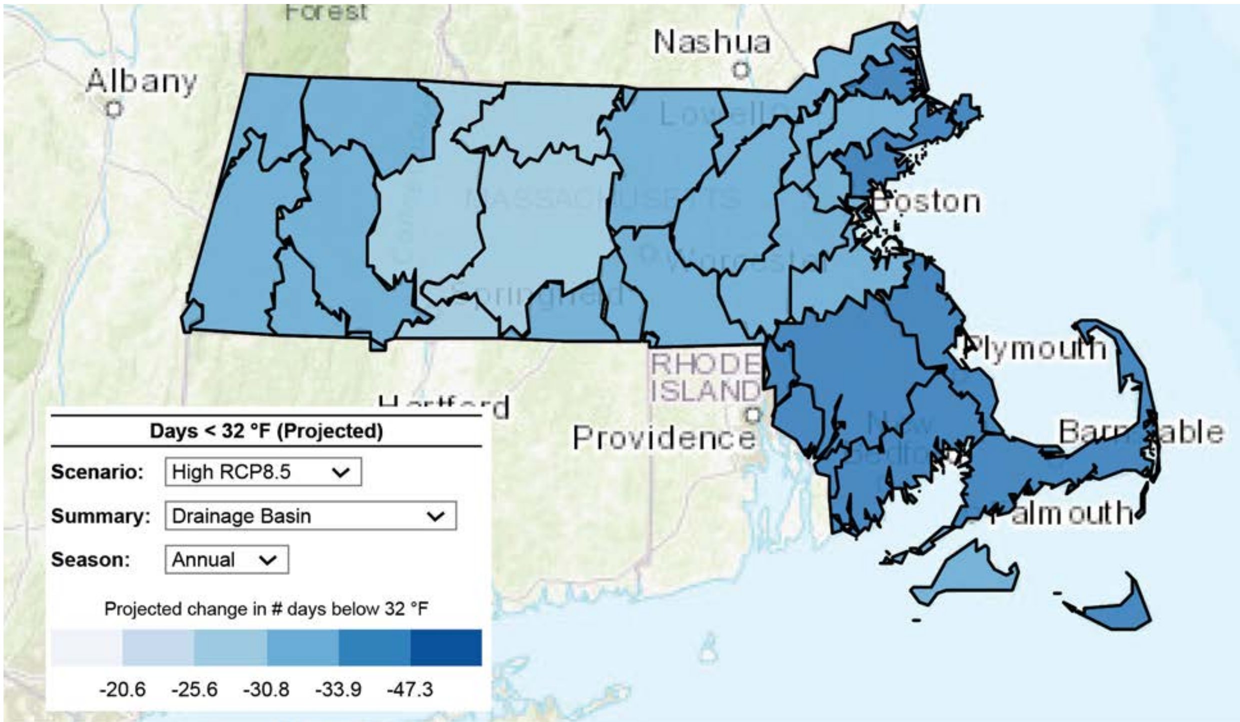
Dartmouth is anticipated to experience an increase in total rainfall over the next 30 years. In Dartmouth's Buzzards Bay Watershed, the 2050 projected annual increase in average total precipitation is 2.2 inches under a high emissions scenario (RCP8.5), or an increase of roughly 4.5%. This is lower than the Taunton Watershed Basin to the north (5% increase) but higher than the Cape Cod Basin (3% increase). Figure 3 demonstrates the annual average precipitation increase under a medium and high (business-as-usual) CO_2 emissions scenario. On a whole, the New England Region can expect increases in precipitation on several inches of magnitude by 2100.

Figure 11.3: Predicted Changes in Annual Total Precipitation (Inches)

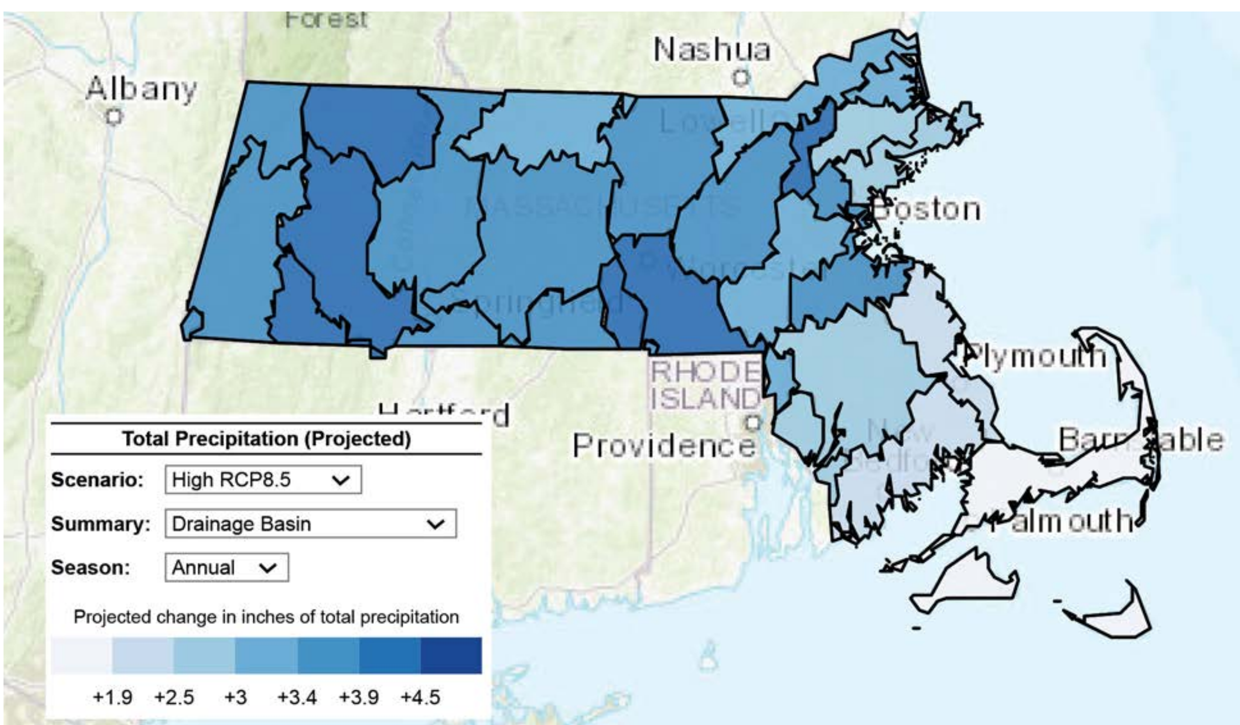
	Baseline	2050	2090
Medium Emissions Scenario (RCP 4.6)	2.65"	+2.7"	+3.3"
High Emissions Scenario (RCP 8.5)		+2.2"	+3.9"

Seasonal Differences

Similar to the seasonal variability of atmospheric warming, so too will the amount of precipitation that we can expect in the future vary over the course of the year. On the whole, the winter and spring will receive the bulk of the increase in precipitation, while summer and fall will see only mild increases in precipitation. Under a high emissions scenario (RC8.5), by 2050 Dartmouth's Buzzards Bay watershed will expect to see an increase of winter precipitation of 1.0 inch, while the spring will increase by 1.5 inches.



This map shows the decline in the number of days below 32 degrees Fahrenheit across Massachusetts by 2050 under a high carbon emissions scenario. The Buzzards Bay watershed is projected to experience a drastic decline in the number of cold days, including a dramatically larger decline than the west of the state.



This map shows the increase in annual average precipitation rates (in inches) across Massachusetts by 2050 under a high carbon emissions scenario. The Buzzards Bay watershed is projected to experience a lesser increase in annual precipitation than other areas of Massachusetts.

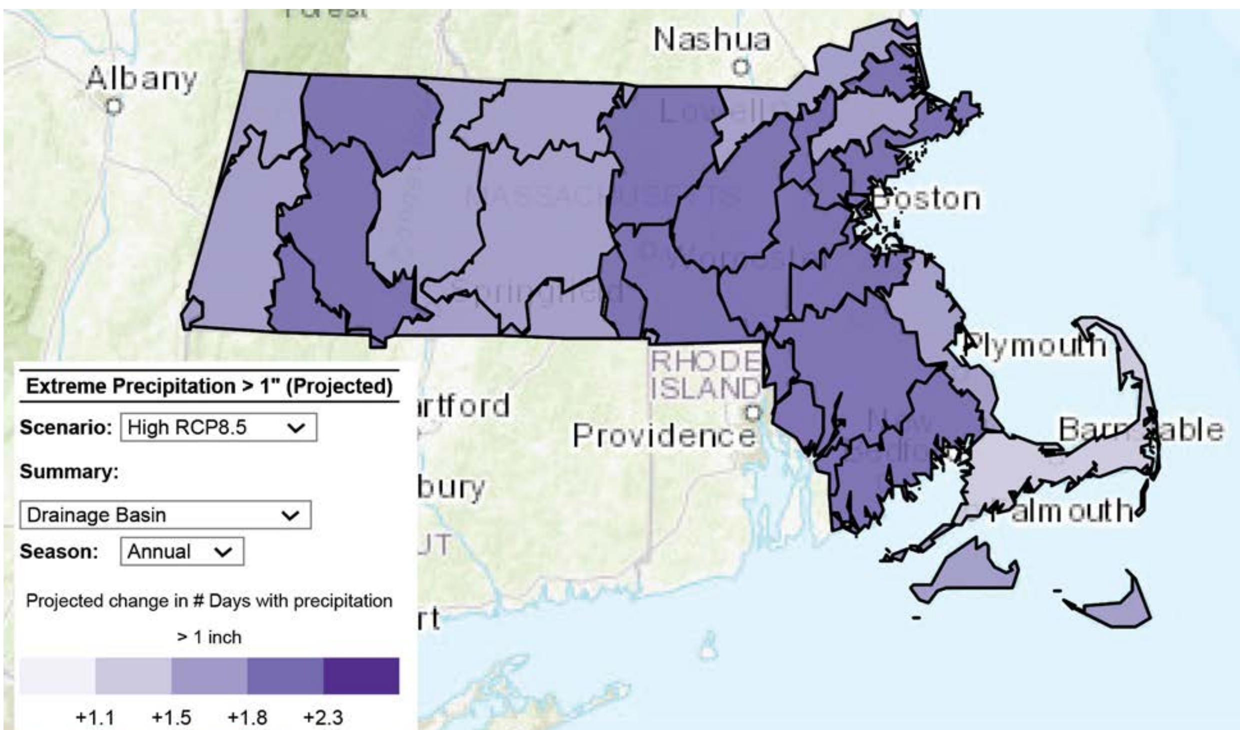
Figure 4 demonstrates the increases in precipitation by season by 2050 under medium and high emissions scenario.

Figure 11.4: Seasonal changes in precipitation under a medium and high emissions scenario by 2050

	Winter	Spring	Summer	Fall
Baseline	12.6"	12.2"	11.0"	12.1"
Medium Emissions Scenario (RCP 4.6)	+0.8"	+1.0"	+0.8"	+0.4"
High Emissions Scenario (RCP 8.5)	+1.0"	+1.5"	-0.1"	+0.7"

Intense Storms

Other hallmarks of climate change are increasing instability of typical weather patterns and the rise of more extreme events during seasons when we would normally see these events. These events would also be apt to occur outside of typical time periods. For example, both stronger hurricanes and an earlier hurricane season. Storms and tropical depressions such as hurricanes form when hot and cold air mix, contributing to conditions where air is pushed up so high that it cools and condenses into clouds and precipitation. Climate change will increase the amount of energy available in this interaction by increasing the ocean temperature, leading to more evaporation and atmospheric humidity. With



This map shows the increase in the number of days with sever precipitation events >1" across Massachusetts by 2050 under a high carbon emissions scenario. The Buzzards Bay watershed is projected to experience an increase in severe precipitation proportional with the rest of the state.

more water in the air, and more energy provided by warmer temperatures, we will see a greater number of storms and extreme events.

Just as precipitation increases will be concentrated in the winter and spring, so too will increased precipitation be concentrated in a fewer number of events. As a result, Dartmouth will see an increase in the magnitude, duration, and severity of storms, striking for longer and more intense periods of time. This trend has already been present in Dartmouth for several decades. For example, from the 1960's to the mid-2000's, the number of days with extreme precipitation events (generally > 1") has increased from 6.5 days annually and 0.8 days in the summer, to 9.1 days annually and 2.2 days in the summer. By 2050, Dartmouth is expected to experience an increase of 1.9 days in the number of days with extreme precipitation events greater than 1 inch. Table 11.5 demonstrates the projected increase in the number of storm events by 2050 per season under a high emissions scenario (RCP8.5).

Figure 11.5: Seasonal changes in extreme precipitation under a medium and high emissions scenario by 2050

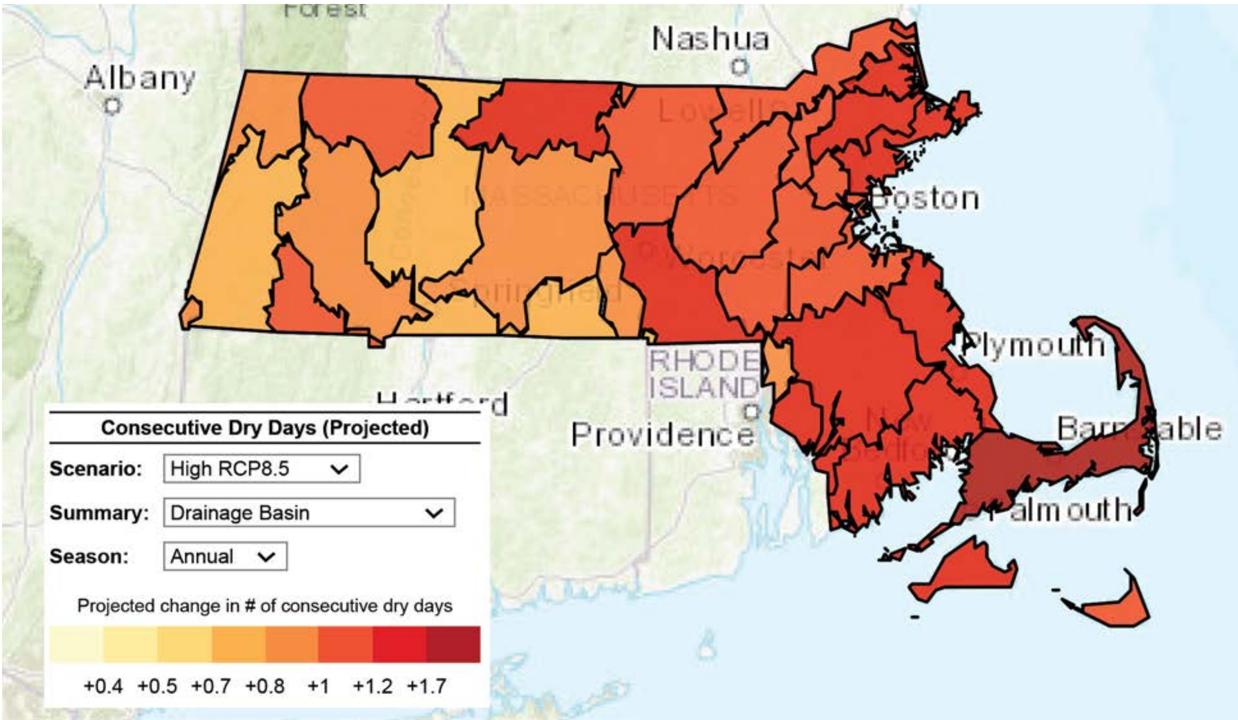
	Winter	Spring	Summer	Fall
Baseline	1.9 Days	1.9 Days	2.1 Days	2.2 Days
Medium Emissions Scenario (RCP 4.6)	+0.5 Days	+0.4 Days	+0.2 Days	+0.2 Days
High Emissions Scenario (RCP 8.5)	+0.7 Days	+0.6 Days	+0.1 Days	+0.5 Days

Drought

As mentioned earlier, while total annual precipitation will likely increase, the actual number of precipitation events will likely decrease. In other words, precipitation will be more likely to fall in the form of fewer, more intense storms. With less regular precipitation during the year and higher atmospheric temperatures, weather conditions will be primed for drought. Several telltale signs of drought are when precipitation levels fall below normal, the water table begins to fall, and plants wither and die due to a lack of freshwater. On the coastal side, there may also be an increase in saltwater intrusion into wells during drought conditions.

The historical pattern of consecutive dry days has historically peaked in the summer, with a low in the fall. Into the future, the annual average number of consecutive dry days will increase by a total of approximately 1.54 days by 2050, under a high emissions scenario. Most of this change will be concentrated in the fall, which can expect to see an increase of approximately 1.53 consecutive dry days by 2050. The summer will see an increase of approximately 0.8 consecutive dry days. The trend towards increasingly dry falls will increase in the future, reaching a maximum of an additional 2.16 dry days by 2090. Figure 6 demonstrates the historical and projected change in the number of consecutive dry days.

Beyond patterns and projections, the region has experienced severe droughts in 2020 and 2022. The 2022 drought has been particularly significant. Following lower than normal rainfall from February to August, higher temperatures and increased risk of wild fires. The Buzzards Bay watershed (along with most of Massachusetts) was considered to be in a Level 3-Critical Drought state, requiring a ban on all non-essential outdoor water



This map shows the increase in the number of consecutive dry days (which can contribute to drought conditions) across Massachusetts by 2050 under a high carbon emissions scenario. The Buzzards Bay watershed, and the Southeast region as a whole, is projected to experience a greater number of dry days than western Massachusetts.

use. The drought impacted the environment in many ways, including extremely low streamflows, decreasing levels in reservoirs, decreases in groundwater, dry streambeds, ponding, and diminished extent of streams leading to issues like lack of flow, increased turbidity, higher water temperature, and increase in growth of plants and algae in the water.

Figure 11.6: Historical and projected changes in the number of consecutive dry days

	1960's	1970's	1980's	1990's	2000's	2030's	2050's	2070's	2090's
Annual	19.3	17.1	17.3	18.4	17.9	18.7	19.0	19.1	19.5
Winter	11.1	9.7	11.2	9.3	11.4	10.5	10.9	11.2	11.6
Summer	11.6	13.7	14.4	14.4	12.7	14.6	14.9	15.2	15.8

Higher Water Levels

Rising Seas

Climate change contributes to rising sea levels in two ways: the first is through the melting of the globe's glaciers and ice sheets, such as the Greenland Ice Sheet. These ice sheets contain trillions of tons of ice, and enough water to raise global sea levels by at least 24 feet. The other contribution to sea level rise is from thermal expansion: as the oceans become warmer, they expand, taking up more space and rising to higher levels. Rising seas are a hazard in and of themselves, however they also magnify the destructive impact of storms and hurricanes.

Dartmouth is a coastal town with more than 47 miles of exposure to Buzzards Bay, which has experienced nearly 10 inches of sea level rise since 1932. This rise in sea level is slightly more rapid than the rate of increase of average global sea levels, which have risen by 8 inches since 1900. This rate of increase may seem small, but as a general rule, "for every centimeter (0.4 inch) rise in global sea levels, another 6 million people are exposed to coastal flooding around the planet."[1]

The rate of sea level rise is going to increase as thermal expansion and icesheet melt become even greater; under a business-as-usual scenario, Dartmouth is expected to receive an additional 2.4 feet of sea level rise by 2050. By 2100, Buzzards Bay sea levels are anticipated to rise 7.7 feet under a high emission (RCP8.5) scenario. **At five feet of sea level rise, nearly 2,434 acres, 568 people, 360 housing units, and 7 road miles in Dartmouth will be impacted or forced to relocate.**

Exacerbated Flood Risks

While sea level rise itself is a slow-moving process that is difficult to view, it has already exacerbated flood risks from waterbodies connected to the Bay or ocean. As sea levels rise, they become more susceptible to wind and tidal variations. For example, sea level rise can increase the height of a river to stages where it is nearly overtopping riverbanks. When the high tide comes in, the river can then swell and lead to 'nuisance' or 'king tide' flooding. This type of Riverine flooding is already causing major issues in Dartmouth, and can contribute to the loss of river banks through erosion, and paradoxically contribute to harbor sedimentation or other similar negative impacts. Hurricanes can also push water far inland, leading to street level flooding, sewer back-ups (where storm water floods into the sewer and comes up out of the street), or even washing out some coastal roads. These conditions are likely to continue and even amplify. The 2020 storm season was the most active Atlantic hurricane season on record, leading to more than 30 tropical storms or hurricanes, and causing more than $47 Billion in property damage.[2]

Picture of a Warming World seen Locally

The temperature and precipitation changes are the primary impacts of climate change. These fundamental atmospheric shifts have a myriad of spill-over implications for natural and human-made systems. For example, will the Northeast continue to have seasons? How might sea level rise affect the shellfishing industry? What will be the impact on public health from a changed environment? These questions are important to ask and answer, because they help us project what it might be like to live in Dartmouth in the next 30 – 40 years.

These potential impacts are detailed in The Fourth National Climate Assessment. The Fourth National Climate Assessment (2018) is the most recent iteration of the report created every four years for the U.S. Congress and President by the U.S. Global Change Research Program to meet the mandate of the Global Change Research Act of 1990. The report analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent decades. The Northeast Chapter of the report presents a very helpful framework, from which the section below is derived.

1. *https://sealevel.nasa.gov/news/178/greenlands-rapid-melt-will-mean-more-flooding*

2. *https://disasterphilanthropy.org/disaster/2020-atlantic-hurricane-season/*

Changing Seasonality

The Northeast region of the United States is known for having four distinct seasons and a diverse landscape that is central to the region's cultural identity and economy. The Northeast is both the most heavily forested and most densely populated region in the country. Colorful autumn foliage, winter recreation, and summertime beach excursions are all important parts of the Northeast's cultural identity, recreational pursuits, and tourism-generated income. The seasonal nature of Dartmouth and the Northeast as a whole is threatened by climate change and its erosion particularly of the cold-weather seasons.

Winters are warming at a rate three times faster than the average summer, and by the middle of the century winters are projected to be even milder with fewer cold extremes. As winters become milder and spring happens earlier, agricultural products that rely on having a certain number of cold chill hours, or which are vulnerable to frost die off may not be viable or as profitable in these changed climate conditions. Farmers will have to plant new crops or learn new climate-resilient forms of agricultural production.

Warming Oceans

Ocean and coastal ecosystems are being affected by large changes in a variety of climate-related environmental conditions. Ocean temperatures in the Northeast are warming three times faster than in the rest of the globe, and increasing ocean temperatures in the region have been linked with fish and invertebrate species migrating northward as they seek cooler temperatures. Hotter temperatures also contribute to the transmission of aquatic diseases and pathogens. All of these factors have a direct impact on the ability to maintain the fishing industry, or rely on fish for sustenance and personal recreation.

Ocean temperatures are also closely linked to ocean acidification, the process by which the ocean's pH levels decline due to the introduction of CO_2. Since the start of the Industrial Revolution, ocean acidity has declined by about 0.1 pH units, which is around a 30% decrease.[3] This acidification has a particularly harmful effect on shellfish, interfering with their ability to collect the calcium needed for healthy and strong shells. The degradation of shellfish is not only an economic loss to the region, but since the identity of Buzzards Bay is so closely tied to marine industries, these changes may represent a significant loss to the community.

Observed and projected increases in temperature, acidification, storm frequency and intensity, and sea levels are of particular concern for coastal and ocean ecosystems. These impacts threaten their ability to provide important ecosystem services including carbon sequestration, wave attenuation, and fish and shorebird habitat.

Infrastructure and Community Vulnerability

Towns in the Northeast like Dartmouth are among the oldest built places in the nation, which poses a number of unique challenges when it comes to protecting against the impacts of climate change. Critical infrastructure that was historically built purposefully in proximity to water has already been impacted, or will likely be impacted, by climate change, including drainage and sewer systems, flood and storm protection assets, transportation systems, and power supply. A combination of age and previously used,

3. https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification but now outdated, engineering techniques means that these key community building blocks may not be up to the task of maintaining adequate service levels into the future.

Moderate flooding events are expected to become more frequent in most of the Northeast during the 21st century because of more intense precipitation related to climate change, stressing infrastructure elements. Increased precipitation leading to high streamflows can also increase streambed erosion. Such erosion around bridges can cause bridge failures with serious consequences.

Rural, suburban and urban communities are also vulnerable to the social and economic disruptions caused by climate change. Dartmouth contains all of these areas within its borders, meaning that it will face many different types of challenges within one municipality. In rural areas where community identity is built around small, multigenerational, owner-operated businesses, the loss of a home or storefront due to flooding can cause severe economic stress, or could even spell the loss of a community gathering location. In urban and suburban areas, community cohesion might be put at risk particularly due to the impacts of urban heat, sea level rise and increased pollution.

Public Health

There are a number of ways in which changing temperature and precipitation rates can impact our individual and community health. The most direct impact is that higher temperatures lead to higher risks of illness and death, particularly among older adults, pregnant women, and children. For example, in the US by 2050 average annual temperatures are projected to increase by 5.1°F under a business-as-usual scenario, which corresponds to an increase of 650 more deaths per year due to heat related illness. Areas with a high prevalence of paved areas and concrete and a lack of overall green space are particularly vulnerable to the Urban Heat Island Effect, where already high temperatures can be exacerbated.

Increased air temperature will also lead to an increase in the atmospheric concentration of air pollutants such as carbon monoxide, lead, nitrogen oxides, ground-level ozone, particle pollution (often referred to as particulate matter), and sulfur oxides. These pollutants come from the burning of fossil fuels such as gasoline and petrol. Other biological allergens such as pollen will also likely have longer seasons. The impact of these atmospheric contaminants and pollutants may interfere with resident's respiratory systems and can lead to asthma attacks or anaphylactic shock.

As mentioned earlier, the increase in global temperatures has led to a decline in the length of the winter season. This means that pests such as deer ticks, fleas, and mosquitoes, will likely not be killed off as they have in the past. As a result, diseases which are transmitted by these pests can become more widespread. One example is that it is projected that the period of elevated risk of Lyme disease transmission in the Northeast will begin 0.9–2.8 weeks earlier in the future compared to the transmission periods observed from 1992–2007. Another example is the projections anticipated with the mosquito borne illness, West Nile Virus. Projections anticipate an additional 490 cases of West Nile virus per year by 2090 under RCP 8.5.

Because of the age of the infrastructure in the region, most of the sewer pipes in the northeast are a combined sewer-water system (CSO). This means that water and untreated sewage move through the same pipe systems. These pipes are vulnerable to overflowing during storm events when there is extra water in the system, and typically tend to overflow into waterbodies where residents may swim, boat, or fish. Because the sewage is untreated, it carries a vast number of toxic bacteria associated with gastrointestinal illnesses. While Dartmouth does not have CSO's its upstream neighbor, New Bedford, does, and these CSOs discharge to Clarks Cove and Buzzards Bay impact Dartmouth.

While climate change impacts us physically, it also takes a toll on our mental health and wellbeing. The disruptions that extreme weather events have on our daily lives, such as preventing us from seeing loved ones or causing us to miss days of work, induce anxiety, depression, and post-traumatic stress disorder. These effects can be short-term for the duration of a disaster, or they can be longer term.

ROADMAP TO THE FUTURE

Community Goals and Objectives for Climate Change and Resilience in Dartmouth

Climate Change Workshops and Engagement in Dartmouth

In preparing this Master Plan, the Town of Dartmouth wanted to better understand the climate change impacts of most concern to residents. To that end, from January 8th – January 28th, 2021, SRPEDD hosted three individually-paced online activities designed to inform Dartmouth residents on climate projections in the Buzzards Bay Watershed, and to solicit their input on the topic and top priorities to address. On January 28th, 2021, SRPEDD also hosted a virtual Zoom meeting for small group discussions in which participants voiced their views on climate change and resilience, shared more in-depth comments, and shaped their vision for Dartmouth's climate future. The suggestions that came from this workshop indicated a willingness to leverage the town's existing assets for social, environmental, and infrastructural resilience.

Activity 1 was a 'Climate Projections Quiz' designed to inform residents of the predicted climate changes that the Buzzards Bay Watershed can expect to see by 2050 by asking what residents anticipate changes to temperature, precipitation, and sea level, and then providing the actual model-based projections. Sixteen users participated in the quiz. Expected and actual outcomes correlated best in the area of the magnitude of precipitation changes (i.e., "By 2050, how many additional days with extreme precipitation over 1" are there expected to be in Dartmouth under a high emissions level scenario?"), while the greatest disparity between expected actual modeling outcomes were around temperature changes (ie, "By 2050, how many fewer days below freezing are there expected to be annually in Dartmouth under a medium emissions scenario?").

Activity 2 was an "Individualized MVP Prioritization' list whereby participants were put in the shoes of the Municipal Vulnerability Preparedness (MVP) Planning team, to express their views on which actions are most critical for mitigating the impacts of climate change in Dartmouth. This activity used the results of the town's 2020 Municipal Vulnerability Preparedness (MVP) workshop (a state-initiated resilience planning program detailed below). Participants were provided with the geographic location and details of each MVP action item in an online map. Participants would then go into the survey, which organized MVP actions by category and used a ranking system to identify their priority action. Three users participated in this survey. The various categories included: Emergency Response; Sea Level Rise and Coastal Erosion; Flooding, Extreme

Storms, Rising Temperatures and Droughts; Water Quality and Habitat Degradation; Supporting Natural and Built Features that Mitigate Climate Change Impacts; and Empowering Populations to Combat Climate Change Impacts.

Activity 3 asked participants for open-ended thoughts about their ideas and concerns related to climate change in Dartmouth. These questions covered topics such as climate adaptive actions already taken by respondents, respondent's likelihood to relocate to another town, and the impact of climate change on property values. Two users participated in the survey, and exhibited a variety of concerns, from a desire to see town departments cooperate more, to protecting salt marshes and wetland habitats.

The real-time virtual public workshop that was hosted on Thursday, January 28th began with an introductory presentation to contextualize the scope of climate change and its expected primary impacts (increases in precipitation, temperature, sea levels, etc.) and secondary impacts (decline in agricultural productivity, longer pest season, etc.) in the region. The presentation also discussed planning efforts that Dartmouth had previously conducted, including the MVP planning process and the town's FEMA-related Pre-Disaster Hazard Mitigation Plan. Additional existing resilience efforts as well as potential future resilience projects were also discussed.

The presentation set the following key themes as central to the goals of the activity:

- Climate Change is ongoing
- Climate Change is uncertain, and the actions we take now will have a dramatic impact on the future of climate change
- Climate Change is uneven, with different outcomes being felt across the globe and across Massachusetts
- Dartmouth has a good track record of resilience planning to draw from, such as the 2020 MVP list.

Following the presentation, workshop participants were organized into four groups to answer a series of questions designed to solicit their personal experiences with climate change and learn more about where they would like to prioritize climate response in Dartmouth. Each group received the same set of questions, and conversations were facilitated and recorded by SRPEDD staff members. The four questions included:

> Q1: What climate change effects have you noticed most strongly in your daily life from season to season in recent years? What concerns you the most about how climate change will hit Dartmouth on a local level?
>
> Q2: Have you taken any actions on your own property in response to these climate change impacts or climate related hazards? Will climate change likely affect your line of work and or employment prospects in this region?
>
> Q3: What, in your view, are the most important actions for the Town of Dartmouth to take to mitigate climate change impacts in Dartmouth (i.e. to lessen GHG emissions)? Ex. Increasing public transportation, lessening the carbon footprint of town buildings, assisting residents in acquiring solar.
>
> Q4: What, in your view, are the most important actions for the Town of Dartmouth to take to adapt to climate change impacts in Dartmouth (i.e soften the blows of Sea Level Rise, intense storms, increased temperatures, and flooding).

Additional questions were provided to further the conversation. The remaining questions covered topics such as communication from the Town of Dartmouth, individual climate mitigation actions, possible relocation of individuals due to climate change, and silver linings to climate change in the region.

Workshop Outcomes and Community Supported Climate Resilience Actions

Because of the unique nature of this workshop, spread across three self-paced and one live activity, it is important to consider the suggestions provided in each forum to gain a complete sense of the community's climate priorities.

From Activity 1 (Climate Quiz) it is clear that residents are most knowledgeable about the impacts that climate change will have on increasing the likelihood and intensity of extreme storm events. Participants also had background in expected rates of sea level rise. However, participants did not have existing knowledge on indicators related to projected annual average temperature increases, nor about the number of additional summer days above a particular temperature under different emissions scenarios. This could indicate that additional outreach and education efforts are needed along these fronts.

The results of Activity 2 (MVP Prioritization) showed a diversity of thought and priorities amongst residents. Recommendations in certain categories received a consistent, unanimous response, such as developing neighborhood-specific emergency response plans. Other categories such as flooding mitigation priorities received mixed reaction. The areas of unanimous agreement included Emergency Response, Rising Temperatures and Droughts, and Water Quality and Habitat Degradation.

In Activity 3, respondents were able to share their personal thoughts, questions, and preferences for responding to climate change and resilience in Dartmouth. Sentiments shared include the feeling that individual departments were excellent at their individual function, however they were not effectively coordinating their activities for a larger impact. This context is changing, particularly as town departments needed to come together during the start of the pandemic.

In Activity 4 – the virtual public meeting – residents were asked to respond to several questions covering a number of topics centered around participants' lived experience with the impacts of climate change and their perspectives on what the town does and does not do well in responding to climate impacts. A few common themes followed. All groups mentioned some concern with the impacts caused by drought, rising temperatures, and extreme storm/precipitation events. All groups also mentioned using existing housing and infrastructure stock more efficiently, including the installation of solar panels, using parcels more efficiently, and increasing access to sewer and water. Some groups mentioned protecting existing marshlands and floodplains from development as a high priority, either through the use of regulation, conservation restrictions, parcel acquisition, or culvert replacement. Several groups also mentioned providing more space for solar power development, as the northern most section of the town is running out of space zoned for solar. Finally, several groups indicated that the town would be able to improve its social, environmental, and infrastructural resilience through better forestry management that protects all available marshlands, as well as public education initiatives related to climate change and emergency response.

Combining the small group discussions with the activity responses shows some common elements of a possible prioritization of climate resilience response in Dartmouth.

1. The town as a whole needs more control over its development processes, including where development is occurring, what types of development occur, and how development is impacting the underlying water and sewer infrastructure. Stronger design principles, conservation development, more efficient use of existing housing stock, low-impact development, parcel acquisition and incremental changes to zoning bylaws are some ways that the town can exert more control in order to develop in the most sustainable places and at the most sustainable scale.
2. As the town develops, it needs to do so in a fashion that will reduce the town's expenses and allow for the sustainable use of town resources. A cost-of-services study and well planned out town services can assist in this realm.
3. Solar power can help the town mitigate its carbon emissions while making the existing housing stock more efficient and durable. However, solar zoning and bylaws need to be developed, and solar development needs to be well balanced so that the Northernmost part of the town is not overdeveloped. Solar infrastructure that does not clear-cut forests are preferable. The town should also consider encouraging Eversource to expedite their processes and increase their provision of services.
4. Electric vehicles factor into reducing the town's carbon emissions and increasing mobility. More EV charging stations are necessary to support EV adoption within the town.
5. Marshes, wetlands, and ponds can greatly contribute to stormwater management and minimize the projected impacts of extreme precipitation and storm events. However, erosion, sedimentation, development (conversion to impervious surface) and a lack of legal protections has led to the dismantling or replacement of some of these areas. Increased protections, conservation design, marsh restoration, marsh migration, and culvert resizing and replacement could compensate.
6. Saltwater intrusion as well as an increase in age and usage are dual threats to individual septic systems. These systems can and should be upgraded with nitrogen reducing septic systems and the town should consider expanding sewer and water coverage.
7. There is a need for more public outreach and education on certain issues such as the MVP process, the role that trees and forested areas play in cleaning air, conservation efforts and their intersection with climate change, the roles that individuals play in mitigating climate change, and finally resources available at the town level for making these changes occur.
8. The town has ample forested areas and potential locations for stormwater management practices. However, these areas are under threat of development, and as a whole are not managed as effectively as they should be. Conservation efforts combined with increased and improved planning for forested areas can protect these spaces and their contribution to carbon storage.

Previous Resilience Planning and Ongoing Projects in Dartmouth

Dartmouth, particularly as a coastal community, has long recognized the need for climate change and resilience planning. Several previous planning processes around climate resilience have borne out specific recommendations for high-priority actions that the town should pursue to limit climate hazards.

Municipal Vulnerability Preparedness Planning Project and 2020 Hazard Mitigation Plan Update

In 2020, Dartmouth participated in the Commonwealth's Municipal Vulnerability Preparedness (MVP) grant program, which provides support for cities and towns to plan for climate change resilience and implement priority projects. The program has a two-stage process: planning and implementation.

The town created a certified **MVP Plan** based on input from key municipal staff and stakeholders and the community at-large. During MVP workshops, facilitators assisted participants in creating a 'risk matrix' that assessed the most pressing climate hazards correlated to specifically mapped vulnerable areas and sites within the town. The MVP planning workshops included a number of important municipal stakeholders, including the Conservation Officer, Environmental Affairs Coordinator, Town Administrator, Planning Director, Director of Development, and Director of Public Works, along with additional community members such as the Dartmouth Natural Resource Trust, UMASS, Mass Audubon, Round Hill Community Corporation, Dartmouth High School, and Department of Homeland Security Staff.

Collectively the group identified flooding, sea level rise, strong storms, and extreme/increasing temperatures as the main hazards the town has faced in the past and will continue to grapple with into the future. After vulnerabilities were identified, participants analyzed these hazards through the lenses of infrastructural, societal, and environmental vulnerability and created a list of priority actions that they believe will reduce Dartmouth's vulnerability to these threats and increase its preparedness for future climate disasters.

Acknowledging that the impacts of disasters and climate change will likely have disparate impacts throughout Dartmouth, the community identified the following priority action areas:

1. **Town-wide storm water resiliency assessment**: continue work with MassDOT on town-wide transportation improvement program funding opportunities to address high flood areas such as the culvert on Horse Neck Road, the low-lying roadway along Little River Road, the Padanaram Village Causeway, Russells Mills Village, and Smith Neck Road.
2. **Acquire key parcels for land conservation and restoration**: continue to conserve land within floodplains and other flood-prone areas to help mitigate future property damage. Priority areas include the Slocums River corridor, the Noquochoke Lake floodplain, the Buttonwood Brook Watershed, and the Paskamanset River watershed.
3. **Mitigate Town Sewer Pump Station Flooding** for several pump stations in the Paskamanset River floodplain. Of particular concern are the Faunce Corner and North Station pump stations.

While these three areas emerged as the current top priorities, the workshop participants developed a number of additional action items that should be pursued to increase resilience. These other high priority actions include:

- Obtain grant funding for new treatment technologies for nitrates. Rising temperatures and an increased frequency of extreme temperatures (days above 90F) are increasing wastewater treatment costs to Dartmouth's municipal wastewater treatment facility.
- Develop a renewable energy plan for all town facilities and properties to be carbon neutral (e.g., solar panels on schools, etc.).
- Assess feasibility of locating a Fire District 2 substation west of the causeway. Conduct an engineering/design study for the installation of an additional culvert under the causeway to reduce flooding by increasing tidal flow and drainage capacity. Storm surge cuts off access to Padanaram Village for emergency services from the Bridge Street Fire Station.
- Tree/forest management recommendations: conduct a Town-wide tree planting plan to improve forested buffers to increase resiliency, continue to implement the Key Trees Removal Plan for the Town, and develop forest management plans for private and town-owned forested areas. Work with NRCS, land trusts, etc. to determine which areas need plans.
- Incorporate disposal and removal of disaster debris into the Dartmouth Emergency Management Response Plan.
- Develop a watershed management plan for the Slocums River which uses previous studies and assessments from the Buzzards Bay Coalition, Buzzards Bay National Estuary Program, the town, and other available data that would also contribute to water quality improvements in conformance with the requirements set forth the Slocums and Little River total maximum daily loads (TMDL) issued by Massachusetts Department of Environmental Protection in September 2019.

Now that the town has undertaken the MVP Planning Process, it is eligible to apply for MVP Action Grant funding. Applying for MVP funding to implement these priority projects is an effective and proven way to reduce the town's vulnerability profile and ensure it is proactively ready for the next major event.

Dartmouth Hazard Mitigation Plan

Prior to the 2020 MVP Plan, Dartmouth's principal set of resilience-related recommendations was established in its 2015 Hazard Mitigation Plan, the purpose of which is to prevent property damage and loss of life and associated with natural hazards, save money by instituting mitigation measures to protect against natural hazards, allow funding through the Federal Emergency Management Agency (FEMA) for post disaster remediation, and expedite disaster recovery. As part of its 2020 MVP Planning grant award, Dartmouth received additional funds to simultaneously update its Hazard Mitigation Plan. The updated plan notes several existing mitigation measures that are currently in place in Dartmouth that contribute to resilience, including:

- Local Emergency Management Agency
- Comprehensive Emergency Management Plan

- Wetlands Protection Bylaw
- Earth and Soil Removal Bylaw
- Water Use Restrictions Bylaw
- Waterways Management Bylaw
- Waterfront Overlay District
- Floodplain District
- Aquifer Protection District
- Subdivision Regulations stormwater and utilities provisions
- Backup Power Supplies
- Emergency Shelters at the Council on Aging (COA) & High School
- Mutual Aid Agreements Neighboring Towns
- Drainage Structure Maintenance
- Tree Trimming
- Proactive Roadway Closures
- Milton & Sharp Street Culvert Upgrades (Buttonwood Brook)
- Public Outreach web, social media, Dartmouth Community Media (DCTV)
- Participation in National Flood Insurance Program
- University of Massachusetts Dartmouth Emergency Planning

All of these elements make Dartmouth more resilient to natural disasters by controlling the proximity of development to sensitive natural features, by providing backup plans for power and shelter, by giving forethought to potential disasters, or by providing means for disseminating essential information during an emergency.

While these existing measures are acknowledged and significant, the Hazard Mitigation Plan seeks to further enhance disaster preparedness with the following proposed actions (in priority order):

1. Petition FEMA to update Flood Insurance Rate Maps (FIRMs), which establish the Special Flood Hazard area in town. [completed]
2. Address the former police station property.
3. Alleviate flooding at Eddy Street.
4. Improve drainage under Padanaram Causeway.
5. Establish additional Emergency Shelter in North Dartmouth.
6. Establish additional Emergency Shelter near Smith Neck Road.
7. Expand use of social media and other public outreach channels.

8. Improve interdepartmental and interagency communications.
9. Establish Evacuation Procedures.
10. Ensure evacuation routes provide adequate traffic flow.
11. Address recommendations on the Russells Mills Dam.
12. Address recommendations on the Corneel Pond Dam.
13. Prepare and formalize mutual aid agreements.

Proposed infrastructure upgrade proprieties are listed separately, and include:

1. Make infrastructure improvements along Buttonwood Brook
2. Provide flood protection at critical wastewater pump stations
3. Improve Padanaram Bridge and Causeway flow capacity
4. Enlarge culvert or raise Old Fall River Road
5. Address UMass drainage and flooding issues
6. Address additional areas prone to periodic flooding

Padanaram Harbor Management Plan

The Padanaram Harbor Management Plan includes resilience recommendations related to Dartmouth's coastal zone and village district. Resilience projects that would have direct outcomes for the harbor include:

- Enforcing and strengthening semi permeable pavement requirements.
- Create standards within the Dartmouth Wetlands Protection By-law to protect saltmarsh and water quality interests from cumulative impacts of docks.
- Identify and remediate the sources of nutrient inputs into the harbor and establish TMDLs.
- Consider participating in the National Flood Insurance Program's Community Rating System (NFIP CRS).
- Develop a plan for boat removal from harbor before storms.
- Ensure that stormwater system is capable of accommodating current and project weather conditions.
- Consider public education measures to convey the risks associated with sea level rise and increased storm related flooding and prepare community members to take actions to minimize the impacts.
- Review and modify the Floodplain Overlay District [completed]
- Explore regulations prohibiting new construction in high velocity zones.
- Take measures to address vulnerable infrastructure (pump house, sewers, storm drains) in areas anticipated to experience flooding.

- Review existing evacuation routes annually and revise with new climate change projections.
- Explore a barrier option for the harbor to protect against storm surge.
- Evaluate the feasibility of acquiring land to connect West Smith Neck Road to Smith Neck Road to use during evacuations due to flooding conditions.
- Prioritize protection of lands behind salt marshes to allow marsh migration landward with rising seas.
- Conduct an analysis of potential inland and precipitation related flooding as a result of projected changes in precipitation.

Shift to Electric Vehicles and Renewable Energy

Dartmouth participates in the state's Green Communities Program. The town's certified Energy Reduction Plan (2018) has resulted in grant applications and awards from the state that support energy savings measures in town buildings and vehicles fleets. Over $800,000 in projects have been installed in Dartmouth since the Energy Reduction Plan was certified.

In particular, the police department is leading the way in converting their gas patrol fleet to hybrid vehicles. Initiated in 2020, it is anticipated that with one last vehicle delivering in 2023, the patrol fleet will have, with minor exception for K9 vehicles, complete this transition. The department has realized significant fuel savings with hybrid vehicles. The majority of the savings with hybrid vehicles occur when the vehicles are at idle and are able to run off of the battery, only using the engine for brief periods of time to recharge the battery. The next evolution in police fleet vehicles is battery electric vehicles (BEVs). Chevrolet has announced an EV police vehicle for 2024. While the up-front costs of EV's are higher than conventional gas or even hybrid vehicles, the overall cost-of-ownership is generally lower with realized savings over the life of the vehicle. EV's run entirely on electricity that usually costs about half of what gasoline costs. These vehicles require very little maintenance which, in additional to saving money, should result in increased up-time.

To support an electric fleet, several level-3 DC fast chargers and possibly some level-2 chargers would need to be installed at the police station. Level-3 chargers can replenish a vehicle's capacity in the 20-30 minutes it takes to perform a shift change. Installation of the required infrastructure to support a fleet of electric vehicles would require planning and funding. It may also be prudent to explore adding solar production with battery storage at the station to support police operations while reducing our reliance on the electric grid.

Goals and Strategies

Given that there have been several recent studies and planning efforts around climate change resilience in Dartmouth, it is interesting to note where recommendations overlap between documents, and how they correspond with the opinions expressed during the Master Plan public engagement efforts on this topic. The Goals and Strategies developed below highlight recommendations by climate change impact area, and focus on those that are high priority across studies and engagement outcomes.

Climate and Resilience Goal 1:

Increase public education around the predicted impacts of climate change.

Why Dartmouth / Why Now?

Climate change is happening now. Even in a hypothetical world where everyone on the globe stopped emitting all fossil fuels tomorrow, there is enough excess thermal energy in the earth's system that we would still experience a decade of warming until reaching a temperature plateau. Given this reality, Dartmouth business owners and residents need the best information on climate change predictions possible in order to make material decisions on how to invest in their property and prepare for climate hazard events.

Key Strategies for Action

Strategy		Responsible Party	Time frame
CR-1A	**Expand town webpage to include a more definitive section for residents with climate change predictions and related resources for protecting and mitigating harm.** The goal of this page would be to first, communicate the predictions for increased temperatures, precipitation events, and sea level rise, and second, to provide resources, such as information about the town's floodplain by-law, best practices for flood-proofing homes, utilities and other structures, information about evacuation routes, locations of emergency shelters, and other such resources all provided in one webpage location.	Town Admin, Planning Board, and Emergency Mgmt Agency	1 Year

CR-1B	**Develop neighborhood-specific emergency response plans**. These area-specific plans can tailor emergency response efforts and create a blueprint for response during a crisis.	Town Admin, Emergency Mgmt. Agency	3-7 Years
CR-1C	Maintain and advocate for governmental resources and involvement in protecting citizens, businesses, property, and the economy from climate change.	Town wide	on-going
CR-1D	Provide a governmental structure and processes that can track and integrate new concepts and teachings for evolving with climate change.	Town admin., boards and departments	on-going

Climate and Resilience Goal 2:

Promote energy efficiency in building design and support renewable energy in Dartmouth, decreasing GHG emissions from both the public and private sectors.

Why Dartmouth / Why Now?

As effects of the global climate crisis are felt locally, the town and its residents can work to reduce their contribution to global warming through targeted reductions in GHG emissions and support for alternative fuels. The town can also mitigate GHG outputs by caring for the health of carbon sinks, such as forest land and marshes, which perform essential carbon sequestration services.

Key Strategies for Action			
Strategy		**Responsible Party**	**Time frame**
CR-2A	**Continue instituting energy savings in town facilities by pursuing Green Communities funding that implements the town's Energy Reduction Plan (ERP).** Dartmouth can lead by example in continuing its recent track record of installing upgrades and new energy efficient systems as funded by the Green Communities program.	Townwide	On-going
CR-2B	**Expand into Green Communities Community Net Zero programming.** With its latest Regional Energy Planning Assistance (REPA) grant cycle, the state Department of Energy Resources has started to expand the activities funded under the Green Communities umbrella to include community Net-Zero Energy Plans. Dartmouth is a prime candidate for transitioning into this next phase of aiming for carbon neutrality. This recommendation also appeared as a high priority item in the town's MVP plan.	Town Admin, Director of Development	1-3 Years
CR-2C	**Publicize Residential Unit Energy Audits.** Encourage residents to participate in the Mass Save program, which includes a free at-home evaluation of potential energy savings measures.	Town Admin, Conservation Commission	On-going

CR-2D	**Renewable Energy Corridors.** Pursue the installation of electric vehicle charging stations for use by the town's fleet and as part of new commercial development for use by the general public.	Town Admin, Planing Board, DPW Highway Division	3-5 Years
CR-2E	**Consider the appropriate siting of renewable energy sources.** Solar power can help the town mitigate its carbon emissions while making the existing housing stock more efficient and resilient. Evaluate the zoning districts that permit solar installations to expand or modify the zone, if necessary, and incentivize solar installation on buildings rather than on greenfield areas.	Assistant T.A., Conservation Commission, and Planning Board	1-3 Years
CR-2F	**Practice forestry management.** Conservation efforts combined with increased and improved planning for forested areas can protect these spaces and their contribution to carbon storage. **Implement the high priority actions related to tree management in the town's MVP Plan,** including the action to conduct a town-wide tree planting plan to improve forested buffers and forest resilience.	Conservation Commission, local land trusts, conservation restrictions, Planning Department, DPW	1-3 Years
CR-2G	For all renewable energy projects, consider the potential impacts on natural resources, public safety, community character, and seek appropriate mitigation and safeguards.	Planning Board, Town Admin., Select Board	On-going

Climate and Resilience Goal 3:

Exercise control over development for the future of the community around climate change and sea level rise.

Why Dartmouth / Why Now?

In the context of reducing overall climate hazard risk, the town needs more control over its development processes in limiting where development is occurring in high hazard areas. Several bylaws and land acquisition measures can be taken that help the town to exert control in order to site development in the most sustainable places and at the most sustainable scale.

Key Strategies for Action			
Strategy		**Responsible Party**	**Time frame**
CR-3A	**Implement the MVP Plan top recommendation to acquire key parcels for land conservation an restoration.** Purchasing and preserving flood-prone land in floodplains removes the potential to construct buildings that would be at in increased likelihood of property damage. Target land in the priority areas of the Noquochoke Lake floodplain, the Buttonwood Brook Watershed, and the Paskamanset River Watershed.	Planning Board, Town Meeting, Conservation Commission, Land Trusts	On-going
CR-3B	**Incentivize sustainable development practices**. Dartmouth has bylaws that present sustainable development options, such as open space residential design options. One way to ensure that this happens more regularly is to incentivize OSRD development options through a moderate density bonus whenever a developer elects these lower-impact choices.	Planning Board, Town Meeting	1 Year
CR-3C	**Evaluate key design standards.** The Planning Board can review impervious surface coverage limitations, and determine if a lower coverage limit might be appropriate for the purposes of decreasing runoff and increasing stormwater infiltration.	Planning Board, Town Meeting	3 Years

CR-3D	**Study saltwater intrusion.** As sea levels rise, private wells and septic systems may be threatened by saltwater intrusion. Connections to public water and sewer may be necessary to service areas of town that experience saltwater intrusion.	Town Admin, Consulting Engineers	3-5 Years
CR-3E	**Atune review boards to consider the topographic information provided in coastal development and permit applications and provide comment on any improvement suggested on land under 5 feet above sea level.** While there may not yet be a precedent for outright prohibiting structures that may soon be underwater, point the implications of sea level rise on any proposals may open conversations about keeping new construction outside of sea level inundation zones.	Planning Board, Conservation Commission	1 Year

Climate and Resilience Goal 4:

Protect life and property from flooding and storm surge.

Why Dartmouth / Why Now?

Increased flooding and stormwater volumes are one of the most present and observable outcomes of climate change. Any actions that can decrease known problem flood areas will help to ensure the safety of residents and the stability of their property.

Key Strategies for Action			
Strategy		**Responsible Party**	**Time frame**
CR-4A	**Implement the top MVP Plan priority of conducting a town wide stormwater resilience assessment**. Such an assessment would create a pathway for addressing the most intractable stormwater pinch points in the town's transportation network. Especially address the three sewer pump stations located in the flood zone along the harbor.	Town Admin, DPW Highway Division, Planning Department	1-2 Years
CR-4B	**Preserve coastal marshes as a key storm surge barrier**. Marshes act like a sponge, helping to soak up stormwater and break the impact of storm surge. However, coastal marshes are under threat from erosion, sedimentation and inundation from sea level rise. The town can ensure that coastal marshes continue to serve this protective role with marsh conservation, restoration, and setting aside uplands for marsh migration. The Padanaram Harbor Management Plan also supports this recommendation, suggesting that lands behind salt marshes be prioritized for protection to allow for marsh migration landward with rising seas.	Conservation Commission, land trusts	On-going
CR-4C	**Floodproof infrastructure.** Implement the town's top priority MVP action of mitigating the flooding of town sewer pump stations in the Paskamanset River floodplain.	Town Admin, Water Division, DPW	1-3 Years

CR-4D	**Reevaluate key components of the town's emergency evacuation procedures.** As per the Hazard Mitigation Plan, ensure that evacuation routes provide adequate traffic flow. As per the Padanaram Harbor Management Plan, consider reevaluate evacuation routes annually and revise with new climate change projections. Also per the harbor, evaluate acquiring land to connect West Smith Neck Road to Smith Neck Road to use during evacuations.	Town Admin, Emergency Mgmt Agency	On-going
CR-4E	**Consider participating in the National Flood Insurance Program's (NFIP) Community Rating System (CRS) Program,** which provides a tiered level of possible participation. The more regulatory, educational, and other actions that a community takes to mitigate flood risk, the higher their rating, and the lower that flood insurance premiums become for all policy holders in town.	Town Admin, Planning Dept.	On-going
CR-4F	**Examine options for Repetitive Loss and Severe Repetitive Loss residential properties.** Repetitive Loss properties are those which have experience damage and submitted flood insurance claims on multiple occasions.	Planning Department, Con. Comm., State and FEMA partners	3 years

Climate and Resilience Goal 5:

Take actions that can provide relief from and mitigation of extreme heat and drought.

Why Dartmouth / Why Now?

Dartmouth's MVP planning participants selected increased and extreme temperatures as one of the principal climate hazards that the town is experiencing; at the same time, Master Plan public outreach found that while the community was generally well-informed about sea level rise, residents had a less clear picture of the types of extreme heat events and changes in annual average temperatures that are expected for the region. Extreme heat is a threat that can cause real bodily harm to individuals, especially seniors and especially in areas like the Northeast that have not traditionally needed to rely on air conditioning, where many old homes were built without it.

Key Strategies for Action			
Strategy		**Responsible Party**	**Time frame**
CR-5A	**Encourage tree planting in residential areas** to promote shade and cooling.	Conservation Commission, Planning Board	On-going
CR-5B	**Increasing Cooling Shelter Capacity.** The town's Hazard Mitigation Plan prioritizes the establishment of additional emergency shelters in North Dartmouth and near Smith Neck Road. As these shelters are established, the town can choose facilities that also have the capacity to serve as cooling stations during periods of extreme heat.	Town Admin, Emergency Mgmt. Agency	1-3 Years
CR-5C	Enforce water inspections during drought periods to ensure compliance with water restrictions.	Water Division	On-going
CR-5D	**Upgrade Dartmouth's municipal wastewater treatment facility in order to better process nitrates.** Another result of warming temperatures is the different composition of pollutants and compounds in Dartmouth's wastewater. New technologies are needed for the town's wastewater treatment operation to keep up with these impacts of extreme temperatures. This action is a high priority MVP action.	Water Division	5-7 Years

Climate and Resilience Goal 6:

Evaluate the socio-economic sectors of town in light of climate change disruption.

Why Dartmouth / Why Now?

In maintaining its economic base, Dartmouth should consider which local industries are vulnerable to disruption from climate change - both hazard events and long-term trends.

Key Strategies for Action			
Strategy		**Responsible Party**	**Time frame**
CR-6A	**Work with the agricultural community to understand shifts in production that may be made possible or required by a longer and hotter growing season.**	Agricultural Commission, Planning Department	On-going
CR-6B	**Work with the marine industry to understand shifts in fisheries and water-based tourism under warmer water conditions.**	Harbor Master, Planning Department, HMPIC	On-going