APC and Nemasket Watershed Management and Climate Action Plan

August 1, 2022

SRPEDD
Southeastern Regional Planning & Economic Development District

HORSLEY WITTEN GROUP
Sustainable Environmental Solutions

The Nature Conservancy

WALBERG CONSULTING

TABLE OF CONTENTS

SECTION 1. INTRODUCTION 6
Project Background 6
Watershed Overview 7
Environmental Justice Communities 11
Tribal Land Acknowledgement 13
Core Concepts 14
Watershed Functions 14
Regional Green Infrastructure Network 17
Nature Based Solutions 19
Climate Change Overview 19
Resilience 22
Plan Overview 23
Planning for a Resilient future 23
Acknowledgements 24
SECTION 2. A GUIDING VISION 27
Vision Statement 27
How We Get There 28
Reduce flood risks to people and property 28
Safeguard public drinking water supplies 29
Improve Water Quality 29
Preserve wildlife and habitat 29
Encourage sustainable development that retains natural functions 30
Enable ecologically appropriate recreation 30
Foster a widespread culture of stewardship 30
Expand opportunities to improve cooperative management 31
Vision Statement Development 31
SECTION 3. WATERSHED CLIMATE CONDITIONS – PRESENT AND FUTURE 33
Projected Regional Climate Change 33
Climate Change and Stationarity 37
4. TOPICAL AREAS OF CONCERN: CONDITIONS AND CHALLENGES 38
Flood Management 38
Existing Conditions 38

Challenges 39
Climate Change Impacts 41
Drinking Water Supply 43
Existing Conditions 43
Challenges 45
Climate Change Impacts 46
Water Quality 47
Existing Conditions 47
Challenges 47
Climate Change Impacts 50
Ecology 50
Existing Conditions 50
Challenges 51
Climate Change Impacts 53
Land Development 53
Existing Conditions 53
Challenges 54
Climate Change Impacts 56
Recreation 57
Existing Conditions 57
Challenges 59
Climate Change Impacts 59
Stewardship 60
Existing Conditions 60
Challenges 61
Climate Change Impacts 63
Interagency Cooperation 63
Existing Conditions 63
Challenges 66
Climate Change Impacts 66
5. KEY WATERSHED MANAGEMENT TENSIONS 67
6. MANAGEMENT ACTION RECOMMENDATIONS 69
Goal 1: Reduce flood risks to people and property 70

Goal 2: Safeguard public drinking water supplies 74
Goal 3: Improve water quality 78
Goal 4: Preserve wildlife and habitat 82
Goal 5: Encourage sustainable development that retains natural functions 86
Goal 6: Enable ecologically appropriate recreation 92
Goal 7: Foster a widespread culture of stewardship 96
Goal 8: Expand Opportunities to improve cooperative management 99
7. CONCLUSIONS AND NEXT STEPS 104
8. APPENDICES 106

Plan Figures

Figure 1. Map of the APC and Nemasket River Watersheds 8
Figure 2. Regional Context Map 9
Figure 3. Watershed Community Population and Area Statistics 10
Figure 4. Map of Environmental Justice Communities in the six Key Watershed Stakeholder Municipalities 12
Figure 5. Ecosystem Services Categories and Examples 15
Figure 6. APC Digital Watershed Tour Video Links 16
Figure 7. APC-Nemasket Regional Green Infrastructure Network Map 18
Figure 8. A Graphical Depiction of Resilience (Patterson & Kelleher, 2005) 22
Figure 9. Plan Steering Committee Membership 25
Figure 10. Average Annual and Seasonal Temperature Predictions for 2050 under Medium and High GHG Emissions Scenarios 33
Figure 11. Total Annual and Seasonal Precipitation Predictions for 2050 under Medium and High GHG Emissions Scenarios 34
Figure 12. Average Annual Temperature Projections for the Taunton River Watershed - 2050 and 2090 Benchmarks 34
Figure 13. Total Precipitation Projections for the Taunton River Watershed – 2050 and 2090 Benchmarks 35
Figure 14. Annual Days above 90 Degree Fahrenheit by 2050 in Massachusetts 35
Figure 15. Extreme precipitation events (>1”) by 2050 in Massachusetts 36
Figure 16. Consecutive Dry days (drought causing days) by 2050 in Massachusetts 36
Figure 17. Spatial Representation of 2010 Floods (based on interviews and documentation) 42
Figure 18. Map of Approximate Water Withdrawal Locations 44
Figure 19. APC-Nemasket Massachusetts Department of Environmental Protection Impaired Waters 49
Figure 20. APC-Nemasket MA NHESP BioMap2 52
Figure 21 Watershed Land Cover Map (MassGIS 2016 Land Cover/Land Use data, 2019) 55
Figure 22. Open Space and Recreation Lands by Purpose 58
Figure 23 Watershed Land Ownership (MassGIS Level 3 Parcel Data for Middleborough, Lakeville, Rochester, Freetown, and New Bedford, 2020) 62
Figure 24. APC-Nemasket 12 Point Priority Action Plan 105

SECTION 1. INTRODUCTION

Project Background

The development of this Watershed Management and Climate Action Plan builds off years of assessments and planning efforts directed by the Assawompset Pond Complex (APC) Management Team. Since its formulation in 2002, the APC Management Team has brought together a group of representatives from the communities of Lakeville, Freetown, Middleborough, Rochester, the City of New Bedford and the City of Taunton Water Supply entities, local stakeholder groups such as the Middleborough-Lakeville Herring Fisheries Commission, and state agencies such as the Department of Environmental Protection and the Department of Fish and Game to coordinate around the protection of the Assawompset Pond Complex as a public good, providing drinking water supply, high quality habitat, and responsible pondside land and Long Pond-based aquatic recreation. The APC Management Team had specific areas of focus, including the establishment of standard seasonal water level targets in the ponds, and coordinated recreational access limitations and permitting procedures.

The very existence of the APC Management Team communicates the variety and intensity of stakeholder interests in the APC; it is a drinking water supply for more than 250,000 people in southeastern Massachusetts; it is unique and sensitive habitat, especially as the spawning ground for river herring that journey between the ponds and Narraganset Bay every year; it is integrated with the lives of residents in Lakeville, Rochester, Freetown, and Middleborough, especially those communities that live along its shoreline and in nearby residential communities that experienced the flooding of these waterbodies in extreme weather conditions in 2010. The APC Management Team is the first and currently only inter-community and inter-agency body in the area that is dedicated to preserving the essential functions of the APC and to examining the needs of all stakeholders in the Ponds in a coordinated and cooperative way.

In 2020, the APC Management Team expanded its traditional scope of activity, serving as the Steering Committee for a project aimed at considering how flood mitigation could be achieved in the context and on balance with preserving other interests in the APC system. The Management Team worked with consultants from the Southeastern Regional Planning and Economic Development District, The Nature Conservancy, Manomet, Mass Audubon and Horsley Witten, with funding from the State's Division of Ecological Restoration, to synthesize decades of historical recommendations and prioritize those addressing current pressing concerns for the APC. Out of 140 existing recommendations, including those from recent local Municipal Vulnerability Preparedness planning reports and addenda, the need for a wholistic and comprehensive APC and Nemasket Management Plan emerged as one of the top priority action items for balancing not only flooding and drinking water supply needs, but a multitude of management and climate resilience goals in the region.

This Plan is that next step in the evolution of comprehensive watershed management and climate action planning. The Plan evaluates proposed management actions and their ability to address both existing and future climate resilience concerns across the watershed. It proposes comprehensive watershed management, climate change adaptation and natural hazard mitigation strategies. Decades of studies of the APC and its resources have been merged with more recent climate hazard planning conducted by all four pondside communities, enabled by the State's Executive Office of Energy and Environmental Affairs (EEA) Municipal Vulnerability Preparedness (MVP) Program. Freetown, Lakeville and Rochester all

became MVP-certified in 2019, and together, completed a Regional MVP Addendum to each of their local MVP Plans that prioritized addressing concerns in the APC. Middleborough later became MVP-certified in 2020. Combining previously studied recommendations with a new climate-aware approach allows this plan to be action-oriented, identifying actions that will help to manage the system today across interests, and against the challenges to of tomorrow from known, oncoming climate change conditions.

Watershed Overview

The Assawompset Ponds Complex (APC) consists of five interconnected ponds arranged in a horseshoe shape. Long Pond is the western prong of the complex, with intensive development along its shores and allowances for water-based recreation. Assawompset Pond, in the middle of the complex, is the largest of the ponds and is the location of water supply withdrawal infrastructure for the City of Taunton and is the immediate location of the complex's main outlet at the APC Dam, serving as headwaters of the Nemasket River. From north to south Pocksha Pond, Great Quittacas Pond, and Little Quittacas Pond make up the eastern prong of the complex. Little Quittacas is the location of water supply withdrawal infrastructure for the City of New Bedford. The APC is the largest naturally-occurring body of fresh water in Massachusetts. Supporting a diversity of plant and animal life, the APC drains into the Nemasket River, which flows for 11 miles to its confluence with the federally-designated Wild & Scenic Taunton River, which then flows southwest to Mount Hope Bay on the Rhode Island border.

The APC and Nemasket River Watersheds (combined and referred to as "the Watershed" herein) is the target area of this Plan. The Watershed covers 44,901 acres of land across two counties. Most of the Complex, including Long Pond, Assawompset Pond, and Pocksha Pond, is part of the larger Taunton River Watershed, which covers 339,077 acres in Southeastern Massachusetts. Great and Little Quittacas Ponds diverge and are part of the greater Buzzards Bay watershed, draining to the south through groundwater and small streams such as the Snipatuit Brook. The majority of the Watershed is located within Plymouth County, though it extends to the southeast into Bristol County. It contains portions of five towns as follows.

Lakeville is located in the western portion of the Watershed, and borders large portions of each of the ponds in the APC, as well as the western bank of the Upper Nemasket River, which serves, in its initial extent, as the boundary between Lakeville and Middleborough. Long Pond, the area with the most intensive pondside development, is mainly located in Lakeville.

Middleborough encompasses the eastern portion of the Watershed, and contains the lower Nemasket River downstream of the rail line as well as the eastern banks of Assawompset, Pocksha, and Great Quittacas Ponds. It is the largest town in the watershed, and the second largest in the state, at over 70 square miles. A historically agricultural community, Middleborough is characterized by a low-density development pattern with a central village area. Agriculture, historically a staple of the local economy, has become less prevalent in recent years, with lands converted to residential and commercial uses.

Freetown contains the southern extent of the Watershed southwest of Long Pond. The town has little in the way of public water and sewer availability. This dependence on private wells and septic systems has fostered a landscape characterized by large-lot, single-family homes. The southern tip of Long Pond is located in Freetown.

Figure 1. Map of the APC and Nemasket River Watersheds

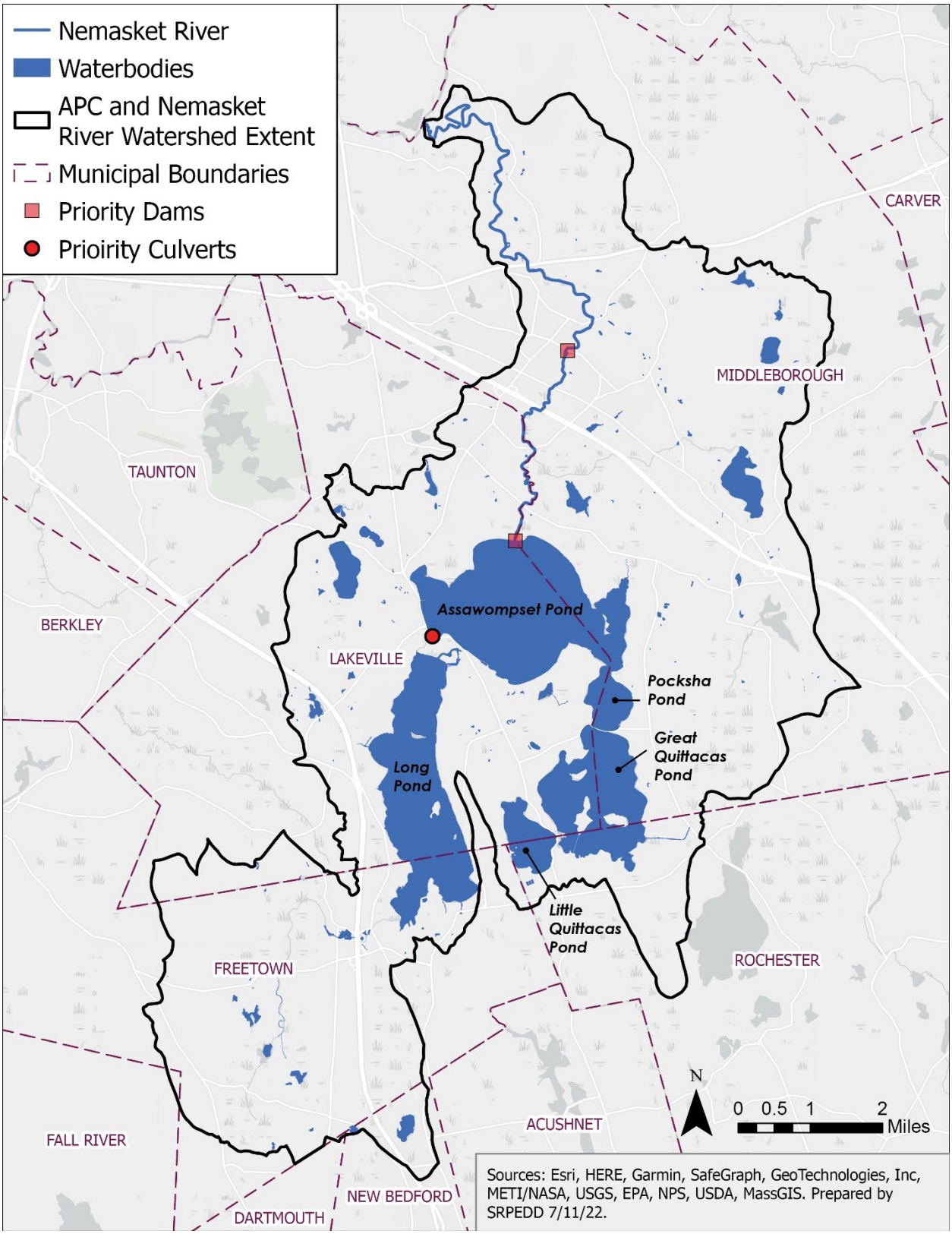
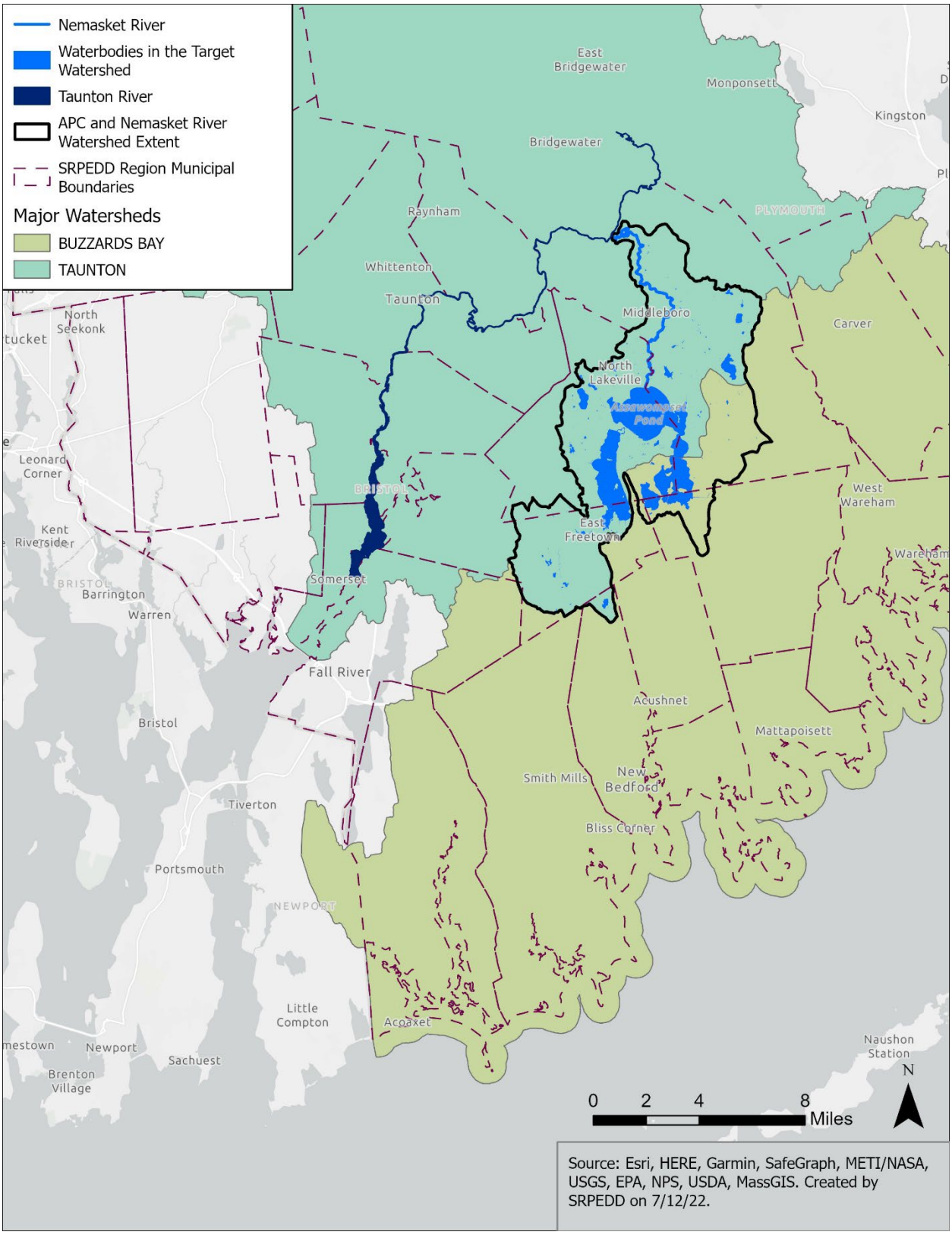


Figure 2. Regional Context Map



A relatively small portion of the Watershed lies within the north west portion of the town of **Rochester** in the corner of town above Snipatuit Pond. This portion of the town is zoned for agricultural-residential use (allowing single-family and agricultural uses, one multi-family dwelling up to 4 units per lot, and additional residences by special permit).

A relatively small portion of the southern extent of the Watershed lies in **New Bedford**, a coastal city and the most intensively-developed community in the Watershed. The portion of the city that lies within the Watershed is zoned for residential and business uses.

Though it does not overlap with the Watershed area, this Plan also includes the City of **Taunton** as a key stakeholder, because as with New Bedford, Taunton's water supply comes from Assawompset Pond.

Overall, the Watershed is predominantly rural in character, with pockets of medium-density development concentrated around major roadways and historic villages. The Population by Watershed Community table below, showing overall population figures for each community in the Watershed, gives some idea of the scale of development. Approximately 5.7% of the Watershed is covered by impervious surface (often used as a proxy for development), with a concentration of development around the shores of Long Pond. Water covers 14.6% of the Watershed. The remaining undeveloped land is a mix of forests, wetlands, and agricultural areas. Significant portions of the watershed are protected for water supply and other purposes, including the New Bedford-owned land around Assawompset, Pocksha, Great Quittacas and Little Quittacas Ponds; Betty's Neck Conservation Easements; the Black Brook Wildlife Management Area; and the Freetown-Fall River State Forest.

Figure 3. Watershed Community Population and Area Statistics

Town	2020 Population[1]	2040 Population Projection[2]	Total Community Area[3]	Area in Watershed[4]
Freetown	9,206	9,313	22,710	8,407
Lakeville	11,523	12,175	23,102	13,647
Middleborough	24,245	34,964	46,194	20,318
New Bedford	101,079	105,284	12,938	511
Rochester	5,717	6,604	23,111	1,982
Taunton	59,408	54,424	30,973	0

1. 2020 Decennial Census Counts
2. SRPEDD 2020 Regional Transportation Plan Projections
3. Acres as calculated in GIS
4. Acres as calculated in GIS

Environmental Justice Communities

In many parts of Massachusetts and the country at-large, communities that are underrepresented or vulnerable by nature of access, resource, or power imbalances are still to this day facing a legacy of disproportionate negative environmental impacts. The quality of localized environments matters significantly to public health and individual well-being. Environmental Justice work and principles proactively seek to reverse legacies of environmental inequities across neighborhoods, create equitable access to environmental resources, and center communities coping with disproportional environmental impacts that are also often on the frontline of the worst effects of climate change.

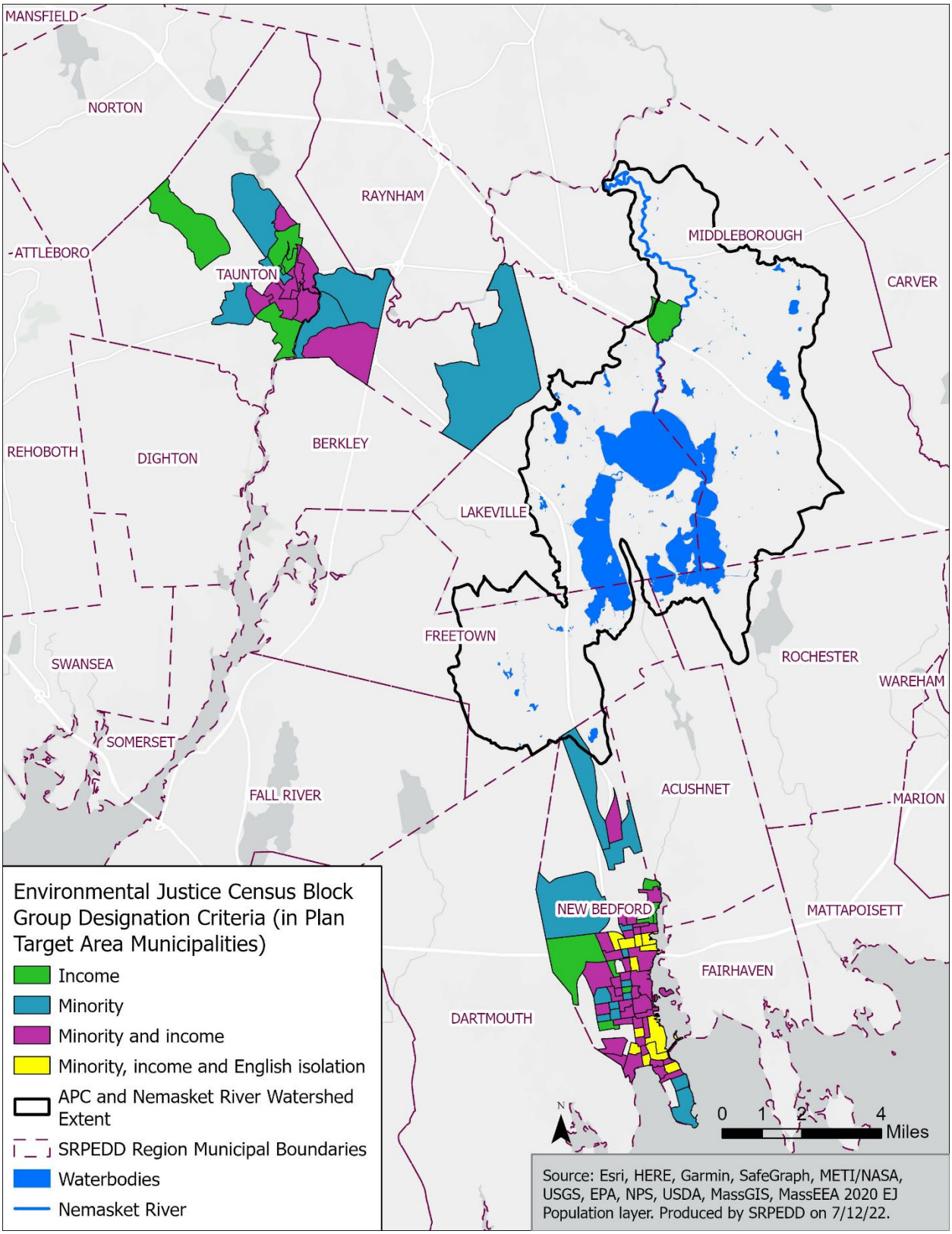
In Massachusetts, a neighborhood is defined as an Environmental Justice population if one or more of the following four criteria are true (EEA, 2021):

- Annual median household income is not more than 65 per cent of the statewide annual median household income;
- Minorities comprise 40 per cent or more of the population;
- 25 per cent or more of households lack English language proficiency; or
- Minorities comprise 25 per cent or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150 per cent of the statewide annual median household income.

Analysis to identify Environmental Justice populations is done on a Census Block Group geographic basis. In some cases, a block group meets more than one of the above criteria.

In the six Watershed stakeholder municipalities of Freetown, Lakeville, New Bedford, Middleborough, Rochester, and Taunton, there are Environmental Justice (EJ) populations in three communities. Middleborough contains one EJ block group that qualifies on the basis of income. Taunton contains 18 EJ block groups; four that qualify on the basis of income, six that qualify on the basis of minority, and eight that qualify on the basis of both income and minority. New Bedford contains 69 EJ block groups; eight that qualify on the basis of income, 13 that qualify on the basis of minority, and 36 that qualify on the basis of both income and minority, and 12 that qualify on the basis of income, minority and English isolation. Throughout this Plan and in developing and prioritizing watershed management actions, we must center the needs of the Environmental Justice populations that are part of the six stakeholder communities, particularly in ensuring that any suggested management actions do not compromise the ability of the cities of Taunton and New Bedford to supply vital, high quality drinking water to residents.

Figure 4. Map of Environmental Justice Communities in the six Key Watershed Stakeholder Municipalities



Tribal Land Acknowledgement

We cannot plan for the future of the Watershed without first reflecting on its past. And we cannot expect to be good stewards of its resources, without recognizing and learning from the stewards who have lived on its land for millennia. The Watershed is situated on the ancestral unceded lands of the Massa-adchu-es-et (Massachusett), Wôpanâak (Wampanoag) and Pauquunaukit (Pokanoket) (Native Land Digital, 2021; The Massachusett Tribe at Ponkapoag, 2022; Speck, 1928; Sowams Heritage Area, 2017). Honor and respect are due to the Watershed for the bountiful natural, recreational, and cultural resources it provides us with today, as well as to the indigenous peoples who discovered, cultivated, and cared for these resources.[1]

The Watershed sustained these indigenous peoples for more than 10,000 years before the arrival of colonialism in the 17th century. Seasonal population centers of Indigenous peoples lived along the Nemasket River and APC, largely sustaining themselves off the spring herring runs (Lakeville Community Access Media, Inc., 2019). Indigenous communities also used the Nemasket River for hunting and gathering along its banks. The word "Nemasket" refers to a particular place on the river, around the present-day Route 105 crossing, and means "the fishing place" or "place of fish" in the Wôpanâak language (Massachusetts Division of Marine Fisheries et al., 2016). Likewise, Assawompset is said to get its name from a Wôpanâak word meaning "the place of the white rock" (Sweeney, 2011). The Nemasket River is also a part of the Wampanoag Canoe Passage, a water trail that Indigenous groups used to travel from Massachusetts Bay to Narraganset Bay (Taunton Wild & Scenic River Study Committee, 2005). The water trail is still used recreationally today.

The arrival of European Traders in the 16th and 17th centuries introduced new diseases to the region, and a devastating plague killed nearly 80% of indigenous people across New England in 1616 (The Massachusett Tribe at Ponkapoag, 2022). Shortly thereafter, English settlers established Plymouth Colony on Wampanoag land, in 1620, and years of systemic oppression followed (Mashpee Wampanoag Tribe, n.d.). In 1675, Assawompset Pond was the site of the conflict between the Wampanoag Tribe and Plymouth Colony that led to King Philip's War, which resulted in the death of more than 40% of the Wampanoag people and the enslavement of many of the remaining men (Sweeney, 2011; Mashpee Wampanoag Tribe, n.d.). Over the next two hundred years, the indigenous populations of the region were forced off their lands and resettled in reservations, overseen by white guardians or overseers, limiting indigenous freedom (Mashpee Wampanoag Tribe, n.d.). Around the start of the 20th century, surviving indigenous children were sent to assimilation boarding schools, where they were forced to change their names, abandon their languages and traditions, and adopt white Christian culture (Mashpee Wampanoag Tribe, n.d.; The Carlisle Indian School Project, n.d.).

[1] SRPEDD and other project team members are in the initial phases of learning how to respectfully and responsibly acknowledge indigenous history and present-day culture in our planning work and documents. We understand that we must take on the task of formulating the description of this history without also burdening indigenous communities further by asking them to explain it to us or for us without compensation for that educational work. If anything in this section offends any reader, SRPEDD is very open to hearing from you. We acknowledge up front that in all likelihood, we will not get it right on the first try, despite our best efforts. Please contact enviro@srpedd.org with any comments, questions, or feedback on this section, and we will listen with open hearts and ears, and work to do better.

Despite this long history of trauma, indigenous groups have nonetheless persevered and continue to inhabit their homelands. Today, three tribes of the original sixty-nine of the Wampanoag Nation survive in this area: the federally-recognized Mashpee Wampanoag Tribe (Mashpee and Taunton area), the Pocasset Wampanoag Tribe of the Pokanoket Nation (Fall River area), and the Assawompsett-Nemasket Band of Wampanoags (Lakeville and Middleborough area) (Department of the Interior, Bureau of Indian Affairs, 2021; Mashpee Wampanoag Tribe, n.d.; Pocasset Wampanoag Tribe, n.d.; Assawompsett-Nemasket Band of Wampanoags, n.d.).

It is important that those who live, work and play in the Watershed today acknowledge this complicated history as we, the public and watershed managers alike, continue to understand the devastating legacies of colonialism that have enabled life as we know it today. Learn more about the Watershed's historical and cultural resources in the "Public Stewardship and Culture of Watershed Protection" white paper in Appendix A.

Core Concepts

This Plan relies on certain concepts throughout the analysis of existing and future conditions, and in the development of watershed management action recommendations. These concepts support a holistic management plan, helping residents, planners, and scientists to start from a common understanding of the underlying dynamics of a functional watershed. With this Plan, we intend to understand the current health and function of the joint APC-Nemasket Watershed, and identify ways to preserve and restore the health of the Watershed. In many circumstances preserving and restoring watershed health, as well as protecting and enhancing human communities in the watershed, will come about by leveraging the functions that intact natural lands perform. Preserving these watershed functions will help to support a healthy and sustainable growing population of people for the next 30 years and more. The following concepts serve as guiding principles. Please refer back to this section as necessary when reading or working with the rest of the Plan.

Watershed Functions

The land and water protection, preservation, and enhancement approaches pursued in this Plan emphasize and seek to bolster the benefits that a community draws from well-functioning natural and semi-natural spaces. Natural systems are constantly performing functions that protect the quality of our air, water and landscape. These functions are sometimes referred to as "ecosystem services," because they represent a service that natural processes provide to people. To provide a deeper conceptual framework, we can think of examples of ecosystem services falling across four categories (Rouse, 2013):

Figure 5. Ecosystem Services Categories and Examples

Ecosystem Service Category	Examples of Functions Performed by Natural Lands
Regulating Services	- Filtering air and water - Sequestering carbon - Absorbing floodwaters - Moderating micro-climates - Aquifer recharge
Provisioning Services	- Food production - Fiber production - Drinking water
Supporting Services	- Sheltering and allowing for the movement of wildlife - Nutrient cycling - Crop pollination
Cultural Services	- Physical activity and recreation - Mobility - Cultural identity - Spiritual inspiration - Community cohesion

As part of the planning process, SPREDD created a series of animated videos that delve into the different natural functions and ecosystem services provided by the landscape in the APC Watershed. We have curated these videos into a Digital Watershed Tour. View them via the QR code links in Figure 6 below.

Figure 6. APC Digital Watershed Tour Video Links

Digital Watershed Tour Videos

Scan the QR code for a fun informational video on a related topic!

FLOODWATER MANAGEMENT

ECOLOGY, UNIQUE HABITATS & NATURAL RESOURCES

DRINKING WATER SUPPLY

RECREATION & STEWARDSHIP

INTER-AGENCY COOPERATION

WATER QUALITY

LAND DEVELOPMENT

Regional Green Infrastructure Network

As discussed above, natural areas such as wetlands and forests play an important role in sustaining communities and helping them mitigate and adapt to climate change with the functions that they perform and ecosystem services that they provide.

Zooming out from specific sites, the concept of a Regional Green Infrastructure Network identifies the connected, cohesive areas of land that are performing these landscape functions and ecosystem services at-scale for the Watershed and its stakeholder communities as a whole. The Conservation Fund's definition of the Green Infrastructure Network is as follows (Benedict, 2006):

The Green Infrastructure Network is:

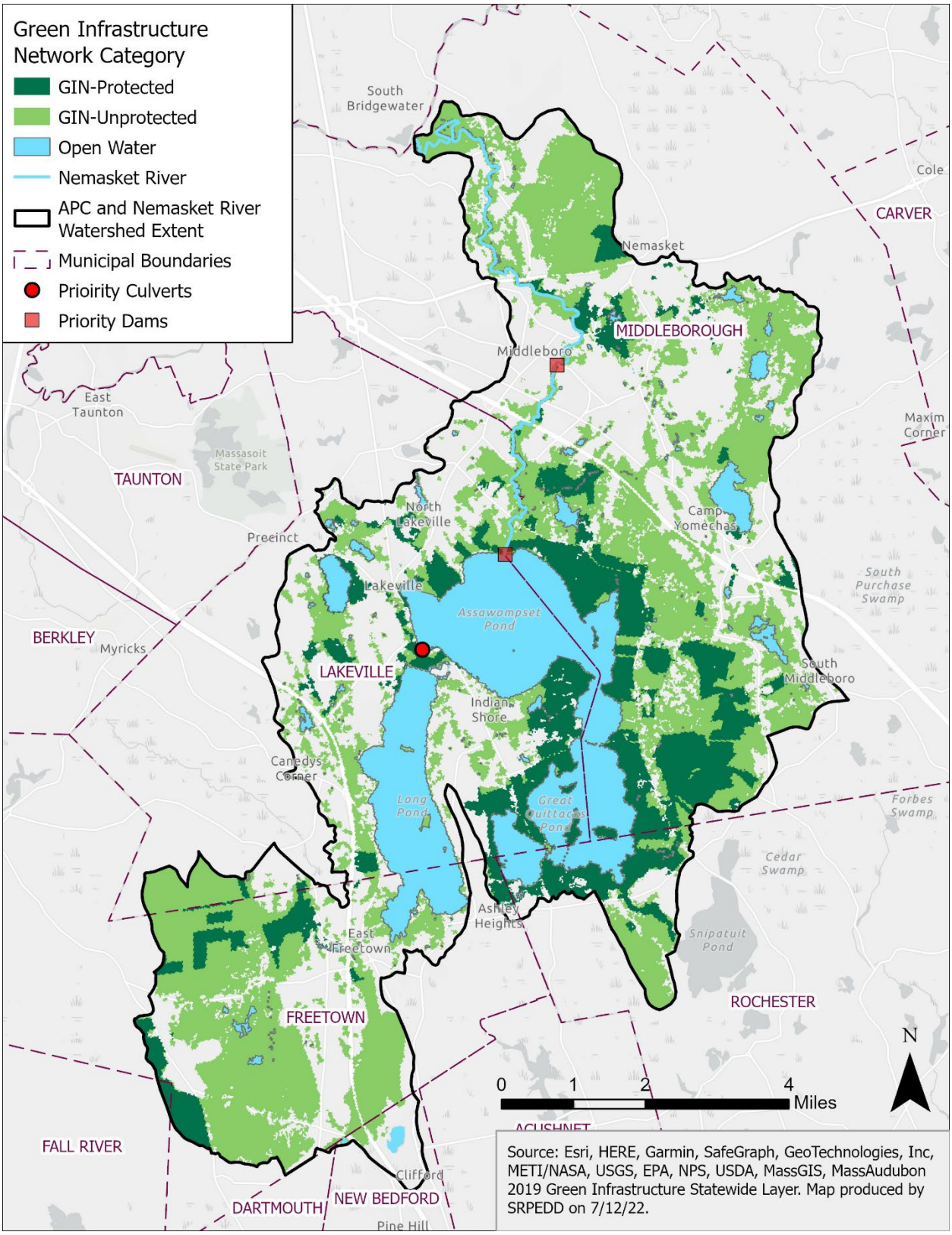
A strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life for America's communities and people.

Maintaining and restoring natural areas and their functions, as our regional Green Infrastructure, within and surrounding our built grey infrastructure, improves climate, economic, social, and environmental resilience. Considering our natural green infrastructure at the watershed scale in particular can help protect a naturally functioning watershed in which rainfall recharges our wetlands, waterways and aquifers, without causing undesirable flooding.

While many land use decisions are made on a local or site-by-site basis, most natural processes, climate conditions, and movements of plants and animals transcend jurisdictions over large contiguous areas shaped by topography and geology. Environmental issues such as pollution, changes in groundwater tables, and rising temperatures require a regional - even national and global - response, with every local community acknowledging the role that their lands and policies play in the larger ecological context. Consider a stream corridor, for example. Protecting and restoring forested areas along the stream provides habitat for both fish and wildlife and accommodates their movement through the landscape (ecological resilience), while also reducing flood risks to downstream communities.

In Massachusetts, we are fortunate to have a tool that allows us to identify the Green Infrastructure Network of high-quality, intact landscapes that are currently performing ecosystem services. The Manomet and Mass Audubon Green Infrastructure Network (GIN) tool identifies sections of land that exhibit climate change resilience, serve a critical landscape function, are a riparian buffer within 100 feet of a wetland, or absorb coastal and inland floodwaters both now and into the future. The tool identifies 58% of the Assawompset Ponds and Nemasket River watersheds' land area as part of its GIN. Within this GIN, 28% is permanently protected open space and the other 72% is unprotected, and thus vulnerable to development. Designing a watershed management plan around these high value natural areas, and prioritizing protection of those areas of the GIN that are susceptible to development, can preserve the Watershed's natural resources and those ecosystem services that make our communities more resilient.

Figure 7. APC-Nemasket Regional Green Infrastructure Network Map



Nature Based Solutions

In many instances, the ability of land to perform these functions outlined above becomes degraded due to both natural causes (e.g. invasive species spread) and/or human activity (e.g. causing more runoff and preventing water infiltration with the installation of impervious materials on the landscape). As a result, many of the recommendations in this plan are **nature based solutions** that repair or prevent damage to natural landscapes so that they continue to play their inherent role in performing functions that benefit human communities.

Nature based solutions are a category of climate adaptation strategies that leverage nature's abilities to protect communities from natural hazards. They offer us a diverse toolbox of methods to both preserve and regain critical ecosystem functions that improve community well-being. Taking advantage of nature based solutions involves the following tiered approach:

1. **Protect** existing natural areas, like the Watershed's Green Infrastructure Network, so that they may continue to function properly and we can take advantage of the ecosystem services that they provide.
2. **Integrate** natural systems and/or engineer systems that mimic nature into all new and redevelopment.
3. **Restore** lost or damaged ecosystems and repair natural system functions.

Effective implementation of nature based solutions means designing community features where the functions of built infrastructure and the natural environment are mutually reinforcing in providing protections and benefits for residents. We can integrate nature into the way we build and grow our communities by adopting **low impact development** practices. Low impact development is a land development strategy that incorporates nature based solutions into site design by preserving natural features as much as possible and minimizing the negative impacts of development on habitats and waterways.

Climate Change Overview

On a global scale, climate change is driving a number of natural system changes that have ramifications for the Watershed. 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 given region at a given time of year. Climate determines the range of weather possibilities we can expect day to day. 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, changing both the range of possible extreme events and the character of typical weather conditions. In fact, temperature and precipitation patterns are changing rapidly, and unless significant progress is made in reducing greenhouse gas emissions, the rate of climate change is projected to accelerate.

Weather is what you get. Climate is what you expect.

Key elements of the climate change threat are communicated by the "3S's" of climate change (Denning, N.D.):

Question 1: How do we know climate change is occurring?

Answer: It's **simple**.

Our human actions are forcing the earth's system to retain more heat. When thermal energy in the form of sunlight reaches earth, two things can happen to it; 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. Certain gases, known as Greenhouse Gases (Carbon Dioxide/CO2, methane, and others) naturally increase the trapping capacity of the atmosphere, causing thermal energy to remain in the system, which causes the world to warm.

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 1900 there has been a massive increase in the global concentrations of atmospheric carbon dioxide, started by the Industrial Revolution and the burning of fossil fuels such as coal, oil, and gasoline. In 2019, atmospheric CO2 concentrations were higher than at any time in at least 2 million years, and concentrations of CH4 and N2O were higher than at any time in at least 800,000 years. Since 1750, increases in CO2 (47%) and CH4 (156%) concentrations far exceed the natural multi-millennial changes between glacial and interglacial periods over at least the past 800,000 years (IPCC, 2021). These trends have created an environment fruitful for trapping thermal energy from sunlight within the earth's atmospheric system. 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 (Hayhoe, 2018).

Question 2: What harm will climate change cause?

Answer: It's **serious**.

Since 1895, 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 increase has been even greater and since 1895 has increased 2.9 degrees Fahrenheit. The climate in eastern Massachusetts has changed significantly during the last 100 years with average annual conditions becoming warmer and wetter. Climate extremes are also changing with increasing prevalence and intensity of extreme heat and more precipitation coming in heavy downpours. Modeled projections of future conditions indicate a continuation of these trends for both average and extreme conditions. On a seasonal basis, rainfall is projected to increase in spring and winter months. The combination of both increasing seasonal precipitation and more prevalent and intense downpours will increase stormwater management challenges and increase flood threat, particularly in areas that are prone to flash flooding. In contrast, a projected increase in consecutive dry

days in summer and fall, combined with increasing average temperatures, has the potential to make drought conditions more impactful.

This dynamic climate situation adds a layer of complexity to management efforts in the APC watershed. Effective watershed management will require planning for the combined effects of increasing temperatures and changing precipitation patterns. It is difficult to know precisely how these changes will play out but it is reasonable to expect that they will result in both wet periods and dry periods that exceed historic patterns. These changes will stress both infrastructure and natural systems by presenting conditions that exceed design criteria for infrastructure and altering the climate envelope for natural systems. As temperature and precipitation change in the future, so too will the aspects of our natural and built environment that rely on them, such as forests and open space, agriculture, and disease/tick seasons, amongst others. Warming temperatures will cause a longer freeze-free period, and earlier leaf-out and bloom. More pests will survive year to year, and they will emerge earlier in the season as well. Changing temperatures will shift the habitable zone for plant, insect, and animal species, prompting their migration. Iconic trees such as Red Maple and Oak have already started to migrate north and west, seeking more suitable climates.

Question 3: What can we do?

Answer: It's **solvable**.

We are looking at an extremely different world by the end of this century if our high rate of CO2 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 greenhouse gas 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 CO2 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.

Climate concerns are central to this Plan and each section of the Plan includes information on projected impacts through 2050 and thoughts on appropriate management response. Section 3 of this Plan contains statistics on climate change over the past 100 years and projections for future conditions developed by the Northeast Climate Science Center. In addition, Appendix B to this plan includes a more detailed treatment of projected climate change in the region with tables showing projections for 2030, 2050, 2070, and 2090.

Adaptive watershed management, monitoring changing conditions and updating management guidance in response, will be required to navigate this dynamic situation. Key variables to be tracked include:

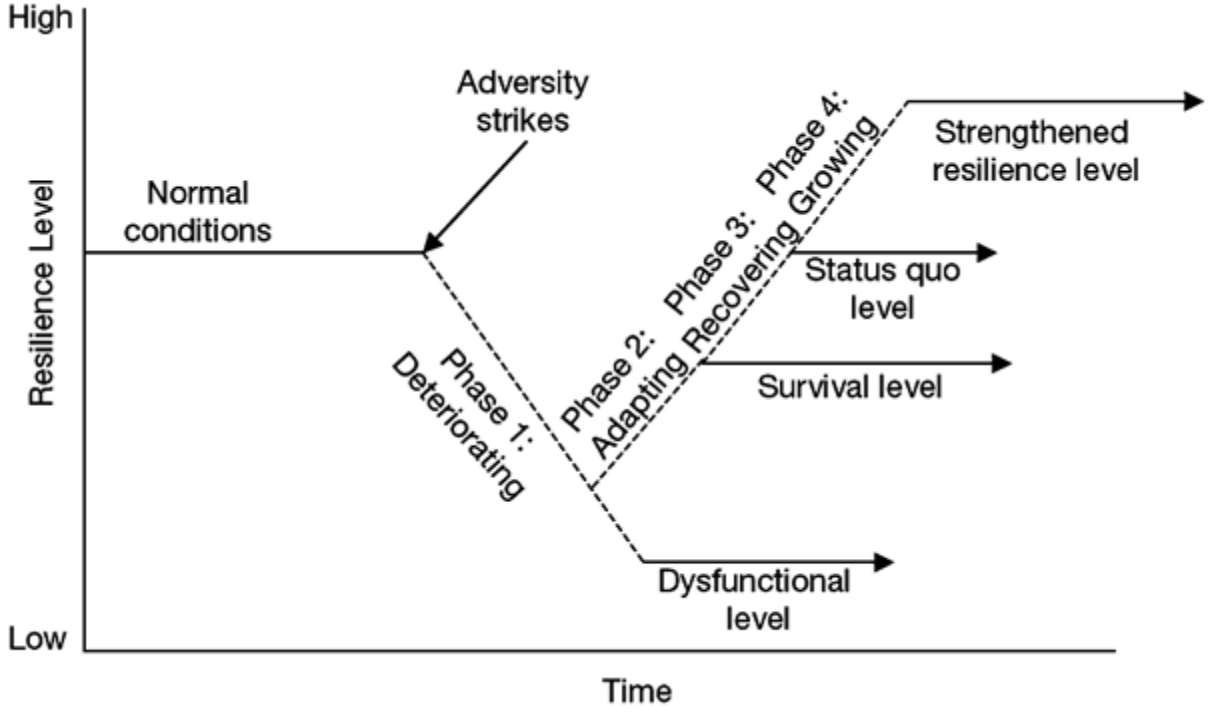
- Weather and climate trends and extremes;
- Infrastructure impacts; and
- Natural system impacts, including forest health, groundwater levels, surface water levels, drought impacts, and flood impacts.

In addition, it will be necessary to update local development and land use bylaws in response to evolving state and federal regulations including stormwater management standards and infrastructure design criteria.

Resilience

Any one of the predicted climate change outcomes for the Watershed described above would be disruptive. The concept of resilience, however, provides hope that communities can prepare for some of these changes. **Resilience** is commonly defined as the ability of social, environmental, and economic systems to return to their original form and integrity after enduring stress or disruption.

Figure 8. A Graphical Depiction of Resilience (Patterson & Kelleher, 2005)



Communities that exhibit high resilience will be able to withstand many impacts of climate change and return to their regular operations after a hazardous event (e.g., intense storm) or prolonged disruption (e.g., drought). Resilience could 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.

The uncertainty associated with future climate change outcomes means that communities must take the long view, and build some of this uncertainty into their decision-making structures with strategies that are flexible and nimble, 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 greenhouse gases (via a reduction in the amount of greenhouse gases 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 and reduce the degree of overall warming.

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, the Nature Based Solutions described above - 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.

Adapting to climate change is the primary focus of the Plan, but in some cases, mitigation of climate change through local reduction in greenhouse gas emissions is a possible co-benefit of adaptation efforts. Achieving resilience requires incorporating both mitigation and adaptation strategies into community planning and management efforts.

Plan Overview

Planning for a Resilient future

Planning for the future of the APC-Nemasket Watershed, we must account for observed trends and future projections. In a watershed as dynamic as this one, solutions must meet the watershed communities' current needs, as well as those into the future. Therefore, this Plan serves as both a Watershed Management Plan and a Climate Action Plan that is designed to carry the Watershed to the year **2050**. Each action and recommendation included in this document has been vetted in the context of both development trends and climate change projections. This Plan proactively sets forth an actionable strategy to manage the watershed's resources and accommodate development needs for an uncertain future.

The challenges posed by intensive development and climate change are intertwined and one cannot be addressed without also addressing the other. That is because while development disrupts natural functions and reduces the land's ability to adapt to climate change impacts on one hand, climate change is continually putting additional stress on our natural and built environment on the other. We know the valuable role our green infrastructure plays in buffering communities from extreme heat and storms, as well as capturing rainfall, purifying runoff and recharging groundwater. These services will only become more important as our communities continue to grow and our planet continues to warm. But proactive planning can help communities prepare for future development while minimizing the loss of our Green Infrastructure Network.

This Plan aims to address challenges that thread through both past and present planning efforts in the Watershed, and continue to present barriers to Watershed management. As a way to organize this Plan and the analysis herein, we have categorized these challenges into the following themed issue areas:

- Flood water management
- Public drinking water supply protection
- Surface and groundwater quality improvement
- Ecology, unique habitats, and biodiversity preservation
- Land development management
- Recreational access management

- Public stewardship enhancement
- Interagency coordination

The Management Goals and Actions proposed in this plan weave together all of these issues into a strategy for the watershed that can be implemented over the next thirty years. It offers a regional, watershed-scale approach to address ongoing concerns while meeting the needs of the Watershed and its communities until the year 2050.

Many of the following sections of the Plan are organized around these issue areas.

Section 2 presents a Vision for the Watershed in the year 2050, which guides the development of Plan action items and recommendations. Future activities are intended to advance the Watershed toward this vision.

Section 3 dives further into the specific climate change impacts predicted for the Watershed, providing the environmental conditions against which we are planning actions for the time horizon of the Plan.

Section 4 describes conditions in the Watershed for each issue area. Information is included on existing conditions and challenges, issue-specific projected climate change impacts, and relationships between issue areas (trade-offs or co-benefits).

Section 5 pulls focus to the few key tensions that present the greatest management challenges, where furthering conditions for one goal area may have a deleterious effect on another area if not pursued with care and under certain conditions. These are the key areas that require balance in watershed management.

Section 6 is, in many ways, the heart of the Plan, containing prioritized management actions to pursue to improve the health of the Watershed along multiple issue area dimensions. Notations are provided on whether or not this action addresses current conditions versus future conditions under climate change impacts, and on the other issue areas where an action would have a co-beneficial, positive outcome.

Section 7 wraps up the Plan with conclusions and next steps.

Section 8 contains Plan appendices.

To meet the community's vision for the future of the Watershed, this Plan proposes a series of actions that can be implemented now and into the future to protect the existing watershed communities from extreme weather and accommodate growing development pressures without sacrificing the Watershed's Green Infrastructure Network and other critical resources. This solution set includes improving our grey infrastructure so that it can withstand future development and climate impacts, protecting and/or restoring the Watershed's natural features, and directing development in such a way that minimizes its impacts on natural systems. Strategically employing these actions together across the Watershed will help to improve the resilience of both our natural and human communities, while improving the Watershed's ability to accommodate future development and climate trends.

Acknowledgements

The APC-Nemasket River Watershed Management and Climate Action Plan would not have come together without the efforts of many, many people. We are first and foremost, so appreciative of the

time and energy that members of the public from the Watershed stakeholder communities of Freetown, Lakeville, Middleborough, New Bedford, Rochester, and Taunton gave to this planning process, attending public meetings and providing their insights into existing watershed problems and ideas for effective watershed management. We are equally grateful to the members of the project Steering Committee. While the existing APC Management Team served as the core of the Steering Committee, membership expanded beyond this group, to represent the full depth and breadth of stakeholder interests in the APC and Nemasket River Watershed. The Plan was developed over a two-year period, with regular Steering Committee meetings throughout the process. Steering Committee membership ebbed, evolved, and flowed through retirements, the formation of new local groups and committees, and the ongoing reality of the COVID-19 pandemic. The figure below notes all persons who were present on the Steering Committee throughout the planning process. Thank you again for your guidance, knowledge, and insight!

Figure 9. Plan Steering Committee Membership

Name	**Affiliation**
Michael Arruda	Water Division - Taunton MA
Tom Barron	Middleboro-Lakeville Herring Commission
Kate Bentsen	Mass Division of Ecological Services
Aaron Best	Massachusetts Department of Fish & Game
Patricia Cassidy	Town of Middleborough Conservation Agent
Dave Cavanaugh	Middleboro-Lakeville Herring Commission
Victoria D'Antoni	Freetown Conservation Commission Senior Clerk
Pete DeFusco	Resident of Long Pond
Phillip Duarte	Taunton City Council
Nancy Durfee	Rochester Town Planner
Lia Fabian	Lakeville Select Board
Laurel Farinon	Town of Rochester Conservation Agent
Maureen Flanagan	District Legislative Aide, Senator Michael Rodrigues
Ymane Galotti	New Bedford Superintendent of Water
Jonathan Hobill	Dept. Of Environmental Protection
Kris Houle	Mass Division of Ecological Services
Patti Kellogg	Mass. Dept of Water Resources
Merilee Kelly	Town of Rochester Conservation Agent
Bren Ladino	Long Pond Association
Joshua Newhall	Legislative Aide, Office of Representative Norman Orrall
Michele Paul	City of New Bedford Director of Resilience and Environmental Stewardship
Chance Perks	City of New Bedford Conservation Agent
Joan Pierce	Mass Wildlife – Dept. of Fish and Game Land Agent
Jodi Raposa	Water Division – Taunton MA
Courtney Rocha	MVP Coordinator
Caitlin Rowley	District Director, Senator Michael Rodrigues
Gary Santos	New Bedford Dept. Infrastructure
Mike Schroeder	Lakeville Open Space Committee
William Schwartz	Dept. Of Environmental Protection
Kate Sousa	Taunton Water Supply
Lu-Ann Souza	Freetown, Executive Assistant to Town Administrator
Nancy Yeatts	APC Ranger
Martha Worley	Resident of Long Pond

Project Consulting Team	
Ellie Baker	Horsley Witten Group
Danica Belknap	Southeastern Regional Planning and Economic Development District
Jenna Bernabe	Horsley Witten Group
Nicholas Cohen	Horsley Witten Group
Marea Gabriel	The Nature Conservancy
Brian Graves	Horsley Witten Group
Kellie King	Horsley Witten Group
Benjamin Myers	Southeastern Regional Planning and Economic Development District
Bill Napolitano	Southeastern Regional Planning and Economic Development District
Jonas Procton	Horsley Witten Group
Kalaina Thorne	The Nature Conservancy
Eric Walberg	Walberg Consulting
Helen Zincavage	Southeastern Regional Planning and Economic Development District

A total of 11 Steering Committee meetings and six public meetings were held as part of the planning and development process for this Plan. Input from these sources filters through every aspect of the Plan. Appendices D and E contain more information on the agendas, schedules, topics covered, advertisements and outcomes of the Steering Committee and Public Workshop sessions.

After two years of meetings via Zoom, the Steering Committee was able to have its final meeting in person on May 5, 2022, and considered proposed action items for their level of priority.

Steering Committee members not only lent their time and expertise during Steering Committee meetings, but were also active participants in public workshops. (Event shown: Managing Floodwater Issue Area Public Workshop, 9/29/21.).

SECTION 2. A GUIDING VISION

The recommendations contained in this Plan are steps toward the following vision for what ideal watershed conditions would look and feel like in 2050, even as climate change progresses. The actions contained herein have been vetted against this vision of an ideal watershed future.

Vision Statement

In the year 2050, the APC and Nemasket River watersheds...

1. Are recognized as a cohesive system of interdependent forest, upland, wetland, and aquatic habitats that are intact, protected, continually monitored, managed cooperatively and holistically, and are generally thriving.
2. Provide a landscape where people enjoy recreating.
3. Are cooperatively managed by their constituent communities, who regularly acknowledge and promote all of the inherent value that they provide, fostering a local groundswell of stewardship and guiding the decision-making and behavior of residents toward actions that protect these lands and waters. The inhabitants of the watersheds have developed an environmental ethic based upon choice, not chance, that drives sound local and regional decision-making.
4. Exist within a regulatory framework that better safeguards their unique natural resources from the impacts of additional development and climate change.
5. Are healthy and sustain life and natural communities, including our own, through clean, safe, and reliable water supply, during both typical conditions and periods of drought.

6. Absorb and mitigate floodwaters in such a way that does not cause severe infrastructure or property damage, or cause public safety concerns that communities are not prepared to address.
7. Are a resilient system that, in turn, provides protection and resilience benefits to their constituent communities. Beyond meeting the needs of our current moment, by 2050, our communities have recognized the critically beneficial role that the watershed's landscape plays in mitigating climate change impacts through functions such as carbon sequestration and water storage. Preservation efforts enhance the ability of the Watershed's landscape to perform these essential services that uphold community resilience in the face of climate change.

Overall, in the year 2050, the APC and Nemasket River Watersheds are healthy, sustaining life and natural communities, including our own through clean, safe, and reliable water supply. The inhabitants of the watersheds have greater protections from climate hazards, and have developed an environmental ethic based upon choice, not chance, that drives sound local and regional decision-making.

How We Get There

Achieving this vision requires targeted goals and measurable indicators of progress, in addition to non-tangible changes in attitudes toward the Watershed. The goals listed below represent guideposts on the path forward to accomplishing the vision laid out above. These goals are expounded on and matched with concrete actions in Section 6 of the plan.

Successful implementation of this plan requires an adaptive and iterative management approach. Some of the recommended actions can take place immediately, while others may be dependent on additional resources, further study, or other necessary prerequisite steps. Others still may require ongoing efforts and improvements, such as educational campaigns and regulatory updates. A designated implementation entity will need to be identified and convened to take charge of this Plan and the recommended management actions within, regularly evaluating progress towards achieving these management goals, reassessing priorities and updating the plan as needed, and, perhaps most importantly, implementing next steps in order to achieve the 2050 vision.

WATERSHED MANAGEMENT GOALS:

Reduce flood risks to people and property

Perhaps one of the critical driving forces that initially sparked this planning process, though one of several stakeholder interests, is reducing flood risks to those residing within the watershed. The aim of this goal is to leverage nature's inherent ability to absorb rainfall. This includes enhancing the watershed's current capacity to soak up stormwater runoff by restoring the floodplain and improving natural areas management. We also need to be more thoughtful of where and how we develop, to ensure new development is not placed in potential hazard areas, where flooding is currently likely, or

may be possible in the future. Lastly, we need to assess how our built infrastructure creates barriers to the flow of water throughout the watershed. Culverts, bridges and dams all allow us to coexist with our water resources, but ensuring these structures are sized appropriately and not preventing the flow of water is essential to reduce flood risks.

Safeguard public drinking water supplies

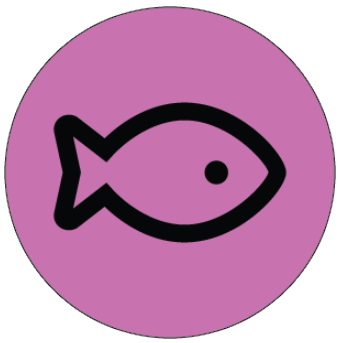
More than 250,000 people rely on the Assawompset Ponds for their drinking water supply, and many more wells throughout the watershed similarly provide for the watershed communities' water needs. Ensuring the Watershed is able to continue to meet growing water demands is essential. This means protecting the watershed's capacity to recharge ground and surface waters, protecting drinking water supplies from pollutants, and considering water use impacts (as well as the Watershed's capacity to accommodate increased demands) when considering future development and land use proposals. Additional steps will also need to be taken to safeguard the resilience of the water supply to future droughts.

Improve Water Quality

Water quality throughout the watershed impacts wildlife, drinking water supplies, environmental health, and people's ability to recreate in, on and around the Watershed's water resources. Development and associated increases in stormwater runoff are contributing to water quality impairments throughout the watershed, but steps can be taken to remove and/or manage these threats and improve the health of our waterways.

Preserve wildlife and habitat

Wildlife and the natural landscapes that they make up provide a wealth of resources to people, and living sustainably alongside nature is as critical for the resilience of people as it is for the Watershed. Protecting these resources includes both preserving the Watershed's existing natural areas through active management that supports health and function, and also strategically expanding the existing open space network to protect priority natural areas from development. All of nature is worth protecting, but those unique and/or culturally significant species and natural communities that are special to the APC, such as river herring, northern red-bellied cooter, breeding bobolinks, and coastal plain pondshore habitats, should be prioritized for protection in particular.



Encourage sustainable development that retains natural functions

Ongoing development to support the watershed's growing population does not need to come at the expense of nature. Thoughtful and proactive planning can help to guide development towards the most appropriate areas across the watershed, and protect priority natural areas that provide important resilience functions. An extensive toolbox of sustainable development techniques is also available to reduce the footprint and environmental impacts of new development. Resilient growth requires the Watershed communities to take important regulatory approaches that encourage sustainable development built with both natural resources and future climate in mind.

Enable ecologically appropriate recreation

For the purpose of watershed and climate resilience planning, a balanced recreation program is one which provides a quality outdoor recreation experience for people within a range of recreational activities that have a low impact on ecology and water quality in the Watershed. Community leaders and recreational users alike share the responsibilities of recreating appropriately in the watershed. Clearly communicated guidelines for how and where community members can enjoy various activities throughout the watershed can empower recreational users to be more mindful and reduce their impact on natural resources. This in turn can enable local capacity to expand the Watershed's open space network and available programming.

Foster a widespread culture of stewardship

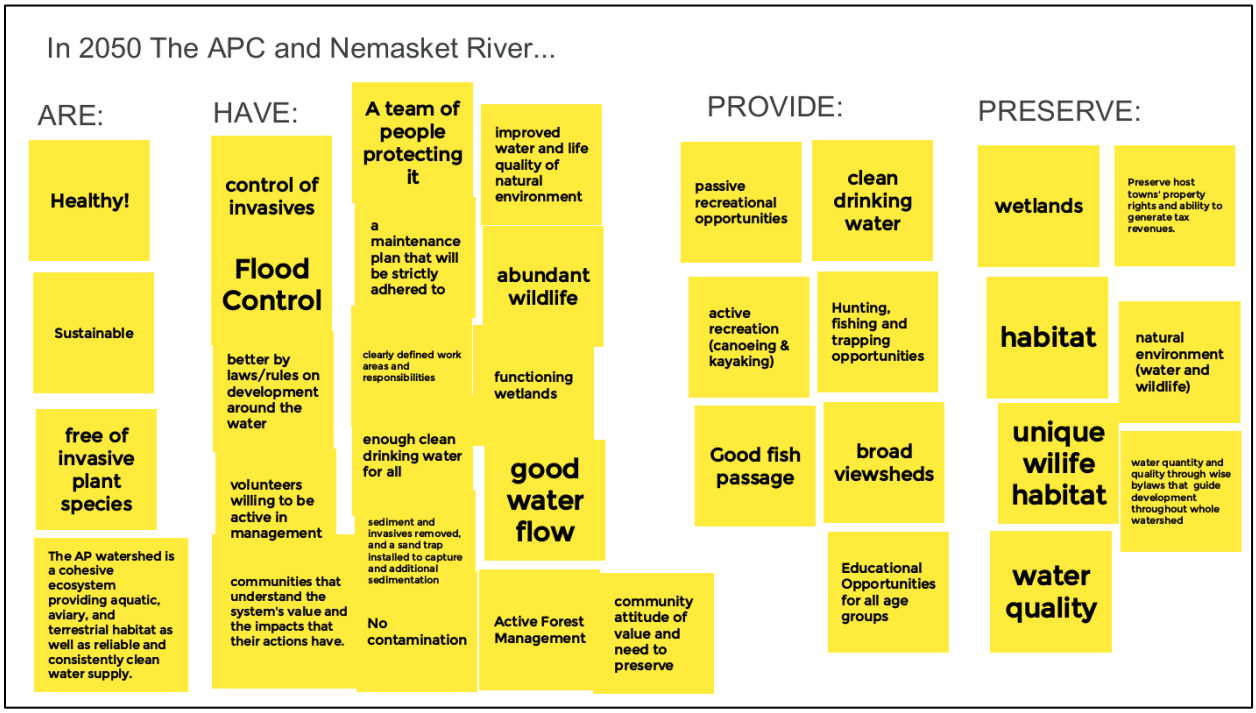
Similar to recreation, stewardship requires a balance between the right to enjoy local natural resources and the responsibility to do so mindfully. It is important to note that everyone plays a role in stewardship, and there are opportunities for municipal managers, residents, recreational users and other stakeholders, through the ways they interact with the Watershed and its resources on a daily basis, to act as environmental stewards. Community leaders and land managers can help foster a widespread culture of stewardship among those who live, work and play in the watershed through education and leading by example, to help the public recognize and adopt best practices.

Expand opportunities to improve cooperative management

For many of the management actions proposed in this Plan, cooperation among various local, regional state and federal entities is essential, particularly where interests and jurisdictions overlap. For example, several Nemasket River bridge crossings managed by the State Department of Transportation are of interest to entities focused on habitat and water quality restoration, as well as to recreational entities interested in river access locations. At a more holistic level, the overall management of the watershed requires continued and strengthened interagency cooperation and communication among local public water supply agencies in New Bedford and Taunton, watershed municipalities, homeowner associations, conservation agencies and organizations and many others. Collaboration across jurisdictions can increase efficiency and likelihood of success in achieving these management goals. Expanding upon the partnerships already existing across the watershed, and establishing platforms for more regular and streamlined communication with each other as well as with the public, will help achieve the 2050 Vision for the Watershed.

Vision Statement Development

The project team devoted portions of the December 9, 2020 and February 10, 2021 Steering Committee meetings to the development of the Watershed Vision statement. A collaborative Jamboard exercise generated initial ideas and themes for a draft vision statement, which was then reviewed and refined by the project Steering Committee. The vision statement was subsequently part of all public workshop presentations. The images below show the ideas generated in the initial Jamboard Steering Committee session.



In 2050, APC and Nemasket River stakeholder communities…

GET _____ FROM THE WATERSHED:

- clean drinking water
- clean drinking water
- Recreation
- passive recreation
- carbon sequestration (conservation lands)
- sustainable life and natural resources
- mental health
- Healthy diverse forest

GIVE _____ TO THE WATERSHED:

- Laws to control overuse
- Management Plan that continues to be a living document and communities that still work together
- respect for natural systems
- protection and preservation of water quality and natural environment
- Educating the public about the importance of the watershed
- cleanup of any releases of hazardous materials
- Support and buy-in
- fixing culverts for better flow and animal passage
- appropriate sited development

In 2050, local residents work to protect ___ in the watershed.

- water quality
- water and natural environment
- by leading walks, picking up trash, and advocating for funding and appropriate regulations
- wildlife/habitats
- stormwater runoff quality
- Wetlands and flood plains
- water supply/flow
- Water Quality and Flood Protection
- Priority Land that surrounds the watershed
- fish passage
- forests
- native species

In 2050, local residents enjoy ___ in the watershed.

- Fishing and boating on Long Pond.
- Kayaking & Canoeing
- passive recreation
- cleaning and protecting
- Passive recreation, Photography & Nature Study
- participating in implementing the management plan
- hiking along the river
- picking up after their pets

SECTION 3. WATERSHED CLIMATE CONDITIONS – PRESENT AND FUTURE

Projected Regional Climate Change

The climate in eastern Massachusetts has become both warmer and wetter over the last century. In Plymouth County the average annual temperature has increased approximately 4 degrees F and average annual precipitation has increased approximately 8 inches between 1901 and 2000 (NOAA National Centers for Environmental information, 2022). Modeled projections for 2050 in the Taunton River Watershed, in which the majority of the Assawompset Pond Complex and Nemasket River watersheds are located, show average annual temperature increasing in the range of 2.7 to 5.9 degrees F and average annual precipitation increasing in the range of 0.3 to 5.4 inches (Massachusetts Climate Change Projections, 2018). These changes are projected to vary by season, a factor that will influence water availability, flood threat and drought impacts.

The following tables show the projected range of change in annual and seasonal temperature and precipitation in 2050 based on a combination of medium and high emission scenarios. Under the medium emissions scenario (RCP 4.5) greenhouse gas emissions are assumed to peak by mid-century. Under the high scenario (RCP 8.5) emissions continue to rise based on the current trajectory. Appendix B, *Climate Change Synopsis for the APC Region,* contains details on projected annual and seasonal change for 2030, 2050, 2070 and 2090 for a broader range of climate variables.

Figure 10. Average Annual and Seasonal Temperature Predictions for 2050 under Medium and High GHG Emissions Scenarios

Taunton River Watershed		Observed Baseline Temperature 1971-2000	Projected Change in 2050s (degrees F)
Average Temperature	Annual	49.9	Increase of 2.7 to 5.9
	Winter	30.0	Increase of 2.9 to 6.7
	Spring	47.3	Increase of 2.4 to 5.4
	Summer	69.6	Increase of 2.2 to 6.3
	Fall	52.1	Increase of 3.4 to 6.3

Figure 11. Total Annual and Seasonal Precipitation Predictions for 2050 under Medium and High GHG Emissions Scenarios

Taunton River Watershed		Observed Baseline Precipitation 1971-2000	Projected Change in 2050s (inches)
Total Precipitation	Annual	47.5	+0.3 to +5.4
	Winter	12.1	+0.0 to +2.0
	Spring	11.9	+0.0 to +2.0
	Summer	11.0	-0.7 to +1.7
	Fall	12.4	-0.9 to +1.5

The following images show the projected progression from 2050 to 2090 for the high emission scenario for both average annual temperature and total precipitation.

Figure 12. Average Annual Temperature Projections for the Taunton River Watershed - 2050 and 2090 Benchmarks

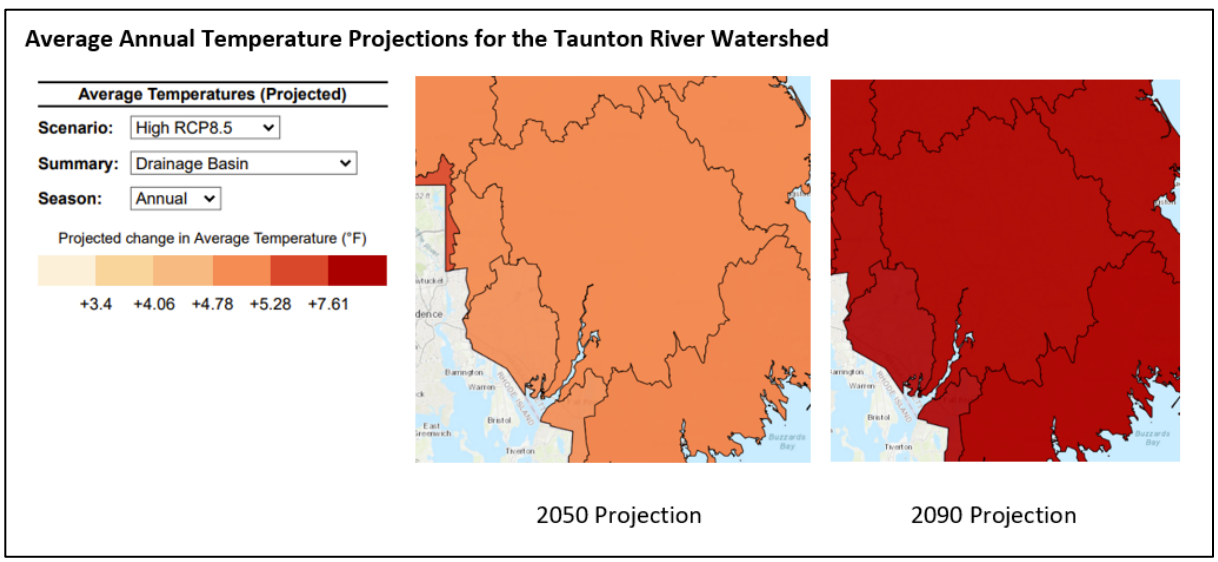
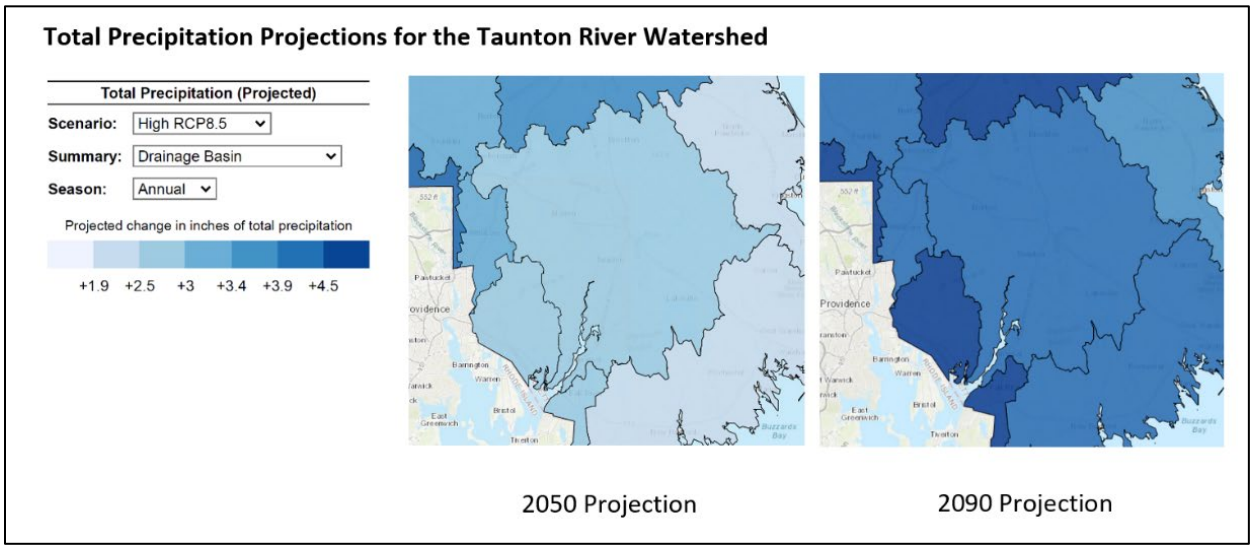


Figure 13. Total Precipitation Projections for the Taunton River Watershed – 2050 and 2090 Benchmarks



Extreme temperature and precipitation conditions have changed in conjunction with changing average conditions and these trends are projected to continue through 2050 and beyond. In particular, both the frequency and intensity of extreme heat is projected to increase and more precipitation is projected to come in heavy downpours. The following figures show projected change in days above 90 degrees, extreme precipitation events, and consecutive dry days by 2050 under the **high** emission scenario.

Figure 14. Annual Days above 90 Degree Fahrenheit by 2050 in Massachusetts

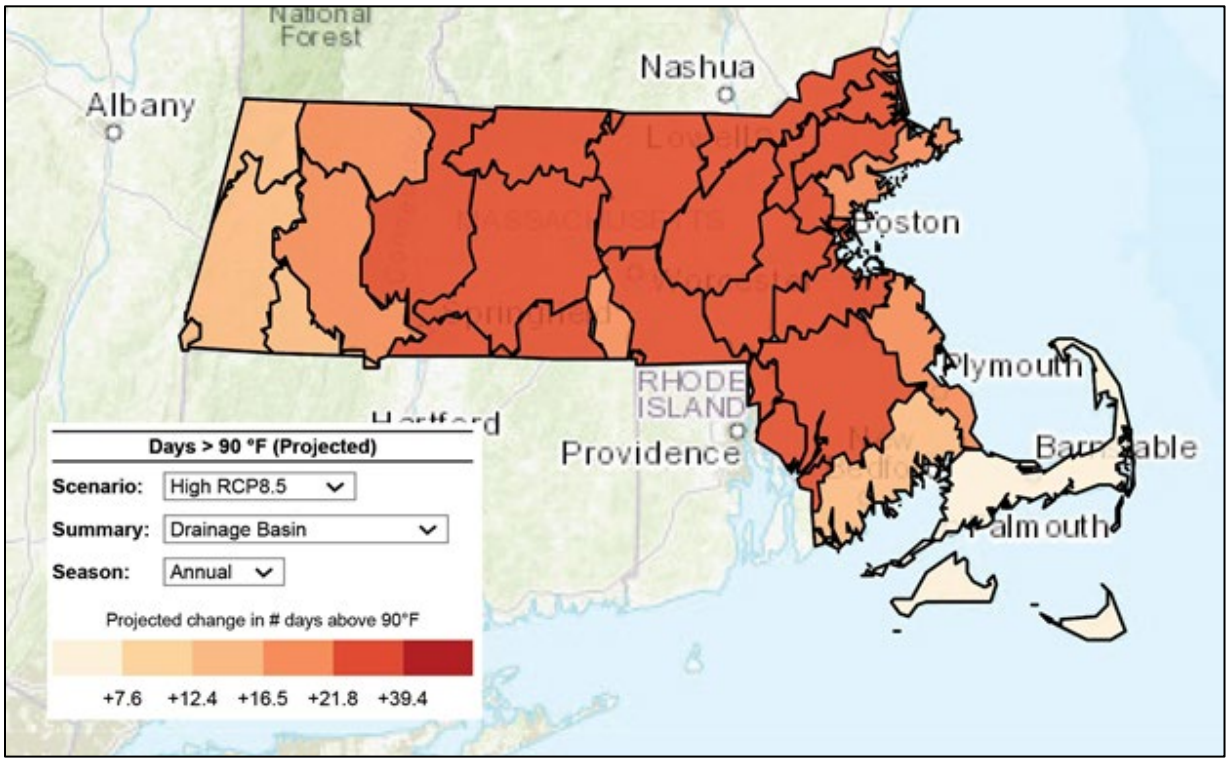


Figure 15. Extreme precipitation events (>1") by 2050 in Massachusetts

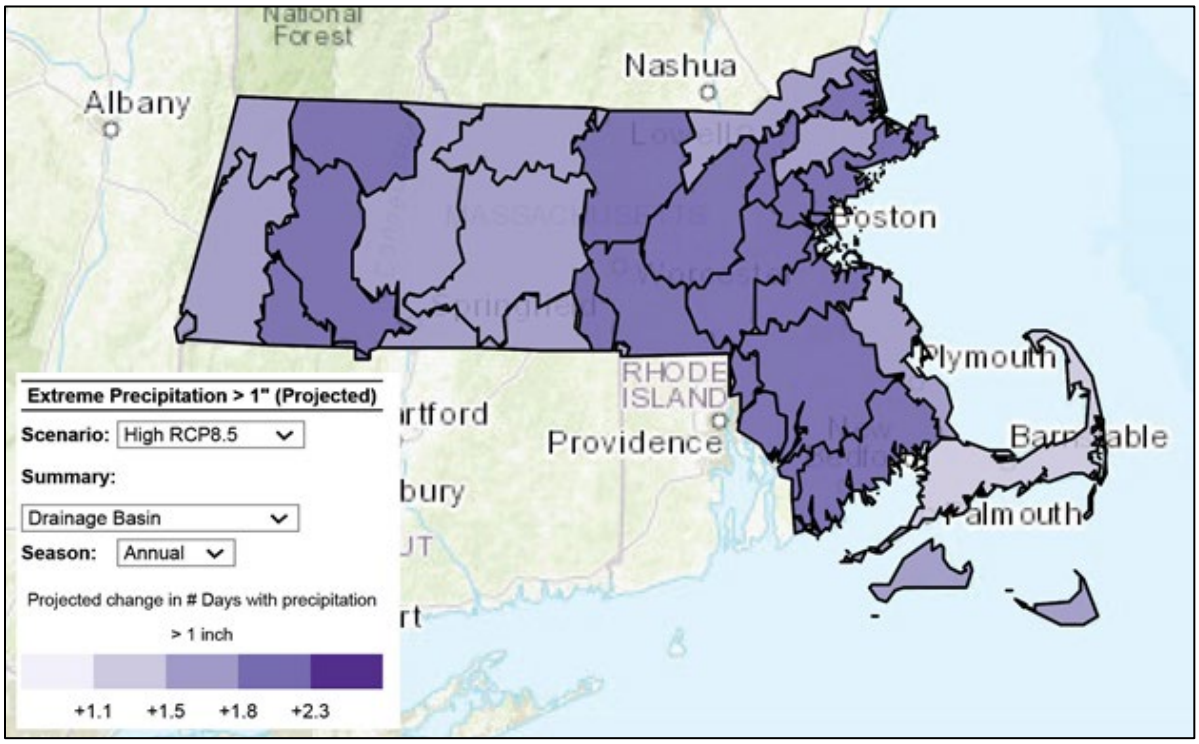
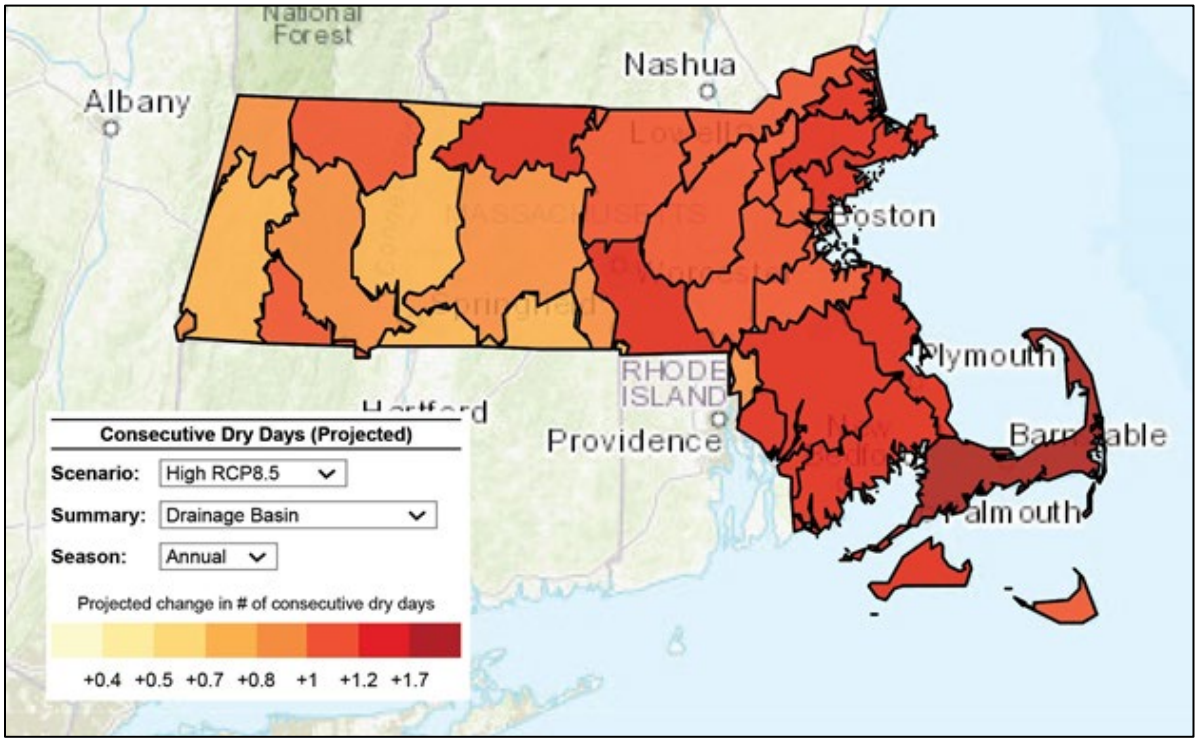


Figure 16. Consecutive Dry days (drought causing days) by 2050 in Massachusetts



Changing Drought, Flood and Extreme Storm Conditions

The combination of increasing temperature, changing seasonal precipitation amounts, and increasing prevalence of heavy precipitation will likely increase drought impacts and increase flood risk, particularly in areas with impervious surfaces that are conducive to flash floods. A Massachusetts-specific analysis by the Northeast Climate Science Center states the following:

"Rainfall is expected to increase in spring and winter months in particular in Massachusetts, with increasing consecutive dry days in summer and fall. More total rainfall can have an impact on the frequency of minor but disruptive flooding events, especially in areas where storm water infrastructure has not been adequately sized to accommodate higher levels. Increased total rainfall will also affect agriculture, forestry and natural ecosystems."

"The climate projections suggest that the frequency of high-intensity rainfall events will trend upward. Overall, it is anticipated that the severity of flood-inducing weather events and storms will increase, with events that produce sufficient precipitation to present a risk of flooding likely increasing. A single intense downpour can cause flooding and widespread damage to property and critical infrastructure. The coast will experience the greatest increase in high-intensity rainfall days, but some level of increase will occur in every area of Massachusetts." (Massachusetts Climate Change Projections, 2018)

Climate Change and Stationarity

In contrast to our likely turbulent climate future, our modern human civilization has developed during a time of relative stability in earth's long geological history. This stability has enabled us to design buildings, communities, infrastructure – all of the cornerstones of modern life – with confidence that in planning these structures, we knew what to expect. The ability to draw on prior conditions to inform our predictions for what we can expect the future to hold is referred to as a 'stationarity.' For example, engineers could design a road to withstand a weather event called a "hundred-year storm," which represented the intense weather conditions that would be expected to occur just once in a one-hundred-year period (or put another way, the type of conditions that would have a 1% chance of happening in any given year). Stationarity allowed us to prepare for the future with the knowledge of prior conditions.

Currently, climate change is shifting what is typical of our region's temperature and precipitation past the boundaries of predictability based on past conditions. The presently occurring climate shifts and anticipated new conditions toward which we are moving with additional GHG (Greenhouse Gas) emissions will continue to move the needle; they represent a paradigm shift into 'non-stationarity;' a condition in which we can no longer rely on historical records to precisely predict future outcomes, and in which we are planning and shaping our communities within a moving target of what will happen in the future. For example, what previously used to be the 100-year storm event may become a much more likely and frequent occurrence; it may become the twenty- or ten-year storm event. This means that everything from emergency response plans, to siting community facilities, to designing roadways, to determining flood insurance rates might continually evolve going forward.

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 are flexible and nimble, that can both mitigate and adapt to the effects of climate change. Future climate projections

show, even under the lower RCP scenarios, some level of change is unavoidable; therefore, planning efforts must integrate both mitigation strategies that limit the impacts of climate change and adaptation strategies that increase resilience to those impacts that cannot be avoided.

4. TOPICAL AREAS OF CONCERN: CONDITIONS AND CHALLENGES

So many concerns and issues in the Watershed are interconnected. It is often difficult, for example, to draw dividing lines, such as "*A* is a water quality issue; whereas *B* is a habitat issue" - when an argument could be made that the reverse is true, or that both *A* and *B* are traceable back to a common root cause. While imperfect, for the purposes of organizing the information in this Plan, we have set down issue area categories, despite the fact that they may, at times, overlap. This section, organized by issue area, describes existing conditions, the most salient issue-related challenges in the Watershed, and finally, the directions in which climate change may magnify or complicate current challenges. The issue area summaries included in this Section are actually abbreviated excerpts and summaries from a series of issue area White Papers that the project team developed, in consultation with the project Steering Committee, to document current Watershed conditions. Full White Papers are included in Appendix A.

Flood Management

Existing Conditions

The Assawompset Ponds Complex (APC) and Nemasket River Watershed has several characteristics—natural and anthropogenic (i.e. caused by humans) —that make it prone to flooding. Natural factors include topography, depth to groundwater, soils, invasive aquatic vegetation, and natural climatic variability Figure 1 and Figure 2. Human-caused. Anthropogenic factors include development patterns, infrastructure locations, installed barriers to connectivity among waterbodies, and climate change. Historically, flooding in the Watershed has resulted from a variety of events and conditions including hurricanes, snow melt on top of spring rains, and thunderstorms in the summer (Federal Emergency Management Agency [FEMA], 2020). In general, stakeholders around the APC have focused flooding concerns on Long Pond and other developed areas that have experienced historic flooding, as well as areas that have mapped or perceived flood risks.

In terms of natural features, the watershed's topography is relatively flat. The Nemasket River drops only 39 feet over its 11.2-mile course from the Assawompset Dam to the Taunton River junction (The Pilgrim Resource Conservation and Development Area, 1980). This low-gradient topography, exacerbated by excessive sedimentation, aquatic vegetation and hydrological disjuncture from dams and other infrastructure along the Nemasket, makes the watershed slow to drain, which can cause a build-up of water during and after precipitation events and lead to flooding.

Human alterations in the Watershed have impacted flood risk as well, particularly related to dams, infrastructure, and sedimentation. The Nemasket River originates at the outlet from Assawompset Pond, which was dammed for water supply purposes in the late 19th century. The Assawompset Dam is owned by the City of Taunton and under the care of the Department of Public Works Water Division. It was constructed in 1894, with a concrete fish ladder added in 1968. It has earthen embankments on either side of a spillway and is approximately 900' long on the west side and 1,900' long on the east side.

A picture of the Assawompset Pond Dam during the extreme drought conditions of fall 2020, taken from the vantage point of Assawompset Pond, looking downstream to the Nemasket River (9/11/20, SRPEDD)

The embankment's design height averages 5'. A 2006 inspection report conducted by CDM noted that the dam was in "fair" condition at that time. The report had two major recommendations (2006):

- Develop and implement an Operations and Maintenance Plan for the dam.
- Develop an Emergency Action Plan that includes an Emergency Early Warning System or rehabilitate the auxiliary spillway on the Middleborough side of the structure.

The Wareham Street Dam is owned by the Town of Middleborough. Originally constructed as a hydroelectric power source, it was reconstructed in 1964 and currently serves limited flood control purposes. Including all earthen embankments and spillway sections, it is approximately 340' long, 23' high, and has a hydraulic height of 15' (Pare, 2020b). A 2020 draft inspection report for the dam indicated that it was in "fair" and "satisfactory" condition. The report recommended additional studies, maintenance, and minor repairs, noting that there is no formalized operations and maintenance plan for the dam, although the Town of Middleborough Department of Public Works conducts routine maintenance (Pare, 2020b). A 2021-2022 hydrological and hydraulic study of the Nemasket River found that removing the Wareham Street Dam, of all evaluated infrastructure-related interventions at crossings along the Nemasket, would have by far the greatest impact in restoring flow and reducing upstream water impoundment, helping to alleviate flood pressure (Horsley Witten, forthcoming).

Challenges

The dam at Assawompset Pond was not designed for flood protection. Instead, the role of Assawompset Pond as a water supply reservoir means that the Assawompset Dam is operated primarily to maintain water storage within the APC. Ensuring the integrity of that water supply is the operational priority of the New Bedford and Taunton Water suppliers. During periods of high water, there are concerns that

A picture of a portion of the Wareham Street Dam (Horsley Witten)

the operational priority of holding back water to maintain adequate water supply may conflict with floodwater management goals. There are concerns among some Watershed stakeholders that maintaining water levels above established seasonal targets—with infrastructure that cannot be readily adjusted to drain excess water from the ponds during periods of high water—exacerbates flooding risk. Periodic lapses in communication may also be contributing to perceived flood risk in pondside neighborhoods. A best communications practice has been established, whereby Taunton Water Supply staff record pond water levels and reported these findings to Lakeville, Freetown, and Middleborough for posting on their municipal websites, so that water levels are readily knowable by local residents. This practice has recently become less consistent, creating an additional unknown that can raise anxiety. Currently, there is no automated water level reader that could populate a database or website independently of manual data entry and export.

Undersized culverts and other aging infrastructure throughout the Watershed restrict flows and further complicate flooding risks. In addition, increased sedimentation—largely driven by development and impoundment of river levels by dams and undersized road crossings—and excessive aquatic vegetation have been documented to exacerbate flooding risks in the APC and Nemasket River Watershed by reducing the flood storage and flow capacity of waterbodies, especially the Nemasket River (Truesdale, 2011). These issues have been documented as particularly problematic in the area immediately downstream of the Assawompset Dam and Vaughan Street, with additional critical areas of sedimentation identified around major developed areas and roads, such as Interstate 495 (Truesdale, 2011). Because of these flow conveyance issues and restrictions, previous studies have concluded that "the Nemasket River cannot be relied upon for a rapid decrease in pond elevation" (Assawompset Pond Level and Dam Committee, 2011). An on-going study is currently examining the extent to which dam and bridge infrastructure in the Nemasket River contribute to constricting water flow and elevating water levels upstream at the APC dam.

These challenges have historical precedent. In 2010, from mid-February through the end of March, three primary storms dropped 17-23 inches of rain in the APC area (FEMA, 2020). The rainfall was exacerbated by seasonal low evaporation leading to record water depths in the Taunton River and upstream waterbodies, including the Nemasket River and APC (FEMA, 2016). The majority of homes and other structures damaged or otherwise impacted by the 2010 floods were those immediately surrounding the APC or its upstream tributaries, including in Lakeville (Staples Shore Road and Clark Shores neighborhoods). Nemasket River flooding in 2010 did affect some homes and structures but especially impacted roads in Lakeville and Middleborough, including Plymouth Street, Murdock Street, Wood Street, Summer Street, and Vernon Street.

Climate Change Impacts

Climate projections for the Taunton River Drainage Basin (Northeast Climate Science Center, 2018) and broader climate assessments (Kossin et al., 2017; Easterling et al., 2017) indicate the following anticipated changes with regard to precipitation and temperature:

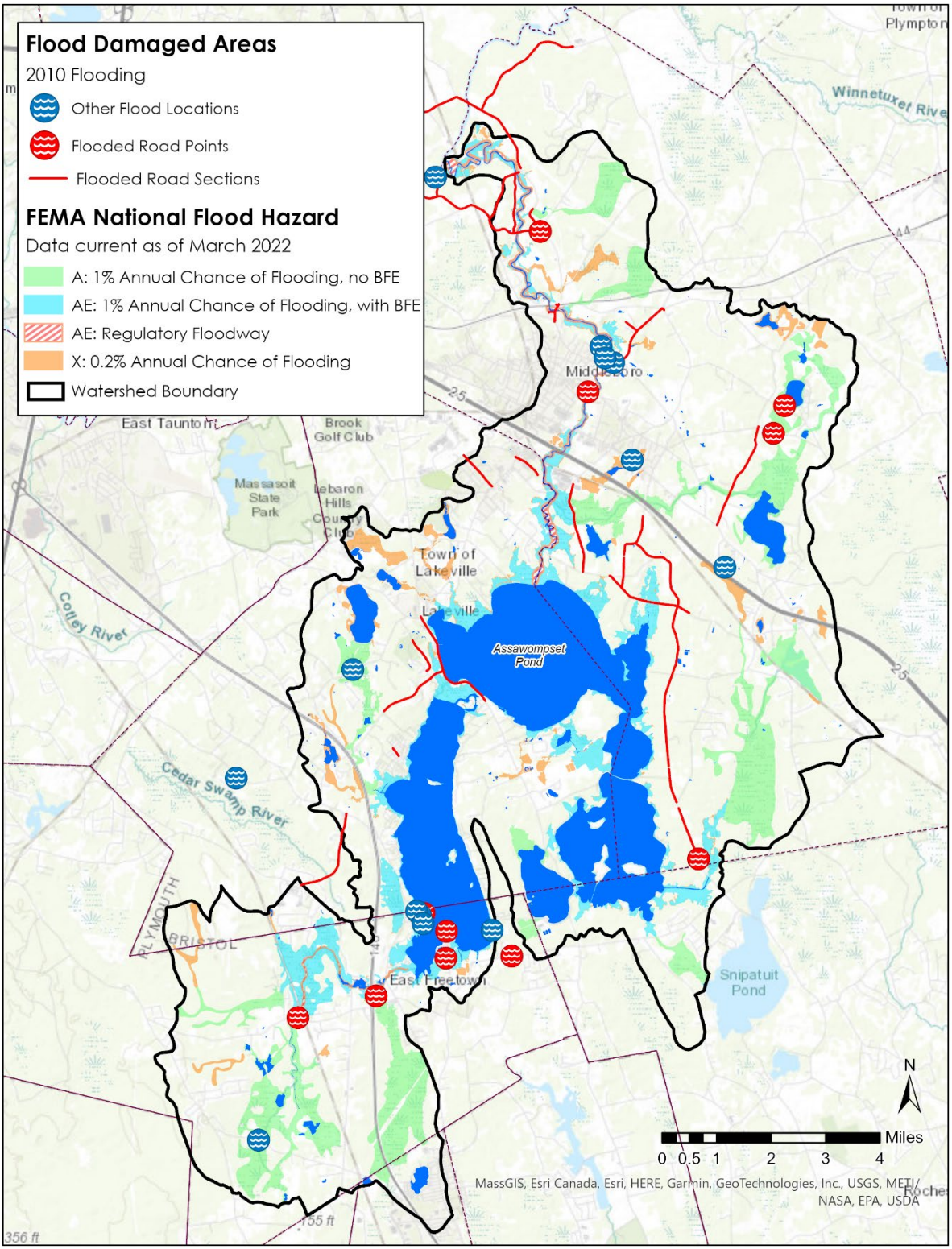
- The frequency and intensity of larger, more intense storm events will continue to increase.
- The total annual precipitation will continue to increase, and most of the increase is likely to occur in the winter and spring.
- The frequency and extent of consecutive dry days will continue to increase.
- The combination of hotter and drier periods will increase the likelihood of drought episodes.

In consequence, historic major flood events such as the 2010 and 1968 floods will likely become more common, including storms which may push the boundaries of what was previously considered '100 year' versus '500 year' floods. For example, the 100-year storm may actually be the 50-year storm as climate change occurs. Such events pose increased risk for the aging and, in some cases, undersized infrastructure described earlier (e.g., culverts and dams). Undersized culverts and dam overtopping—or even failure—are of particular concern in this context. The continued shift towards heavy precipitation events will also increase the threat of flooding, especially flash flooding. This problem will likely worsen as urbanization continues and impervious surface area in the watershed increases.

More frequent storms, in combination with increasing total precipitation, will change the water budget in the Watershed and impact infiltration rates, storage capacity, and drainage rates. As the 2010 floods were driven in part by extreme precipitation occurring on top of large amounts of total springtime precipitation, these events will likely become more common. Changes in precipitation quantity and timing will also likely require broader redesigns and sizing of existing and new infrastructure, as design standards based on historic conditions become obsolete.

Shifts in precipitation and temperature extremes will also lead to a more intense flood-drought cycle, which challenges our previous methods of managing water levels in the pond. This in particular can amplify the already existing tradeoff between maintaining water storage at levels required for the water supply and ensuring that there is adequate water storage to protect against rain events. Given the pond's slow drainage time, sudden shifts between flood and drought can further aggravate this challenge.

Figure 17. Spatial Representation of 2010 Floods (based on interviews and documentation)



Drinking Water Supply

Existing Conditions

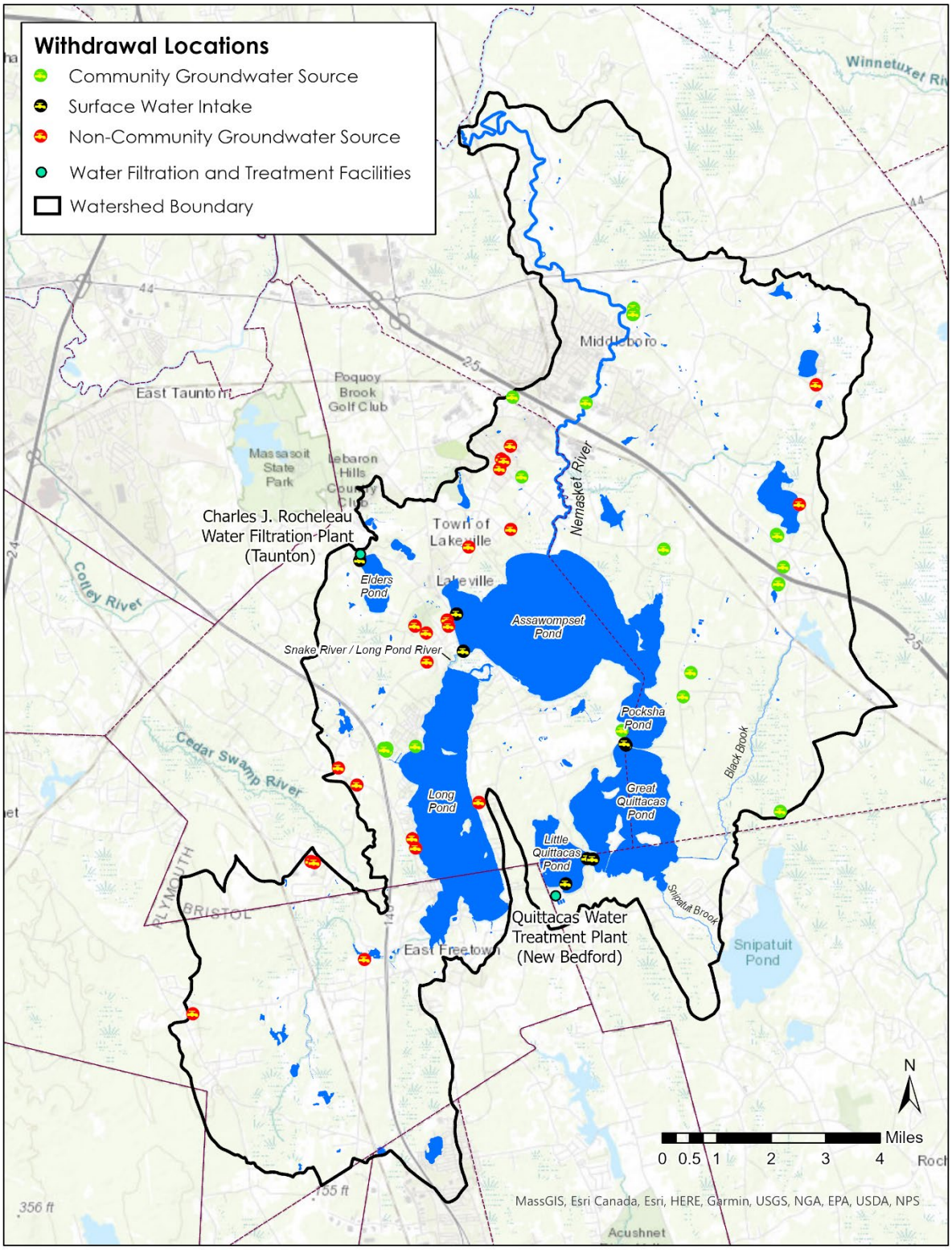
The Assawompset Ponds Complex (APC) is a critical drinking water source, serving approximately 250,000 people in southeastern Massachusetts. The ponds are the primary drinking water source for the City of Taunton and City of New Bedford. Taunton and New Bedford's public water supplies date to the late 19th century after a series of Massachusetts Legislative Acts granted the cities rights to water sources, including those of the APC. An act in 1875 granted Taunton the rights to construct a dam at the outlet of the Nemasket River on Assawompset Pond, which was constructed in 1894. By 1899, New Bedford had developed a new waterworks system that used a coal-powered pump station, with Little Quittacas as the sole source of New Bedford's supply. In 1924, the Massachusetts Legislature granted New Bedford rights to also withdraw water from Assawompset, Pocksha, and Long Ponds.

A picture of the APC Dam circa 1920, as published in the book *Nemasket River Herring: A History*, by Michael J. Maddigan (2014)

Taunton's drinking water is managed by the Water Division of the city's Department of Public Works. The Water Division pumps raw water from Assawompset Pond underground to Elders Pond (technically not part of the APC, but located within the APC and Nemasket River Watershed) before treating the water at the Charles J. Rocheleau Water Filtration Plant on the north side of Elders Pond in Lakeville. With a treatment capacity of 14 million gallons per day (MGD) for meeting peak summer demand, the plant removes color and turbidity through filtration, and bacteria through ultraviolet disinfection and the addition of chloramines. In fact, Taunton was the first system in New England to use ultraviolet disinfection, starting in 2004 (Kempe, 2006). Taunton also supplies water to the Village of North Dighton and the Bridgewater Correctional Complex, and also services parts of Berkley, Lakeville, Middleboro, Norton, and Raynham (Taunton Water Division, 2020). In total, Taunton's system consists of 371 miles of pipes and serves 60,000 customers (Taunton Water Division, 2016a).

New Bedford's drinking water is managed by the Water Division of the city's Department of Public Infrastructure. New Bedford draws its water from the five ponds of the APC, treating water from its intake in Little Quittacas Pond at the Quittacas Water Treatment Plant.

Figure 18. Map of Approximate Water Withdrawal Locations



The plant has a treatment capacity of 45 MGD and provides conventional filtration, disinfection, corrosion control, and fluoridation for oral health (City of New Bedford Department of Public Infrastructure, 2019). After leaving the treatment plant, drinking water is distributed to over 283 miles of pipes. Beyond the city, New Bedford also serves parts of Freetown and Acushnet, seasonally serves Dartmouth, and serves Fairhaven in emergencies (City of New Bedford Department of Public Infrastructure, 2019). These other municipalities generally have their own water divisions that purchase water from New Bedford; in some cases, they have additional supplies outside the APC Watershed.

In addition to the public water suppliers described above, the communities of Lakeville and Middleborough obtain public water supplies via groundwater wells located in the APC watershed. In addition, individual homes and businesses in pondside communities are supplied by individual private groundwater wells. While these groundwater wells do not physically withdraw water from any of the individual ponds in the APC, the water they withdraw is part of and interdependent on the same groundwater/surface water system that forms the APC itself.

New Bedford and Taunton's treated drinking water quality both met all EPA standards for regulated substances based on each city's 2020 Annual Water Quality Report. Currently, water withdrawals are dictated by Massachusetts Department of Environmental Protection (MassDEP) water withdrawal permits under the 1986 Water Management Act and subsequent revisions.

New Bedford's draft 2021 permit from MassDEP maintained the previously registered volume up to 20.79 MGD from the previous permits (18.27 plus 2.52 MGD), although it notes that New Bedford's average daily withdrawal was 12.19 MGD in 2018. The permit asserts, "If water needs are expected to exceed the 20.79 MGD potentially available through a permit amendment and New Bedford is meeting all of its permit conditions, New Bedford may apply for additional volume...However, any withdrawals requested above New Bedford's baseline of 18.27 MGD will require the mitigation of that volume" (MassDEP, 2021a, p. 3). Taunton's draft 2021 permit reiterated the 7.49 MGD (2,660.85 MGY) total authorized combined volume for Taunton for the APC and Dever School wells. However, because of Taunton's recent water use, the permit (MassDEP, 2021b) also set a baseline volume of 6.44 MGD, requiring the city to limit its withdrawal volume to this level, with the option to apply for a permit amendment requesting authorization to withdraw up to a total authorized volume of 7.49 MGD, and a plan to mitigate the amount by which the total requested authorized withdrawal volume exceeds the baseline. There are additional requirements for water conservation measures in both cities' draft 2021 permits, as well as commitments for APC management.

Aside from New Bedford and Taunton's municipal systems, additional public water withdrawals account for an estimated total 6,465.02 MGY in the APC and Nemasket River Watershed; private well withdrawals within the Assawompset Pond watershed total 447.03 MGY (MassDEP, n.d.). Middleborough, for example, sources its drinking water from eleven groundwater wells. Of these wells, seven are in the Watershed (MassDEP, 2006, 2016).

Challenges

Taunton and New Bedford are drinking water supply stakeholders. Associated drinking water quality priorities include protecting source water, providing necessary treatment for finished water, and maintaining infrastructure. MassDEP has designated water supply originating from the APC as "high susceptibility" to potential contamination due to surrounding land uses. Both New Bedford and Taunton

engage in source water protection activities, including significant land acquisition in the Watershed. Public access for recreation is allowed at some source water protection lands, but swimming and boating are allowed only in Long Pond (Dupere, 2019). Maintaining recreational use boundaries is difficult, and largely undertaken by the APC Rangers, with limited staff and staff hours.

Maintaining adequate water quantities for reliable supply is another chief concern and principal challenge for water supply stakeholders. Seasonal drought is a serious concern, and one that will only become more salient under climate change conditions. In dry conditions when water levels are low, New Bedford can pump water from Great Quittacas Pond into Little Quittacas Pond. Taunton has less flexibility, especially given the fact that its intake sits at a higher relative elevation within the APC (New Bedford, n.d.). As drought concerns spread throughout the region, historical themes are brought back to the surface; pondside communities, Rochester in particular, note that while they contain a portion of the ponds, they have no access to water supplies from these local sources (Colageo, 2021; Town of Rochester, 2019; Sparling, 2015).

At present, a challenge to collective watershed management is a lack of clear information around the relationship between water supply operational practices and flooding. Currently, New Bedford and Taunton manage their water supplies based on their respective water withdrawal permits and historical legislative acts granting them authority. According to New Bedford, the Assawompset Dam is generally kept open during flood seasons. Water is held back only in anticipation of having enough water in the system during drought conditions to maintain water supply (Upper Nemasket River Enhancement Steering Committee, 2020). There is a perception that water supply practices can cause a retention of water above certain thresholds that put pondside communities at greater risk for flooding. Additional information is required to understand the actual parameters of this linkage. Recent technical studies have noted that the dam is “highly porous and minimally effective at controlling the pond level” (Assawompset Pond Level and Dam Committee, 2011). Two such studies during recent floods found that removing the bascule gate at the Wareham Street Dam also did not affect APC levels, indicating that these two dams are not the primary drivers of APC water levels (Assawompset Pond Level and Dam Committee, 2011; Fennessey 2013). As of writing in 2022, there is ongoing research and modeling of these dams and flooding levels. In the meantime, there is no single entity to which local pondside residents can turn for information about current pond levels or whether dam boards are in place. That condition adds a layer of anxiety around this issue that could be averted with a single consistently updated information source on dam status. With their continuous participation in the APC Management Team, water suppliers are considering their decisions in coordination with other topics, such as flood risk or ecosystem health, but could be showcasing this work with additional transparency.

Climate Change Impacts

Climate projections for the Taunton River Drainage Basin (Northeast Climate Science Center, 2018) and broader climate assessments (Kossin et al., 2017; Easterling et al., 2017) indicate the following anticipated changes with regard to precipitation and temperature:

- The frequency and intensity of larger, more intense storm events will continue to increase.
- The total annual precipitation will continue to increase, and most of the increase is likely to occur in the winter and spring.
- The frequency and extent of consecutive dry days will continue to increase.

- The combination of hotter and drier periods will increase the likelihood of drought episodes.

Intense storm events will increase flooding risks, adding additional urgency to the need to address regional concerns about flooding and its relevance to water supply operational practices. Flooding associated with intense precipitation could damage or make inoperable critical water supply infrastructure and/or block personnel access to water infrastructure for operations. Increased extreme precipitation events will increase erosion, requiring additional treatment and causing new challenges for water treatment. Further, intense storm events would be associated with changes in precipitation levels, potentially invalidating existing and historic baselines for management decisions. Some of these baselines date back to the late 19th and early 20th centuries, and more recent decisions are based on a study from 1988.

Extended dry periods will create additional needs to store more surplus water and/or required the implementation of more frequent and longer duration water use restrictions in Taunton and New Bedford, potentially exacerbating trade-offs. Drought conditions are of particular concern in the APC because the water supply (via New Bedford treatment and distribution) is the seasonal and emergency backup for the Town of Dartmouth's public water supply. The APC is, therefore, called upon for additional withdrawals during times of regional water scarcity, compounding water supply management challenges. In periods of low water, New Bedford has the ability to pump from Great Quittacas Pond into Little Quittacas Pond. New Bedford had to do so during the Phase 3 drought that occurred in the summer and fall of 2020 for the first time in many years. Taunton has less flexibility given the location of its water intake infrastructure. Extended dry periods will also strain the existing trade-offs between water supply levels and habitat. Under climate change, the respective Taunton and New Bedford estimated firm yields from the APC may be diminished.

Increasing water temperatures can cause water quality issues, such as increased cyanobacteria blooms and nitrogen loading, further requiring additional treatment. In the absence of water conservation measures, higher temperatures also tend to be associated with additional public water supply demand and withdrawals. Extreme temperatures can also harm existing water treatment infrastructure.

Water Quality

Existing Conditions

Assawompset, Pocksha, Great Quittacas, and Little Quittacas Ponds are the primary water supply source for over 250,000 people in the Cities of New Bedford and Taunton, as well as portions of adjacent communities, and much of its surrounding uplands have been largely protected to help maintain suitable water quality. Good water quality is also vital for the fish and rare aquatic species that live within the APC and Nemasket River, as well as for the wide range of species that that rely on it for habitat needs, such as feeding Eagles, migrating waterfowl, and foraging otters.

Challenges

The Long Pond shoreline is heavily developed and allows public access and portions of the larger APC and Nemasket River Watershed are among the most rapidly developing areas in the state (Massachusetts Audubon Society, 2020). Problematically sited development can fragment and degrade

intact functioning ecosystems while increasing impervious surfaces, pollution sources, and stormwater runoff. Combined with an increase demand for drinking water, these factors contribute to diminished water quality for both people and nature.

MassDEP's Final Integrated List of Waters for the federal Clean Water Act 2018/2020 Reporting Cycle notes the following (MassDEP, 2021):

- **Long Pond**: assessed as Impaired for not supporting the Aquatic Life Use due to non-native aquatic plants with significant variable milfoil and fanwort problems.
- **Upper Nemasket River** (Assawompset Dam to Middleborough Waste Water Treatment Plant): assessed as Impaired and requiring a Total Maximum Daily Load (TMDL) for not supporting the Aquatic Life Use due to low dissolved oxygen, high temperatures, and aquatic toxicity.
- **Lower Nemasket River** (Middleborough Waste Water Treatment Plant to Taunton River): assessed as fully supporting the Aquatic Life Use based on fish community data and excellent Wastewater Treatment Plant (WWTP) effluent quality but has an Alert Status due to non-native aquatic Asian Clam.
- **Fall Brook** (Nemasket tributary): assessed as Impaired for not supporting the Aquatic Life Use due to diadromous Fish Passage Barriers.

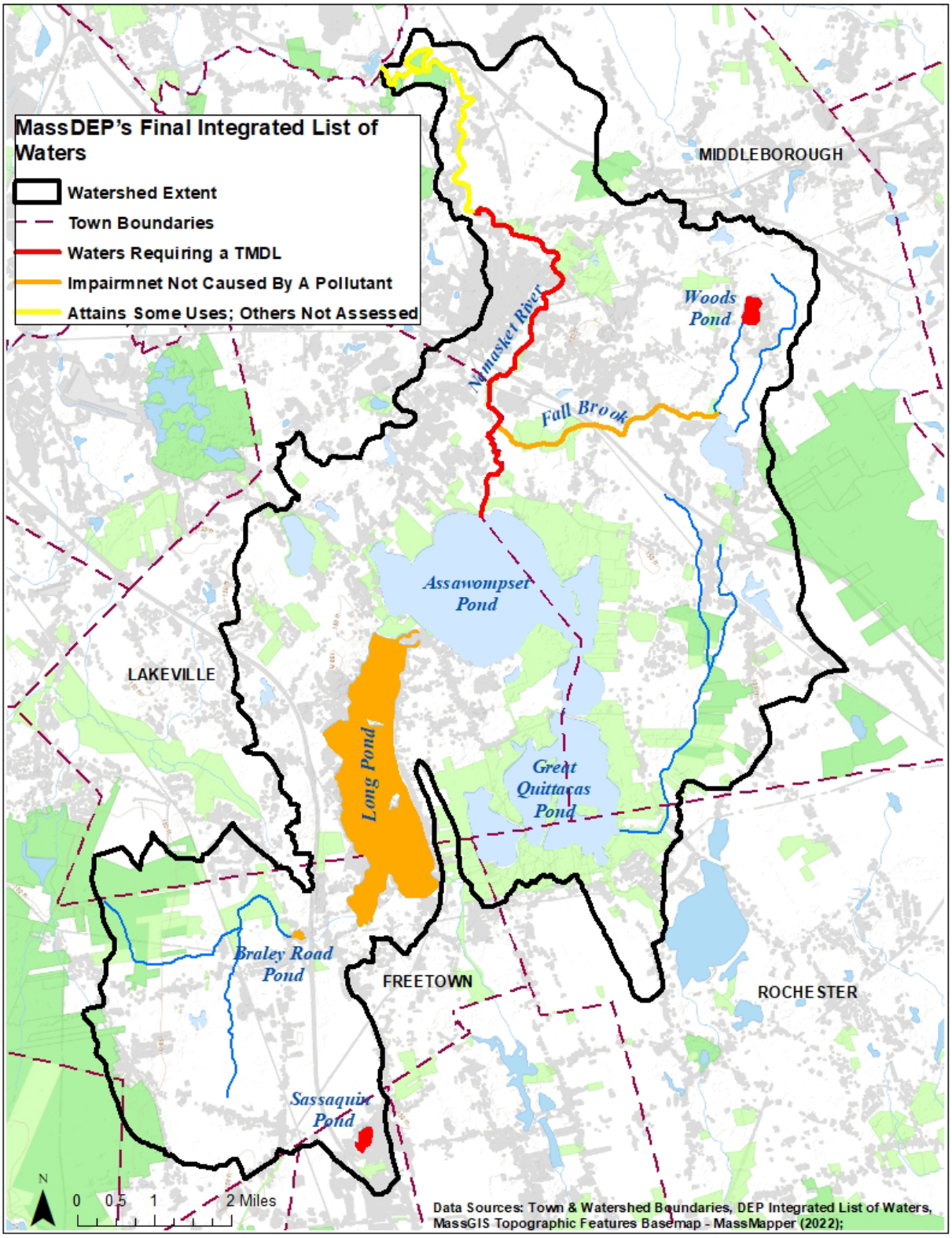
MassDEP's Source Water Assessment and Protection Program Reports (SWAP) assigned 'High Susceptibility' rankings to the New Bedford and Taunton Water Supplies due to four major potential water supply pollution sources: active cranberry bogs and small horse farms, local roads and highways, septic systems and cesspools, and residential land uses. Both cities have implemented APC water quality protection efforts, including land conservation, forestry management, ranger patrols, and participation in the regional APC Management Committee (MassDEP 2002, 2003; City of New Bedford, 2020; Rojko et al., 2001).

The APC and Nemasket River drain to the Taunton River which empties into Mount Hope Bay in Rhode Island - both of which require pathogen TMDL reports due to fecal coliform, E. coli, and enteroccoci bacteria impairments (MassDEP et al., 2011; MassDEP, 2010). MassDEP recommends that these TMDLs guide management activities for waters throughout the entire Taunton watershed to reduce bacteria and protect water quality.

High algae and depressed dissolved oxygen in the Taunton River Estuary and Mount Hope Bay are attributed to high nitrogen loads (Howes and Samimy, 2007) and sources include WWTPs, stormwater runoff, residential and commercial fertilizer use, improperly maintained septic systems, and agriculture including cranberry bogs and manure management (MA DEP 2003; MA DEP 2021; The Taunton River Watershed Alliance 2022). With Middleborough's recent upgrade to its WWTP, the EPA now considers a 20% nonpoint source reduction — from both ocean and watershed loads — a good target to reach allowable Total Nitrogen loads for the estuary.

These same pollution sources, in combination with pinch points in the upper Nemasket River—from dams, bridge crossings, undersized culverts, sand bars, and aquatic vegetation — reduce flows and impound water, further degrading water quality due to increased water temperatures, decreased dissolved oxygen, and excessive turbidity.

Figure 19. APC-Nemasket Massachusetts Department of Environmental Protection Impaired Waters



Climate Change Impacts

The increased frequency and intensity of storms and precipitation anticipated with climate change will lead to more water entering the APC and Nemasket during concentrated periods of time—bringing increased sediment, nutrients, disease pathogens, and invasive species— degrading drinking water quality and aquatic habitats. As this pollutant load travels downstream to estuaries and the ocean, it can increase harmful algal blooms and bacteria. Increased temperatures and warmer waters, which hold less dissolved oxygen, can lead to eutrophication and excess algal growth degrading water quality and creating conditions more tolerable for some invasive aquatic plants. Drought and reduced flows, combined with problematically sited development and an increase demand for drinking water, will exacerbate these stressors and contribute to diminished water quality for both people and nature. Planning for increased water volume and more impactful drought periods will be required to protect water quality. Additional water quality monitoring sites/data and both rapid response and long-term management plans to address invasive species are needed (Northeast Climate Science Center, 2018; Kossin et al., 2017; Easterling et al., 2017).

Ecology

Existing Conditions

The APC and Nemasket River Watershed is critical habitat for the largest herring run in the state and its variety of wetlands and uplands provide a wide range of habitats rich in biodiversity. Nearly 52% of the Watershed is designated as Natural Heritage BioMap2 (BM2) Core Habitat and/or Critical Natural Landscape—areas most critical to ensuring long-term persistence of rare and native species and their habitats, exemplary natural communities, and a diversity of intact, functioning ecosystems (BioMap2, 2010).

Sixteen state-listed rare species and a high number of globally imperiled species are present—including the northern red-bellied cooter (*Pseudemys rubriventris)*, bald eagle (*Haliaeetus leucocephalus*), Plymouth gentian (*Sabatia kennedyana*), water-willow borer moth (*Papaipema sulphurata*), bridle shiner (*Notropis bifrenatus*), and two freshwater mussel species (BioMap2, 2010; Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program [MA DFW-NHESP], 2021). Common loon (*Gavia imm*er) chicks, translocated to the APC as part of a restoration project, resulted in the first chick to hatch in southeastern in over a century (MA DFW-NHESP, 2020a). The APC is a waterfowl hotspot and nnumerous uncommon wildlife and plants are present, including environmentally sensitive river otters and eastern brook trout, uncommon breeding birds such as bobolinks and purple martins, and excellent examples of vulnerable coastal plain pondshore and kettle hole bog natural communities.

Much of the Watershed is further designated as BM2 Aquatic Core Habitat—intact river systems where important physical and ecological processes function for fish and aquatic species of special concern (BioMap2, 2010). These healthy aquatic systems are due in part to the surrounding extensive areas of intact natural vegetation and contiguous forests and wetlands, including a BM2 Landscape Block—an area most likely to maintain dynamic ecological processes such as buffering, connectivity, natural disturbance, and hydrological regimes. These attributes support wide-ranging wildlife and many other species, as well as provide important ecosystem services, such as clean drinking water, flood mitigation,

and carbon sequestration. Over 4000 acres around Assawompset, Pocksha, Great Quittacas, and Little Quittacas Ponds have been conserved to protect the public water supply, further enhancing these healthy aquatic ecosystems (MassGIS, 2020c).

Additionally, 60% of the BM2 Core Habitat and/or Critical Natural Landscape have high TNC Resilience scores and are areas estimated to be most resilient to climate change. The intact natural properties of these areas, with high microclimatic diversity and low levels of human modification, provide species with connected, diverse climatic conditions they will need to persist and adapt to changing regional climates (Resilient Land Mapping Tool, 2022).

Challenges

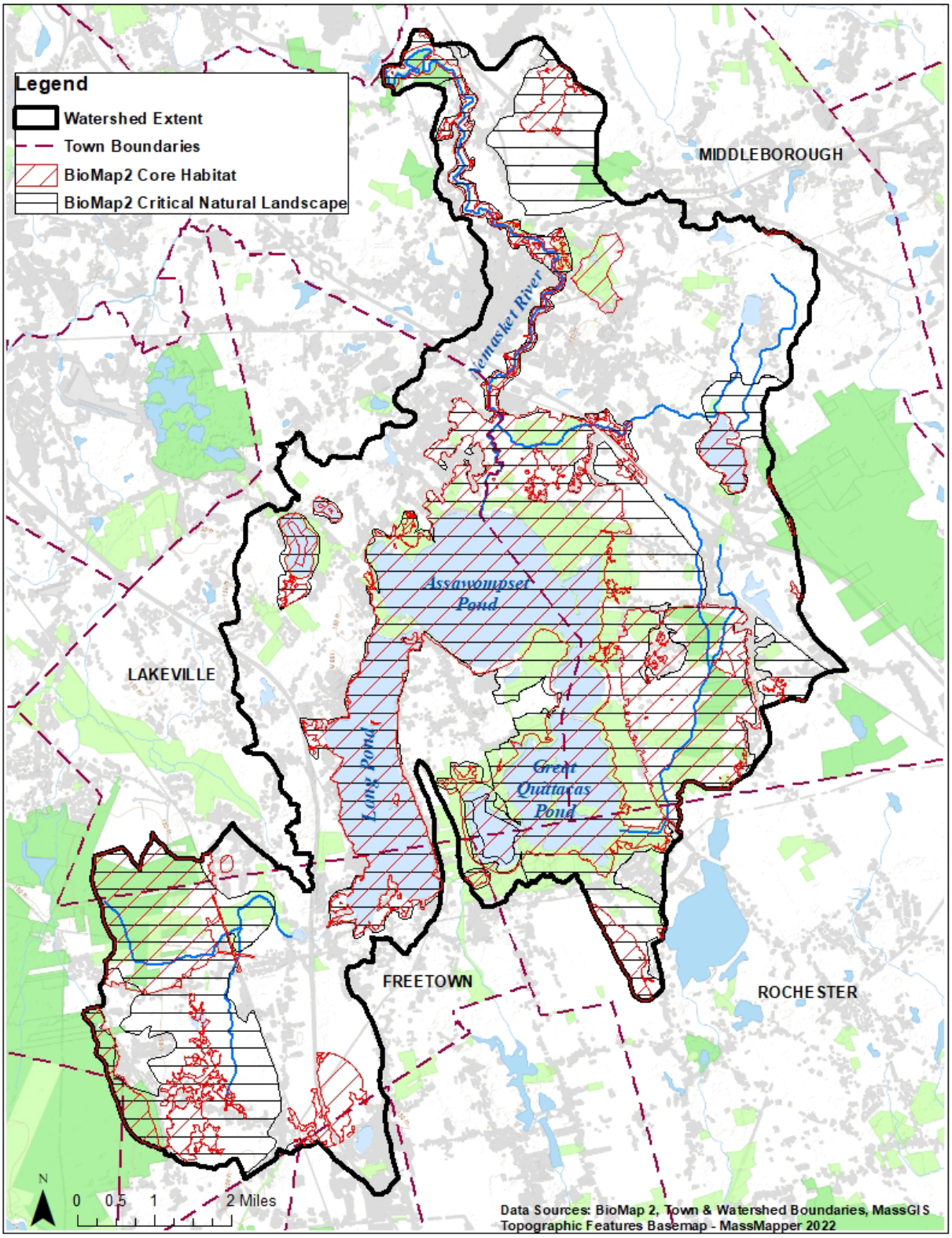
Despite being flat and slow, conditions in the Nemasket River currently allow the spring upstream herring migration beyond three dams and numerous culvert, road, and railroad crossings. Emergent aquatic vegetation, however, above the Wareham Street Dam and other slow-moving sections have caused impediments for migrating fish (Reback et al., 2004; T. Barron, personal communication, 2021). In the fall, these pinch points in combination with water supply withdrawals, reduced pond levels and river flows, sediment aggradation, and invasive aquatic vegetation, present challenges to downstream herring emigration and juveniles have been trapped behind the Assawompset Dam (T. Barron, personal communication, 2021).

The Long Pond shoreline is heavily developed and allows public access. The larger APC and Nemasket River Watershed also faces increasing development, portions of which are among the most rapidly developing areas in the state (Massachusetts Audubon Society, 2020). This trend has the potential to fragment and degrade functioning intact ecosystems while simultaneously increasing water supply needs and impervious surfaces, exacerbating droughts and flooding, and reducing ecosystem services for both nature and people.

The upper Nemasket River, from the Assawompset Pond Dam to the Middleborough Wastewater Treatment Plant, was recently added to MA DEP's 303(d) list as not supporting the Aquatic Life Use due to low dissolved oxygen, high temperatures, and aquatic toxicity (ambient bioassays) (MassDEP, 2021). Long Pond has long been designated as Impaired (2019) for Aquatic Life due to non-native aquatic plants with significant variable milfoil and fanwort problems. Both species are now found in Assawompset and Pocksha ponds and milfoil is present throughout the Nemasket (Massachusetts Audubon Society, n.d.). Purple loosestrife (*Lythrum salicaria),* reed canary grass (*Phalaris arundinacea),* and Oriental bittersweet (*Celastrus orbiculatus)* have been documented intermittently within the basin and a large population of invasive Asian clams occurs in Long Pond (MA DFW, 2019), downstream in the Nemasket, and is likely present in other waterbodies.

Further development and urban expansion in the Watershed, which already contains substantial disturbed forest, favors fast-growing disturbance and edge species able to tolerate degraded conditions. Due to the forest's relatively high species diversity - a key feature for adaptation - if forest composition changes, the continuity of some species should enable continued key ecosystem functions, including carbon storage, flood water attenuation, and runoff filtration (Duveneck and Thompson, 2016).

Figure 20. APC-Nemasket MA NHESP BioMap2



Climate Change Impacts

The increased frequency of storms and precipitation will lead to more water entering the APC and Nemasket during concentrated periods of time, which will bring increased sediment, nutrients, disease pathogens, and invasive species, and degrade water quality and aquatic habitats. Increased temperatures and warmer waters, which hold less dissolved oxygen, can lead to eutrophication, invasive plants, and excess algal growth degrading water quality and habitat for fish and other aquatic species and altering food webs. These pollutant loads can travel downstream to estuaries and the ocean leading to blooms of harmful algae and bacteria.

Droughts and low flows will further reduce stream connectivity and species dispersal and potentially fragment aquatic species populations (Northeast Climate Science Center, 2018; Kossin et al., 2017; Easterling et al., 2017). Furthermore, these conditions are predicted to alter many coldwater streams which may become too warm in the summer to support eastern brook trout (Chague, G. 2020). Even some warmwater fish species could be pushed towards thermal tolerance limits, forcing them to seek new cooler habitats if hydrologic connectivity is intact (Yoder, 2012; Climate Central, 2018). A warming climate will reduce summer ranges for some birds, such as eagles and bitterns, and breeding habitats will be sought further north (National Audubon Society, n.d. a; National Audubon Society, n.d. c).

As the climate warms and precipitation patterns change, multiple stressors including pests and disease, will impact forests, likely leading to a restructuring of the dominant forest types in the Watershed - including the reduction of white pine, increase in oak species that can resist stressors, and in black cherry, eastern redcedar, and beech. Those species with low adaptability are the most vulnerable.

In combination, these and other factors not only exacerbate ecological impacts, but associated environmental and community impacts. Planning to maintain ecosystem function and conservation and restoration of intact landscapes will help maintain ecosystem services for nature and people.

Land Development

Existing Conditions

The APC-Nemasket Watershed is dominantly rural in character with extensive areas of medium and low-density residential development, forests, wetlands, and agricultural areas. It sits within a unique region of the state, where natural areas remain abundant, but are being developed at a rapid pace. The surrounding Taunton River Watershed is 29% developed, the tenth most developed of Massachusetts' 27 watersheds, and has 62% natural land cover (i.e. forests, wetlands and water bodies), based on satellite imagery (Mass Audubon, 2020). The APC-Nemasket Watershed itself is 5.7% impervious (i.e. pavement, buildings, and other non-natural land cover) and about 82% natural land cover (MassGIS, 2019). Forested land cover types in particular (including deciduous, evergreen, and palustrine forested wetland) occupy approximately 61% of the watershed (MassGIS, 2019).

Levels of development vary across the Assawompset Ponds Complex. Great and Little Quittacas Ponds' shores are completely protected from development, and Pocksha and Assawompset Ponds' shores are

largely protected, mainly for water supply protection. In contrast, Long Pond is unprotected and heavily developed (Mass Audubon, n.d.).

Another measure of development is land use, which categorizes individual parcels of land by their primary use, based on assessment records. Land use records for the Watershed reveal that existing development is predominantly residential. Collectively, on a parcel basis, about half of the Watershed's area is taxed as residential land (MassGIS, 2015, 2018a, 2018b, 2019a, 2019b, 2020a, and 2020b). 21% of the Watershed is Open Space and Recreation land, with at least some level of on-going protection from development or alternative use (based on 2020 MassGIS Open Space and Recreation data). Commercial and industrial-type land use parcels collectively make up about 3% of the Watershed, and are largely concentrated along commercial corridors such as I-495 and Route 28 in Middleborough, and Route 140 in Lakeville and Freetown.

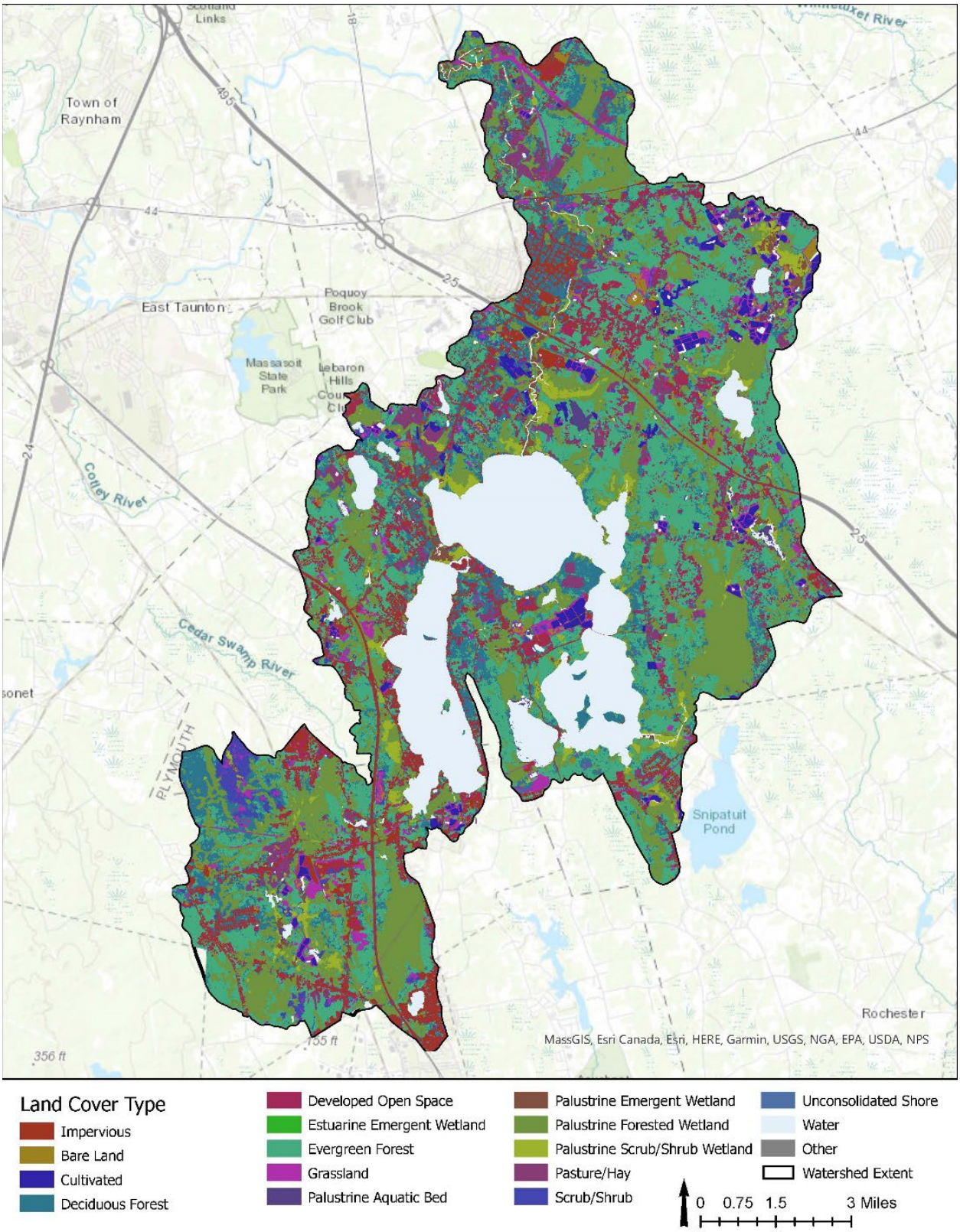
Local zoning determines where certain land uses are allowed, and thus the types of development we can expect to see across the Watershed. Low-density residential zoning districts predominate within the Watershed, a contributing factor to the current context in which this type of development is the most ubiquitous across the Watershed (City of New Bedford, 2015; Town of Freetown, 2019b; Town of Lakeville, 2018; Town of Middleborough, 2015a; Town of Rochester, 2016). Absent any zoning changes, this low-density development is also what we can expect to see across the Watershed into the future. Freetown has an "Open Space and Recreation" zoning district that restricts many types of development, encompassing the area around Long Pond (Town of Freetown, 2019a, 2019b). Other local controls on development, such as Wetland Protection Bylaws and Floodplain Zoning, can protect particular resource areas (i.e. wetlands, which provide flood storage, and wetland and riparian buffers, which protect water quality). Each of the watershed communities have some level of protection for these features in their local zoning and wetlands regulations; however, the levels of protection vary across the watershed.

Challenges

The conversion of natural areas to development creates many challenges for the Watershed and the communities within it. The removal of forests and wetlands not only releases stored carbon dioxide into the atmosphere, further exacerbating climate change, but it also removes many of our defenses against climate impacts and reduces environmental quality. Natural areas purify our air and water, cool our neighborhoods, and infiltrate rainfall to prevent flooding. Conversion of our natural areas to impervious surfaces, like roadways, parking lots, and buildings, instead increases local temperatures and contributes to stormwater runoff and pollution. Development directly adjacent to the APC has a distinct impact on water quality in the Ponds. Residential fertilizer use and private septic systems, some of which pre-date Title V septic standards, around Long Pond in particular are a source of nutrient contamination that contribute to the entrenchment of invasive aquatic weeds that have become a nuisance to recreation and threaten native species (Mass Audubon, n.d.). Further strain on water quantity may also result when impervious surfaces prevent rainfall from recharging groundwater supplies, while increased development can increase demands on the existing supply.

Recent development trends warrant careful consideration and attention to these impacts. Since the late 1990s and early 2000s, the Taunton Watershed, and the southeastern region of Massachusetts in general, have experienced some of the highest development rates across the state. From 2012 to 2017, the Taunton Watershed was the fourth most rapidly developing watershed in the state, at a rate of 4.6 acres per square mile (Mass Audubon, 2020).

Figure 21 Watershed Land Cover Map (MassGIS 2016 Land Cover/Land Use data, 2019)



The Watershed straddles Plymouth and Bristol Counties, the first and fifth most rapidly developing counties in the state between 2012 and 2017, at 6.1 and 3.9 acres per square mile, respectively (Mass Audubon, 2020). Residential housing demands, particularly along the I-495 corridor in Middleborough and surrounding the MBTA Commuter Rail Stations in Lakeville and Plymouth, are contributing to high development rates (Town of Middleborough, 2002). New state regulations requiring multi-family zoning surrounding MBTA stations (MGL Ch. 40a, Section 3A, as updated in 2021) could drive additional development in the Watershed, potentially exacerbating the above challenges if land preservation does not keep pace with development (Executive Office of Housing and Economic Development, 2022).

Communities can implement low impact development (LID) strategies that minimize the negative environmental impacts of development by reducing its footprint, preserving natural features and functions, and infiltrating stormwater as close to the source as possible (United States Environmental Protection Agency, 2021). Local regulations may limit developers' abilities to utilize such strategies, however, as is the case in the Watershed communities. The majority of the Watershed is zoned for low-density, single-family residential development, requiring large minimum lot sizes and strict dimensional standards that do not grant developers flexibility to accommodate existing natural features, and result in habitat loss and/or fragmentation (City of New Bedford, 2015; Town of Freetown, 2019b; Town of Lakeville, 2018; Town of Middleborough, 2015a; Town of Rochester, 2016). The communities have taken some steps to encourage the utilization of LID locally (for example, Middleborough has adopted a Stormwater Bylaw and permitting system that requires LID for projects disturbing over 10,000 square feet of land; Town of Middleborough, 2020), but further regulatory updates can be implemented to encourage more widespread adoption of LID practices and to enforce their use.

Climate Change Impacts

More frequent intense storm events, as predicted for the Taunton River Watershed (Northeast Climate Science Center, 2018), are expected to compound stormwater management issues associated with development and increase the size and extent of current flood hazard areas. Large volumes of rainfall in a short period of time can cause localized flooding in developed areas, especially with aging stormwater infrastructure that is built to accommodate outdated rainfall trends and design storms. As larger storms become more frequent, the failure of public infrastructure, such as culverts, dams, bridges and storm drains, may also become more frequent, resulting in increased flooding damages.

More intense storms will also impact the Watershed's natural capacity to manage larger volumes of rainfall by expanding the natural floodplain. The Federal Emergency Management Agency (FEMA) compiles flood risk data for communities for use in both insurance rating and floodplain management, which includes flood hazard maps that predict the area of inundation during storms (FEMA, 2021). These maps, which are often used for site design and land use planning, are based on historic precipitation data. Climate change means that these maps are already outdated by their time of publication. To accommodate larger volumes of rainfall more often, the floodplain (and its associated flood hazard area) will expand over time, putting more infrastructure in potential harm's way while also reducing the available inventory of land that is safe to build on, creating challenges for planning future development.

More extreme temperatures (both more intense cold weather in the winter and hot weather in the summer) and drought cycles expected in the region are also putting stress on our built environment (Northeast Climate Science Center, 2018). Extreme temperatures, and heat in particular, are a significant public health concern. Impacts are intensified in built areas with less natural cover. Extreme

temperatures and extended drought periods affect forest health, increasing the likelihoods of falling trees and fire hazards, which threaten both public health and property. Since development and climate impacts often build off one another, planning for climate resilience as the watershed communities continue to grow is critical.

Recreation

Existing Conditions

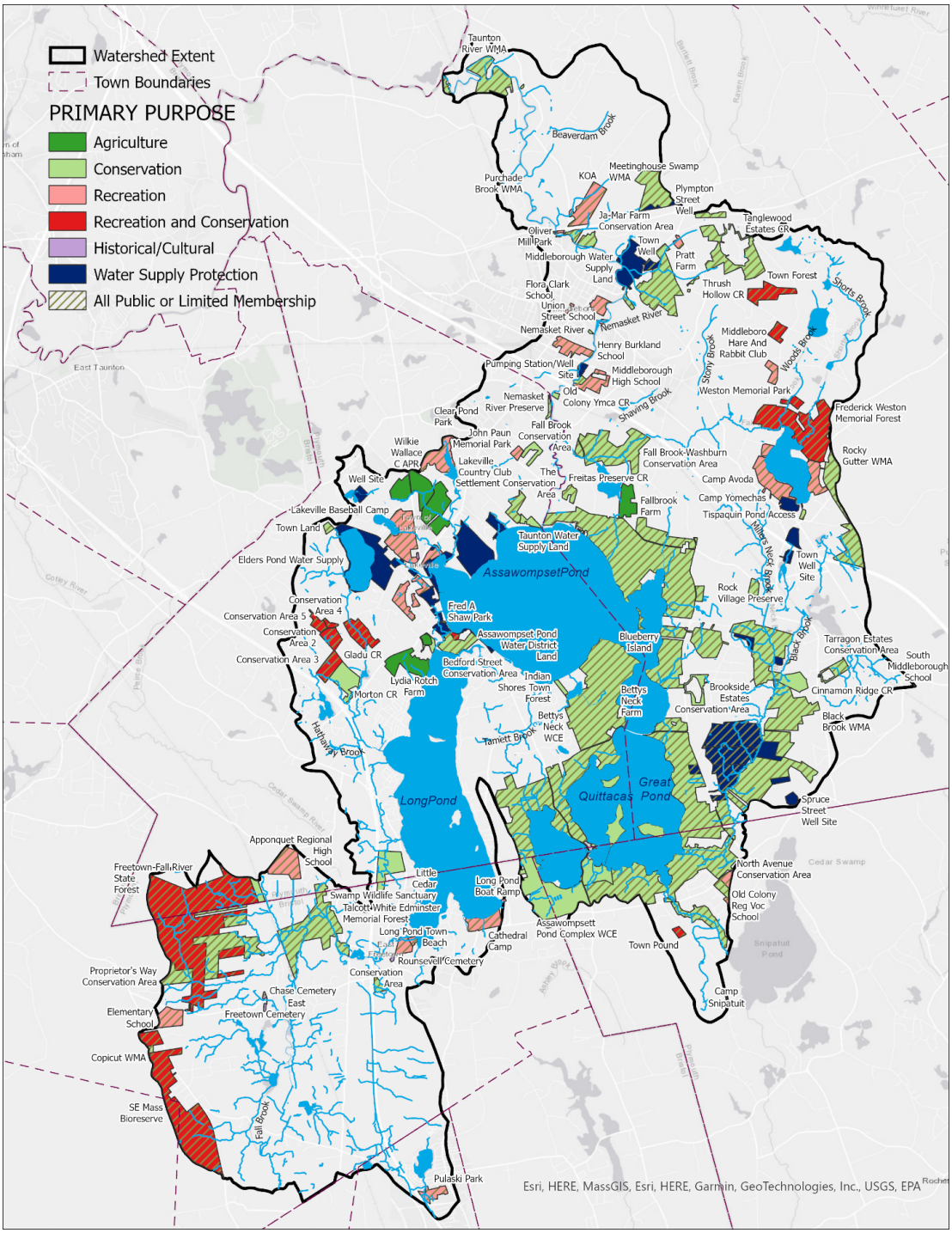
Open Space and Recreation areas represent a significant portion (about 21%) of the APC and Nemasket River Watershed's total land area (MassGIS, 2020c). The APC and Nemasket River waterbodies serve as a hub for open space and recreation lands in the immediate region. Forty-three percent (4,016 acres) of the Watershed's open space lands are situated in tracts that are adjacent to the APC or Nemasket River, 80% of which are categorized as publicly accessible (MassGIS, 2020c).

Much of the open space and recreation land in the Watershed area is owned by specific public entities. Approximately 83% of the watershed's open space and recreation lands are owned by municipalities and state agencies. Among these, the City of New Bedford is by far the largest landowner of open space and recreation lands by total acreage holdings, especially because the city is the owner of 2,942 acres of water supply protection lands around Assawompset, Pocksha, Great Quittacas and Little Quittacas Ponds (MassGIS, 2020c).

Long Pond is the hub of water-based recreation in the APC. Most kinds of water-based recreational activities are permitted, including swimming and motorized and non-motorized boating (by permit). Given its role in drinking water supply, no water-based recreation (except for shoreline fishing) is permitted in the APC outside of Long Pond, with limited exceptions. Boating is allowed only for shoreline residents on Assawompset and Pocksha Ponds. All boats used on Assawompset and Pocksha must have a special permit (APC Management Plan Steering Committee, meeting discussion, 2022). The Nemasket River additionally offers public canoe and kayak put-ins such as at Oliver Mill Park and the Nemasket Herring Run Park at Wareham Street in Middleborough, and Old Bridge Street and Vaughn Street in Lakeville. Kayaking from Oliver Mill Park to Vaughn Street is approximately 5.15 miles of paddling with portages. Low water levels and extensive plant growth limit the reach of canoers and kayakers in the river, with paddling best in early spring when water levels are high. The Nemasket River's paddling access ends at the Assawompset Pond Dam, and paddlers are not allowed to portage over the dam.

There are extensive areas of publicly-accessible recreation land around the APC for passive recreation activities without water contact, such as walking, hiking, and nature study. There are sites with parking areas, trails, and picnicking and fishing amenities, including New Bedford Waterworks (Rochester), Betty's Neck (Lakeville) and Stuart F. Morgan Conservation Area (Middleborough). Popular recreational areas for land-based activities along the Nemasket River include the Nemasket River Village/Ja Mar Turkey Farm Property and Oliver Estate Property & Conservation Land, both in Middleborough. Farther afield from the ponds and river, several regionally significant nature-based recreation areas in the watershed's uplands include several state-operated Wildlife Management Areas, Pratt Farm (Middleborough), Freetown-Fall River State Forest and the Southeastern Massachusetts Bioreserve (Freetown).

Figure 22. Open Space and Recreation Lands by Purpose



We note that the Map above is an imperfect and incomplete resource. It was compiled from the MassGIS Protected and Recreational Open Space data layer, vintage 12/15/2020, with minor updates based on local knowledge from the APC Management Team January 2022. One of the clear outcomes of this research process is that a comprehensive, up-to-date map of open space and recreation resources does not exist for the watershed. In future, the development of such a map could be a priority action item, particularly in the context of a regional Open Space and Recreation Plan, or a Water-Access Master Plan.

Challenges

In such an environmentally sensitive and significant water supply area, recreational programming and access has to balance multiple competing needs. For the purpose of watershed and climate resilience planning, a balanced recreation program is one which provides a quality outdoor recreation experience for people within a range of recreational activities that have a low impact on ecology and water quality in the APC and Nemasket River. Accordingly, recreational uses in the Watershed are governed by federal, state, and local regulations. Rule violations, knowingly or unknowingly perpetrated, are an on-going threat to a balanced recreational program in the Watershed.

The main enforcement arm of water access limitations and public land regulations around the APC is the team of APC Rangers. Jointly funded by the City of New Bedford Water Supply, the City of Taunton Water Supply, and the Town of Lakeville, the Ranger team fluctuates between two and four part-time staff members depending on the time of year. Attracting and retaining staff is difficult, in part due to funding constraints and low salaries. A small team limits the capacity for monitoring the Watershed's vast public lands. The State Environmental Police are another enforcement resource, though there are so few environmental police shared by the entire state of Massachusetts that any calls placed by the Rangers have hours-long response times before environmental police officers can be on site.

Some rule violations might be avoided if the public were more aware of which activities were allowed where and when throughout the Watershed. Public access information is disparate and inconsistently available, either online or posted at recreational sites. Varied stakeholders, including towns and environmentally oriented non-profits, have developed substantial materials explaining the range and location of permitted recreational activities in the Watershed. A key current question is the extent to which these informational materials are reaching their intended audiences. It is unclear if these resources are posted and available where potential users would look for information on recreational opportunities, rules, and regulations. Providing and maintaining clear and consistent signage throughout the Watershed's open spaces is also challenging given limited resources.

Climate Change Impacts

Projected climate change impacts to the Watershed would increase the likelihood of several natural hazards that pose a threat to nature-based recreation. More frequent intense storm events could inundate or otherwise damage recreational amenities, while associated flooding may mobilize pollutants, threatening water quality and ecological health. Tree blow-downs can also create hazards to recreational users in forested open spaces, while increasing maintenance demands on recreational land managers.

More intense flood drought cycles are likely to impact water-based and water-adjacent recreation throughout the watershed by creating hazardous flooding and more intense river flows, which may limit safe access during wetter weather periods. On the other hand, more intense and frequent droughts will decrease water levels and flow to streams and ponds, further limiting the times of year when the Nemasket River (and potentially other water bodies) is navigable by canoe or kayak. Changes to these annual cycles will make water-based activities in the watershed both more challenging and less predictable.

The correlation between increased temperatures, especially in the summer, and recreational demand is not certain. On the one hand, water-based recreation may increase in areas like Long Pond where there is existing recreational infrastructure and where an expanded array of water-based uses like swimming and boating, which can have a cooling effect, are possible. On the other hand, specific increases in summer temperatures may cause high use periods to shift from the summer months into the cooler spring, fall, and even winter months for more strenuous activities, such as river paddling. Planning for both scenarios should be pursued, especially in scheduling the peak need for Ranger monitoring.

Increased temperatures are, however, increasing the prevalence of mosquito and tick populations, increasing the public's susceptibility to vector-borne diseases in outdoor spaces. Eastern equine encephalitis ("Triple E") has become a regular threat from year to year in the watershed, varying in lesser or greater extent with weather and breeding patterns, prompting sprays. As people recreate outdoors and near the water, it will become more imperative to remind recreators of the risks and of the steps that can be taken to mitigate (but not eliminate) these public health risks.

Changing temperature and weather patterns can also enable the migration of, as well as increase stressors on, certain plant and wildlife species. These shifts could potentially tip the scales in favor of existing non-native and/or invasive species already present throughout the watershed, and potentially introduce new species. Some of the major recreational interests around the ponds include passive enjoyment of views, nature study, and photography. These activities can be diminished by the presence of invasive species that overtake natural landscapes. Invasive aquatic weeds also impede paddlers and swimmers in the Nemasket River and Long Pond, and climate change-fueled water quality impacts may favor the growth of these weeds over many native species. Proactive invasive species management will become even more vital to preserving aspects of passive and active recreation, and in assisting in limiting the spread of invasives through best management practices like boat washing and nutrient management.

Stewardship

Existing Conditions

Environmental stewardship in the context of the APC-Nemasket Watershed is the practice of consciously acting (or not acting) in ways that respect humans' interdependence with nature and protect essential natural resources. Everyone plays a role in stewardship, and these roles can be as diverse as picking up after your dog or implementing a forestry management plan on your land. Each of the communities surrounding the Assawompset Ponds and Nemasket River (Lakeville, Middleborough, Freetown, and Rochester), as well as the communities that get their drinking water from the Ponds (New Bedford and Taunton), are involved in stewarding the Watershed and its resources. While every individual who lives, works or plays in the Watershed has a responsibility to be a steward of the resources they utilize, there is also a complex framework of local, regional, and state entities playing an active role in the management and protection of the Watershed.

Each municipality plays a significant role in managing watershed lands within its jurisdiction, protecting water quality and promoting environmental stewardship in its daily operations. Municipalities and state agencies are the largest owners of open space and recreation lands and associated natural resources in the Watershed (collectively managing 83% of the watershed's open space and recreation lands; MassGIS, 2020c). The Cities of New Bedford and Taunton own more than a third (37%) of the watershed's open space and recreation lands, managing large parcels of protected land surrounding the APC (in Lakeville and Rochester) for drinking water supply protection (MassGIS, 2020c). Each watershed municipality's Conservation Commission is responsible for managing municipally-owned lands. Maintenance and upkeep of these lands, particularly those in recreational use, is critical, both for watershed health and public benefit. Well-kept recreational lands are more likely to provide high value recreational opportunities, whereas visibly unkept areas may discourage a public stewardship ethic (APC Management Plan Steering Committee, meeting discussion, 2022).

With the majority of the overall Watershed area privately owned, and a large portion of that privately-owned land in residential use, individual landowners tend to have the largest stewardship responsibility (MassGIS, 2015, 2018a, 2019a, 2019b and 2020a). This challenge can be addressed through strong local land use regulations and enforcement as well as public education that encourages sustainable land development and property management practices, such as proper septic system maintenance, restraint in installing new impervious cover, and responsible fertilizer usage.

Municipal and private landowners can access assistance to develop forest management plans for their property from the Natural Resources Conservation Service (Natural Resources Conservation Service, n.d.) of the United States Department of Agriculture (USDA) and from the Massachusetts Department of Conservation and Recreation (DCR) (Massachusetts Department of Conservation & Recreation [DCR], n.d.). State programs like the Community Preservation Act (CPA) also give community members the option to prioritize natural resource protection locally. Lakeville, Middleborough and New Bedford have all adopted CPA, meaning their residents opted in to paying a surcharge on their taxes that goes into a local Community Preservation Fund for open space protection, historic preservation, affordable housing, and outdoor recreation (MassGIS, 2021).

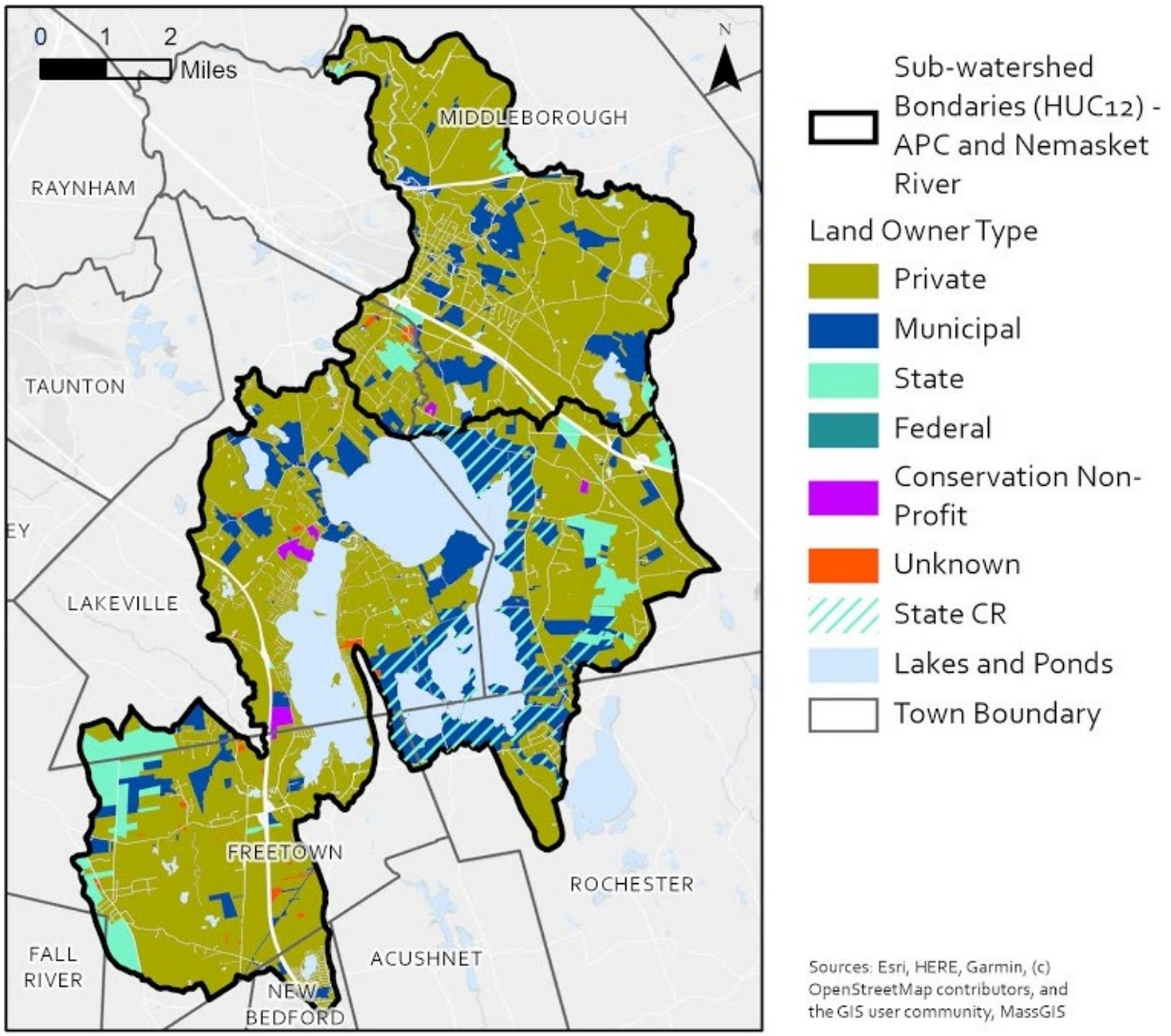
Representatives from each of the Watershed communities participate in the Assawompset Ponds Complex Management Team, an inter-municipal and inter-agency committee that meets regularly to discuss challenges and collaborate on management actions related to the ponds. Furthermore, there are local and regional stewardship organizations actively engaging the public through community events and educational programming that help to promote responsible recreational access and promote a local stewardship ethic.

Challenges

Sustainable land use and resource management are a critical component of stewardship; however, private ownership of the majority of the Watershed's land can make resource management a challenge. Municipal land managers and the public must work together to steward the Watershed's open spaces; however, the majority of responsibility falls on very limited municipal budgets for land management and enforcement of environmental regulations. Each of the watershed municipalities have only a handful of town staff between their local Conservation Commissions and Parks and Recreation Departments, and rely on volunteer members for their local Park Commissions (APC Management Plan Steering

Committee, meeting discussion, 2022). This limits municipal capacity, both to manage their own lands and to conduct homeowner outreach to encourage more responsible practices by the public.

Figure 23 Watershed Land Ownership (MassGIS Level 3 Parcel Data for Middleborough, Lakeville, Rochester, Freetown, and New Bedford, 2020)



Land protection is an important component of environmental stewardship, as has been implemented on water supply management lands surrounding the ponds. Restricted public access in some locations may be counterproductive towards encouraging public stewardship, however, if the public feels disconnected from or even unaware of the waterbodies because of the restrictions. That potential disconnect furthers the importance of public engagement and education, as well enhancing public access where appropriate to do so. This makes a case for developing and maintaining a select number of very high quality, publicly accessible recreation opportunities around APC and Nemasket River where it is possible to do so without compromising drinking water supply quality. Such spaces might include recreational activity offerings such as nature walks at sites with facilities that are capable of accommodating a large number of people, like Pratt Farm in Middleborough or Betty's Neck in Lakeville,

and kayak access on the Nemasket River with clear signage explaining why Assawompset Pond is off-limits (APC Management Plan Steering Committee, meeting discussion, 2022).

Lack of awareness of the Watershed's many historical and cultural resources also poses a challenge to stewardship of these resources alongside (and in many cases overlapping with) environmental resource management. Three Wampanoag tribes remain in the area: the federally-recognized Mashpee Wampanoag Tribe (Mashpee and Taunton area), the Pocasset Wampanoag Tribe of the Pokanoket Nation (Fall River area), and the Assawompsett-Nemasket Band of Wampanoags (Lakeville and Middleborough area) (Department of the Interior, Bureau of Indian Affairs, 2021; Mashpee Wampanoag Tribe, n.d.; Pocasset Wampanoag Tribe, n.d.; Assawompsett-Nemasket Band of Wampanoags, n.d.). There are several areas of spiritual importance to these Indigenous groups, particularly along the Nemasket River and the Ponds shores, that are vulnerable to flooding and erosion (APC Management Plan Steering Committee, meeting discussion, 2022). Expanding land protections in these areas of interest, and providing more opportunities to learn about the history of the region can expand stewardship opportunities of these resources.

Climate Change Impacts

Climate change impacts that threaten environmental health, such as temperature and precipitation shifts, likewise impact the public's relationship to and stewardship of the Watershed. Flooding and erosion, which are likely to become more problematic as more intense storms become more frequent (Northeast Climate Science Center, 2018), already threaten shoreline environmental, historical and cultural resources, and downed trees can create hazards for people accessing the Watershed's many open spaces. Constantly changing conditions call for more intensive and adaptive management plans in a Watershed already struggling with limited capacity for management. While climate change is making stewardship more and more challenging, the need to protect the services provided by natural lands, including flood storage and temperature regulation, becomes increasingly important. Public education that equips communities with the knowledge and tools to steward their environment with climate change in mind is imperative for protecting the Watershed.

Interagency Cooperation

Existing Conditions

There exists a vast number of local, state, regional and federal agencies as well as private organizations involved in various aspects of watershed management within the APC-Nemasket Watershed. Each agency and organization has its own individual purpose, responsibility and interest in the Watershed. For example, some of these public agencies are responsible for managing resource use in the Watershed, some are responsible for activities, some are responsible for protecting resources in the Watershed, and some are responsible for facilitating growth and development. This list of responsibilities is not exhaustive, but rather representative of the potential tensions among the agencies. In addition, some agencies and organizations are interested in and responsible to specific

locations within the Watershed, such as towns, parks, ecosystems, animal species habitats, etc. As a result, interagency cooperation[2] is vital to the successful management of the Watershed.

With the APC serving as a long-standing and high-quality source of public water for New Bedford and Taunton, both large municipalities located outside of the contributing watershed, there is an essential need for interagency cooperation around management decisions for the APC and Nemasket River as well as the contributing Watershed area. Out of this recognized need for cooperation emerged the Assawompset Ponds Complex Management Team, formed in 2002 with the originally-limited purpose of coordinating around the purchase and protection of Betty's Neck. In 2011, following the flooding of 2010, the Management Team took up a review of APC levels and operations, after which a cooperative agreement was proposed between New Bedford, Taunton, Middleborough, Freetown, Lakeville, and Rochester. Under this agreement, the cities would share data related to weather, dam adjustments, and the ponds with each other and other stakeholders. The stakeholders would meet at least four times annually and review the prior three months of operations. Following these reviews and discussions, the target levels would be adjusted. The development of interim pond levels considered six factors (Assawompset Pond Level and Dam Committee, 2011):

1. Seasonal needs of the water suppliers and communities;
2. Adequate groundwater to supply Middleborough's well;
3. Adequate flow and storage to provide for anadromous fish passages up and down the Nemasket seasonally;
4. Adequate storage capacity to prevent or minimize damage from precipitation events;
5. Minimize winter ice damage to personal property; and
6. Adequate capacity for recreational uses.

As can be seen in the list above, there is a need to balance the requirement of the water suppliers to supply reliable water at all times with other watershed services, including habitat, recreational enjoyment, flood mitigation, land use and economic growth. The APC Management Team includes representatives from the watershed municipalities, appointed by local decision-making bodies, from the cities of Taunton and New Bedford, and from State agencies. This organization provides a sturdy mechanism for discussion and shared understanding across the watershed, and indeed served as a basis for the Steering Committee in developing this Watershed Management Plan.

However, to adequately meet its original scope and focus on water supply management, it cannot take on, in its current makeup, the role to serve as a forum for all watershed management issues. One current challenge in the Watershed with regard to interagency cooperation is establishing an appropriate, effective and consistent forum for information sharing and discussion across the Watershed with an expanded array of stakeholders. The number of agencies and organizations with interests in watershed management decisions in the watershed is vast; at the risk of inadvertently excluding an organization or agency, below is a summary of watershed stakeholders.

Watershed Towns and Cities:

[2] For simplicity, interagency is used here as an inclusive term to denote 'among agencies and organizations.'

- Freetown
- Lakeville
- New Bedford
- Middleborough
- Rochester
- Taunton

Municipal departments, boards, and commissions:

- Conservation
- Planning
- Health
- DPW/Highway
- Water
- Wastewater
- Historical Commissions
- Agricultural Commissions

Intermunicipal Boards and Commissions:

- Middleboro-Lakeville Herring Fishery Commission
- APC Management Team

Water Suppliers that use APC Water Sources:

- Taunton Water Department
- New Bedford Water Department

State Entities

- State Representatives and State Senators
- MA Department of Environmental Protection Southeast Region
- MA Department of Conservation and Recreation, Division of Fisheries & Wildlife, Office of Fishing and Boating Access and Preservation Planning/Office of Cultural Resources
- MA Division of Marine Fisheries
- MA Natural Heritage and Endangered Species Program
- MA Massachusetts Historical Commission
- MA Emergency Management Agency
- MA Department of Transportation
- Massachusetts Bay Transportation Authority

Federal Agencies

- US Environmental Protection Agency
- US Fish & Wildlife Service
- US Department of Agriculture, Natural Resource Conservation Service

Tribal Interests

- Wampanoag
- Massachuset
- Pokanoket

Non-Governmental Conservation and Business Organizations

- The Nature Conservancy
- Southeast Regional Planning and Economic Development District
- Mass Audubon
- Wildlands Trust
- Taunton River Watershed Alliance
- Long Pond Association
- Resilient Taunton Watershed Network
- Taunton River Stewardship Council
- Cape Cod Cranberry Growers Association
- Rochester Land Trust
- Local and regional cultural and historical societies, and preservation trusts

Challenges

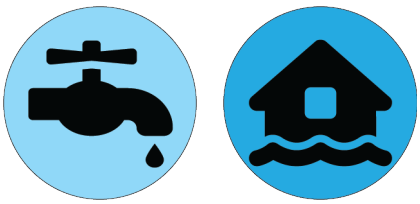
The existence of overlapping natural resource management and political jurisdictions within the APC and Nemasket Watershed, and their unique and sometimes conflicting management concerns, are a stressor on the interagency cooperation within the region. The overlap between the water supply rights and responsibilities of the Taunton and New Bedford Water Suppliers (and their customers) and the Towns of Middleboro and Lakeville in managing the normal municipal services and rights of pondside communities creates a difficult point of contention at its core. The water suppliers are authorized to withdraw water and manage the storage or outflow of water in the APC by permit from the state. The water suppliers benefit from the protections and limitations placed on the watershed citizens of Lakeville, Middleboro and Rochester in their enjoyment of the APC and Nemasket River. The APC and Nemasket River and surrounding watersheds also benefit in many ways from the protections applied to the system as a result of being a significant public water supply. The interagency cooperation required to create and maintain an open line of communication and shared decision making in the Watershed is perhaps the most significant challenge in the Watershed.

Climate Change Impacts

With so many multiple jurisdictions and interests across the Watershed, and the changing conditions resulting from economic and population growth and climate change, regional collaboration is ever more important. The changing climate makes this cooperation ever more important and challenging; ever changing conditions means that the watershed conditions must be regularly assessed and management decisions reevaluated and revised.

5. KEY WATERSHED MANAGEMENT TENSIONS

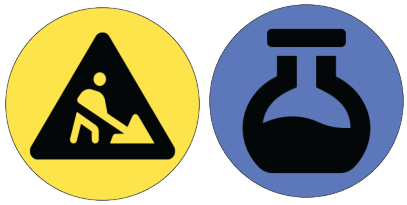
The crux of effective watershed management is first understanding that everything is interrelated. Tinkering with one element of the Watershed for a given purpose will cause a ripple effect across the Watershed. This can inadvertently, in some cases, result in less than ideal outcomes for other elements of the Watershed. In other words, there are inherent tensions in the Watershed, and constantly changing conditions. The development of this management plan includes the important process of recognizing and exploring these tensions, and opening the dialogue among watershed stakeholders to explore conflicting as well as common goals. Successful management is challenging because there is an inherent need for compromise and collaboration, and the inevitable outcome that every individual goal cannot be fully achieved. However, success is achieved when the tensions are explored, stakeholders are open to considering the concerns, ideas and solutions from other stakeholders and advisors, and actions are identified and agreed upon. A successful management plan is an evolving document, such that it can be updated with new understanding and changing conditions. This is particularly important in our current age of climate change, as we work to both understand the future climate and work to mitigate climate change. The management actions and the management infrastructure, be it water supply, drought management, ecology, land development regulations, or what have you, must include an element of flexibility to allow decision-makers to adjust to changing conditions throughout the year, and throughout the decades to come. The result, the ultimate goal of the watershed plan, is to achieve a series of win-win solutions that relieve the inherent tensions in the Watershed and allow the Watershed to thrive and continue to provide the diverse services to humans and nature that we all have come to depend on.



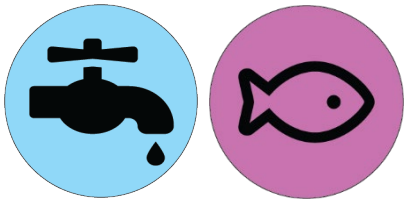
The key watershed tensions that have emerged during this planning process are summarized below. This plan is a result of better shared understanding of these tensions, recognition of immediate term opportunities, and development of a roadmap for medium-term and longer-term actions.

Water Supply Management and Flood Mitigation: Within the APC-Nemasket River Watershed, there is on ongoing and completely reasonable tension that exists between the ability of the Watershed to provide a reliable source of public drinking water to over 250,000 people and the ability of the watershed to absorb floodwaters without damage or increased risk to private property, public infrastructure and public safety. This tension creates an undisputable need for understanding, balance and management of water resources among the many actors within and beyond the Watershed that rely upon the APC-Nemasket River system. In basic terms, the use of the Watershed for water supply calls for water suppliers to manage the system to ensure that sufficient water is available in the APC to safely meet (or exceed) demand at all times, including during the challenge of drought conditions. Effective water supply management requires that the water management infrastructure be forward-thinking and flexible enough to allow operators to respond to changing conditions, such that water can be both retained in and released from the Ponds effectively as needed. The need for flood storage and the mitigation of flood damage within the Watershed calls for the management of the APC ponds to provide additional storage when floods may be anticipated. The relatively flat topography in the Watershed as well as the sediment, invasive plants and infrastructure along the Nemasket River results in the slow movement of water, which challenges the ability of managers to adjust the storage in the APC in a timely manner, either to raise or lower the water levels.

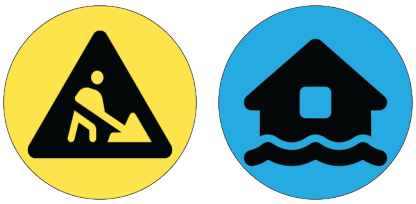
Land Development and Flood Hazard Mitigation: Flooding is a natural phenomenon of any natural water course, generally occurring when the water overtops the natural bank of a stream or pond due to significant precipitation. Flooding becomes a problem when it causes damage to the surrounding community, including individual properties, structures and infrastructure, and when it results in public safety concerns. Within the APC-Nemasket Watershed, the rapid pace of new residential development is creating an additional challenge to flood mitigation. There is a nationwide housing crisis that is creating additional pressure for development of housing units throughout the Watershed and beyond, and it is within this context that watershed management decisions must be made. New development, converting vegetated lands to less pervious land uses, creates more stormwater runoff. When this is augmented by the increased storm intensity and storm precipitation volumes anticipated to result from climate change, the increase in land development poses an even greater challenge to the flood mitigation services of the Watershed. With greater volumes of runoff and greater flashiness of runoff, the ability of the Watershed to accommodate addition flood flows will be diminished. In addition, increased development can put additional people and property at risk by encroaching on the floodplain as well as increasing the flood flows that then require a larger floodplain for safe flows. This encroachment also diminishes the ability of the floodplain to function as it should, interrupting or increasing flood flow volumes, rates and directions. Therefore, the design and standards by which new development and redevelopment occur within the Watershed are important in maintaining the ability of the Watershed to accommodate flood flows without increasing risk to people, property and infrastructure within the Watershed.

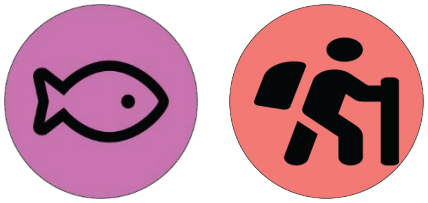


Land Development and Water Quality / Ecology: The water quality and ecology of the APC-Nemasket Watershed are the very core characteristics of the Watershed that make it so unique. What is not unique to the Watershed are the challenges that land development poses to water quality and ecology. As land development increases in the Watershed, the risks to the very water quality and ecology that draw people to the area also increase. Therefore, the design, standards and locations by which new development and redevelopment occur within the Watershed are important in maintaining the unique habitats and healthy water quality of the Watershed.



Water Supply Management and Ecology: The ecology of the APC and Nemasket River is dependent on a certain general water regime that has evolved over time. As the Watershed has been developed over time, the conversion of land and the placement of certain infrastructure into the system such as dams, bridges, culverts and roadways has altered the hydrologic regime in the Watershed. The Nemasket River has experienced significant sedimentation, invasive species have settled in, flow has been restricted, and withdrawals for drinking water have increased. The Watershed topography is already naturally very flat, resulting in relatively slow river flows. This flow becomes even slower and less robust during times of drought, which unfortunately is the same time that water suppliers are also in need of water to meet their public needs. This drought condition creates a tension between the ecological needs in the Nemasket River and the water supply needs, including the needs of those public suppliers withdrawing from the APC itself as well as those (both public and private) withdrawing from wells within the APC-Nemasket watershed as a whole.





Recreation and Ecology: The APC – Nemasket Watershed offers a variety of water-based, water-adjacent and upland recreational opportunities, and is a draw for nature lovers and outdoors people because of its uniqueness, tranquility, and healthy ecosystem. However, because the system is also the water supply source for so many people in so many communities, and because the system is also the home to such unique and important habitats and species, recreational opportunities need to be managed to reduce harm. As development in the Watershed has been increasing, so too has the challenge in managing recreation within the system. With more land development comes more people, more demand for recreational access to the river and ponds, and fewer available locations for formal and informal recreation and access. When individuals access the water for recreation, they can inadvertently trample vegetation and increase bank erosion. The unique wildlife in the area is a draw for people, but can also be at increased risk when people get too close to and/or harm wildlife. And the introduction of boats and gear in the surface waters can also bring along invasive species from other locations that can spread rapidly in their new environment. Watershed residents and visitors need to understand the rules and limitations for recreational uses in the ponds and conservation properties, and communicating and enforcing those rules is increasingly challenging as demand increases.

6. MANAGEMENT ACTION RECOMMENDATIONS

The Management Goals and Actions proposed in this plan weave together all of the above issue areas into a strategy for the Watershed that can be implemented over the next thirty years. It offers a regional, watershed-scale approach to address ongoing concerns while meeting the needs of the Watershed and its communities until the year 2050.

The series of actions herein are meant to advance the Watershed toward the Vision articulated in Section 2. They are suggested as a means to protect watershed communities from extreme weather and accommodate growing development without sacrificing the Watershed's Green Infrastructure Network and other critical resources. This solution set includes improving our grey infrastructure so that it can withstand future development and climate impacts, protecting and/or restoring the Watershed's natural features, and directing development in such a way that minimizes its impacts on natural systems. Strategically employing these actions together across the Watershed will help to improve the resilience of both our natural and human communities, while improving the Watershed's ability to accommodate future development and climate trends.

Notations are provided to indicate where an action addresses both current and future conditions under climate change impacts, where it is an example of a nature based solutions, and any other issue areas where an action would have a co-beneficial, positive outcome across categories.

Goal 1: Reduce flood risks to people and property

OBJECTIVE A: Limit Development in the Floodplain and enhance protection for existing development

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
*A-1. Pursue regional participation in **FEMA's CRS** program, on a local and regional basis.*		✓	Conservation Commission, Planning Board	3-5 years	Local staff time; Investigate grant options
Co-benefits					
*A-2. Create a voluntary **buy-out program** and/or prepare to participate in a potential state-run program (currently under consideration) to acquire properties for flood storage. [More details below]*	✓	✓	Planning Board, Conservation Commissions, APC Management Team	10-15 years	FEMA
Co-benefits					
A-3. Adopt shared wetland regulations across all communities that expand the Conservation Commission's authority to uniformly protect floodwater storage areas and their buffers across the watershed from development. [More details below]	✓	✓	Conservation Commission, Planning Board	3-5 years	Local staff and board member time; grants; technical assistance from SRPEDD or another consultant
Co-benefits					
A-4. Expand the floodplain overlay district to the 500-year FEMA flood zones, and take a climate change - aware stance in accounting for floodplain shifts.		✓	Conservation Commission, Planning Board	3-5 years	Local staff and board member time; grants; technical assistance from SRPEDD or another consultant
Co-benefits					
A-5. Restrict development encroachment into the floodplain by requiring special permit review in the flood overlay district, subject to review by Conservation Commission, Planning Board, Board of Health, Dept		✓	Conservation Commission, Planning Board	3-5 years	Local staff and board member time; grants; technical assistance from SRPEDD or another consultant

of Public Works, and/or building department. [More details below]					
Co-benefits					

Wetlands and floodplains serve critical functions in controlling the flow of water and minimizing the negative impacts of flooding caused by extreme, or regular, storm events. However, development can interfere with these systems' natural abilities to control water and exacerbate flooding events, resulting in property damage and threat of bodily harm. Restrict development in and over these critical areas by enacting zoning laws and bylaw regulations, particularly in the 25-100 feet buffer surrounding them.

Local wetland protection bylaws and regulations especially are an important tool to protect floodplains from development, and should explicitly state "flood control" and "climate change resilience" upfront in the purpose and definitions of the bylaw, as well include the loss of flood storage capacity in the definition of "alter." The Conservation Commission's jurisdiction in permitting projects could also be expanded by including a minimum 100ft buffer area within the locally defined wetland resource area.

Likewise, municipalities can expand their jurisdiction in permitting projects within the floodplain by updating local floodplain overlay district zoning to include "climate change resilience," expand the district to include the 500-yr floodplain, and require special permits for new and re-development. Project reviews within or potentially impacting the floodplain should be subject to a comprehensive review by the Conservation Commission, Planning Board, Board of Health, Department of Public Works, and building department. And when development is permitted in the floodplain, the project should be required to follow FEMA standards for floodproofing, and require a 2:1 ratio for compensatory storage, with adequate provisions to ensure success of wetland replication projects.

Adopting shared regulations across all four watershed pondside communities can streamline updates and make siting and permitting of projects more uniform and streamlined for developers. When considering any bylaw updates, communities should ensure regulations are consistent with FEMA and state regulations restricting building in wetlands and are more expansive than state standards.

For pre-existing development in the floodplain, steps such as enrolling in **FEMA's Community Rating System (CRS)** encourage municipalities to increase community-wide flood resilience so that local homeowners may collectively receive a discount on their flood insurance premiums. There are four series of activities which communities can take to enroll in the CRS program:

1. Public information: outreach projects
2. Mapping and regulations: higher building standards
3. Reduce losses to structures that are already there (removing buildings with flood damage)
4. Emergency Response (how to minimize property damage)

Enrolling in the CRS not only reduces costs, but also helps reduce flooding risks to homes, businesses, ecosystems, and people. Where such adaptation measures to increase flood protection is not logical or feasible, removing existing development from the floodplain may also be necessary. **Buy-out programs** can provide a mechanism for vulnerable homeowners to receive compensation for their homes if they choose to relocate, without placing someone else in harm's way. Prioritizing problematic infrastructure, such as aging septic systems, could also help protect the Watershed from environmental hazards,

alongside moving vulnerable people out of harm's way. While removing structures from the floodplain is the safest strategy for avoiding flood hazards, an alternative interim action is to instead raise structures above the anticipated flood elevation. FEMA also offers grants for homeowners to raise their homes.

OBJECTIVE B: Leverage natural functions that protect communities from flooding, extreme heat, and intense storms

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
B-1. All local jurisdictions should adopt a current Hazard Mitigation Plan that prepares the community for future climate impacts, incorporating the latest information and projections.		✓	All municipal departments	3-5 years	Grants (MEMA, MVP)
Co-benefits					
B-2. Identify and prioritize areas where nature-based stormwater management (i.e. green infrastructure, swales, etc.) may have the greatest impact on mitigating stormwater and flooding.	✓	✓	Conservation Commission, Board of Health, Planning Board	3-5 years	Grants (MEMA, MVP)
Co-benefits					
B-3. Restore natural wetland habitat and function so that these lands can act like a sponge to hold and slowly infiltrate and filter water.	✓	✓	Conservation Commission, Board of Health, Agricultural Commissions	5-7 years	Grants (DER, SNEP)
Co-benefits					

Natural areas play an important role in capturing, treating and infiltrating stormwater runoff. Supporting and expanding nature's ability to protect us from floodwaters through restoration and green stormwater management infrastructure, which mimics natural flood storage properties, will help to protect communities from flooding. Wetland restoration and protection efforts can focus on retired cranberry bogs, particularly along Route 18. A systematic review of potential sites for restoration and/or nature-based stormwater management options, including cost-benefit analyses to compare effectiveness, can help to identify and prioritize where these solutions can have the greatest impact. Community planning, and Hazard Mitigation Plans in particular, can also help to identify and implement priority resilience projects. The City of New Bedford also provides an example path forward, after having applied for and received an MVP Action Grant to develop a citywide Green Infrastructure Plan.

OBJECTIVE C: Improve the flexibility of the APC-Nemasket System to move water between its constituent parts

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
C-1. Replace the Snake River Culvert Box between Long Pond and Assawompset Pond (but not before addressing invasive weeds in Long Pond to minimize transfer between waterbodies).	✓	✓	Lakeville & Freetown Conservation Commission, Planning Board	10-15 years	FEMA BRIC (but requires Lakeville to have an approved HMP), DER
Co-benefits					
C-2. Restore the Nemasket River channel (especially in the first 600-1,200 ft), including limited and targeted sediment removal or dredging on a regular basis as required, and vegetation removal.	✓	✓	Lakeville & Middleborough Conservation Commission, Planning Board; APC Management Team	Ongoing, as needed	SRPEDD ARPA APC funds
Co-benefits					
C-3. Remove the Wareham Street Dam to gain topography, increase flows, and reduce impoundment. [See notes on interim measures that can be implemented now below]	✓	✓	Middleborough Conservation Commission, Planning Board, APC Management Team	5-7 years	State Dam and Seawall Grant, NOAA, NWF, TNC, other non-profit partners
Co-benefits					

A holistic system-based approach can also help to mitigate flooding. Restoring the Watershed's ability to move water through the system (in the case of the APC-Nemasket Watershed, north through the Ponds to Assawompset Pond and then into and through the Nemasket River) can reduce flooding upstream and help the Ponds drain faster after large rain events. This includes identifying and addressing barriers to flow along the Nemasket River. Hydrologic modelling has revealed that removing the Wareham Street Dam in particular would improve flow conditions, and replacing other bridges and culverts throughout the system with wider structures could also add improvements (Horsley Witten, forthcoming). Since dam removal is a long process, a recommended interim action is to continue ongoing coordination between the water suppliers and Middleborough DPW to proactively manage the bascule dam level and reduce the retention of water upstream of Wareham Street.

Perhaps a more immediate priority, the first 600 – 1,200 ft of the Nemasket River, where water enters from Assawompset Pond, is currently very clogged with accumulated sediment and invasive aquatic vegetation growth, likely a result of stagnant flow that allows sediment to drop out of slow-moving water. Efforts are underway to remove this excessive sediment and aquatic weed growth through dredge. This measure is, however, a stop-gap until meaningful channel restoration can be undertaken to

return the Nemasket to its proper, narrower-than-present bankful width. A sonar side-scan survey of the entire length of the Nemasket River above the Wareham Street Dam and fish passageway could assist in planning for channel restoration. Removing downstream impediments to flow will also help toward achieving a solution by restoring more natural flow conditions.

The planned objective in the area connecting Long Pond and Assawompset Pond is to replace the existing undersized Snake River box culvert with a structure that uses a natural bottom, situated at the approximate original elevation of the bottom of the Snake River. Ideally, the new structure would be designed to provide anadromous fishery spawning access between Long Pond and Assawompset Pond without the use of a fish ladder. Such a new structure itself may present tradeoffs. Fisheries habitat would be improved, and Long Pond shoreline residents will likely be flooded less often after the replacement of the undersized culvert. However, recreational use in Long Pond maybe be impacted in the summer, when the other four lakes of the APC are drawn down due to water supply withdrawals, increased surface evaporation, and dam releases/leakage. A mass balance model would likely assist in assessing the trade-offs and consequences of replacing the present culvert with an alternative design.

Goal 2: Safeguard public drinking water supplies

OBJECTIVE A: Anticipate and guard against drought, especially as climate change causes more frequent and extended drought periods in summer and fall

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
A-1. Adopt uniform Water Resource Protection Overlay Districts and Regulations that protect groundwater recharge areas to the ponds, as well as local water supply wells elsewhere in the watershed. [More details below]	✓	✓	Planning Board, Conservation Commission, Water Suppliers	3-5 Years	Local staff and board member time; Technical Assistance from SRPEDD or other consultant; grants (EEA, MVP, etc.)
Co-benefits					
A-2. Update and increase transparency about thresholds and implementation measures for enforcing water use restrictions during drought. [More details below]		✓	APC Management Team; Water Suppliers; Planning Board, Board of Health, Conservation Commission	1-3 Years	Local staff and board member time
Co-benefits					
A-3. Use a multi-platform approach to notify the public of restricted water use periods and conservation measures, including webpage, social		✓	APC Management Team; Water Suppliers; Planning Board, Board of	1-3 years, and ongoing	Local staff and board member time.

media, and roadway signage boards. [More details below]			Health, Conservation Commission		
Co-benefits					
A-4. Regularly evaluate and update drought protocols and back-up supply plans.		✓	Water Suppliers	1-3 years, and ongoing	Local staff time
Co-benefits					

As climate change progresses, trend analyses indicate that while the southeastern Massachusetts region will experience an overall increase in annual precipitation, the effects will be seasonal in nature, with the summer and fall expected to see less precipitation than in the past, and lengthening drought periods. This requires local decision makers (both water supply managers and local planners) to continually evaluate drought protocols and water restriction measures and thresholds to ensure sustainable water use. Transparency and communication are key when it comes to notifying the public about how water supplies are being managed for the future, and to help the public play its part in conserving water.

When droughts occur, cities and towns have the ability to institute water control measures such as household watering limitations. For these measures to be effective, clear and consistent communication between communities and with the public is key. Since both public water supply and private wells are pulling from the watershed, coordinated water conservation measures may be beneficial, and would benefit those who are on well-water as well as those on public water supply. The APC Management Team could add a standing "drought conditions" agenda item to their regular quarterly meetings. This measure would likely assist in helping regional stakeholders become familiar with the drought condition thresholds that trigger water conservation measures in each community, as well as with the means and methods of enforcement.

When water restrictions are put in place, the first challenge, even before enforcement, is to communicate the parameters of the restriction to the public. When water restrictions are put in place, APC watershed communities can get the message out most widely by utilizing multiple communications platforms, from local news press releases, to posts on community websites and social media, to electronic signage boards and communications at public gatherings that can notify residents of the restrictions. Both residents within the Watershed, as well as those who get their water supply from it, need to be aware of and follow water use restrictions. Water use within the watershed has a direct impact on recharge to the water supply, but demand for water being removed from the system is also important.

Aside from how we use water, local regulations, such as Water Resource Protection Overlay Districts, can help protect groundwater recharge areas to the ponds and local water supply wells elsewhere in the Watershed. Watershed communities should adopt uniform overlays that require development proposals to accommodate on-site groundwater recharge using best practices to treat and infiltrate stormwater, and require special permits for any development or land disturbance, regardless of use, within the overlay district.

OBJECTIVE B: Take steps to improve knowledge and management capabilities to enhance water supply management

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
B-1. Complete a full groundwater study and model of the ponds system.		✓	APC Management Team	1-3 Years	Grant funding secured (DER)
Co-benefits					
B-2. Determine an updated ***safe yield (also sometimes referred to as firm yield)*** *of the ponds.*		✓	Water Suppliers	7-10 Years	Local staff time; explore grant opportunities
Co-benefits					
B-3. Reconfigure the APC dam spillway for greater control over water levels in the ponds.		✓	Water Suppliers, APC Management Team	10-15 Years	Grants (NOAA, DER, SNEP, MVP etc.)
Co-benefits					

Responsible and effective water supply management requires a clear understanding of the system in which that supply exists, and inputs to and withdrawals from the supply. A full groundwater study of the system can help to understand how water flows throughout the Watershed and how and where water supplies (the Assawompset Ponds and public and private wells) are being replenished. Complete and accurate data can allow the modeling of various conditions and management actions to plan and prioritize steps that can be taken to protect water supplies. Regularly assessing and updating the **safe yield**[3] for the Ponds water supply as conditions change is also important to ensure informed management. Taking these steps will protect pond levels and water withdrawals, and improve coordination among managers.

Some additional notes on how the groundwater and safe yield determinations could be pursued and designed are as follows:

- Typical groundwater models (USGS MODFLOW) do not handle dynamic (time varying) head or flux boundary conditions, or infiltration and exfiltration (evapotranspiration) well. Given the hydrogeology of the APC, the firm yield model development needs to incorporate dynamic "bank" storage into the model's active storage component.
- Due to the location and elevation of Taunton and New Bedford's intake structures, the firm yield will be different for each system.

[3] "Safe yield" and the concept of "firm yield," are similar but distinct concepts. Firm yield is the maximum average daily withdrawal from active storage that could be sustained during a "significant" drought (usually the period-of-record drought). Previously, safe yield referred to the same thing. Today, DEP WMP staff refer to Firm Yield as that average daily withdrawal rate which can be sustained from active storage during a period of extensive drought as used by modern Water Supply systems analysis (Fennessey, 1996) and Safe Yield when referring to the SWMI defined watershed, not reservoir, safe yield.

- To consider the potential impacts due to climate change, the firm yield model input time series also need to be re-scaled for mid-century and late-century General Circulation Model (GCM) climate change modeling temperature and precipitation RCP 4.5 and 8.5 emission output scenarios.
- A sonar side-scan bathymetry study of the five APC ponds will produce data that is necessary to create stage-storage tables for each of the five ponds as needed for the firm yield and groundwater study.
- Determine the leakage/seepage rate of the APC earthen dam and gatehouse as a function water surface elevation. Create a discharge-stage/elevation rating curve of the APC dam and gatehouse as will needed by the firm yield model.
- Fennessey (1996) developed the method that is required to estimate the firm yield when a municipality with a surface water supply system applies for a Water Management Act permit. The Fennessey (1996) firm yield estimation method requires the use of a proxy/index stream gage to drive the QPPQ Transform and provide a long history of daily inflows to the reservoir system being modeled. For future planning purposes, an additional DCP (real-time) stream gage (potentially maintained by the US Geological Survey) could provide a key source of additional data. One potential stream gage site identified by Neil Fennessey is on Fall Brook, using the dam located on the corner of County Street and Washburn Rd (Lawrence Park) in East Freetown as the gauge's hydraulic control structure.

The current APC Dam spillway configuration could also be replaced to facilitate safer and more efficient control over the pond levels. This would allow greater flexibility in controlling water levels in order to be able to act during periods of prolonged high water (wet springs and winters, especially) and relieve flood pressure while also retaining the critical ability to hold back water in preparation for drought. The current operating system, which uses a series of flash boards to influence water levels and releases into the Nemasket River is dangerous for water supply operators. Before taking this step, watershed stakeholders can address the sedimentation issues in the river and remove the Wareham Street Dam so that water can exit the system at an accelerated rate when necessary, to see how these downstream actions affect conditions at the APC Dam. All stakeholders would likely benefit from more flexible and reliable dam operations in order to be able to prepare management strategies accordingly and improve transparency.[4]

OBJECTIVE C: Keep contaminants out of the water supply

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
C-1. Support additional drinking source water testing and monitoring for regulated and emerging contaminants, especially those that would require treatment by water suppliers.			Water suppliers, APC Management Team, local volunteer organizations	3-5 Years, then ongoing	Grants or partnership with groups like the TRWA and local wastewater treatment plant

[4] In the event that the existing APC Dam spillway is replaced, maintaining or replacing the existing fish ladder must be incorporated into the designs. It has also been recommended that the old granite structures be repurposed for a historical monument somewhere in the Watershed.

Co-benefits					
*C-2. Continue to monitor compliance with **WMA** registration / permit water withdrawal limits and other special conditions.*			Water suppliers, APC Management Team, local environmental groups	Ongoing, but especially at permit renewals	Local staff and volunteer time
Co-benefits					
*C-3. Eliminate the use of herbicides in the ponds, which pose an unacceptable risk to public drinking water supplies, by encouraging **integrated pest management** and mechanical/source intercepting invasive weed control options.*	✓		APC Management Team; Long Pond Association; Conservation Commission	Ongoing	Local staff and volunteer time
Co-benefits					

Continual monitoring will help detect potential contaminants early and improve water quality management. Managers and other stakeholders can help with regular water sampling and testing, as well as monitoring compliance with state **Water Management Act (WMA)** permitted water withdrawal limits and other special conditions. This applies to public water supply withdrawals, cranberry bogs, golf courses, and other major water users within the watershed. Stakeholders should review annual water quality reports that are required under WMA permits, and work together to address any emerging contaminants. Following **Integrated Pest Management** approaches, and encouraging landowners, particularly around the APC and other bodies of water, to limit pesticide and herbicide treatments can protect the water supply from unnecessary pollutants. These chemical control methods pose an unacceptable risk to public drinking water supply.

Goal 3: Improve water quality

OBJECTIVE A: Eliminate potential contaminants at the source using physical treatment and regulation

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
A-1. Explore grant and loan funding for septic system upgrades from conventional to denitrifying systems.			Dept of Public Works, Board of Health, Conservation Commission, Planning Board	Ongoing	Local staff and board member time; technical assistance through SRPEDD or another consultant
Co-benefits					
A-2. Adopt uniform local septic bylaws that go beyond			Planning Board, Board of	3-5 Years	Local staff and board member

*minimum **Title V** regulations to reduce nutrient releases from septic systems contaminating groundwater. [More details below]*			Health, Conservation Commission		time; grants (MVP, EEA, etc.); technical assistance through SRPEDD or another consultant
Co-benefits					

Septic systems are a major contributing source of nutrients that, through groundwater, pollute neighboring waterbodies. Excessive nutrients are currently contributing to invasive aquatic weed growth, which degrades environmental health and recreational capacity in the Watershed. Technologies exist today that prevent the release of nitrogen from septic systems; however, many of the existing systems throughout the Watershed were installed before such technology was widely available. Furthermore, many of the existing systems are aging and failing, either because the original capacity of the system is no longer sufficient to support current uses, or because of maintenance issues. Local planners can take steps to encourage better maintenance of existing systems to ensure they continue to function properly and help homeowners update or replace aging systems with more adequate ones. These efforts should be focused first on properties and neighborhoods adjacent to water bodies, and Long Pond in particular, but when applied across the Watershed will greatly improve water quality.

The Watershed Towns should adopt uniform local septic bylaws that require the best available technology and maintenance in all new development as well as redevelopment that may impact septic use (such as expanding existing buildings or changes in use, including conversion from seasonal to year-round occupancy). These bylaws should require denitrifying systems for all new installations that limit total nitrogen effluent to 19mg per liter or less. Septic system inspections should also be required with all property sales and changes in use to ensure systems are functioning properly and adequately sized. Example bylaws exist in Marion, Wareham and Tisbury, for reference. The towns should also explore potential grant and loan programs to fund septic system upgrades, and encourage and assist local homeowners in taking advantage of such programs in order to offset potential increased costs to homeowners for complying with new septic bylaws.

OBJECTIVE B: Prevent and monitor the spread of contaminants into waterbodies

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
B-1. Restore buffers on lands adjacent to wetlands and waterways for increased water filtration and purification. Where these buffers are currently in place, retain and enhance them.	✓	✓	Conservation Commission, Dept of Public Works	3 – 5 Years	Local staff time; grants (SNEP, MVP, etc.)
Co-benefits					

B-2. Alter mowing practices that compromise the integrity of buffer areas, and establish "no-mow zones" on municipal lands surrounding water bodies and wetlands. [More details below]	✓	✓	Conservation Commission, Dept of Public Works	2 – 4 Years	N/A (routine staff operations, though training could be pursued as needed to identify buffer areas)
Co-benefits					
B-3. Adopt local wetland bylaws that protect wetlands and their buffers for stormwater filtration. [More details below]		✓	Conservation Commission, Planning Board	1-3 years	Local staff and board member time; grants (i.e. MVP), technical assistance from SRPEDD or other consultant
Co-benefits					
*B-4. Install **permeable reactive barriers** to filter nutrients from groundwater, as appropriate. [More details below]*			APC Management Team; homeowners	1-3 years	SNEP, explore other grant opportunities
Co-benefits					
B-5. Install more water-quality monitoring stations and develop a volunteer network dedicated to routine water quality sampling. [More details below]			Local environmental groups, Conservation Commission	3-5 years	Local staff and volunteer time, explore grant opportunities
Co-benefits					
B-6. Reduce excessive sediment transport by removing sandbars near water crossing infrastructure and improving drainage outlets where feasible.		✓	Local Dept of Public Works, MassDOT	3-5 years	Staff time; explore grant opportunities
Co-benefits					

Where the introduction of contaminants into water sources is inevitable, preventing the spread of contaminants from their point of origin into waterbodies represents a 'last line of defense'. Protected and restored "buffer" habitats border wetlands and waterways, helping to filter contamination in runoff before it enters the water, and to regulate temperature by shading waterways. Existing buffers can be protected through local Wetland Bylaws that go above and beyond the state minimum requirements

and include buffer areas within the defined resource area to protect them from development. Where possible, buffers should be restored by altering mowing practices or removing impervious cover and adding beneficial buffer plants. Municipal land managers can set an important example with no-mow zones on their properties, and educate the public about the associated water quality benefits. Clear signage should be installed along no-mow borders, both to facilitate maintenance for DPW staff and provide public education and awareness.

Additional measures can also be implemented to target specific contaminants of concern. **Permeable Reactive Barriers (PRBs)** can be placed at strategic locations adjacent to waterbodies to filter nutrients out of groundwater. Candidate sites for PRBs have already been identified throughout the watershed, and funding is needed for implementation (The Nature Conservancy, 2018). Additional sources of sediment and other pollutants have also been identified at certain road crossings on the Nemasket River and stormwater management infrastructure. Each town should work with their local DPW staff and state entities, where necessary, to improve and routinely maintain roadway drainage structures to prevent sediment transport that causes water turbidity.

Lastly, recruiting volunteers to assist with ongoing water quality monitoring will help to identify and track pollutants, and potential sources, throughout the Watershed. Regular sampling data can help to identify, for example, candidate riparian restoration sites for particular types of nutrient control (phosphorus, nitrogen, etc.). Local volunteer groups could look to the Taunton River Watershed Alliance, who manages a volunteer water sampling program in the Taunton River Watershed, for guidance and to potentially combine efforts with their longstanding successful monitoring program.

OBJECTIVE C: Educate stakeholders on methods they can take to reduce contaminant inputs

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
C-1. Educate landowners about MDAR's fertilizer use regulations and encourage Farm Conservation Plans that implement best practices. Coordinate with retailers to provide consumer information.			Agricultural & Conservation Commissions	2 – 5 years	Local staff and board member time; technical support from practitioners, such as SRPEDD, TNC, UMass Amherst
Co-benefits					
C-2. Develop and spread water quality protection best practices (particularly as it relates to nitrogen and fertilizer runoff). Lead by example on public lands.	✓		Agricultural & Conservation Commissions	2 – 5 years	Local staff and board member time; support from partners, such as SRPEDD, TNC, UMass Amherst; grant funding for implementing best practices (i.e. NRCS)
Co-benefits					

Land management practices have a significant impact on local water quality, particularly with regards to landscaping and fertilizer use. There is already a wealth of resources for land managers to learn about best practices, for example from the Massachusetts Department of Agricultural Resources (MDAR) and the University of Massachusetts Amherst Cooperative Extension's Center for Agriculture, Food and the Environment. Municipal land managers can look to these resources to improve management of their own lands, and also coordinate with those institutions to educate private landowners about best practices. The communities can also work with local retailers, such as plant nurseries and hardware stores, that sell fertilizer to promote responsible use of fertilizers by consumers and prevent excessive fertilizer application that leads to nutrient pollution in waterways.

Another avenue to address land management practices is to encourage farmers to take advantage of planning resources from the US Department of Agriculture's Natural Resources Conservation Service (NRCS). Farmers can work with NRCS to adopt Farm Conservation Plans that utilize and implement best management practices.

Goal 4: Preserve wildlife and habitat

OBJECTIVE A: **Strategically expand the Watershed's open space network**

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
*A-1. Preserve the regional **Green Infrastructure Network**, through both land acquisition and by minimizing land disturbance during development.*	✓	✓	Planning Boards, Open Space Committees, Conservation Commissions, Select Boards; APC Management Team	Ongoing	Local staff and volunteer time; grants (i.e. MVP, State Planning Grants, DCR Grants); Local CPA Fund
Co-benefits					
*A-2. Keep Open Space & Recreation Plans current, prioritizing high value and connected natural areas, such as the **Green Infrastructure Network**, for protection. Consider the development of a Regional Open Space and Recreation Plan.*	✓	✓	Planning Boards, Open Space Committees, Conservation Commissions	Ongoing, every 7 years as OSRPs expire	Local staff and volunteer time, municipal budgets, grants (i.e. Technical Assistance grant programs through SRPEDD)
Co-benefits					
A-3. Launch public education campaign to garner support for land acquisitions.			Open Space Committees, Local Environmental Groups, APC Management Team	1-3 years, and ongoing	Local staff and volunteer time, utilizing resources from MassLand and Mass Audubon

Co-benefits					
*A-4. Adopt the **Community Preservation Act** to fund open space protection.*		✓	Freetown & Rochester Open Space Committees, Planning Board	1-3 years	Local staff and volunteer time, utilizing resources from the Community Preservation Coalition
Co-benefits					

A strategic approach to open space protection that prioritizes high-value natural areas, making the most of limited resources, is essential for the long-term resilience of the Watershed. Preserving large & unfragmented natural land, rare & endangered species habitats and migratory corridors, as well as ecosystem function like flood storage and water purification will provide the greatest improvements for both wild and human community resilience. These lands are readily identifiable thanks to tools that define and show the regional **Green Infrastructure Network.** Since Open Space and Recreation Plans (OSRP) play a significant role in guiding local land protection efforts, and having an up-to-date OSRP unlocks state grant funds for land acquisition, each community within the Watershed should be sure to keep their plans current, and when the time comes to update them, identify the Green Infrastructure Network among the local conservation priorities. In drafting this Plan, it became apparent that current data sources do not consistently show or reflect local understanding of key open space and recreation land features, such as the level of public access and the types of recreational activities permitted at each site. Compiling a current and full set of consistent data across the Watershed could be achieved as part of a regional Open Space and Recreation or Water Access Master Plan.

Local Community Preservation Funds also direct resources for land protection; Freetown and Rochester should consider joining their watershed neighbors in adopting the **Community Preservation Act** to establish such local funds that can be applied to preserving land in the Watershed. Lastly, regardless of the acquisition method, public education on the importance of land protection in perpetuity, and the role it plays in improving community well-being and resilience, will be essential to gather local support for land acquisition efforts.

OBJECTIVE B: **Improve habitat through natural resource management**

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
B-1. Adopt and/or update forestry management plans that improve forest health and resilience to climate change.	✓	✓	Forest owners & managers; Conservation Commissions	3-5 years, and ongoing	Local staff & volunteer time; technical & financial assistance from NRCS
Co-benefits					
B-2. Address barriers to fish passage in the Nemasket River and APC at dams, fish	✓		APC Management Team;	5-10 years, and ongoing	Partnership with MA DOT; grants

ladders, and stream crossings (i.e. dam removal, bridge and culvert replacement).			Lakeville Middleborough Herring Fishery Commission		(i.e. NOAA, MVP, DER)
Co-benefits					
B-3. Protect headwater stream flow and shading for cold-water fish.	✓	✓	APC Management Team; Conservation Commissions; local environmental groups	3-5 years, and ongoing	Grants (i.e. MVP, DER), local CPC, volunteer efforts
Co-benefits					
B-4. Install wildlife corridors & road crossing structures.	✓	✓	APC Management Team; Conservation Commissions, Dept of Public Works, MassDOT	5-7 years, and ongoing	Explore grant opportunities – MassDOT may be a source where wildlife crossing currently poses safety risks
Co-benefits					

Management and stewardship of the Watershed's existing open spaces is critical to ensure that the open space network continues to support wildlife and natural processes that human communities rely on, such as climate regulation and floodwater storage. With over half of the watershed forested, and forests making up much of the existing open space network, monitoring and actively managing the health of these lands will be critical for ensuring the region's climate resilience. Municipal staff should prioritize adopting or updating management plans for town forests (including Betty's Neck and James Jasper Vigers Jr. Conservation Area) in coordination with the Natural Resources Conservation Service, as well as the New Bedford and Taunton water suppliers for water supply lands. Private land owners should likewise be encouraged to do the same for their properties. Forestry Management Plans should address ongoing concerns such as invasive species, disease, pests, and drought, as well as provide ongoing removal plans for downed trees (especially from red pine die offs observed on the lands surrounding the ponds in recent winters) and other debris, which pose hazards to recreational users and are potential forest fire threats. Plans should also include long-term monitoring strategies as climate change continues to impact community composition and condition, and allow for adaptive management in response to these changes.

While improving forest health will improve habitat for the Watershed's wildlife, some additional actions are recommended to support and protect priority species. Stream crossings along the Nemasket River, including multiple dams and bridges that restrict flow and create barriers to aquatic species migration (particularly river herring), should be removed or replaced with larger and less restrictive structures to help the river return to a more natural state of flow. A calendar schedule of target minimum flows to be sustained in the Nemasket River for ecological and habitat requirements (sustained by the combination of APC governed releases and leakage through the dam) may also further this objective. The Snake River

Culvert between Long Pond and Assawompset Pond also restricts fish passage. Cold-water fish species are particularly under threat from loss of habitat, due to altered stream flows and water quality. Taking steps to protect headwater stream flows, protect vegetated stream buffers that provide shading, and avoid channel alterations that cause water impoundments will help to protect the availability of this unique habitat type. Lastly, wildlife corridor and road crossing structures that connect fragmented habitats at significant barriers, such as multi-lane roadways, can facilitate wildlife migrations and reduce vehicle collisions (particularly for turtle species).

OBJECTIVE C: Manage and prevent the spread of invasive species

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
C-1. Implement public education campaigns to increase awareness and knowledge of invasive species, and help with containment and early detection.			Conservation Commission; Long Pond Association; APC Management Team	1-3 years, and ongoing	Local staff and volunteer time
Co-benefits					
C-2. Institute volunteer monitoring programs for rapid detection and management of invasive plants.			Conservation Commission; Long Pond Association; APC Management Team	1-3 years, and ongoing	Local staff and volunteer time; explore grant opportunities
Co-benefits					
C-3. Implement a holistic ***integrated pest management*** *approach for controlling invasive plant species.*	✓		Conservation Commissions, Long Pond Association, APC Management Team; public	Ongoing, but especially when reviewing permit applications	Local staff and board/ commission member time
Co-benefits					
C-4. Monitor and minimize the spread of aquatic invasive plants from Long Pond to Assawompset Pond.			Conservation Commissions, Long Pond Association, APC Management Team	Ongoing, but especially before action taken to update Snake River culvert	Local staff and board/ commission member time
Co-benefits					

Invasive species management requires a holistic and multi-faceted approach. Perhaps the most critical component of managing invasives and preventing their spread is increasing public awareness and understanding of the issue. A public education campaign should be implemented Watershed-wide to

increase residents' and recreational users' awareness of invasive species, how to identify them, how to prevent their spread, and how to report sightings, in order to prevent and detect new infestations before they become established. Residents should also be educated on the proper ways to remove and dispose of aquatic invasive weeds on Long Pond in particular, in order to avoid unintended spread of the weeds and water quality impacts associated with the use of herbicides. Furthermore, volunteer monitoring programs can greatly facilitate rapid detection and intervention; watershed communities should identify and train interested local residents to help with invasive plant management.

In order to control existing infestations, an **integrated pest management** approach should be taken that first addresses the causes of the infestation (including nutrient pollution) and utilizes the most targeted mechanical treatments (i.e. pulling out the target species, either by hand or with a machine such as an Ecoharvester). Herbicide application should be avoided as it has negative impacts on non-target species, and poses too great of a risk to water supply at present. Post treatment monitoring and adaptive management strategies should be built into any management program, in order to improve effectiveness and avoid unintended consequences.

Lastly, monitoring and management efforts should recognize the connection between Long Pond and Assawompset Pond, and avoid the spread of aquatic weeds between waterbodies wherever possible.

Goal 5: Encourage sustainable development that retains natural functions

OBJECTIVE A: Plan for and manage expected growth, and its impacts to the Watershed

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
A-1. Prioritize areas for development vs. protection in long-range planning efforts (including Master Plans). [More details below]	✓	✓	Planning Boards, Open Space Committees	Ongoing, as community plan updates take place	Local staff and board member time, grants (i.e. technical assistance funds through SRPEDD)
Co-benefits					
A-2. Address the impacts of expansion and winterization of homes around the Ponds transitioning from seasonal to full-time.		✓	Planning Boards, Conservation Commissions, Boards of Health; APC Management Team	Ongoing, especially as permits are reviewed	N/A (routine staff operations)
Co-benefits					
A-3. Consider increasing capacity at the Middleborough Waste Water Treatment Plant to accommodate future development.			Middleborough Public Works Dept.	10-15 years	Local staff time; explore grant opportunities

Co-benefits					
A-4. Engage the state in updating new MBTA multi-family housing zoning requirements; and protect watershed resources while meeting the new regulations locally.	✓	✓	Planning Boards, Conservation Commissions, Select Boards; APC Management Team; SRPEDD	1-3 years	Local staff and volunteer time; grants (i.e. state planning grants, technical assistance grants through SRPEDD)
Co-benefits					
A-5. Consider the effects that new land development will have on the Watershed's water table and ability to maintain drinking water to public and private well sources.		✓	Planning Boards, Conservation Commissions, Boards of Health, Peer Review Engineers, developers	Ongoing, as permits are reviewed	N/A (routine staff operations)
Co-benefits					

Watershed communities should be prepared to accommodate continued growth, especially in terms of residential development. Up-to-date Master Plans play an important role in guiding local planning and development, and identifying Priority Development Areas (PDAs) and Priority Preservation Areas (PPAs) upfront in these and other local planning documents (like Open Space and Recreation Plans) can ensure future planning efforts accommodate these priorities. In particular, high value natural areas that protect wild and human communities, like the Green Infrastructure Network, should be identified as PPAs, whereas already developed areas and designated commercial corridors should be targeted for further development as PDAs, and these areas should be linked wherever possible with neighboring communities as well. Brownfield sites and other post-industrial areas could also be targeted for redevelopment. These designations can then be followed up with specific zoning and other regulatory updates, as further described in Objective B. It is important for communities to reference these priorities when updating local bylaws and making land use decisions to ensure their implementation. Communities should continue to refine the areas as needed in future plan updates.

Each community should also ensure current infrastructure can withstand continued growth trends. As more and more vacation homes around the Ponds get expanded and converted to year-round homes, each community should establish a clear permit review process that ensures the existing water and septic infrastructure can handle the increased use, without impacting the availability and quality of either surrounding wells or the water in the Ponds (i.e. nutrient impacts from failing septic systems or reduced flows from groundwater withdrawals). Public infrastructure, such as the Middleborough Waste Water Treatment Plant, should be assessed for its capacity to continue supporting a growing population, and town officials should consider the feasibility of increasing the capacity of such critical infrastructure or otherwise plan accordingly. When reviewing permit applications, local planning boards should also consider the proposed development's impacts on drinking water supplies (i.e. groundwater

diversion/recharge impacts and increased demand, as well as impacts to the water table from package treatment plants or other withdrawals).

Lastly, new state regulations for zoning that enables multi-family housing growth in MBTA communities (which impacts all Watershed stakeholder communities, as draft guidelines currently stand,) may require increased development at a higher density than Watershed communities are used or. Furthermore, the Nemasket River and its floodplain are located within a half mile of the Middleborough/Lakeville Commuter Rail Station, the target area for this multi-family zoning. Watershed communities should engage the state during the development of the new regulations to advocate for measures that protect Watershed resources and accommodate local concerns. Communities can then work together to comply with the new regulations in such a way that will not negatively impact water quality, contribute to local flooding, or interfere with sustainable recreational opportunities.

OBJECTIVE B: Encourage low impact development practices in local bylaws and regulations

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
B-1. Allow flexible lot designs in zoning and subdivision regulations, and require development that conforms to, rather than alters, natural features.	✓	✓	Planning & Zoning Boards	1-3 years	Local staff and board member time; grants (i.e. state planning grants, technical assistance grants through SRPEDD)
Co-benefits					
*B-2. Allow Cluster and **Open Space Design (OSD)** development **by-right** that protects priority natural land.*	✓	✓	Planning & Zoning Boards	1-3 years	Local staff and board member time; grants (i.e. state planning grants, technical assistance grants through SRPEDD)
Co-benefits					
B-3. Consider mixed-use developments with a commercial component that can add to the tax base as other lands are put into permanent preservation (i.e., removed from the tax base).		✓	Planning Boards	Ongoing, especially as bylaw updates are considered	Local staff and board member time; grants (i.e. state planning grants, technical assistance grants through SRPEDD)
Co-benefits					

In addition to proactive land use planning, codifying **low impact development (LID)** practices in local bylaws and development regulations will minimize the environmental impacts of future development. Zoning and subdivision regulations should avoid large minimum lot sizes and dimensional requirements

(which encourage sprawling development that consumes land), and instead encourage flexible lot designs that conform to the existing landscape, while requiring the preservation of natural features (including large trees and wetlands and their buffers, and minimizing regrading) and favoring infill over sprawling development.

Cluster and **Open Space Design (OSD)** development are proven LID strategies that reduce development's footprint and can help a community protect priority natural land at no additional cost and should be allowed **by-right** (without requiring a special permit) in appropriate areas across the Watershed. OSD bylaws should overlap with and refer developers to a community's priority development and preservation areas (PDAs and PPAs) as identified in local community planning documents, and specifically require the permanent protection of high priority natural parcels, contiguous both within and with adjacent lots, that contribute to the regional Green Infrastructure Network.

Mixed-use developments, within cluster developments and/or within other zoning districts, can also reduce sprawl while enabling more resilient and walkable neighborhoods. Incorporating a commercial component into these types of developments can provide additional tax revenue that may help offset potential lost revenues as protected lands are removed from the tax base.

Public education around the impacts of development and how these LID strategies can address those impacts will be an essential component of any local regulatory updates in order to help garner local support for passing the updates and ensuring compliance with new regulations.

OBJECTIVE C: Ensure new development is built with the future climate in mind, and doesn't contribute to stormwater runoff

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
C-1. Establish impervious cover controls in zoning and site design to limit conversion of natural areas that contributes to stormwater runoff.	✓	✓	Planning & Zoning Boards	1-3 years	Local staff and board member time; grants (i.e. state planning grants, technical assistance grants through SRPEDD)
Co-benefits					
C-2. Require the inclusion of 100- and 500-yr floodplains and the most up-to-date rainfall rates in site planning, to ensure all new infrastructure is built for the future.		✓	Planning & Zoning Boards	1-3 years	Local staff and board member time; grants (i.e. state planning grants, technical assistance grants through SRPEDD)
Co-benefits					
C-3. Strengthen local regulations to meet MS4	✓	✓	Planning & Zoning Boards	1-3 years	Local staff and board member

requirements and further protect water quality and groundwater supply through low impact development techniques (i.e. permeable pavement and bioswales).					time; grants (i.e. state planning grants, technical assistance grants through SRPEDD)
Co-benefits					

Increased runoff volume is one major impact of development, and as climate change brings more intense rainfall it is becoming more critical that communities take steps to both minimize stormwater contributions and ensure infrastructure is built to withstand the storms of the future. The conversion of natural areas that absorb rainfall to impervious surfaces like roads and parking lots should be avoided or minimized wherever possible, particularly adjacent to waterbodies and within floodplains.

In local zoning and subdivision regulations, communities should consider implementing tiered maximum impervious lot coverage allowances, like Middleborough's zoning bylaw utilizes, as well as tiered maximum widths for roads and parking lot sizes. Permeable pavement options that reduce runoff should also be allowed, where appropriate. Subdivision regulations and site plan review bylaws should require the accommodation of both the 100- and 500-year floodplains in site plans, to avoid development in the floodplain that impacts water storage and puts properties at risk of future flood damages, and require developers utilize the most up-to-date and locally available precipitation rates (such as NOAA Atlas 14) for drainage designs, to ensure all new development is built to handle both current and future climate conditions without increasing stormwater flows.

Lastly, communities should work together and with regional entities, such as SRPEDD and state agencies, to manage stormwater in a way that complies with MS4 permit requirements, but also goes above and beyond to protect environmental resources, particularly water quality and supply. Local development regulations should require the use of low impact development stormwater management practices in all new and re-development, as well as parking and roadway updates, that treat and directly infiltrate stormwater on site through options such as rain gardens, bioswales and permeable pavement, which will prevent stormwater pollution in waterways and recharge groundwater supplies.

OBJECTIVE D: Increase local capacity and education around sustainable land use

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
D-1. Increase local staffing capacity, including resources and training, for land use planning and enforcement.			Community managers, Select Boards	3-5 years, and as needed	Municipal budgets, utility and development fees
Co-benefits					
D-2. Work with and create easy-to-understand materials for developers to clearly define priority development vs. preservation areas, and preferred development practices.	✓	✓	Planning Boards	3-5 years	Local staff and board member time

Co-benefits					
D-3. Increase public education about ecologically responsible land management practices.		✓	Planning Boards, Conservation Commissions, APC Management Team	1-3 years, and ongoing	Local staff and board member time; technical assistance from local & regional environmental planning entities (i.e. TNC, SRPEDD)
Co-benefits					

Local capacity among town staff and volunteer board and commission members who are the decision-makers regarding local land use, permitting and enforcement is a common challenge the Watershed communities face. Securing and prioritizing funding to increase local planning and conservation department staff will provide much needed capacity for more thorough permit application reviews and enforcement, and allow communities to adopt more stringent permitting requirements that will help meet local environmental protection goals. Identifying and providing land use training & guidance materials for planning and zoning boards and conservation commissions will also provide the foundation necessary to understand the implications of development proposals reviewed and to make more informed decisions regarding permits.

Working proactively with developers specifically, and clearly defining where and how each community encourages them to build, will ensure local priorities (i.e. PDAs and PPAs and LID) are incorporated into development designs and can greatly streamline permitting processes. Easy to understand guidelines, provided within regulations, design standards and outreach materials (i.e. a local developer guidebook), along with required pre-application consultations and/or preliminary site plan review meetings can help developers understand and incorporate desired strategies early in the process, a win-win for developers and permit reviewers.

General public education about low impact development and ecologically responsible land management practices can also help residents become better stewards of their land and further decrease the negative environmental impacts often associated with development. Public education campaigns should focus on the adverse impacts of residential fertilizer, herbicide and pesticide applications and best practices for homeowners. Municipalities should distribute recommendations on the “do's” and “don'ts” of fertilizer and pesticide use, and consider providing these in a packet to all new residents at the time of property sale. One or more model properties (public or private) should also be identified and showcased so that residents can learn and replicate best practices.

Goal 6: Enable ecologically appropriate recreation

OBJECTIVE A: Improve signage and communication regarding permitted uses, access locations, and proper standards for recreating in the Watershed

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
A-1. Encourage responsible and appropriate recreation in the region by improving signage in and around the area about public access and use limitations. [More details below]			Conservation Commissions, Parks Commissions, APC Rangers	Ongoing	Local staff and board member time; CPA funds; explore grant opportunities
Co-benefits					
A-2 Increase public access to online information about where and how to recreate across the Watershed.			Conservation Commissions, APC Rangers, Town Managers	Ongoing	Local staff and board member time; CPA funds; explore grant opportunities
Co-benefits					

Lack of information about permitted uses throughout the Watershed has contributed to certain undesirable scenarios, such as kayakers going over the top of the Assawompset Pond Dam, the use of motorized watercraft in the Nemasket River, and use of unauthorized / unregistered boats in Assawompset Pond. This has led to over-use of certain natural areas and ecological degradation (including on trails around the Quittacas Ponds). Information sharing must happen in a variety of ways: high quality signage facilitates on-the-ground compliance with the rules, while increasing ease of on-demand access to information online can help visitors understand appropriate uses and plan accordingly for their trip.

Clear and consistent signage at recreational sites throughout the Watershed is essential to inform visitors which types of activities are allowed where, and to facilitate enforcement efforts. Installed signage should be robust (i.e., metal or plastic) and located (not on trees) to help ensure its longevity. Accompanying regulatory signage and additional information about recreational resources and events can be shared at new and existing kiosks on site.

Recreational users should also be able to access these types of information before they get to the site, so that they know the recreational activities available at each site and can plan their trip accordingly. It is important that complete and accurate rules and regulations regarding open space use are posted in easily accessible locations across each town's website. Print-out brochures with detailed maps depicting access and trails (posted online and distributed through kiosks) are an easy way to share information on amenities and rules. Effective advertisement of the Watershed's varied recreation sites can help to avoid overcrowding at sensitive sites by alerting users to additional sites and directing people to larger and more suitable sites.

OBJECTIVE B: Increase local municipal capacity for oversight and enforcement of recreational activities across the Watershed

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
*B-1. Provide a larger annual budget for the **APC Rangers** program to increase their presence around the ponds during peak months, for public education, enforcement and safety.*		✓	APC Management Team, Town Managers & Select Boards	Ongoing	Municipal Budgets, water utility & boat permit fees
Co-benefits					
B-2. Increase municipal funding for local Parks Commissions and/or departmental staff to improve maintenance of open space.		✓	Town Managers & Select Boards, Parks & Conservation Commissions	Ongoing	Municipal Budgets; explore potential grant opportunities
Co-benefits					
*B-3. Create a formal system for logging reports submitted by the **APC Rangers** to keep track of repeat rule breakers.*			APC Rangers, APC Management Team	1-2 years	Local staff & volunteer time; explore potential grant opportunities
Co-benefits					
B-4. Invite and advocate for more oversight from MA Environmental Police throughout the region, and at the boat launch for Long Pond, especially if a boat washing station is installed.	✓	✓	APC Rangers, Local Police, State Environmental Police	Ongoing	Local staff & volunteer time
Co-benefits					
*B-5. Highlight the importance of the **APC Rangers** in town communications.*			Conservation Commissions, APC Rangers, APC Management Team, Town Managers	Ongoing	N/A (routine staff operations)
Co-benefits					

Increasing local capacity to manage and expand recreational access is critical. Currently, the **APC Rangers** are the first line of defense for protecting the watershed and water supply from inappropriate use. The APC Watershed Management Team has already agreed to an increase in the funding available for the APC Rangers to conduct regular enforcement and educational activities. Funding streams for this and future increases should be formalized and coordinated to keep up with future inflation and

minimum wage increases that may again impact the budget. Increasing the budget further would allow for more outreach and educational activities, which intersects with water supply and water quality goals for water quality protection. Highlighting the important role the Rangers play in managing recreational access and increasing public awareness through communications, including but not limited to annual town reports, at town meeting and in social media posts, can help make the case for increased funding for the program.

Lack of user awareness of regulations (see Objective A) pushes oversight responsibilities on to the APC Rangers and town conservation commission staff. Anecdotally, there has been an increase in the number of confrontations between park rangers and visitors, owing to the increased use of the Watershed as a recreation location. Installing standardized signage at the ground level so that APC Rangers can point directly to supporting signage may decrease the need for rangers to intervene and support them while they enforce rules. Keeping track of rule breakers through a formal system with an accompanying database of incidents and perpetrators could be immediately set up with currently accessible technologies, such as an online Google Sheet (including a Google Form which could allow Rangers to submit regular reports and query by license plate or name).

Since the APC Rangers are not law enforcement, they sometimes rely on support from local police and Massachusetts Environmental Police (MEP) to respond to violations, but responses to calls are often delayed due to limited officers. The MEP cover broad regions with limited staff on duty at a time, often delaying response times. Advocating for increased budgets (including by encouraging hunting, fishing and trapping, the licenses for which fund MEP, where those uses are allowed) can help improve local enforcement capacity and emergency response. A more regular presence at the state-operated boat launch on Long Pond can boost awareness and adherence to regulations at a major water access point for the region. If a boat washing station is installed there, MEP presence can also help enforce its use, which will prevent the spread of contaminants to and from Long Pond (see Objective C). Improving local and regional capacity for maintenance and emergency response will also become more important in the future as climate change increases the frequency and intensity of natural hazards.

OBJECTIVE C: Maintain and center ecological integrity in recreational offerings

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
*C-1. Install a **boat washing station** at the Long Pond Boat Ramp in Freetown to reduce the spread of invasive plants.*			MA DCR, State & Local Police, Freetown Conservation Commission	1-2 Years	State budget
Co-benefits					
C-2. Manage over-use of recreational areas that threatens ecology and natural resources by directing users to more appropriate locations.			Conservation Commission, Parks and Rec Departments, APC Rangers	Ongoing	Local staff and commission time
Co-benefits					

*C-3. Establish Downtown Middleborough **River Walk** with educational and stewardship signage about the Nemasket River.*			Middleborough Conservation Commission, Parks and Rec Dept; APC Management Team	3-5 years	Grants (state & federal trails grants); CPA funds
Co-benefits					

Decontamination measures aimed at cleaning boat hulls and interiors after and before their use on waterbodies are one effective means of reducing invasive species, a widespread threat to both recreation and ecology across the Watershed. These decontamination measures typically involve washing and flushing a boat's interior, hull, bilge pumps, live wells, motors, and any other locations where contaminated water may collect. Effective cleaning requires high water pressures and temperatures as well as cleaning chemicals that may not be available to recreational users except at established boat washing stations. The Long Pond boat ramp off Route 18 in Freetown is an ideal location for a boat washing station since it is the major entry point for local and regional boaters to Long Pond. Long Pond already has invasive aquatic species problems, but a **boat washing station** can prevent the introduction of new species as well as reintroductions following future management efforts, and it can also minimize the spread of invasives from Long Pond to other water bodies. The MA Department of Fish and Game's Office of Fishing and Boating Access has a process to plan, permit, design, engineer, and construct boat washing stations. Since they own the boat ramp, local advocates will need to coordinate with them to get a washing station installed. The MA Division of Conservation and Recreation must also review the proposal as they are responsible for dealing with aquatic invasive species.[5] Local town managers, planning board, conservation commission, and regional rangers have a role to play in permitting, day-to-day operations at the boat ramp and washing station, and promoting public awareness of the importance of properly cleaning boats between uses.

Recreation can also threaten area ecology through over-use. The trails around the Quittacas Ponds in particular have been identified as an area under stress from excessive use. Local land managers can take steps to reduce access at particular locations, perhaps through parking restrictions. Additionally, better communication and advertisement of alternative areas that can accommodate larger volumes of users at a time, like Pratt Farm in Middleborough for example, can help alleviate pressures on other sites (see Objective A).

Lastly, there is a conceptual Nemasket **River Walk** in development through Downtown Middleborough that could provide an educational recreation opportunity through a very visible corridor of the Watershed. The River Walk would run through public properties from Route 28 to Route 105/East Main Street near the Nemasket River. There are some private properties interrupting the proposed pathway at present, but many properties are already public that could accommodate a walkway and/or bike path. Educational signage placed along the walk could increase awareness about the River's history and natural resources, and encourage more ecologically-mindful recreation.

[5] Per Communication with Doug Cameron, Chief Engineer and Director of MA Office of Fishing and Boating Access.

Goal 7: Foster a widespread culture of stewardship

OBJECTIVE A: Expand outreach to increase education and awareness of the impact of stewardship

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
A-1. Engage local schools and provide educational opportunities for youth.			Conservation Commissions, School Departments, environmental groups	1-3 years, and ongoing	Local staff time; in-kind services from environmental groups and consultants; explore grant opportunities
Co-benefits					
A-2. Reach out to property owners who live on the water and share recommendations on how they can be effective stewards. [More details below]			Conservation Commissions, Planning Boards, Long Pond Association	1-3 years, and ongoing	Local staff time; in-kind services from environmental groups and consultants; explore grant opportunities
Co-benefits					
A-3. Increase public awareness of the scenic and ecological value of the Nemasket River, and support efforts to nominate this corridor for potential designation programs. [More details below]			APC Management Team, APC Rangers	3-5 years, and ongoing	Local staff & volunteer time; explore grant opportunities
Co-benefits					
A-4. Expand spiritual, cultural, and historical education and recreation offerings to encourage better relationships with, and understanding of, the Watershed.			Local arts and culture organizations, Conservation Commissions, Historical Commissions, Parks Depts & Commissions	1-3 years, and ongoing	Local staff & volunteer time; in-kind services from local orgs; CPA; explore grant opportunities
Co-benefits					

Fostering a culture of stewardship starts with educating residents on the impacts of their relationship with the Watershed and why they should want to be good stewards in the first place. Informational materials on the history, ecology, and development trends of the region are one way to effectively teach people about their region. In addition to annual reports, town meetings, and online communications,

effective forms of outreach include a peer-to-peer advocacy model through which residents share the reasons why stewardship is important to them with their neighbors. Recreational programming can also provide an avenue for outreach by expanding offerings focusing on stewardship of environmental, cultural and historic resources, and incorporating educational messaging into all ongoing programs. The Watershed may be eligible for certain designations, such as a Natural Heritage Corridor (like the Blackstone Valley), State Heritage Corridor, or Greenways State Park (like the Connecticut River Valley), which can further spur local stewardship and may also unlock resources and funding sources.

Local educators often target youth in their outreach efforts, as early education can often have lasting impacts on individuals and encourage a more mindful relationship with the environment. Local environmental groups should continue engaging local schools as much as possible with outdoor learning experiences that help kids understand how recreate outdoors appropriately, and be sure to reach out months in advance when coordinating outings or visits.

Property owners also have a significant impact on Watershed health through the way they manage and care for their land, whether acres of farmland or a typical residential garden. Town staff and local environmental groups should take care to reach out to homeowners adjacent to Assawompset and Long Ponds in particular, and especially new homeowners, to help them understand the reasons and methods for minimizing their impacts on the Watershed. Informational sheets and videos can communicate best practices via mailings, social media, and local cable. They should also include information on actions that the municipalities are taking so property owners know they are not alone and have examples.

OBJECTIVE B: Enable residents to apply their knowledge of stewardship to active stewardship projects

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
B-1. Engage archeological and historical groups in stewardship efforts on a more regular basis.			Town Boards & Commissions, local community groups, Historical Commissions	Ongoing	N/A (routine staff operations)
Co-benefits					
B-2. Encourage public review and comment on new water withdrawal permits from the Watershed to assure healthy ground and surface water flow levels.		✓	Town Boards & Commissions; APC Management Team, local & regional environmental groups	Ongoing	N/A (routine staff operations)
Co-benefits					
B-3. Organize and mobilize local volunteers and environmental groups to help	✓	✓	Conservation Commissions, local environmental	Ongoing	Local staff & volunteer time; in-kind services from

steward open space and outdoor recreation facilities.			groups, APC Management Team		environmental groups; explore grant opportunities
Co-benefits					
B-4. Enlist high school and college student-run clubs and/or programs to help monitor local ecological conditions and track changes.		✓	Local environmental groups & schools	Ongoing	Local staff & volunteer time; in-kind services from environmental groups; explore grant opportunities
Co-benefits					

Moving to an action-oriented version of stewardship allows municipal staff and local groups to tap into the support of environmental advocates from around the region. Community clean-ups, trainings (especially one for invasive species management and identification), and participation in community planning all enable community members to become engaged and apply their knowledge. It is important that each training opportunity provides participants with a positive action that they can take to protect the environment.

Community leaders should be sure to continue to reach out to all local stakeholders when it comes to community planning and stewardship. This includes local Historical Commissions, tribal groups, environmental & cultural organizations, students and more. Note that archeological investigations on CR land require a permit from Mass Historic.

Volunteers can add significant capacity for open space maintenance. Engaging interested individuals, volunteer groups, and student environmental clubs and other types of youth groups can help with identifying and removing invasive species and monitoring environmental health conditions to inform management. Ongoing monitoring and adaptive management are essential to protect the Watershed's open space network, and volunteer monitoring can make such a daunting task much more feasible. Middleborough's Conservation Commission coordinates with a local volunteer stewardship group – this program could be expanded and other communities could adopt similar programs to help provide much needed capacity for open space stewardship.

OBJECTIVE C: Take municipal actions to improve stewardship

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
C-1. Install public art in community and civic spaces throughout the region to foster a connection and celebration of the Watershed's special natural resources.			Planning Boards, Dept of Public Works, Arts and cultural groups	Ongoing	Local staff and volunteer time; CPA Funds; explore grant opportunities

Co-benefits					
C-2. Manage growth in historical villages to enhance and preserve what is special.			Historical Commissions, Planning Boards, developers	Ongoing	N/A (routine staff operations)
Co-benefits					
C-3. Encourage good stewardship of cranberry bogs and their preservation and/or restoration as wetlands.		✓	Conservation Commissions, Planning Boards, Cranberry Bog owners	Ongoing	Local staff and bog owner time; utilize resources and grant funding from DCR, MDAR and NRCS
Co-benefits					

Municipalities, with support from local organizations and advocates, can take steps within their jurisdiction to promote public stewardship. They can include stewardship messaging in public spaces (i.e. signs, murals, banners, etc.) and also consider stewardship in their day-to-day operations, particularly when reviewing local permit applications. New and redevelopment applications should be reviewed for potential impacts to environmental, cultural and historical resources, among other considerations, and these interests should be protected in local decisions. Historical villages and cranberry bogs are examples of culturally important resources that should be protected and expanded upon in a way that preserves and enhances what is special about them. Cranberry bogs throughout the region have recently been popular sites for solar development. While installing solar provides an important income source to growers, local planners should take steps, potentially through local solar development bylaws and regulations, to manage this growing threat to cranberry bog habitat, or to weigh this option against the restoration of cranberry bogs to naturalized wetlands where operators are looking to exit the industry.

Goal 8: Expand Opportunities to improve cooperative management

OBJECTIVE A: Continue the efforts of the APC Management Team to enhance regional coordination and transparency of pond level management and water supply-related protections

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
A-1. Provide ongoing transparency and clarity into Assawompset Pond water level management, particularly around target water thresholds.			APC Management Team, Water Suppliers	Ongoing	N/A (routine staff operations)
Co-benefits					
A-2. Consistently monitor and report water levels to a		✓	APC Management	Ongoing	N/A (routine staff operations)

centralized online location where residents (and water suppliers) can access pond level information and the status of the dam (boards in or open) on demand.			Team, Water Suppliers		
Co-benefits					
A-3. Install automated pond water level gauges that can streamline water level monitoring and reporting.			APC Management Team, Water Suppliers	3-5 years	Explore grant opportunities
Co-benefits					
A-4. Formalize fisheries and wildlife considerations in APC dam management through continued coordination between water suppliers and the Lakeville-Middleborough Herring Fisheries Commission.		✓	APC Management Team	1-3 years	Local staff and board member time
Co-benefits					

Managing the water supply in the Assawompset Ponds is a complicated task that requires ongoing collaboration among the many stakeholders with varied interests in the ponds and their outlet, the Nemasket River. The APC Management Team convenes stakeholders on a quarterly basis to coordinate management of the ponds, but improvements could be made to facilitate coordination and transparency with the public.

On-going communication around pond levels, both to the public and among APC Management Team members in between quarterly meetings, is of great interest. Understanding current pond levels, and how the APC Dam is being managed to control them, will help ease public concern about both water supply protection and potential flood threats to the pondside communities. Greater clarity and transparency about the different target water level thresholds necessary to maintain the water supply and those that represent a potential flood hazard should be provided. Right now, these water level updates will need to be reported manually, preferably in a universally accessible location online, and updated regularly, until such time as these readings can be automated.

Maintaining water flows from the ponds to the Nemasket Rivers is of particular interest, to minimize conflict between water supply management and ecological requirements, especially during low-flow periods that could have negative impacts on wildlife. The Middleboro-Lakeville Herring Fisheries Commission represents fishery interests on the APC Management Team, and could help formalize protocols for protecting flow requirements for species in the Nemasket River during routine dam management (the Management Team should also coordinate with regulatory agencies like DMF, Natural Heritage, Army Corps, etc.).

OBJECTIVE B: Improve regional collaboration and coordinate on environmental monitoring and management efforts

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
B-1. Increase coordination with state agencies for improved regulation, education, management, and monitoring of invasive plant removal strategies.			Conservation Commissions; MA DCR, NHESP; APC Management Team	Ongoing	N/A (routine staff operations)
Co-benefits					
B-2. Coordinate efforts between towns and local stewardship groups to remove and monitor the spread of invasives plants.			Conservation Commissions, Long Pond Association, local environmental groups	Ongoing	Local staff and volunteer time
Co-benefits					
B-3. Increase collaborative efforts to preserve land in the Watershed through an inter-municipal committee dedicated to prioritizing acquisition targets and generating funding.	✓	✓	APC Management Team, Conservation Commissions, Open Space Committees, local & regional environmental groups	1-3 years	Local staff and volunteer time; in-kind time of environmental groups
Co-benefits					

Non-native, invasive plant species are an issue across the Watershed, and so a regional approach to weed control is necessary. Coordination between groups performing local monitoring and removal (like the Long Pond Association), municipal entities who conduct their own management and provide permits for local activities, and state agencies who provide guidance for and also regulate management activities, is necessary. Furthermore, increasing ongoing partnership among these various groups can help to streamline regulation, education about best practices, and management and monitoring efforts. This partnership could address the existing weed issue, and then create a rapid response plan for addressing future instances of invasive aquatic plant emergence. Aquatic weeds in Long Pond and the Nemasket River are a top priority for invasive plant management, but land plants, including Japanese knotweed and oriental bittersweet in riparian areas as well as phragmites and reed canary grass bordering waterways, are also priorities for ongoing management.

Land protection to preserve and maintain ecological integrity across the Watershed has also been identified as a top priority among local managers. Coordination to identify and prioritize regional priorities for land conservation can help to make the most of available resources for land protection. A regional group could be formed that focuses on land preservation priorities. These efforts should target the regional Green Infrastructure and Open Space Networks, as well as regional linkages that help to

establish wildlife and climate migration corridors and enhance regional resilience. The committee can proactively plan for acquisition opportunities, like the use of Chapter 61 right-of-first-refusal.

OBJECTIVE C: Enhance coordination among local, regional and state management entities for infrastructure management and improvements

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
*C-1. Review **MOUs**, **OOCs** and operating procedures with entities like MassDOT and DEP that have a role in scheduled maintenance that affects drainage, sedimentation and water flow.*			APC Management Team, Dept of Public Works	Ongoing	Local staff and board member time
Co-benefits					
C-2. Work with MassDOT to explore new road surface quality and road bed design and maintenance standards that will reduce runoff.		✓	APC Management Team, Dept of Public Works, Conservation Commission	Ongoing	Local staff and board member time
Co-benefits					

Some roadways and their associated infrastructure (including bridges and culverts) located within the Watershed are owned and operated by the state. In these cases, increased coordination between local and state agencies on how these structures are maintained to prevent negative environmental impacts (such as sediment being introduced into waterways via drainage outlets or undersized bridges and culverts restricting water flow) can improve water quality across the watershed. Acquiring and reviewing the various **Memorandums of Understanding (MOUs)**, **Orders of Conditions (OOCs)**, and routine operating procedures that determine how these various structures are maintained can provide clarity and reveal opportunities for local staff to guide and facilitate maintenance operations. Hosting copies of these documents and active maintenance permits in a centralized online location will help transparency and communication. Additional cooperation on design and maintenance of roadway drainage systems and maintenance could help reduce flood and water quality impacts.

OBJECTIVE D: Improve communication and public awareness of environmental regulations and ongoing efforts across the Watershed

Action	NBS?	Climate Resilience Priority	Responsible Party	Timeline	Funding Source
D-1. Establish a public communications platform to share information about the watershed and communicate the status of various ongoing			APC Management Team	Ongoing	Local staff and volunteer time; explore grant opportunities

projects across the Watershed.					
Co-benefits					
D-2. Identify and address inconsistencies in bylaws and enforcement approaches between communities.			Planning Boards, Conservation Commissions, APC Management Team	1-3 years, and ongoing	Local staff and board member time; explore grant opportunities
Co-benefits					
D-3. Work with state representatives and other communities to lobby for additional resources for MA Environmental Police.		✓	APC Management Team, local and regional environmental/ advocacy groups	Ongoing	Local staff and volunteer time
Co-benefits					

Public education and awareness are essential to gaining support for ongoing watershed management activities and regulations. A centralized public resource page, widely advertised across the Watershed communities, that has everything the public needs to know about the Watershed would be immensely helpful in creating an informed public who can steward and advocate for the Watershed and its resources. This effort requires ongoing communication among the APC Management Team and the various local and regional management entities and stakeholders throughout the watershed. Creating such a resource is not within the current purview of the APC Management Team, but perhaps a newly formed "Plan Implementation Committee" (either separate from, or as a subcommittee of the APC Management Team) could take on the responsibility of collecting information on public access and allowed activities throughout the Watershed, guidance for recreating responsibly, and up to date information on the various activities and projects taking place across the watershed, and post this information along with relevant updates as they happen to a new platform (to be identified) that the public knows to look to for information. An email or print newsletter could also be considered to maintain public awareness of issues, events and regulations throughout the year.

Improving regulatory transparency and efficiency is also important to ensuring that the public is following required procedures and not unintentionally harming the Watershed. This could be done by reviewing and addressing inconsistencies between regulations across communities, and adopting uniform enforcement approaches. These regulations could then be shared on the public communication platform so all are aware of them and how to follow them.

Lastly, the Massachusetts Environmental Police are an important resource for protecting environmental resources, and the APC Rangers would like to rely on them for backup in certain situations, but there is an acknowledged lack of Environmental Police capacity statewide. Ongoing outreach about the important role they play to the public and state legislators can help advocate for and secure additional

funding for them to expand their capacity. This could greatly help with enforcing environmental regulations and responding to emergencies (including from natural hazards) in the Watershed.

7. CONCLUSIONS AND NEXT STEPS

As we have developed this Plan, other efforts were simultaneously under way that both informed the Plan and brought its initial conclusions toward implementation.

- A hydrologic and hydraulic study of the Upper Nemasket River from the headwaters at the APC Dam to Route 105 was undertaken to understand which infrastructure on the river was causing the greatest constraints to river flow, fisheries, and flood control. The results of this study identified the Wareham Street Dam as the most problematic pinch point. A companion public engagement series allowed the project team to describe the study to area participants and residents over time, and the final workshop zeroed in on participants preferred alternatives, with a vast majority of people in support of the removal of Wareham Street Dam.
- With initial understanding of the pinch points in the River, the project team began to pursue and received funding to consider the feasibility of options for removing the Wareham Street Dam and a retrofit of the APC Dam, as well as to install groundwater monitoring wells to better understand how groundwater moves through the Watershed.
- Seeing the high priority actions between this Plan and the DER Floodwater Management Study, the project team developed a 12-Point Priority Plan for the Watershed (shown below), organized by action item priority and degree of actionability, and began to seek and receive the endorsement of this prioritized list from pondside communities (to date, Lakeville and Middleborough have endorsed the Priority Plan). The figure of the Priority Plan below shows the status of each action item as of July 2022.

It is of vital importance that this Plan remain a living document through its 2050 time horizon. There needs to be an entity charged with carrying recommended action items forward, and periodically revisiting the Plan in light of new climate change projections and changed local conditions. While the APC Management Team has diligently and expertly served as the core of the Steering Committee in developing the Plan, they have a narrower charge and need to be able to achieve their original mission and quarterly meeting requirements. A new entity, perhaps envisioned as the A**PC-Nemasket Watershed Management Plan Implementation Committee,** should be formed that would have expanded and flexible membership beyond that which was designated for the APC Management Team. This group would help to pursue all of the action items in this Plan, starting with the 12 Point Priority List.

Figure 24. APC-Nemasket 12 Point Priority Action Plan

12-POINT PLAN FOR PRIORITY APC-NEMASKET PROJECT PHASING

PHASE 1: WORK THAT IS HIGH PRIORITY AND ACTIONABLE (in priority order)

1. **Address sedimentation build-up with a 5-year emergency permit**
   - Building off model emergency permit from several years ago
2. **Removal of weeds from Long Pond and the Nemasket River**
   - Plan for eco-harvester weed removal based on areas of weed concentration shown in solutions study
   - Present to permitting agencies (local Con Comms, US Fish and Wildlife, Natural Heritage)
   - Contract with eco-harvesting company
   - Repeat seasonally as necessary
3. **Install automatic pond level loggers**
   - Direct transmission of level data to a publicly-facing website / database
4. **Signage Plan and Installed Signage / Monitoring around the ponds**
   - Aimed at curbing inappropriate recreation

Initiated; currently pursuing local and state permits; funded by state ARPA allocation.

Initiated; currently pursuing local and state permits; funded by state ARPA allocation. Will require successive years of activity.

Not yet initiated

Not yet initiated

PHASE 2: WORK THAT IS HIGH PRIORITY BUT REQUIRES SOME FURTHER STUDY OR ANTECEDENT ACTIONS (in priority order)

5. **Wareham Street dam removal**
   - Several phases (feasibility, design, engineering, construction)
6. **Permeable Reactive Barrier / Buffer Strip Long Pond Pilot Program**
   - We've removed immediate issue in item 2 above, now let's keep the weeds from coming back; goal of PRB technology
7. **Installation of boat washing station at the Freetown Boat Ramp**
8. **Replacing the Snake River Culvert**
   - Note that it is after items 1 and 6, which helps to address trans-missible weeds
9. **Buy high priority preservation land**
10. **Amend local bylaws with low-impact development principals on the ponds**

Initiated; on-going project is exploring removal feasibility.

Grant application submitted 6/30/22.

Initial site work (electrification, gate installation) being pursued

Funding not identified. BRIC potential in future.

Projects 9-12

PHASE 3: WORK THAT WOULD BE MOST DISRUPTIVE TO STATUS QUO - NEEDS ONGOING STUDY AND CONSIDERATION (in priority order)

11. **APC Dam upgrade / reconfiguration**
12. **Initiating a property buy-out program**

Project specifics not yet fully developed; funding pathway not yet developed.

[Lakeville Select Board endorsed 3/21/22; Middleborough Select Board endorsed 3/14/22]

8. APPENDICES