

CITY OF GROTON COMMUNITY RESILIENCE PLAN MAY 2022



This Plan was developed under a grant from the National Fish and Wildlife Foundation's Long Island Sound Futures Fund (LISFF).

Executive Summary

The City of Groton is no stranger to climate hazards; severe storms, coastal flooding, heavy rainfall, and other extreme weather events have impacted the City numerous times throughout its history. The threats from climate-related hazards have been increasing, however, and this increase will accelerate in the future as climate change leads to rising sea levels, worsening storms, more severe high temperature and drought events, and other acute and chronic changes. These threats pose a risk to the City's infrastructure; parks, open spaces, and coastline; cultural and community resources; and operations and services.

To address these threats, the City has developed its first ever Community Resilience Plan. This Plan includes an introduction to climate risks and community resilience (Section 1) and an overview of the planning process (Section 2). A detailed look at the vulnerabilities and exposure levels of each part of the City across sectors and hazards follows, culminating in a comprehensive assessment of climate risk facing different parts of the City (Section 3).

The Vulnerability Assessment portion of the Climate Risk Assessment in Section 3 considered vulnerabilities across the following sectors:



SOCIAL
(DEMOGRAPHIC
FACTORS)



RESIDENTIAL
(POPULATION DENSITY)



COMMERCIAL
(BUSINESSES)



**CRITICAL FACILITIES
& INFRASTRUCTURE**
(ROADS, FACILITIES,
UTILITIES)



**COMMUNITY
RESOURCES**
(CULTURAL BUILDINGS,
COMMUNITY ORGS)



NATURAL SYSTEMS
(PARKS & OPEN SPACE)

The Exposure Analysis includes coastal and riverine flooding, erosion, stormwater flooding, and extreme heat.

Based on the vulnerability assessment and exposure analysis, the Risk Assessment identifies six key risk factors:

1. Stormwater Flooding and Impervious Surfaces
2. Extreme Heat and Lack of Shade
3. Local Business Exposure to Climate Risks
4. South Shore Flooding
5. Vulnerable Roadways and Transportation Network
6. Vulnerable Population Exposure

As a core component of the City's Plan, a suite of Climate Resilience Objectives, Recommendations, and Actions (Section 4) were developed. The first six Resilience Objectives directly respond to the six risk factors identified in the Risk Assessment, while the final Objective centers on municipal assets and operations to encourage the City of Groton to lead by example and take action swiftly.



Each Objective acts as an overarching strategy to address an identified risk, and includes specific Recommendations for the City to pursue. Each Recommendation, in turn, includes a Toolbox of specific Actions for the City to consider. The seven proposed Objectives are:

-  1. Reduce Stormwater Flooding from Impervious Surfaces
-  2. Mitigate Increasing Urban Heat Island Effect Impacts
-  3. Enhance Resilience of Local Businesses
-  4. Create a Flood-Resilient Shoreline
-  5. Improve Resilience of Transportation Network
-  6. Increase Resilience of Socially Vulnerable Populations
-  7. Lead by Example – Municipal Resilience Actions

From the Recommendations, four specific Resilience Concepts were developed to provide the City with examples of how ideas can translate into projects. These Concepts are summarized in Section 5 and included in detail in Appendix C.

Finally, the Plan concludes with ideas for Next Steps (Section 6). This Community Resilience Plan is an important milestone for the City of Groton; however, it is only the beginning. The City can use this Plan as a basis to build climate resilience awareness and capacity internally, establish partnerships, prioritize next steps, and proceed towards implementation of selected actions.



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GLOSSARY

Adaptive Capacity	Describes how a community, asset, or feature can prepare, respond, and/or recover from a natural hazard event.
Climate Hazard	Extreme weather natural events, such as flooding or hurricanes, that can cause varying degrees of damage and may be exacerbated by climate change impacts.
Exposure	A measurement of the likelihood a climate hazard will impact a community feature.
Flood Zones	<p>The Federal Emergency Management Agency (FEMA) has delineated Special Flood Hazard Areas (SFHAs) which are the areas susceptible to inundation during the base flood. The base flood is the 1% annual chance (100-year) flood and includes zones A, AE, and VE. Zones in Groton city include:</p> <p>A & AE: These zones are the 100-year base flood areas. AE zones have delineated flood depths while A zones do not. There are also “floodways” associated with these ones. A floodway is a regulatory channel that is reserved for flow discharge; communities must regulate development in these areas.</p> <p>VE: Velocity zones are adjacent to the coast. These zones have flood depths and have the highest wave activity.</p> <p>X (0.2% annual chance): this is considered the 500-year flood zone. While not considered part of the SFHA, this zone is considered a moderate flood hazard area.</p>
Risk	The combination of a community, asset, or population’s vulnerability and exposure to a given climate hazard.
Sensitivity	Describes how a feature or asset could be impacted or affected by a climate hazard.
Vulnerability	The extent to which a climate hazard may damage or harm people, structures, systems, or other community features.



ACRONYMS

ACS	American Community Survey
AZ	Assessment Zone
BFE	Base Flood Elevation
CBG	Census Block Group
CDC	Centers for Disease Control and Prevention
CIRCA	Connecticut Institute for Resilience & Climate Adaptation
CT DEEP	Connecticut Department of Energy and Environmental Protection
CT DEMHS	Connecticut Dept of Emergency Management and Homeland Security
ConnDOT	Connecticut Department of Transportation
CT ECO	Connecticut Environmental Conditions Online
DFIRM	Digital Flood Insurance Map
DPW	Department of Public Works
FEMA	Federal Emergency Management Agency
GIS	Geographical Information System
HVAC	Heating, Ventilation, & Air Conditioning
LID	Low Impact Development
NFIP	National Flood Insurance Program
NOAA	National Oceanographic and Atmospheric Administration
NWS	National Weather Service
PED	Planning and Economic Development
POCD	Plan of Conservation and Development
seCTer	Southeastern Connecticut Enterprise Region
SFHA	Special Flood Hazard Area
SLOSH	Sea, Lake, and Overland Surge from Hurricanes
SVI	Social Vulnerability Index
TDR	Transfer of Development Rights
UConn	University of Connecticut
UHI	Urban Heat Island
WPCA	Water Pollution Control Authority



1 Introduction

The City of Groton faces increasing threats from climate-related hazards as climate change leads to rising sea levels, worsening storms, more severe high temperature and drought events, and other acute and chronic changes. These threats pose a risk to the City's infrastructure; parks, open spaces, and coastline; cultural and community resources; and operations and services. Climate change has the potential to directly and indirectly impact city residents, employees, and visitors.

Using a grant from the National Fish and Wildlife Foundation's Long Island Sound Futures Fund (LISFF), the City of Groton has embarked on its first ever Community Resilience Plan. The findings and recommendations presented here within are a result of a thorough and detailed community resilience planning effort.

Section 1 of the report provides an overview of the community, and the climatic changes underway that led the City to pursue development of a Community Resilience Plan.

Section 2 presents the steps taken during the planning process, including a review of existing studies and documents, engagement with stakeholders and the public, and spatial analysis of hazards and risks.

Section 3 describes the evaluation of climate risks across hazards, sectors, and geographies. Climate risk is determined by combining vulnerability and exposure levels.

Section 4 proposes a suite of risk-driven Recommendations for the City to pursue to increase the community's resilience to climate change. These Recommendations are divided into seven overarching Resilience Objectives, and each includes a "toolbox" of specific Actions.

Section 5 provides a summary of four Resilience Concepts that were developed to advance specific Recommendations one step further toward implementation. These Resilience Concepts can be used to maintain momentum toward community resilience, informing next steps both for the specific projects they address, as well as related projects proposed in Section 4.

Finally, Section 6 lists some of the steps for the City to take to continue moving forward with community resilience planning, using the contents of this Plan.

1.1 Community Overview

For the purposes of this Community Resilience Plan, the City was divided into six Assessment Zones (AZ). These AZ are used to identify discrete geographic areas where certain climate hazards are a concern, and certain resilience approaches are appropriate.

AZ were mapped to align with specific areas identified in the City of Groton 2019 Plan of Conservation and Development (POCD)¹, the 2006 City of Groton Harbor Management Plan

¹ Relevant maps within the 2019 POCD include the Community Form Plan (POCD p. 9) and the Economic Development Plan (POCD p. 25).



(Harbor Plan), and 2010 Census Block Group (CBG) geographies², in order to facilitate consistency across planning efforts.

The six AZ are shown in Figure 1 and summarized below:

A. Thames Street Assessment Zone

This is the oldest section of the City, with historic structures, marinas, docks, and water-dependent uses along the shoreline. This AZ covers the Thames Street Action Area identified in the 2019 POCD, aligns with Harbor Plan area A, and is identical to the area of CBG #24002. The Zone is bounded by Grove Avenue to the north; North Street and Mitchell Street to the east; Baker Avenue to the south; and the Thames River to the west. It includes the Groton Bank Historic District and Fort Griswold Battlefield State Park.

B. Technology Campus

This area consists of the Electric Boat and Pfizer campuses (Pfizer Groton campus, and the Pfizer West campus), as well as a number of other primarily industrial land uses. The AZ shares the borders of the Technology Campus along Eastern Point Road identified in the 2019 POCD. It also aligns with Harbor Plan area B. Although this AZ includes portions of CBG #25002 and #26001, it has no residential use, and so demographic data from the census cannot be applied.

C. Five Corners

Five Corners, as defined in this Risk Assessment, encompasses the Five Corners Action Zone identified in the 2019 POCD, as well as surrounding residential areas. The area is considered the City center, and includes retail and other commercial uses, single and multi-family residential buildings (including a number of larger apartment buildings), and schools and other community resources; it also includes numerous large parking lots. The Five Corners AZ includes all of the residential uses within CBG #25002, as well as a large portion of CBD #24003. It does not include any shoreline. The northern boundary of the AZ is Baker Avenue and the northern edge of the Sacred Heart School property. The AZ is then bounded by Brandegee Ave to the east, Shennecossett Road to the South, and Eastern Point Road to the west.

D. South Shore

The South Shore refers to the portion of the City to the south of the Pfizer campuses. The northern boundary follows the Pfizer campus edges and then Shennecossett Road and Thomas Road. The AZ aligns with Harbor Plan areas C, D, and E, and mostly aligns with CBG 26001. South Shore is largely residential and includes the Shennecossett Golf Course, Eastern Point Beach, the Shennecossett Beach Club, two wetland areas along Shennecossett Road, and the University of Connecticut (UConn) Avery Point campus.

² Decennial 2020 Census data was not yet available at the time of plan development; 2019 five-year estimates used for the project utilize 2010 geographies.



Smaller neighborhoods encompassed by the South Shore include:

- **Eastern Point:** residential area with public parks and water access points, and part of the Shennecosset Golf Course
- **Avery Point:** hosts the UConn Avery Point campus (non-residential university campus)
- **Pine Island Bay:** residential area interspersed with boating facilities: Shennecosset Yacht Club, Pine Island Marina, and Bayberry Lane Boat Launch.
- **Jupiter Point and Baker Cove:** low-lying residential area with some water-related commercial facilities.

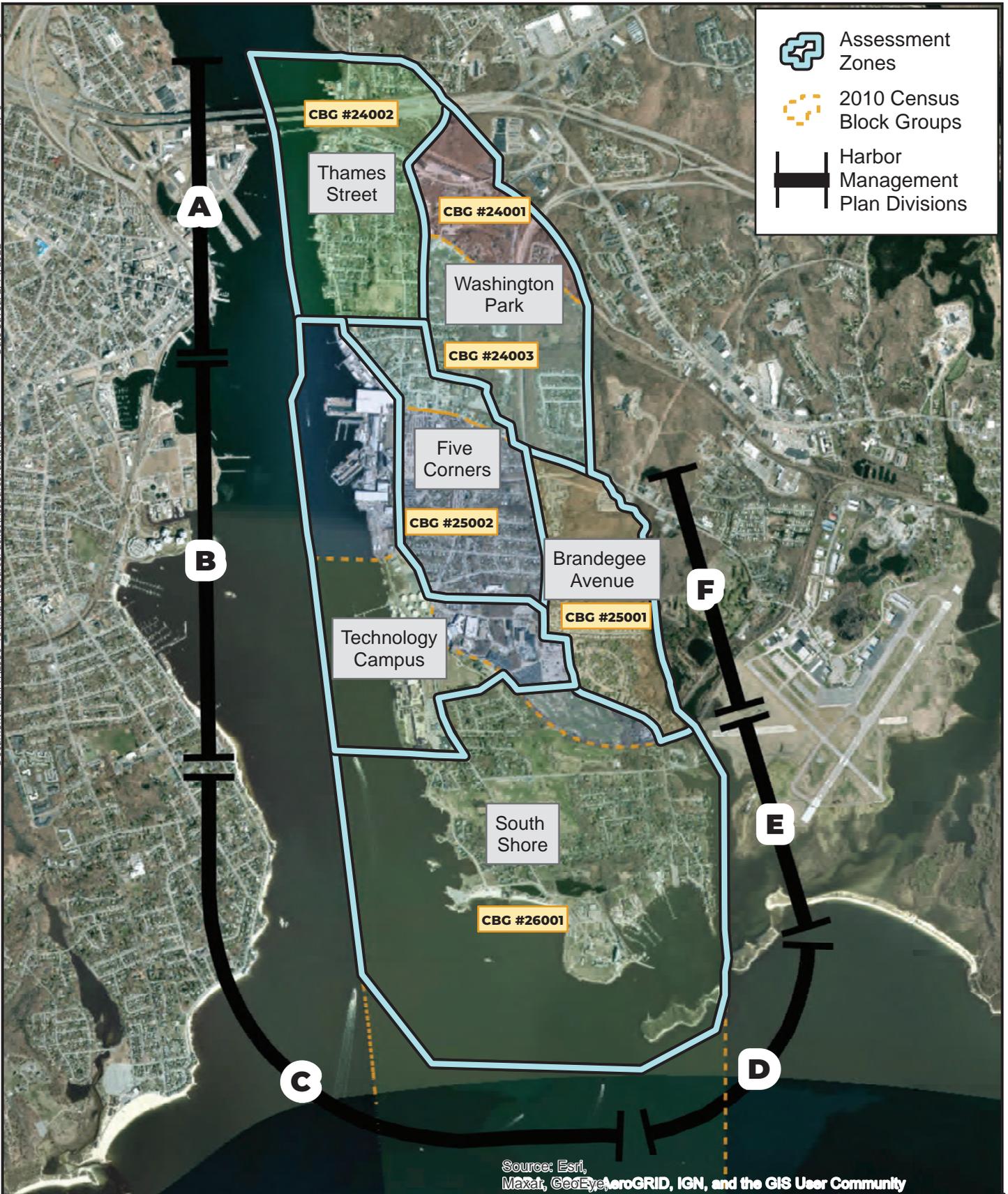
E. Brandegee Avenue

The area described as Brandegee Avenue borders Birch Plain Creek between Thomas Road and Poquonnock Road (Route 649). The western edge of the AZ is marked by Brandegee Ave. This AZ aligns with Harbor Plan area F and CBG #25001. It includes Birch Plain Creek, conservation areas of salt marshes and forests, and large apartment complexes.

F. Washington Park

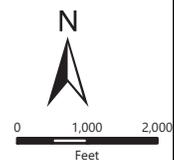
The Washington Park AZ is north of Poquonnock Road on the eastern side of the City and includes the City municipal building campus and Washington Park, the Old Farm Road neighborhood, and a mix of residential and commercial properties. The area is not included in Harbor Plan; though, it largely aligns with CBG #24001 and #24003. The AZ is bounded to the west by North Street and Mitchell Street; Poquonnock Road to the south; Birch Plain Creek to the east of Mira Drive; and the railroad to the north and northeast.





99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

CITY WIDE ASSESSMENT ZONES
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 2,731'
 DATE 3/23/2022
 141.12536.00015
 PROJ. NO.

FIG. 1

1.2 Defining Climate Risk and Community Resilience

Climate risk is defined in this climate risk assessment as the combination of **vulnerability** and **exposure** to a given climate hazard (Figure 2).

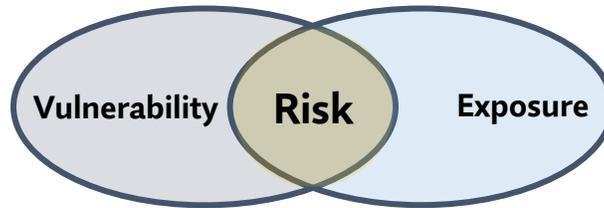


Figure 2: Conceptual Model of Climate Risk.

Vulnerability is defined here as the extent to which a climate hazard may damage or harm people, structures, systems, or other community features. Vulnerabilities can be viewed in the context of primary and secondary impacts. Primary impacts describe direct damages to building and infrastructure, while secondary impacts can include disruptions to commerce, isolation of areas from emergency services, and other indirect effects.

Vulnerability depends on the following:

- ❖ **Sensitivity:** how bad would it be if the feature were impacted by a climate hazard?
- ❖ **Adaptive Capacity:** how well can the feature prepare, respond, and recover from a hazard event?

Critical infrastructure, care facilities, socially vulnerable populations, or rare habitats may have **high vulnerability**. Open spaces and adapted buildings or infrastructure may have **low vulnerability**.

Exposure is a measurement of the likelihood a climate hazard will impact a community feature. Exposure depends on the following:

- ❖ **Frequency and Severity:** How often does a climate hazard of a given severity occur?
- ❖ **Physical Characteristics:** Topography, land cover, and other factors inform the ability of a given climate hazard to impact a community feature.

A home in a low-lying area next to the shoreline may have **high exposure** to flood hazards. Power lines near tall trees may have **high exposure** to wind.

1.3 Need for Community Resilience Planning in Groton

Climate hazards include both acute events and chronic conditions related to precipitation, wind, and temperature, that cause damage or disruption to the built environment, the economy, social systems, and public health. Global climate change caused by anthropogenic greenhouse gas emissions is increasing average global temperatures and changing climate hazard profiles around the world. While occurring globally, the effects of climate change are being felt at the local level, and may vary depending on geographic location. In the City of Groton, historic and projected changes as a result of climate change include:



- ❖ Rising average and maximum annual temperatures, and increasing frequency of extremely hot days
- ❖ Rising average and maximum annual precipitation amounts, and increasing severity of extreme precipitation events
- ❖ Increasing frequency and severity of drought periods
- ❖ More frequent and severe storm events, including severe wind events
- ❖ Acceleration of rising sea levels

Based on a review of historic events and municipal experience, along with stakeholder input, the following list presents the climate hazards of concern for the City:

- ❖ **Coastal Flooding** from storm surge
- ❖ **Stormwater Flooding** during severe precipitation events
- ❖ **Sea Level Rise**, and the stresses and inconveniences it will cause in the long term
- ❖ **Extreme Heat**, and its negative health impacts
- ❖ **Severe Storms**, including high winds, severe rain or snowfall, and the combined effects of winds, precipitation, and storm surge

CHANGING CONDITIONS AND CHANGING RISK

In planning for long-term community resilience, the City of Groton must consider changing levels of both vulnerability and exposure. Both climate change and human activities can lead to changes in each:

- ❖ **Development** within hazardous areas places community assets at risk, increasing both the exposure and vulnerability of the community. Conversely, development designed with climate resilience in mind can minimize the risk to assets and to the community.
- ❖ **Impervious Surface** expansion can increase runoff from precipitation events and raise local temperatures, increasing the severity of (and potentially exposure to) those hazards. Conversely, reducing impervious surfaces can reduce the severity of those hazards.
- ❖ **Climate Change** will increase the frequency and severity of weather and climate events such as severe precipitation, high wind events, extreme hot days, and coastal flooding. This will increase overall climate risk to the City, unless the City acts to reduce vulnerabilities.



2 Community Resilience Planning Process

2.1 Review of Existing Studies and Documents

The City of Groton has a long history of participating in regional and local efforts to become a more climate resilient community. Previous city plans, programs and projects have laid a strong foundation towards the ongoing work of becoming a more resilient community.

A thorough review of local and regional documents was performed to ensure that the current Community Resilience Planning effort incorporates and builds upon past efforts. Understanding how existing city and Regional planning documents address climate resilience, and identifying gaps in those documents with this regard, will also facilitate future updates that more effectively consider resilience, and will build toward a consistent local and regional planning vision with regards to resilience.

Documents reviewed for this evaluation were:

- ❖ City of Groton Zoning Regulations (2020)
- ❖ Plan of Conservation and Development (2019)
- ❖ Community Resilience Building Workshop (2019, see Figure 3 to the right)
- ❖ Hazard Mitigation Plan (2018)
- ❖ Harbor Management Plan (2006)
- ❖ Resilience and Sustainability Task Force: Human Health and Safety Recommendations (2020)
- ❖ Intra-Regional Water Supply Response Plan (2019)
- ❖ Critical Facilities Assessment (2017)
- ❖ Historic Resources Resiliency Planning (2017)
- ❖ Southeastern Connecticut Regional Resilience Vision Project (2017)
- ❖ A Salt Marsh Advancement Zone Assessment of Groton, CT (2015)
- ❖ Preparing for Climate Change in Groton, Connecticut (2011)

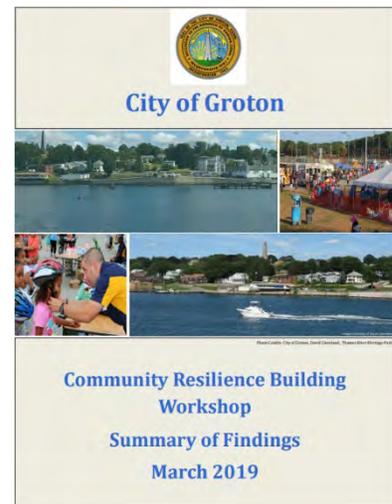


Figure 3: Community Resilience Building Workshop Report, 2019
Identified climate hazards of concern, local vulnerabilities and strengths, and a prioritized list of actions.

The documents reviewed in this exercise identified a wide range of concerns and vulnerabilities, strengths and capacities, and recommendations that were considered in the current community resilience plan. A summary of these takeaways is presented below. A detailed review of each document is presented in Appendix A.

2.1.1 Concerns and Vulnerabilities

Coastal Flooding and stormwater flooding are the primary flood-related concerns discussed, with sea level rise and increasingly severe precipitation events expected to exacerbate those hazards. Riverine flooding is noted, but is a relatively minor concern; Birch Plain Creek is the only stream impacting the City, and flooding from this source is predominantly tidal in nature, rather than riverine. Coastal erosion is not a significant concern locally.



Severe weather concerns focus predominantly on intense wind and storm events, as these events tend to produce the most dramatic impacts, and have caused damage in the City in the past. Extreme temperatures (cold and heat) and wildfires are mentioned infrequently. The lack of attention to extreme heat is an important gap to address, as increasing annual average temperatures as well as longer periods of extreme heat are expected to occur across the region and could have significant impacts for the City of Groton.

Other concerns that are noted in numerous documents include:

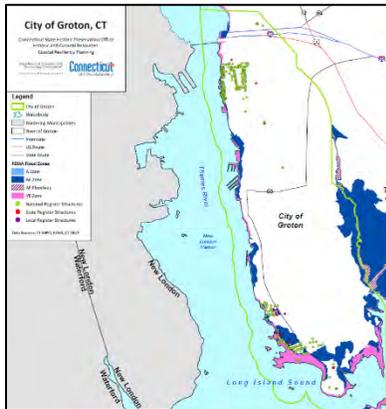


Figure 4: Historic Resources Resiliency Planning Report, 2017 Described vulnerabilities to historic and cultural resources, and best practices for preservation-friendly resilience.

- ❖ Vulnerability of drinking water resources to pollution (primarily from non-point sources, i.e. runoff), saltwater intrusion as sea levels rise, loss of access during high water events, and drought.
- ❖ Evacuation challenges due to the large number of commuters who travel to the City for work, exacerbated by possible obstacles to egress routes from flooding, erosion, or downed tree limbs and power lines. Related to this are other concerns related to the City's emergency response and recovery protocols.
- ❖ Damage to coastal ecosystems (particularly the Birch Plain Creek tidal wetland) from the compounding stressors of sea level rise and both non-point source (runoff) and point source (leaks from industrial facilities along the Thames River) pollution.
- ❖ Damage to properties and an associated decrease in property values and loss of essential tax revenue (damage to historic properties is one specific concern; see Figure 4 to the left).

Key gaps within existing documents include a lack of the following:

- ❖ Evaluation of extreme heat risks
- ❖ Evaluation of risks to local small businesses
- ❖ Evaluation of risks to vulnerable populations
- ❖ Evaluation of the potential for increased frequency of future power outages due to the impacts of heat, increased demand, and worsening storm events.

2.1.2 Strengths and Capacities

Based on review of these documents, the City of Groton has many strengths that can be leveraged and expanded on for the purpose of the City's climate resilience planning.

Groton Utilities, its reliable delivery of electricity and water, and its ability to rapidly respond to outages and interruptions, is clearly an essential strength of the City. Other municipal and regional services, including municipal leadership and staff, the Ledge Light Health District, and DEMHS Regional 4 Regional Emergency Planning Team, are also noted as capabilities. Local businesses (small and large) are also identified as important partners that the City can leverage to build resilience.



Local community-based organizations or community-service organizations, including religious institutions and vulnerable-population service-providers, are not identified as capabilities in most of the documents reviewed. Identifying these organizations, increasing their capacities to respond to climate change impacts, and including them in resilience planning efforts and conversations, will be essential to building community resilience.

Other capabilities identified include past structural flood-protection projects, and comprehensive zoning regulations. Natural systems are also generally identified as important capabilities, including tidal marshes and public parks, and Birch Plain Creek, specifically.

An important gap in the identification of strengths presented in the reviewed documents is that the impacts of sea level rise and other climate-change effects on the effectiveness of existing flood-protection projects and zoning regulation is not directly addressed.

2.1.3 Recommended Actions

Resilience actions recommended in the documents reviewed include adopting regulations and policies to limit hazard exposure, performing studies to better understand risks and adaptation options, improving municipal and community capacities to prepare and respond to climate-related hazard events, increasing the resilience of the City's businesses, preserving natural systems in the face of changing environmental conditions, and protecting and maintaining essential infrastructure and properties.

Specific recommendations identified by multiple documents include:

- ❖ Strengthening and Enforcing Flood Protection Regulations
- ❖ Conducting Flood and Drainage Studies
- ❖ Conducting Traffic and Evacuation Studies
- ❖ Coordinating with Regional, State, and National Stakeholders
- ❖ Integrate Climate Change Across Municipal Planning Efforts (for example, incorporating climate change into the Plan of Conservation and development; see Figure 5)
- ❖ Conduct Community Engagement, Education, and Outreach
- ❖ Conserve Natural Areas
- ❖ Utilize Living Shorelines and Green Infrastructure
- ❖ Increase the Capacities of, and Adequately Maintain, Culverts, Bridges, and Drainage Infrastructure
- ❖ Floodproof Critical Facilities
- ❖ Elevate Roads
- ❖ Protect Residences through Elevation or Managed Retreat

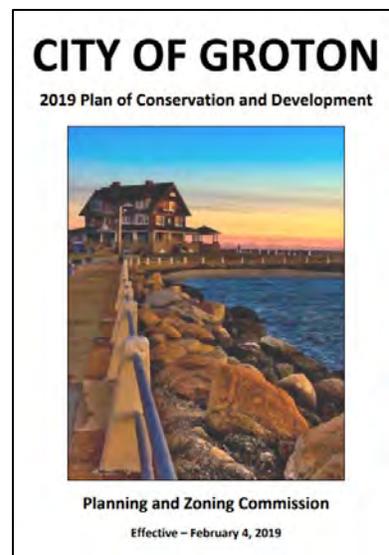


Figure 5: Plan of Conservation and Development, 2019 Presents the City's overall vision and specific objectives for future growth.



2.2 Stakeholder and Public Input

A critical part of the process for developing this Community Resilience Plan was the participation of community members in identification of climate hazards of concern, local vulnerabilities and capabilities, and opportunities for adaptation and resilience. Members of the public, municipal staff and elected officials, and other community stakeholders were engaged throughout the project to provide their unique perspectives, opinions, and experiences.

2.2.1 Engagement Process

A Community Resilience Building (CRB) workshop³ was held on June 29, 2021, early in the project (see Figure 6). The overall objectives for this workshop were to:

- ❖ Develop a collaborative understanding of climate-risks, vulnerabilities, and resilience options in the City of Groton.
- ❖ Capture the perspectives of a variety of local stakeholders with regards to community resilience.
- ❖ Advance previous planning efforts by including new climate change projections and accomplishments made by the City of Groton in the past years, as well as by spending more time mapping out specific resiliency action steps.

This workshop was targeted to Groton city staff and key stakeholders that were identified prior to the event, although it was open to the public as well. During the four-hour workshop attendees reviewed the findings of a previous CRB workshop in 2019, discussed updates to state guidance and climate change projections, and identified climate change challenges for the City, and proposed priority resilience actions for pursuit in the future.



Figure 6: Community Resilience Building Workshop, June 2021

In addition to the CRB, stakeholder participation was solicited through seven interview sessions facilitated by the project consultant. Participants were representatives of the Connecticut Department of Energy and Environmental Protection (DEEP), Groton Utilities (GU), the Baker Cove Watershed Commission (BacWac), the Southeastern Connecticut Enterprise Region (seCTer), General Dynamics Electric Boat (EB), and the consultant team working on the Visioning Thames Street project (<https://bit.ly/thames-street>), as well as Mayor Keith Hedrick of the City of Groton. Interview participants were identified based on their relevance to specific challenges or resilience options identified. Objectives for the interviews were to:

- ❖ Understand each stakeholder's unique perception of the City of Groton's climate-hazard risks, vulnerabilities, capabilities, and resilience options.
- ❖ Understand the primary resiliency challenges and opportunities facing the stakeholder's organization.

³ Based on the framework developed by The Nature Conservancy. For more information visit www.communityresiliencebuilding.com.



- ❖ Identify opportunities for mutual support and collaboration, and secure buy-in for municipal resilience efforts.

The stakeholder-directed engagement described above was designed to be detailed and thorough, and to include a wide range of perspectives and interests. In addition to that targeted approach, broader public outreach was also a critical component of the planning process.

Two public workshops were held over the course of plan development. The first was held virtually on August 12, 2021. This workshop reviewed general climate-change resilience concepts, including state-specific climate change projections and planning guidance. Attendees were then briefed, and invited to provide input, on preliminary findings from the stakeholder engagement events. These findings included the City vulnerabilities, strengths, and potential actions.

A second workshop was held in-person on March 3, 2022 (Figure 7). Attendees at this workshop were presented with a high-level update on the Community Resilience Plan, including progress and deliverables, risk assessment results, the process for identifying priority projects, and an overview of the identified priority projects. After the presentation, attendees were able to spend time reviewing concept designs in a charette style exercise. Four concept posters were developed, and attendees were encouraged to note questions and comments on the concepts. In addition to the concepts, attendees were able to provide their thoughts on where they might like to see tree plantings at Eastern Point Beach; this exercise was included to inform future city efforts with increasing tree canopy.



Figure 7: Public Workshop, March 2022

2.3 GIS Analysis

The GIS analysis evaluated community features with regard to their proximity to spatially-specific climate hazard zones. Each of these climate hazard zones is described below along with accompanying maps depicting where the climate hazard zone exists within City of Groton.

2.3.1 FEMA Special Flood Hazard Areas

The 1% annual chance (100-year) flood has been adopted by the Federal Emergency Management Agency (FEMA) as the *base flood*. Special Flood Hazard Areas (SFHAs) are the areas susceptible to inundation during the base flood, as delineated as part of the National Flood Insurance Program (NFIP). FEMA uses a variety of flood zones to delineate areas of annual chance flood hazard, as shown below in Figure 8.



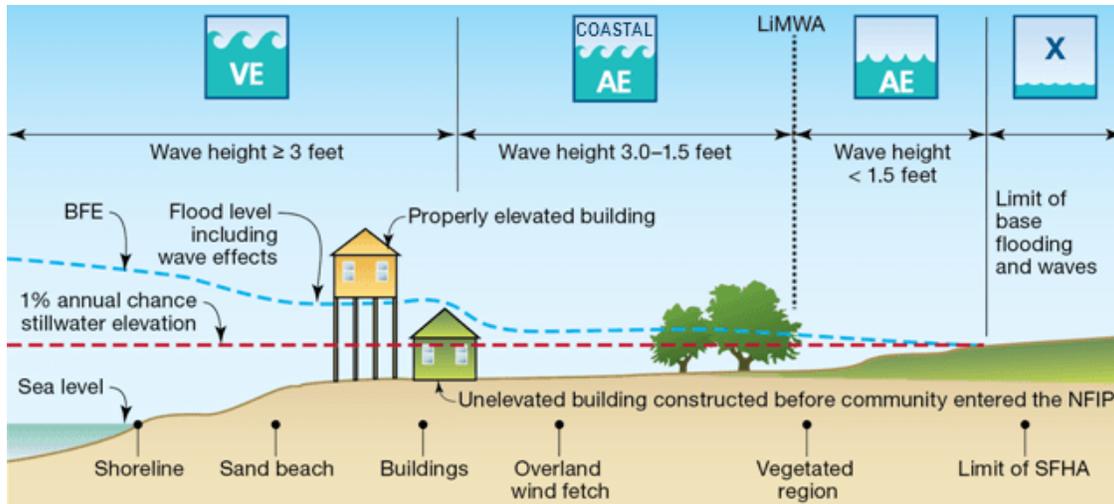


Figure 8: Conceptual Model of FEMA Flood Zones (Source: FEMA)

FEMA flood zones in the City of Groton are shown in Figure 9. The most recent Digital Flood Insurance Rate Map (DFIRM; effective August 5, 2013) for the City was used in this risk assessment.

2.3.2 Hurricane Storm Surge

The US Army Corps of Engineers has created Sea, Lake, and Overland Surge from Hurricanes (SLOSH) maps for each Connecticut coastal community. The SLOSH model, developed by the National Weather Service, maps expected flood extents caused by storm surge associated with multiple hurricane magnitudes. The model accounts for atmospheric pressure, size, forward speed, and storm track data for historical, hypothetical, and predicted hurricanes.

This resource provides an additional tool beyond FEMA maps for evaluating storm surge flood exposure. Note that FEMA mapping accounts for precipitation-caused flooding, which SLOSH maps do not. Hurricane inundation maps for the City of Groton are presented in Figure 10.

2.3.3 Sea Level Rise

The impact of projected sea level rise on both storm surge and daily tides was evaluated using the Connecticut Sea Level Rise and Storm Surge Viewer developed by the Connecticut Institute for Resilience & Climate Adaptation (CIRCA). This tool depicts flood extents given 20 inches of sea level rise and the following tidal conditions:

- ❖ Mean Higher-High Water (average highest daily high tide) – see Figure 11
- ❖ 10-Year Flood Event (10% annual-chance flood) – map included in Appendix B
- ❖ 30-Year Flood Event (3% annual-chance flood) – see Figure 12
- ❖ 100-Year Flood Event (1% annual-chance flood) – map included in Appendix B

CIRCA’s report (O’Donnell, 2019) on Connecticut sea level rise provided the basis for the sea level rise projection chosen. The planning threshold of 20 inches (0.5 meters) of sea level rise, considered likely by 2050, was formalized in 2018 in Connecticut Public Act 18-82, *An Act Concerning Climate Change Planning and Resiliency*.



Floodzones

-  Zones A and AE; 1% annual chance flood hazard
-  Zone AE; Floodway; 1% annual chance flood hazard
-  Zone VE; 1% annual chance flood hazard
-  Zone X; 0.2% annual chance flood hazard

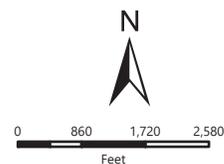


FEMA, State of Connecticut, Maxar



99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

CITY WIDE
FEMA FLOOD HAZARD AREAS
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 2,579'

DATE 3/30/2022

141.12536.00015
PROJ. NO.

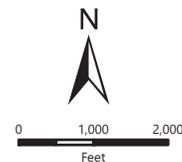
FIG. 9

	Category 1
	Category 2
	Category 3
	Category 4



99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

CITY WIDE
HURRICANE SURGE INUNDATION
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 2,558'
DATE 3/23/2022
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FIG. 10



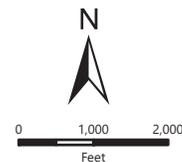
Mean Higher High Water Plus 20 inches SLR

- Low-lying Areas
- Inundated Areas



99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

CITY WIDE MEAN HIGHER HIGH WATER
 WITH 20 INCHES SEA LEVEL RISE
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 2,558'
 DATE 3/23/2022
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 PROJ. NO.

FIG. 11

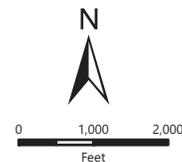


 Inundated Areas



99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

CITY WIDE THIRTY-YEAR FLOOD
WITH 20 INCHES SEA LEVEL RISE
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 2,558'
DATE 3/24/2022
141.12536.00015
PROJ. NO.

FIG. 12

2.3.4 Erosion

Erosion can be caused by waves or flowing water, and can occur during flood events or under normal conditions. Importantly, erosion can impact community features located above flood levels by undermining the ground below them; therefore, reviewing flood zone maps alone is not sufficient to understand this additional hazard.

Erosion hazards were evaluated using two sources:

- ❖ The Connecticut Erosion Susceptibility Map (CT DEEP, 2005; https://cteco.uconn.edu/guides/Erosion_Susceptibility.htm)
- ❖ The Connecticut Shoreline Change Analysis Database (O'Brien, et. al. 2014; <https://shorelinechange.uconn.edu>)

The Connecticut Erosion Susceptibility GIS layer, published by the Connecticut Department of Energy and Environmental Protection (DEEP) in 2005, combines soil type and surficial geology to classify soil erosion susceptibility as follows:

Most Susceptible to Erosion
Highly Susceptible to Erosion
Surficial Materials Susceptible to Erosion
Soils Susceptible to Erosion

Areas with “Surficial Materials Susceptible to Erosion” and “Soils Susceptible to Erosion” are identified within the City of Groton; no areas classified as “Highly Susceptible to Erosion,” and only one small area classified as “Most Susceptible to Erosion,” are found within the City.

The Connecticut Shoreline Change Analysis program analyzed how the state’s shoreline changed between the late 1800’s and 2006 based on aerial imagery and detailed shoreline maps. A GIS dataset was produced showing net shoreline change, as well as short-term and long-term average shoreline change rates.

Figure 13, on the following page, shows a map of the City with both Connecticut Erosion Susceptibility and Connecticut Shoreline Change Analysis data mapped.

2.3.5 Impervious Surfaces

Evaluation of impervious surface distribution across the City can provide valuable insight into both the occurrence of stormwater runoff flooding and extreme heat events.

Impervious surfaces are those that water cannot penetrate, such as concrete and asphalt, causing increased rates of runoff that accumulate pollutants and increase in temperature before reaching a wetland or waterway. Figure 14 depicts the differences between natural ground cover and impervious surface on the local water cycle. This increase in stormwater volume can lead to street or property flooding, cause disruptions and damage, and can overwhelm drainage systems.





Short-Term Shoreline Change Rate

- > 0.5 m/yr Erosion
- > 0.0 m/yr Erosion
- < 0.5 m/yr Accretion
- < 1.0 m/yr Accretion
- < 5.0 m/yr Accretion
- > 5.0 m/yr Accretion

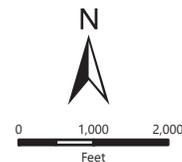
Erosion Susceptibility

- Most Susceptible to Erosion
- Highly Susceptible to Erosion
- Surficial Materials Susceptible to Erosion
- Soils Susceptible to Erosion



99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

CITY WIDE
 EROSION SUSCEPTIBILITY
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 2,558'
 DATE 3/24/2022
 141.12536.00015
 PROJ. NO.

FIG. 13

These sealed surfaces also absorb sunlight (unless light-colored materials or coatings are used to mitigate this effect), and as they heat up, they warm the surrounding air, contributing to the urban heat island effect.

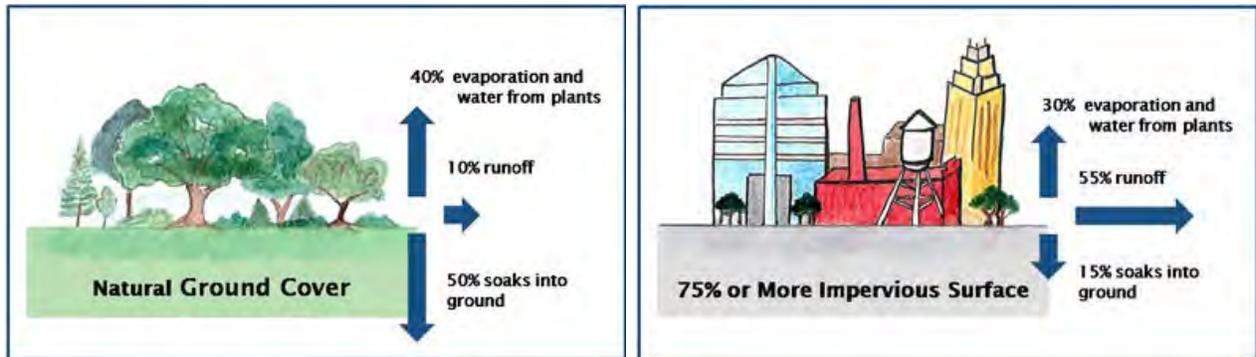


Figure 14: Effects of Impervious Surfaces on Infiltration, Evaporation, and Runoff
 From: city of Durham, NC. <https://durhamnc.gov/864/Impervious-Surface>

For this assessment, the CT DEEP Connecticut Environmental Conditions Online (CT ECO) 2015 Land Cover GIS layer was used (see Figure 16).

2.3.6 Urban Heat Island Effect

A more direct method for evaluating localized heat variations is available through the Trust for Public Lands “Urban Heat Island Severity for U.S. Cities” GIS dataset. Figure 15 demonstrates how temperatures are relatively higher in urban centers than in areas with other, less developed areas. The map in Figure 17 was developed using satellite imagery (Landsat 8 Imagery Band 10 data; ground-level thermal sensor) collected during the summers of 2019 and 2020. Areas within each evaluated city that are

hotter than the average temperature of the City as a whole are identified, with relative heat severity values assigned on a scale of one (temperatures are slightly above the City average) to five (temperatures are significantly above the mean for the City). This relative ranking allows for evaluation of localized hot-spots.

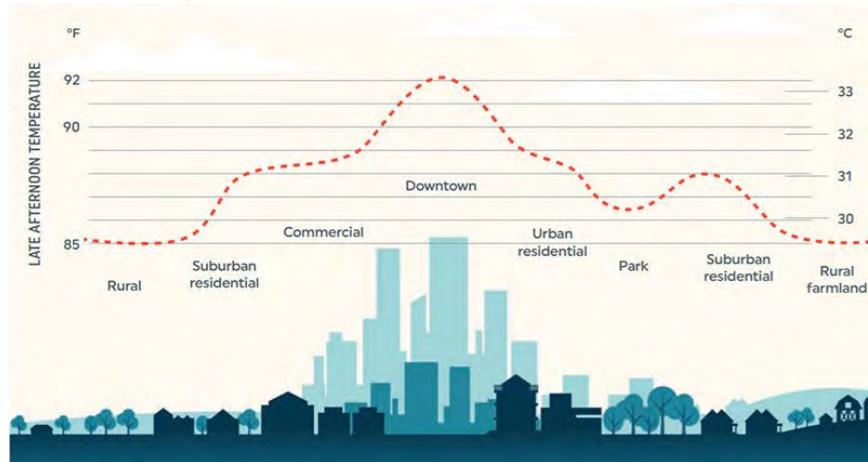
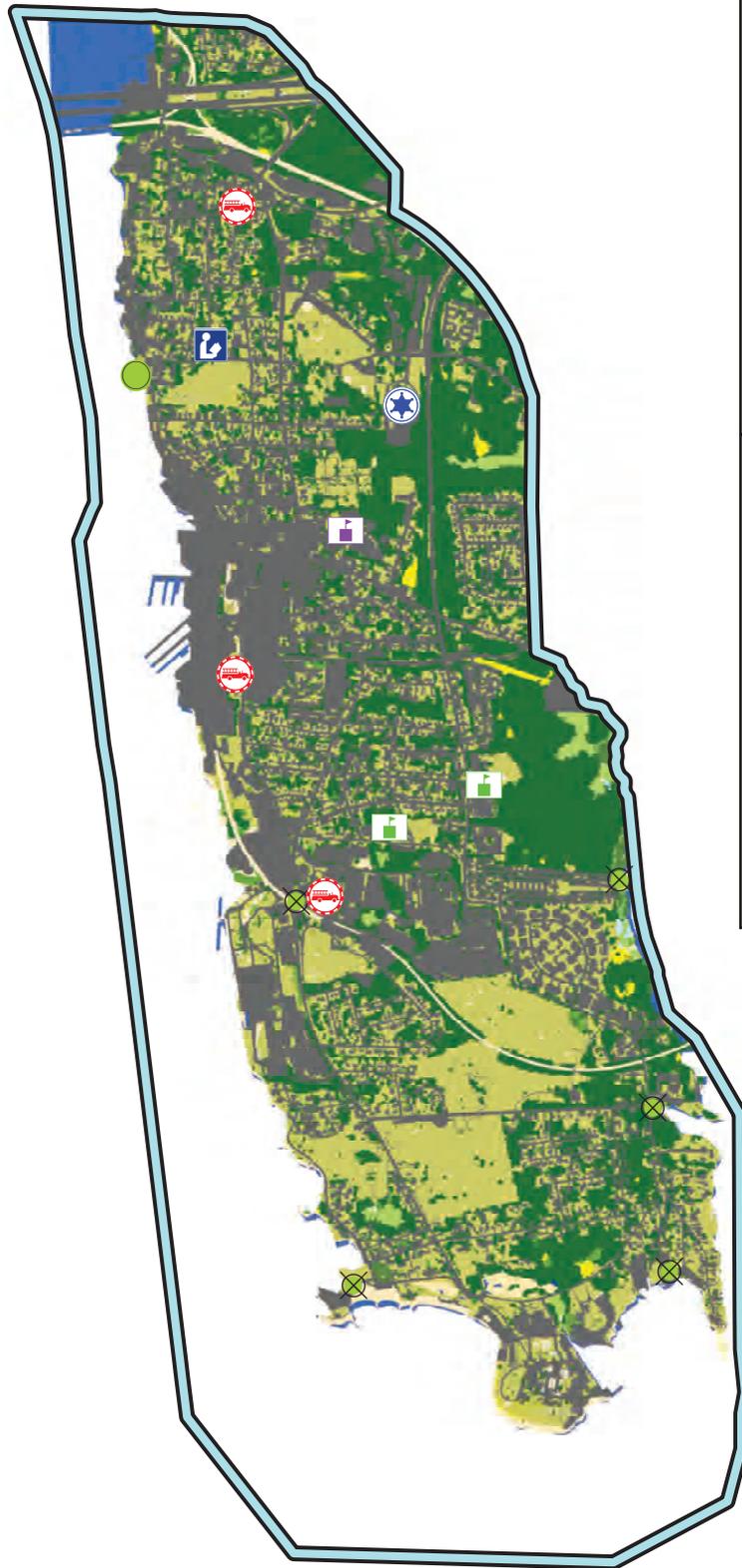


Figure 15: Urban Heat Island Profile.
 From: Urban Land Institute





- Impervious
- Developed Open Space
- Grassland
- Mixed Forest
- Scrub/Shrub
- Palustrine Forested Wetland
- Palustrine Scrub/Shrub Wetland
- Palustrine Emergent Wetland
- Estuarine Scrub/Shrub Wetland
- Estuarine Emergent Wetland
- Unconsolidated Shore
- Bare Land
- Open Water
- Palustrine Aquatic Bed



99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

CITY WIDE
 LAND COVER

CITY OF GROTON COMMUNITY RESILIENCE PLAN

295 Meridian Street
 Groton, CT 06340

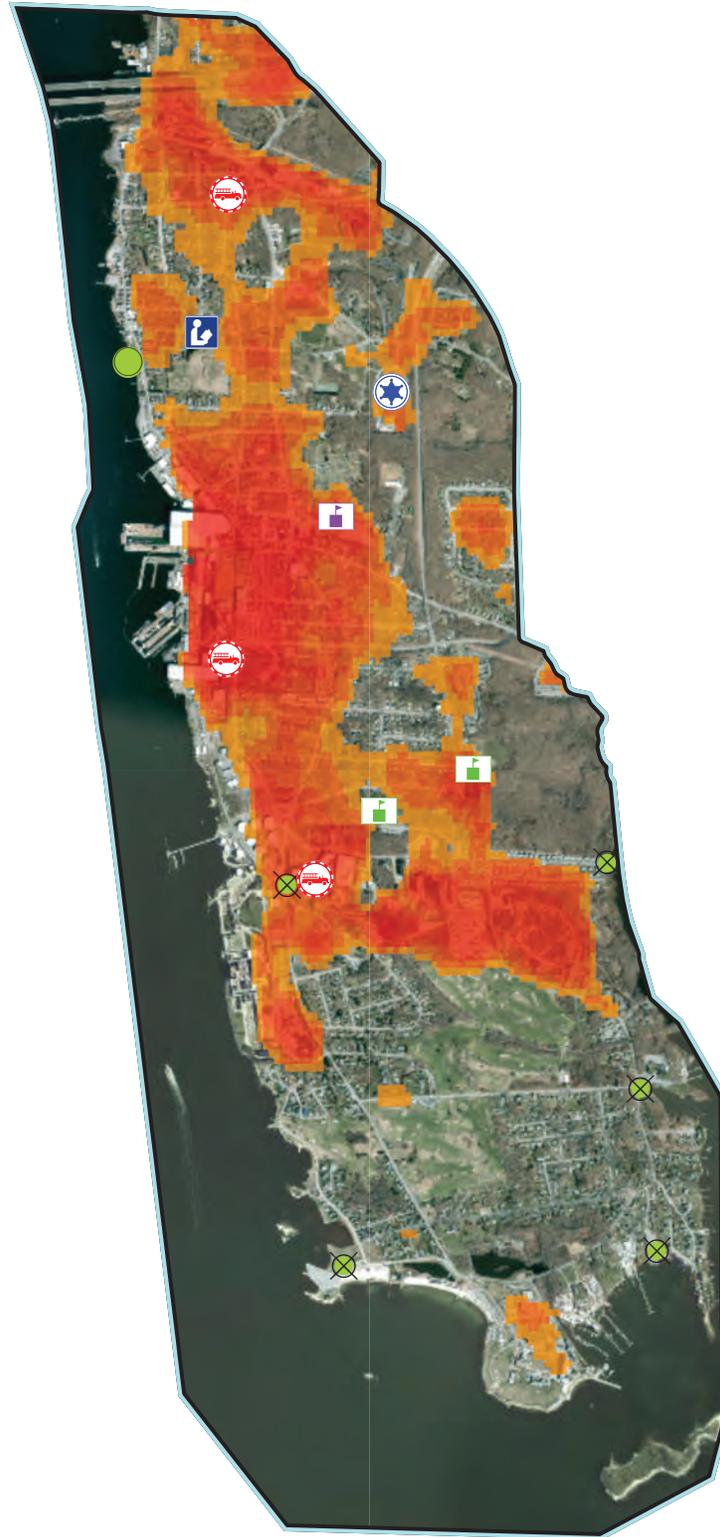


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DATE 3/24/2022

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FIG. 16

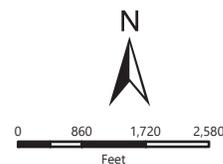


State of Connecticut, Maxar



99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

CITY WIDE
 URBAN HEAT ISLAND EFFECT
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 2,583'
 DATE 3/30/2022
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 PROJ. NO.

FIG. 16

3 Climate Risk Assessment

This section describes the identification and classification of vulnerabilities, exposure levels, and degree of risk faced by the City of Groton from climate change. A comprehensive Climate Risk Assessment is included in Appendix B.

3.1 Vulnerability Assessment

The vulnerability assessment identified assets and resources present throughout the City of Groton.

3.1.1 Vulnerability Assessment Methodology

The level of sensitivity and the adaptive capacity of different parts of the City was evaluated through analysis of social and physical infrastructure across six sectors. The specific categories of vulnerability assessed were:

- ❖ **Social Vulnerability⁴:** According to the Centers for Disease Control and Prevention (CDC), social and economic factors can affect the capacity of individuals to anticipate, confront, repair, and recover from climate hazards (CDC, 2021; Flanagan, et. al., 2018).
- ❖ **Residential Vulnerability⁵:** This category provides a measure of how the people who live in the City of Groton will be directly affected by climate hazards; the more individuals who live in a given area, the more people present to experience the impacts of a hazard event. Additionally, damages that occur to residences will directly impact the lives and finances of City of Groton citizens.
- ❖ **Commercial Vulnerability⁶:** Climate hazards may cause direct damage to business facilities, interrupt operations through loss of utility services or supply chain function, and disrupt client engagement through loss of access or decreases in visitor numbers. Businesses serve essential roles in supporting a community, and business recovery following a climate hazard event is often a first step to broader community recovery (Kim, 2018; McKay, 2018).

⁴ CDC Social Vulnerability Index (SVI) factors extracted from the U.S. Census 2019 American Community Survey (ACS) 5-year estimates dataset. Factors were: Per-Capita Annual Income, Residents with Limited English, Residents with a Disability, Households without a Vehicle Available, Percent Non-White.

⁵ Housing density and occupancy sourced from building footprint GIS files (City of Groton, Southeastern Connecticut Council of Governments), parcel GIS files (Town of Groton GIS database), and Google Earth.

⁶ Commercial users identified using parcel GIS shapefiles from the Town of Groton, Google Earth, City of Groton 2019 Plan of Conservation and Development, municipal staff input, and field reconnaissance.



- ❖ **Critical Facilities and Infrastructure Vulnerability⁷:** Critical facilities and infrastructure assets are those essential to municipal operations, emergency services, and utility providers. Climate hazards may cause direct damage to those assets, and may interfere in the City’s capacity to engage in recovery efforts; they can even lead to cascading impacts and damages. Assets considered include Emergency Services, Care Facilities, Municipal Administration and Operations Facilities, and Utilities.
- ❖ **Community Resource Vulnerability⁸:** Sites and services important to community identity and function play an essential role in supporting the City’s community, identity, health, and wellness. Assets considered include: Schools and Daycare Centers; Religious Sites; Historic and Cultural Resources; and Community Organizations.
- ❖ **Natural System Vulnerability⁹:** Natural systems provide important benefits to quality of life and community character while also serving to mitigate impacts from many climate hazards. Natural systems evaluated in this risk assessment include: Forests and Trees; Tidal Wetlands; Beaches; and Managed Parks and Open Space.

These six sectors were evaluated to determine the types of assets and resources present throughout the City. In the next section, the analysis performed to determine the level of exposure the City has to climate hazards is discussed. The risk assessment was conducted by evaluating the intersection of vulnerabilities and exposure.

⁷ Critical facility locations sourced from U.S. Department of Homeland Security. Roadway GIS shapefiles sourced from Connecticut Department of Transportation. Other essential facilities and infrastructure assets identified using input from city staff and community stakeholders.

⁸ Community resources identified using Google Earth and input from city staff and community stakeholders.

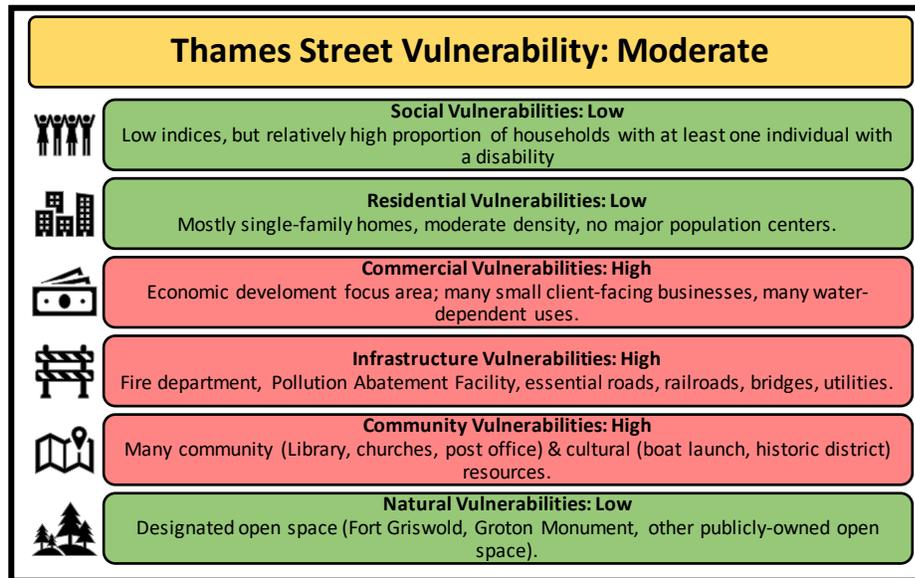
⁹ Natural systems identified using 2016 CT ECO land cover maps and aerial imagery.



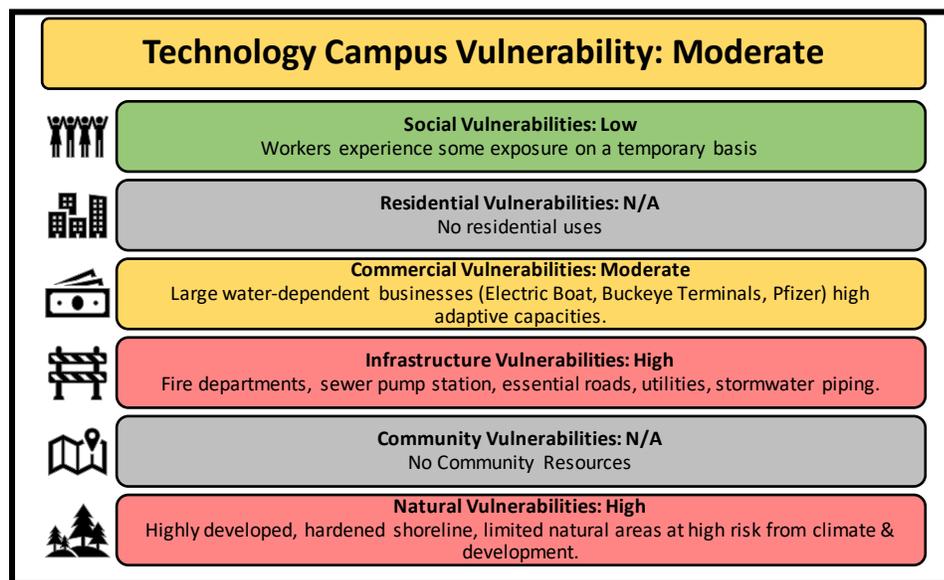
3.1.2 Vulnerability Assessment Results

Graphics summarizing the results of the vulnerability assessment for each Assessment Zone (AZ) across each of the six sectors evaluated are presented below.

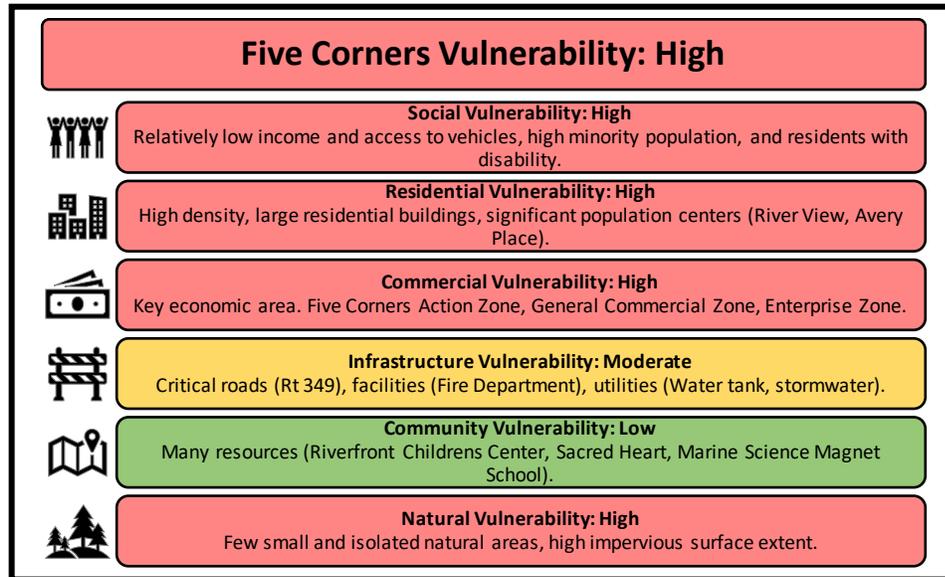
The Thames Street AZ is characterized by commercial and community resources important to the local economy and community identity, as well as a number of critical facilities, utilities, and pieces of infrastructure. Moderate-density residential areas tend to be single-family homes.



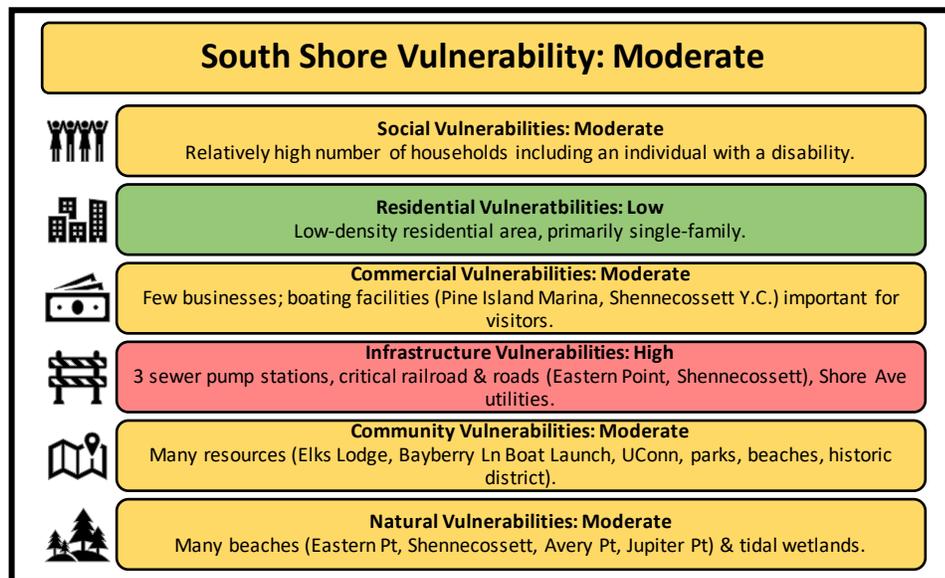
The Technology Campus AZ does not include any residential uses or community resources. It includes large commercial properties that have high exposure to risks, but also have significant economic resources to facilitate adaptation. Critical facilities and infrastructure are present, and the few natural areas located in the AZ are highly vulnerable.



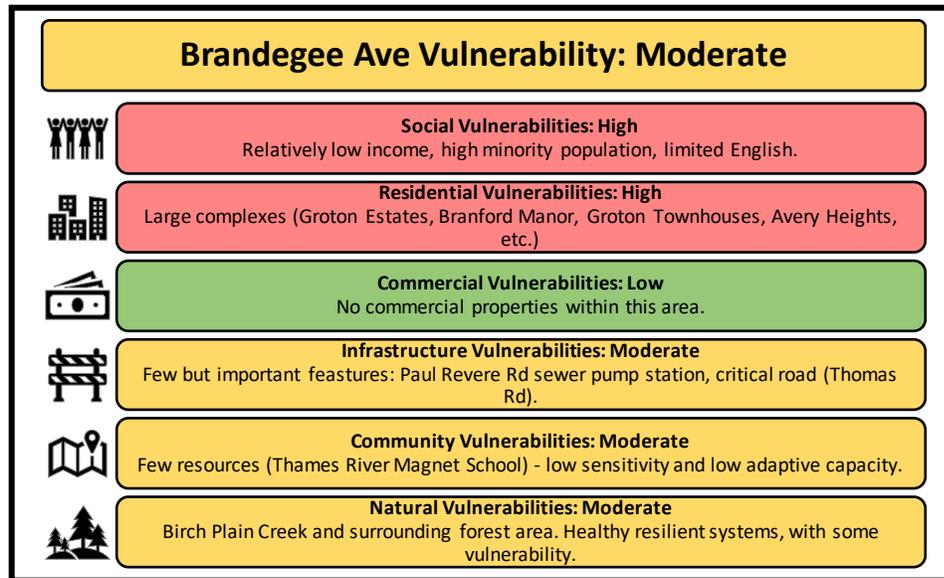
The Five Corners AZ is densely developed, and includes significant residential, commercial, and community uses that are vulnerable to climate change. The community resources in the AZ also provide the area with adaptive capacity, reducing vulnerability.



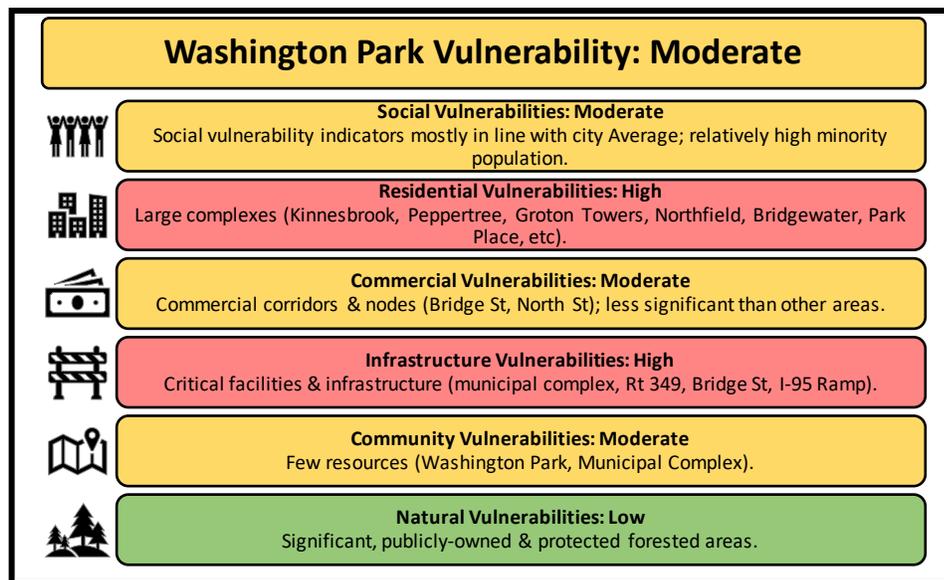
The South Shore AZ has relatively low social vulnerabilities, low density residential uses, few commercial operations, and healthy natural systems. There are a small number of water-dependent businesses, which by their nature have relatively high vulnerabilities, especially to flooding. There are many community resources that provide adaptive capacity in the form of gathering spaces or local resources, while also being vulnerable to climate change themselves. The highest vulnerability is to the numerous critical utility and transportation assets located in the AZ.



The **Brandegee Avenue AZ** includes significant population centers within large apartment complexes, and has relatively high social vulnerability indices; these two factors drive the area’s climate vulnerability. It also contains large, forested areas and a tidal portion of Birch Plain Creek.



The **Washington Park AZ** contains the important community resource of Washington Park, the Municipal Facility, and a number of large apartment complexes. Critical roadways connecting the City to neighboring communities and regional transportation routes pass through this AZ.



The densely-developed City of Groton has relatively high climate hazard vulnerability levels. High population levels concentrated within a number of large apartment complexes present high “residential vulnerability” levels, and the large number of small local businesses and water-dependent businesses represent high commercial vulnerability. Social vulnerability is a significant



factor in some areas of the City. Infrastructure vulnerability is significant throughout Groton City. The highest level of natural system vulnerabilities in the City are in the highly-developed areas where such systems are already stressed.

The Five Corners AZ has a high density of residential uses and is an important economic development zone for the City; it has the highest level of vulnerability within the City.

3.2 Exposure Analysis

Exposure levels to a variety of climate hazards were evaluated throughout the City of Groton.

3.2.1 Exposure Analysis Methodology

Climate hazard exposure was assessed using the sources discussed in Section 2. The four categories of climate hazard evaluated were:

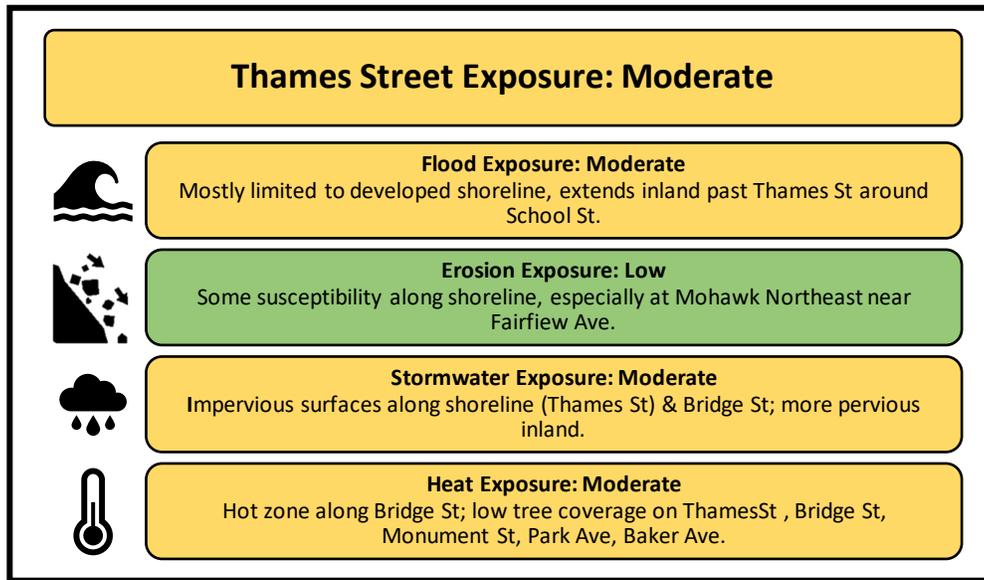
- ❖ **Flood Hazard:** coastal or riverine flooding; based on FEMA, hurricane surge, and sea level rise maps.
- ❖ **Erosion Hazard:** exposure to erosion that may undermine an area or cause damaging deposition of eroded material onto an area; based on the presence of soils susceptible to erosion as well as historic shoreline change.
- ❖ **Stormwater Flood Hazard:** flooding in urban areas away from coastal or riverine flood sources, caused by runoff from precipitation; based on impervious surface extent and other land cover considerations.
- ❖ **Heat Hazard:** extreme heat that may impact health or cause other damage; based on land cover, the presence of tree cover for shading, and mapped urban heat island effect.



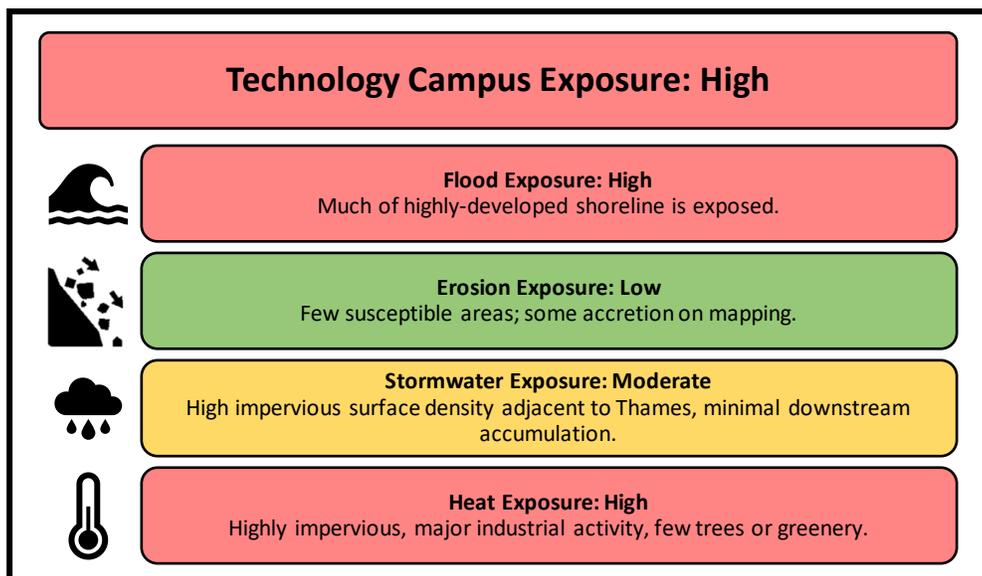
3.2.2 Exposure Analysis Results

Graphics summarizing the results of the exposure assessment for each Assessment Zone are presented below.

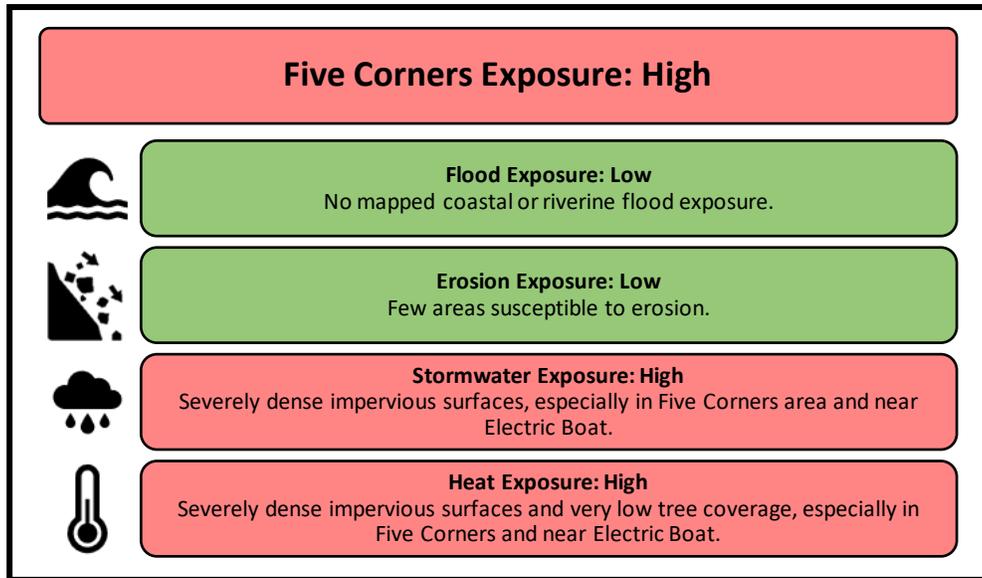
The Thames Street AZ has moderate exposure to coastal flooding, concentrated along the shoreline. It also has moderate exposure to stormwater flooding and extreme heat due to the relatively large amount of impervious surfaces and low street-tree coverage.



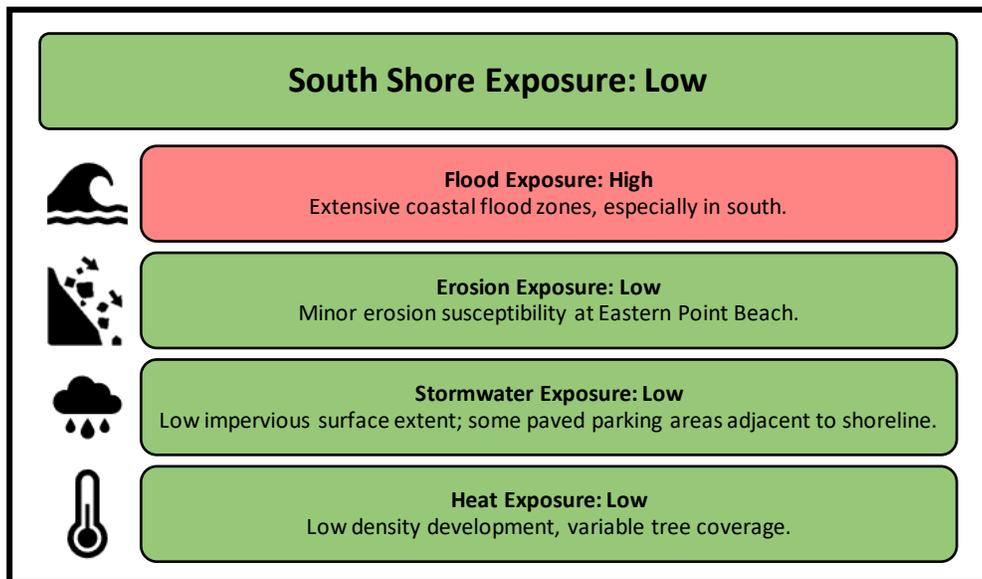
The Technology Campus AZ has high exposure to coastal flooding that affects nearly the entire heavily-developed shoreline. Industrial uses and widespread impervious surface coverage create a high level of exposure to extreme heat. Significant stormwater runoff is also produced from these impervious surfaces; however, the area's location adjacent to the Thames means that accumulation of that runoff is of less concern, leading to a Moderate ranking for stormwater exposure.



The Five Corners AZ has low flood and erosion exposure, but, due to its dense development and widespread impervious surface coverage, there is high exposure to stormwater flooding and extreme heat.



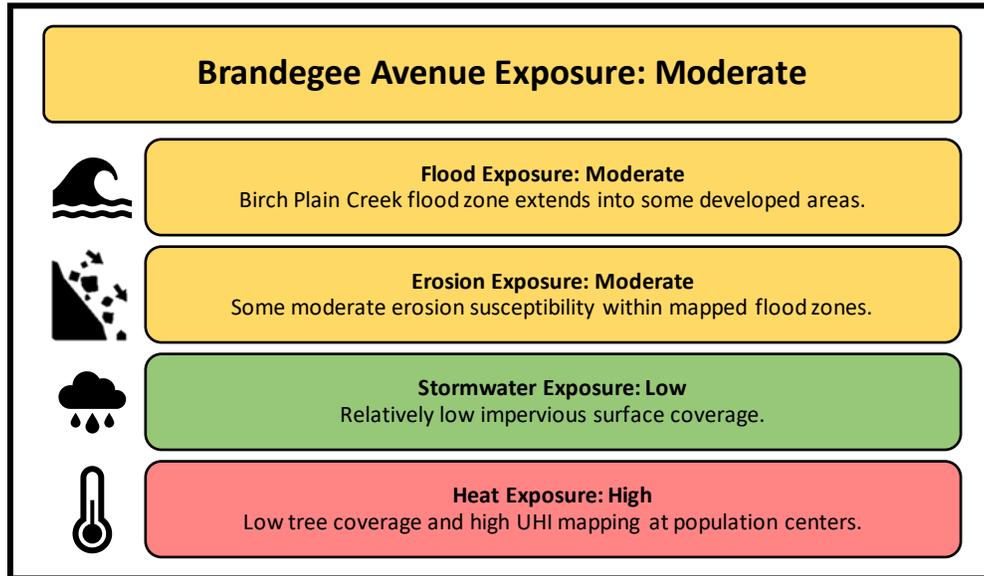
The South Shore AZ has the most widespread mapped coastal flood exposure extent. All other climate hazard exposure levels are ranked as low.



The Brandegee Avenue AZ hazard with the most exposure concern is extreme heat. The high-population residential areas have minimal shade tree coverage; UHI mapping also shows that heat



is a concern in those parts of the AZ. Flood and erosion exposure are moderate and are driven by Birch Plain Creek flooding.



The Washington Park AZ has low climate hazard exposure, with some exposure to extreme heat based on UHI mapping and low tree coverage.



Coastal flood hazard exposure is a concern along most of the City of Groton shoreline. The highest exposure levels are found at the Technology Campus and the South Shore. Heat exposure and stormwater flooding tend to overlap within highly-developed and impervious areas such as the Technology Campus and Five Corners. The Technology Campus AZ and the Five Corners AZ have the highest overall levels of exposure. The City overall has only moderate exposure to climate hazards.



3.3 Climate Risk Assessment

The vulnerability assessment and exposure analysis were combined to assess risk within the City of Groton.

3.3.1 Climate Risk Assessment Methodology

Climate risk for the City was determined by combining the results of the vulnerability assessment and the exposure analysis. Figure 18, along with the list below, demonstrate how vulnerability and exposure levels were combined to determine risk:

- ❖ **High** Vulnerability and **High** Exposure = **High** Risk
- ❖ **High** Vulnerability and **Low** Exposure = **Moderate** Risk
- ❖ **Low** Vulnerability and **High** Exposure = **Moderate** Risk
- ❖ **Low** Vulnerability and **Low** Exposure = **Low** Risk

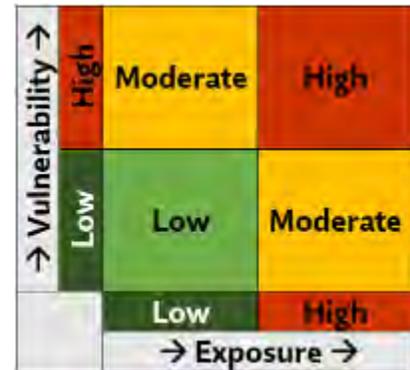


Figure 18: Illustrative Vulnerability-Exposure Risk Matrix

Climate hazard vulnerability and exposure throughout the City were determined in the preceding section.

The following section presents the results of the climate vulnerability assessment, exposure analysis, and subsequent climate risk assessment.

3.3.2 Climate Risk Assessment Results

This section shows the Climate Risk Assessment results for each AZ. Climate Risk is also summarized for the entire City.

Thames Street Risk Summary

Table 1 below summarizes the risk assessment results for the Thames Street AZ.

Table 1: Thames Street Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	Moderate	Moderate	Low
Residential	Low	Low	Moderate	Moderate	Low
Commercial	High	Moderate	Moderate	Moderate	High
Infrastructure	High	Moderate	High	Low	High
Community	High	Low	Moderate	Low	Moderate
Natural	Low	Low	Low	Low	Low
Overall Risk	Moderate	Low	Moderate	Moderate	Moderate

The overall risk level for the Thames Street AZ is moderate. Higher risks face commercial and infrastructural assets, and community resources. Risks are located along the Thames Street corridor, which is susceptible to all four identified climate hazards. The Bridge Street corridor is another area of elevated risk, primarily from heat and stormwater.



Technology Campus Risk Summary

Table 2 below summarizes the risk assessment results for the Technology Campus AZ.

Table 2: Technology Campus Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	Low	Moderate	Low
Residential	N/A	N/A	N/A	N/A	N/A
Commercial	High	Moderate	Moderate	High	High
Infrastructure	High	Low	Moderate	Moderate	Moderate
Community	N/A	N/A	N/A	N/A	N/A
Natural	High	Low	High	High	High
Overall Risk	High	Low	Moderate	High	High

The Technology Campus AZ has a high level of risk. The primary hazards are flooding from the Thames River and extreme heat. Stormwater flooding also poses a risk due to the high level of impervious surface coverage; however, representatives from Electric Boat report that stormwater flooding has not been a significant problem on the campus itself because the company has sufficient stormwater drainage infrastructure to avoid localized flooding.

The role this AZ plays as an economic driver is a primary concern. The resilience of the open spaces and natural resources in this area – especially considering the role they can play mitigating heat and stormwater runoff hazards – is another top concern.

Five Corners Risk Summary

Table 3 below summarizes the risk assessment results for the Five Corners AZ.

Table 3: Five Corners Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	High	High	High
Residential	Low	Low	Moderate	High	Moderate
Commercial	Low	Low	High	High	High
Infrastructure	Low	Low	High	Moderate	Moderate
Community	Low	Low	Low	Moderate	Low
Natural	Low	Low	Moderate	High	Moderate
Overall Risk	Low	Low	High	High	High

The Five Corners AZ has a relatively high risk-level. Although risks from flooding and erosion are low due to the low level of exposure, the high risks presented by stormwater flooding and extreme heat events are of particular concern. Stormwater and heat risks are given extra weight in the overall risk analysis because of the significant impacts on the public health and economic sustainability of the entire city. This results in an overall risk of high, rather than moderate.



South Shore Risk Summary

Table 4 below summarizes the risk assessment results for the South Shore AZ.

Table 4: South Shore Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Moderate	Low	Low	Low	Low
Residential	High	Low	Low	Low	Moderate
Commercial	Moderate	Low	Low	Low	Low
Infrastructure	High	Moderate	Low	Low	Moderate
Community	High	Low	Low	Moderate	Moderate
Natural	High	Moderate	Moderate	Moderate	Moderate
Overall Risk	High	Low	Low	Low	Moderate

Climate Risks in the South Shore AZ are relatively low. Coastal flood risks, however, are relatively high due to the large area susceptible to coastal flooding. The low-density and high socioeconomic status of the area means overall vulnerabilities are relatively low. The area does host important natural resources that may be at risk from rising seas and coastal flood events.

The primary risks facing this AZ are flood risks to residential properties, important infrastructure and transportation networks, community resources, and natural systems.

Brandegee Avenue Risk Summary

Table 5 below summarizes the risk assessment results for the Brandegee Avenue AZ.

Table 5: Brandegee Avenue Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	High	Moderate	Low	High	High
Residential	Moderate	Moderate	Low	High	Moderate
Commercial	Low	Low	Low	Low	Low
Infrastructure	Moderate	Moderate	Low	Moderate	Moderate
Community	Moderate	Low	Low	Moderate	Low
Natural	Moderate	Low	Moderate	Low	Moderate
Overall Risk	Moderate	Moderate	Low	High	Moderate

The Brandegee Avenue AZ has a moderate level of risk from climate hazards. Overall risk is moderate. The AZ has a high level of Social Vulnerability, and relatively high exposure to heat hazards. The high-population centers and socially-vulnerable communities in this AZ face elevated risks from climate hazards.

Birch Plain Creek itself is an essential natural resource for the community and the region. This ecosystem is at-risk, particularly from sea level rise, coastal flooding, and stormwater pollution. Birch Plain Creek is also a resource that mitigates risk levels in this area.



Washington Park Risk Summary

Table 6 below summarizes the risk assessment results for the Washington Park AZ.

Table 6: Washington Park Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	Low	Moderate	Low
Residential	Low	Low	Low	Moderate	Low
Commercial	Low	Low	Low	Moderate	Low
Infrastructure	Moderate	Low	Moderate	Moderate	Moderate
Community	Moderate	Low	Moderate	Moderate	Moderate
Natural	Low	Low	Low	Moderate	Low
Overall Risk	Moderate	Low	Moderate	Moderate	Moderate

The large apartment complexes, Municipal Campus, and important infrastructure raises the overall risk level in this AZ “moderate,” despite the relatively low levels of exposure to climate hazards. The primary hazard of concern is extreme heat, followed by stormwater flooding.

3.3.3 Climate Risk Summary

This report identifies climate risks across different sectors and geographies within the City of Groton. The results can be used to identify, develop, and prioritize climate resilience actions and opportunities. Six key risk-factors identified through this assessment are:

1. Stormwater Flooding and Impervious Surfaces

The primary hazard for the City, based on this study, is stormwater-related flooding, driven by the large amount of impervious surface. The level of exposure to stormwater flooding will rise as climate change leads to increased annual precipitation and extreme precipitation events. Stormwater flooding exposure will increase further if impervious surface area increases within and around the City. The primary AZs at risk from stormwater flooding are Five Corners, Thames Street, and the Technology Campus, especially at Electric Boat due to the high level of impervious surface coverage there. As noted above, Electric Boat representatives report that stormwater flooding is not a challenge on site.

2. Extreme Heat and Lack of Shade

Extreme heat is a hazard of concern. Elevated risk areas in the City are those with high-density development, a large amount of impervious surface, few trees and vegetation, and a lack of access to shade. Highest-risk areas are the Five Corners AZ, The Technology Campus AZ, and at the large housing complexes in the Brandegee Avenue AZ.

Extreme heat tends to have disproportionately significant negative health effects on individuals with low incomes, lower-quality housing, and preexisting health issues. The City has a large population of socially-vulnerable residents, and will need to pay particular attention to this risk.



3. Local Business Exposure to Climate Risks

Local businesses face significant risks from climate hazards. Flooding is a particular concern along the Thames River. Small local businesses in the Thames Street AZ are subject to property damage and business disruption from flood events. Large industrial uses in the Technology Campus AZ, like Electric Boat, Pfizer, and Buckeye Terminals, have high exposure as well. Disruption or damage to these businesses can result in cascading negative impacts to the community and local economy.

4. South Shore Flooding

Coastal flooding is a concern for the southern portion of the City. Risks are highest for the mostly single-family residential properties in this area. In addition to posing a threat to homeowners, this risk may be a concern for the City's tax-base. Coastal flooding also threatens some of the sensitive coastal habitats on the South Shore, including Birch Plain Creek.

5. Vulnerable Roadways and Transportation Network

Some of the key roadways throughout the City, including Thames Street, Eastern Point Road, Shennecossett Road, and Thomas Road, are vulnerable to flooding. Flooding or erosion of these roads pose a risk of isolation or delayed access and egress for residents and emergency services. Additionally, public transportation may be limited and not all residents have equal access to mobility or important resilience resources such as comfort stations (see Section 4.2.3).

6. Vulnerable Population Exposure

Socially-vulnerable populations exist throughout the City, with higher concentrations in the Brandegee Avenue AZ and Five Corners AZ. These populations face higher levels of risk to climate hazards and disruptions because of their elevated vulnerabilities, and particular care is needed to support them.



4 Community Resilience

To respond to the risks the City of Groton is facing, a community resilience plan is warranted that includes a suite of actions across hazards, geographies, and sectors. The six key risk-factors identified through the Risk Assessment drove the development of the seven targeted **Resilience Objectives** listed below. The first six objectives directly respond to the six identified risk factors. The final objective focuses on municipal assets and operations, encouraging the City of Groton to lead by example and take swift action.

1. Reduce Stormwater Flooding from Impervious Surfaces
2. Mitigate Increasing Urban Heat Island Effect Impacts
3. Enhance Resilience of Local Businesses
4. Create a Flood-Resilient Shoreline
5. Improve Resilience of the Transportation Network
6. Increase Resilience of Socially Vulnerable Populations
7. Lead by Example – Municipal Resilience Actions

Within each Resilience Objective, a series of **Recommendations** is presented; these Recommendations will form the core of the City's resilience strategy moving forward, driving decision-making around planning and implementation.

Each Recommendation includes a Toolbox, listing some of the **Actions** that the City can take to implement the Recommendation. The City may choose to use some of the actions listed, or, as this Plan is meant to be a living document in which the City's resilience continues to evolve, it may identify additional actions in the future.



4.1 RESILIENCE OBJECTIVE: REDUCE STORMWATER FLOODING FROM IMPERVIOUS SURFACES

A primary climate change concern for the City of Groton is an increasing risk of stormwater flooding exacerbated by the extensive impervious surface areas within the City. Runoff from parking lots, roads, and buildings is already known to flood the intersection at Thames Street and Eastern Point Road, has required the City to perform major upgrades to its stormwater drainage infrastructure, and has damaged Electric Boat property. As climate change leads to more frequent severe-precipitation events, the risk to the City from such events will rise, and even drainage infrastructure that has been upgraded in recent years may see its capacity exceeded.

To reduce the risk of stormwater flooding, the following recommendations are put forth:

- 1. Conduct Comprehensive Stormwater Runoff Studies**
- 2. Encourage Reduction of Stormwater Runoff from Private Property**
- 3. Fund Municipal Stormwater Reduction Efforts**
- 4. Decrease Impervious Surface Extent**
- 5. Implement Retention, Detention, and Infiltration Techniques**
- 6. Increase Capacity of Stormwater Infrastructure**

4.1.1 Recommendation: Conduct Comprehensive Stormwater Runoff Studies

Conduct comprehensive studies and investigations to fully characterize stormwater sources and flow paths, catch basin watersheds, and the networks, capacities, and conditions of the City’s drainage system. Fully understanding the stormwater systems and stormwater runoff patterns will allow the City to effectively pursue runoff reduction and flood mitigation projects.

TOOLBOX: Conduct Comprehensive Stormwater Runoff Studies	
Action	Description
Conduct a Stormwater Hydraulics and Hydrology Study of Five Corners	Conduct a detailed hydrological study of the Five Corners area in order to fully understand the sources, pathways, and destinations of stormwater runoff. The objective of this study will be to identify appropriate stormwater flooding mitigation measures, and the most effective locations for implementation of those measures.
Create a Digital Map of the City’s Drainage Systems	Develop a digitized map of the City’s drainage infrastructure in GIS to facilitate improved analysis of limitations and needs, as well as opportunities for improvement.
Identify Drainage Hot-Spots	Identify locations where the existing stormwater drainage infrastructure is insufficient or is operating incorrectly. Examples may include locations where drainage capacity is insufficient, where grading or alignment is incorrect, or where degraded or missing tide gate structures allow surcharging at high tides.



4.1.2 Recommendation: Encourage Reduction of Stormwater Runoff from Private Property

Encourage private property owners to reduce runoff. Much of the impervious surface within the City of Groton is located on private property. Reducing the risk of flooding from stormwater will require assistance from those property-owners.

TOOLBOX: Encourage Reduction of Stormwater Runoff from Private Property	
Action	Description
Conduct Stormwater Runoff Reduction Education Campaigns	Perform community education around how individuals can help mitigate stormwater flooding (from installing a raingarden to avoiding dumping debris in storm drains)
Provide Stormwater Reduction Technical Assistance	Proactively offer technical assistance to private property owners on how to reduce stormwater runoff, including permeable pavement use, installing rain barrels, planting rain gardens, and more.
Provide Property-Tax Credits for Runoff Reduction	Provide property-owners with property-tax credits in exchange for implementation of runoff reduction techniques. These credits would reduce the property-tax owed by an owner.
Provide Permitting "Credits" for Runoff Reduction	Provide property-owners with permitting "credits" in exchange for implementation of runoff reduction techniques. These credits may be used to allow a property owner to perform work not otherwise permitted.
Incentivize Runoff Reduction on Private Property	Use incentives other than those listed previously to encourage private property owners to reduce impervious surfaces and utilize stormwater retention, detention, and infiltration techniques. Case studies from other U.S. communities can be found here: https://sustainablecitycode.org/brief/previous-cover-minimums-and-incentives/ . Additional regulatory tools are presented later in this list of Recommendations.

4.1.3 Recommendation: Fund Municipal Stormwater Reduction Efforts

Raise funds for stormwater reduction projects by pursuing grants and securing public support for municipal spending. Consider establishing a Stormwater Authority¹⁰, which would have the ability to impose a stormwater utility fee.

Stormwater Utility:
➤ Fee for using stormwater infrastructure
➤ Reliable funding source
➤ Separate from general fund
➤ Typically based on impervious cover
➤ Growing number in response to MS4

¹⁰ Substitute House Bill 6441, *An Act Concerning Climate Change Adaptation*, was adopted by the Connecticut General Assembly May 27th, 2021. Connecticut municipalities can now establish Stormwater Authorities to implement fees to fund stormwater projects. In 2018, New London established a Stormwater Authority.



TOOLBOX: Fund Municipal Stormwater Reduction Efforts	
Action	Description
Establish a Stormwater Authority and Utility	<p>In May of 2021, Governor Lamont’s Climate Bill (substitute House Bill 6441) was passed, enabling Connecticut municipalities to establish new stormwater authorities. The stated purposes of the stormwater authority include:</p> <ul style="list-style-type: none"> • Develop and administer a stormwater management program • Provide public education and outreach relating to stormwater management activities • Facilitate a fee on real property to fund the stormwater management program <p>Explore the establishment of a local stormwater authority and assessment of stormwater utility fees (or work with Town of Groton as necessary), with fee amounts varying based on amount of runoff generated by a property. This will help encourage private-property owners to reduce runoff on their site, while also raising funding for impervious surface reduction, drainage improvements, or other stormwater-related resiliency projects.</p>
Conduct Public Education on Stormwater Reduction Costs	Perform community education around the costs of stormwater management and flood risk-reduction, and how the public may share in that cost
Pursue Stormwater Mitigation Grant Opportunities	<p>Because of the multiple interrelated challenges posed by stormwater runoff (including both flooding of developed areas and ecosystem damage to natural areas), there are a number of different potential funding sources to support stormwater mitigation. Sources may include:</p> <ul style="list-style-type: none"> • Southeast New England Watershed Implementation Grant • EPA Clean Water State Revolving Fund (administered by CT DEEP) • EPA Environmental Justice Small Grants Program • EPA Urban Waters Small Grants Program • Clean Water Act Section 319 Grants (administered by CT DEEP) • National Fish and Wildlife Foundation Long Island Sound Futures Fund • FEMA Building Resilient Infrastructure and Communities (BRIC) Grant (administered by DEMHS) • Community Development Block Grant, U.S. Dept. of Housing and Urban Development

4.1.4 Recommendation: Decrease Impervious Surface Extent

Reduce the area generating stormwater runoff by replacing of impervious surfaces with pervious land uses or permeable pavements. This will help reduce the risk of flooding from stormwater runoff. Impervious surface reduction also reduces the urban heat island effect, reducing the risk posed by extreme heat events. Reduction of impervious surface is particularly important in the Five Corners and Technology Campus areas.



TOOLBOX: Decrease Impervious Surface Extent	
Action	Description
Identify Appropriate Locations for Impervious Surface Reduction	Based on the results of the stormwater runoff studies of Recommendation 1.2, as well as feasibility, stakeholder input and support, and other practicalities, identify appropriate locations to pursue reduction of impervious surfaces. Candidates will likely be large, privately-owned parking areas, as well as roadways.
Pursue Impervious Surface Reduction on city Properties	<p>Prioritize impervious surface reduction on city property in order to lead by example and provide case-studies for the feasibility and benefits of impervious surface reduction. Impervious surfaces may be replaced with green infrastructure, other vegetated uses, or even permeable pavements to reduce the loss of parking or driving area.</p> <p>The parking lot of the Municipal Complex is a prime candidate for reduction, as is impervious surface at Washington Park. Eastern Point Beach Park is a strong candidate for impervious surface reduction for the specific purpose of demonstrating feasibility; however, its location at the “base” of the watershed (low-elevation, near the Thames River and Long Island Sound) means that the runoff-reduction benefits are limited.</p>
Reduce Parking Footprint Demand	<p>The primary contributor to impervious surface in the City is privately-owned parking areas. Construction of multi-story parking garages could reduce the overall footprint of parking lots while maintaining (or increasing) parking capacity. The City of Groton can use regulatory and ordinance tools to encourage or require implementation of these types of measures.</p> <p>The City can also reduce the amount of land dedicated to parking by reducing the demand for parking; this can be accomplished by encouraging carpooling or other modes of transportation (see Recommendation 4.5.1).</p>
Lower Parking Requirements	<p>City of Groton parking requirements are listed in the Zoning Regulations Section 7.1. Parking is required for residential, institutional, marine, retail and service, office, hospitality, industrial, and other uses. Reducing parking requirements, where feasible, may encourage a reduction in the amount of space developers dedicate to impervious parking surfaces. Revising the parking requirements could entail:</p> <ul style="list-style-type: none"> • Lowering the number of spaces required for different uses • Expanding modification opportunities (as listed in Section 7.1.C) • Applying alternative methods for meeting requirements (as noted for Industrial Uses in 7.1.B.7) to a broader range of uses, and increasing the “value” of those alternatives.
Revise Zoning Regulations around Impervious Surface Extent	Add maximum impervious surface extent limits to the Zoning Regulations Section 7: Standards. Such limits are found in a number of other Connecticut municipalities, including Brooklyn, Avon, Hartford, Durham, Stamford, and Winchester.

4.1.5 Recommendation: Implement Retention, Detention, and Infiltration Techniques

Slow or reduce the flow of stormwater into stormwater drainage pipes through installation of cisterns, swales, ponds, and other measures, focusing on the use of green-infrastructure. This will reduce the stress on drainage systems and the risk of flooding, while creating additional environmental co-benefits such as improved habitat and increase presence of native plant species.



TOOLBOX: Implement Retention, Detention, and Infiltration Techniques	
Action	Description
Collaborate with Electric Boat on Stormwater Cisterns Below Parking Lots	Coordinate with Electric Boat to pursue installation of underground cisterns beneath the company's parking lots in the Five Corners area (for example, lots B, C, E, H, and G). This structure would collect stormwater runoff from Electric Boat parking areas and temporarily detain it underground, preventing a large surge of flow that could overwhelm the City's drainage systems. This would allow for stormwater flooding mitigation without reduction in the number of available parking spaces for the company.
Pursue Installation of Rain Gardens	Rain gardens are gardens planted in depressions that collect stormwater runoff. Water that flows into the garden is taken up by the vegetation or infiltrates downward into the soil, reducing overall runoff from a site. Rain gardens also provide important pollutant removal and treatment benefits.
Incentivize Low Impact Development Techniques	Strengthen language around Low Impact Development (LID) in the City's Stormwater Management Regulations (Zoning Section 7.7) to more strongly encourage its implementation. Currently the regulation allows but does not encourage LID techniques. One approach may be to require developers to generate an LID alternative for any large project, so that the alternative is at a minimum available for review. Another approach is to require LID techniques in certain situations. The City should collaborate with DEEP on LID implementation. https://portal.ct.gov/DEEP/Water/Watershed-Management/Low-Impact-Development-and-Green-Infrastructure-Municipal-Outreach .
Increase Runoff Abatement Requirements in New Developments	Runoff abatement for new development is currently required through the City's Stormwater Management Regulations (Zoning Section 7.7). Requirements could be increased to zero net runoff during the 1% annual-chance storm. Climate change impacts on precipitation return-periods can also be incorporated.

4.1.6 Recommendation: Increase Capacity of Stormwater Infrastructure

In coordination with stormwater runoff reduction measures, increase the capacity of the City's stormwater drainage system with consideration of rising precipitation projections.

TOOLBOX: Increase Capacity of Stormwater Infrastructure	
Action	Description
Increase Drainage Infrastructure Standards Using Climate Change Data	Update the City's standards for drainage capacity using the most recent storm return period data from the NOAA Atlas 14 or the Northeast Regional Climate Center. Additionally, monitor state guidance around projected climate change impacts on precipitation in Connecticut to determine whether such projections should be incorporated into standards in the future.



TOOLBOX: Increase Capacity of Stormwater Infrastructure	
Action	Description
Conduct a Climate-Change-Informed Drainage Capacity Evaluation	Based on the increased capacity needs identified in the action above, evaluate citywide drainage infrastructure to identify areas where the system is under-capacity, and prioritize system components in need of upsizing.
Perform Targeted Drainage Improvement Projects	Based on the results of the Comprehensive Stormwater Runoff Studies described in Recommendation 4.1.1, and the climate-change-informed capacity evaluation described above, perform targeted improvements to the City’s stormwater drainage infrastructure.



4.2 RESILIENCE OBJECTIVE: MITIGATE INCREASING URBAN HEAT ISLAND EFFECT IMPACTS

The Risk Assessment shows that significant portions of the City of Groton are at an elevated risk from extreme heat events due to relatively elevated urban heat island effects. This risk from extreme heat is concentrated in the more densely-developed parts of the City with more extensive impervious surfaces. The risk is exacerbated by a lack of tree coverage in these areas. As climate change leads to ever-higher average annual temperatures, and in particular to increasingly-frequent extreme-heat events, these urban-heat-island areas will be especially at risk. Studies have shown that socially-vulnerable populations, such as low-income, elderly, and people of color, are particularly at-risk from extreme heat.

To reduce the risks posed by rising temperatures, the following recommendations are put forth¹¹:

1. **Enhance Understanding of Local Heat Risks and Costs**
2. **Develop a Citywide, Healthy Urban Forest**
3. **Provide Public Access to Cooling Areas**
4. **Include Heat Considerations in the Building Code**

4.2.1 Recommendation: Enhance Understanding of Local Heat Risks and Costs

Conduct a detailed heat vulnerability assessment, and communicate results to community decision-makers and the public through public engagement and education. Improve local understanding of the risks that extreme heat events pose to health and wellbeing, infrastructure, ecosystems, and more. Use this information to inform municipal protocols, capital spending, and public behaviors.

TOOLBOX: Enhance Understanding of Local Heat Risks and Costs	
Action	Description
Conduct a Detailed Heat Vulnerability Assessment	Conduct a detailed citywide assessment to establish the social, economic, and physical impacts of high heat, and to understand how impacts vary throughout the City due to differences in exposure and vulnerability. This will help direct extreme heat mitigation efforts.
Conduct a Public Engagement and Education Campaign about Heat Risks	Engage a wide range of stakeholders and members of the public to help the City understand how extreme heat impacts residents, businesses, workers, and visitors, as well as to educate the public about heat dangers and climate change projections.

¹¹ More information about urban cooling techniques can be found at the C4o Knowledge Hub: www.c4oknowledgehub.org/s/article/Urban-Cooling-Toolbox.



4.2.2 Recommendation: Develop a citywide, Healthy Urban Forest

Develop an aggressive and forward-looking urban-forestry program that will significantly increase the density of trees throughout the City. The program should:

- ❖ Increase shading on public sidewalks;
- ❖ Plant trees in the most densely-developed parts of the City, including Five Corners;
- ❖ Ensure equitable distribution, focusing on socially-vulnerable residents and communities.

Trees can provide relief from high temperatures through shading, and reduce local temperatures through transpiration and evaporative cooling. A healthy urban forest at a city-wide scale can mitigate the urban heat island effect over a wider geography, and provide benefits more equitably. Urban forests also reduce stormwater runoff, purify air, provide ecological benefits, and increase property values.

TOOLBOX: Develop a citywide, Healthy Urban Forest	
Action	Description
Conduct a Detailed Feasibility Analysis for citywide Tree Planting	A detailed analysis will be necessary to identify appropriate locations for tree planting, and appropriate tree species for planting, in consideration of property ownership, underground and overhead utilities, vehicle-operator visibility, and other concerns. This action should be informed by, or performed in concert with, the Detailed Heat Vulnerability Assessment (Recommendation 4.2.1) and the Stormwater Hydraulics and Hydrology Analysis (Recommendation 4.1.1) in order to maximize the benefits from a citywide tree planting effort.
Plant Trees on city Property	Where possible and reasonable, lead by example and plant trees on city property, including at the Municipal Campus, Washington Park, Eastern Point Beach (including the park area and the parking lot), and Thames View Park.
Coordinate with the Town and State on Street Tree Planting	Coordinate with the Town and ConnDOT to pursue a robust street-tree planting and maintenance program. Planting street trees would advance goals of both the Town of Groton and ConnDOT, including those related to sustainability, resilience, traffic-calming, and quality-of-life. The City would likely need to agree to provide tree planting, maintenance, removal, replacement, and debris-removal services. Instituting a local “Adopt a Tree” program may help raise some of the funds needed for this effort.
Establish a Program Incentivizing Private Tree Planting	Encourage and incentivize private property owners to plant native trees on their properties in a location that provides shade in the public right of way. One approach may be to provide trees to property owners who are interested, or to provide “credits” by which a property owner may be granted a permit for certain other activities in exchange for planting native shade trees.

4.2.3 Recommendation: Provide Public Access to Cooling Areas

Provide access to passive and active cooling areas for all residents. Compensate for the disproportionate effects heat has on socially-vulnerable populations. Passive cooling includes artificial shade structures, “blue infrastructure” like spray parks and water fountains, and green



corridors. Active cooling includes air-conditioned public comfort stations (spaces where the public can go to warm up, cool off, and charge electronic devices during protracted power outages) and emergency shelters.

TOOLBOX: Provide Public Access to Cooling Areas	
Action	Description
Implement Passive-Cooling Best Practices on City Properties	Pursue implementation of passive-cooling measures on city structures. Techniques include green roofs, reflective external paints or materials, façade shading, reflective window glazes, insulation, natural ventilation, and other passive cooling strategies. This action would have the City lead by example while also reaping the benefits of more reliable protection from extreme heat events. An evaluation of all city properties to determine which specific approaches are appropriate is recommended, although the Municipal Building is a strong candidate.
Artificial Shade Structures on Thames Street	Evaluate options and feasibility for installation of artificial shade devices along the sidewalks of Thames Street to mitigate the impacts of extreme heat. Options may include shade sail, slats, panels, or other creative designs. Complete installation following evaluation.
Pursue Creation of a “Blue Infrastructure” Network	<p>Blue Infrastructure refers to water-based installations, either temporary or permanent, that provide opportunities for members of the public to cool off. They include drinking fountains, swimming or wading pools, and water spray parks and fountains. Public access to the waterbodies surrounding the City of Groton is an important part of the City’s existing Blue Infrastructure network.</p> <p>Evaluate appropriate locations throughout the City for installation of Blue Infrastructure sites. This evaluation should consider elevated heat areas (such as those identified through a Detailed Heat Vulnerability Assessment, Recommendation 4.2.1), vulnerable population locations, and existing access to cooling areas. Public input will be essential to equitable distribution.</p> <p>Following evaluation, pursue implementation.</p>
Upgrade Comfort Stations	<p>Work with appropriate internal departments (e.g., Parks and Recreation, Facilities), Town of Groton departments (e.g., Facility Management), and other relevant entities (such as the Bill Memorial Library) to improve the effectiveness of existing active comfort stations in the City. Improvements may include:</p> <ul style="list-style-type: none"> • Upgrades to emergency generators, air-conditioning units, and other critical utilities and mechanics • Increased facility capacity • Improved facility accessibility (including ramps, railings, parking, etc.) • Training facility staff, municipal support staff, and volunteers
Increase Community Comfort Stations	Work with local organizations (such as schools, churches, or businesses) to identify appropriate facilities that may be used as comfort stations in case of power outages, extreme heat, etc. Collaborate with identified facility owners and operators to enable their use as comfort stations.
Increase Awareness of Local Comfort Stations	Establish and conduct an ongoing educational campaign (for example, annually at the beginning of the summer season) to inform residents and visitors of comfort station locations and protocols for use. Post information permanently on the City website and in public spaces.



TOOLBOX: Provide Public Access to Cooling Areas	
Action	Description
Promote “Green Corridors”	<p>According to the C4o Knowledge Hub (www.c4oknowledgehub.org) Urban Cooling Toolbox, Green Corridors are connected collections of trees and vegetation that reduce the local ambient temperature while also provide a cooling effect to surrounding areas.</p> <p>Leverage existing “green” spaces by improving access and connectivity. Specifically, develop a “Resilient Green Corridor” connecting Washington Park with the existing Birch Plain Creek Open Space by way of a multi-use recreational path that runs behind Colonel Ledyard Cemetery, along Poquonnock Road, and then through the forested areas east of Brandegee Avenue. This Green Corridor can further connect to Fort Griswold State Park and Thames View Park by way of increased Street Trees, as recommended elsewhere.</p>

4.2.4 Recommendation: Update Building Codes to Include Extreme Heat Considerations

Update the local building code to require that residential buildings are properly designed, equipped, and maintained to minimize negative effects of extreme heat events on residents¹². Requirements may address:

- ❖ Airflow
- ❖ Windows Size and Location
- ❖ Insulation
- ❖ Roofing Materials and Color
- ❖ Outside Wall Color
- ❖ HVAC Systems
- ❖ Solar Orientation

TOOLBOX: Update Building Codes to Include Extreme Heat Considerations	
Action	Description
Assess Best Practices for Incorporating Heat Considerations into Building Codes	Identify other, similar communities that have incorporated heat considerations into their building codes to identify best practices and approaches applicable to the City of Groton.

¹² The U.S. Department of Energy Climate-Specific Passive Building Standards (Wright and Klingenberg, 2015) report is a good source of information for incorporating climate-resilience standards into the building code (<https://www.nrel.gov/docs/fy15osti/64278.pdf>). A more general source of information on the concept of passive cooling of buildings is available through the Australian Government’s online Guide to Environmentally Sustainable Homes (<https://www.yourhome.gov.au/passive-design/passive-cooling>).



TOOLBOX: Update Building Codes to Include Extreme Heat Considerations	
Action	Description
Collaborate with Connecticut State Officials on Building Code Improvement Options	Collaborate with State of Connecticut officials on updating the City building code to include heat considerations, in order to ensure any updates are in line with state requirements.



4.3 RESILIENCE OBJECTIVE: ENHANCE RESILIENCE OF LOCAL BUSINESSES

The Risk Assessment found that City of Groton businesses are vulnerable to the effects of climate change. The primary climate change related threats to these businesses are:

- ❖ Direct damage to property or assets from coastal flooding or stormwater flooding
- ❖ Business interruption due to coastal or stormwater flooding, other storm events, or extreme heat events that affect access, supply chains, operations, or customer engagement

Another potential climate change threat to businesses is loss of operations due to utility outages that may be caused by flooding, severe storms, or extreme heat. However, power outages have not been identified as a challenge of concern in the City (in fact, numerous stakeholder interviews described local power supply as highly reliable), so this risk is not considered a priority to be addressed within this Plan. That said, changing conditions could alter that risk assessment in the future, so the resilience of the City's energy supply and grid should be revisited in future assessments.

Operational local businesses are essential to recovery following a disruption, and maintaining a resilient local business community will be essential to maintaining a resilient City of Groton. This objective, therefore, calls for the City to implement measures to increase the resilience of local businesses, including small businesses and large corporations with facilities in the City of Groton, to the effects of climate change and extreme weather events.

Specially, the following Recommendations are put forth:

- 1. Enhance Resilience of Small Businesses to Climate-Related Disruptions**
- 2. Support and Encourage Floodproofing of Commercial Properties**
- 3. Enhance Climate Resilience Communications with Local Employers**

4.3.1 Recommendation: Enhance Resilience of Small Businesses to Climate-Related Disruptions

Support efforts by local businesses, in particular small businesses, to become more resilient by developing continuity and recovery plans and protocols, and by making changes to their operations, physical layout, and organization. Business continuity efforts that address climate change related disruptions will help business owners be more resilient to non-climate disruptions, and vice versa. The City may also be able to implement its own protocols to facilitate more rapid or sustainable recovery following a climate change disruption. These small businesses are essential to the City of Groton's community, economy, and character.



TOOLBOX: Enhance Resilience of Small Businesses to Climate-Related Disruptions	
Action	Description
Support Business Continuity Planning for Small Businesses	Provide technical support to small businesses on business continuity planning. One option is to develop an Emergency Plan or Business Continuity Plan template and provide it to local businesses.
Partner with seCTer on Resilience Initiatives	SeCTer and the City of Groton have been collaborating on encouraging local business owners to complete their Open for Business EZ Forms (https://preparecenter.org/resource/ofb-ez-open-for-business-ez/). Through seCTer, businesses are able to access regional resources such as the Connecticut Small Business Development Center (CTSBDC) and the Connecticut Procurement Technical Assistance Center (PTAC) for technical assistance as they work to complete the form. Continue working with seCTer on this and similar projects in the future.
Adopt Municipal Protocols and Policies to Facilitate Small Business Recovery	Conduct a “Lessons Learned” analysis of best practices within the City of Groton and around the region to identify techniques and tools used by communities to support small businesses through the COVID-19 disruption. Examples may include providing simplified permitting for temporary off-site operations (outdoor dining being one example) and contracting local businesses for disaster response and recovery services.

4.3.2 Recommendation: Support and Encourage Floodproofing of Commercial Properties

Provide education, regulations, and funding to encourage commercial property owners to retrofit their buildings located along the City of Groton coastline to better withstand flooding. Retrofits may include preventing water from accessing the building interior (dry floodproofing), allowing water to enter the building while causing minimal damage (wet floodproofing), or elevating the building to be above flood levels (elevating).

Floodproofing is recommended for businesses located along Thames Street, in the Technology Campus (Electric Boat Corporation, Buckeye Terminals, and Pfizer West campus), and in the South Shore Assessment Zone (including marinas and the UConn Avery Point campus). Note that loss of access due to roadway flooding is a concern in the South Shore area, so any floodproofing efforts should take into account the fact that any individuals who remain in floodproofed buildings during a flood may become trapped.

TOOLBOX: Support and Encourage Floodproofing of Commercial Properties	
Action	Description
Educate Business Owners about Floodproofing	Conduct an educational campaign targeting local business owners around the benefits of, and resources available to support, commercial floodproofing.



TOOLBOX: Support and Encourage Floodproofing of Commercial Properties	
Action	Description
Strengthen Zoning Regulations to Encourage Floodproofing of Commercial Properties	<p>The City of Groton regulates floodplain development in Section 5.3 of its Zoning Regulations. The degree of protection required in these regulations is the minimum required by State and Federal law. The City can encourage more robust floodproofing by increasing flood management standards, for example:</p> <ul style="list-style-type: none"> • Substantial Damage: currently calculated over a 10-year period, based on one or two events. Increase “lookback period” to 12 years, and consider all damage events over that period. • Substantial Improvement: currently calculated over a one-year period. Increase “lookback period” to 5 or 10 years. Another alternative is to include a Substantial Repair of a Foundation measure, by which significant foundation repair triggers compliance requirements (Massachusetts recently adopted such a provision statewide). • Freeboard: Require buildings to be elevated to two or more feet above freeboard; alternatively, incorporate a science-based freeboard that utilizes state-adopted sea level rise projections. • VE Zone Development: Prohibit all new development in the VE Zone.
Establish a Program to Fund Floodproofing of Commercial Properties	Establish a dedicated fund to support commercial property floodproofing.

4.3.3 Recommendation: Enhance Climate Resilience Communication with Local Employers

Develop and maintain relationships with local businesses, small and large, to facilitate cooperation on resilience efforts addressing shared vulnerabilities. The resilience of local employers is critical to the resilience of the local community and economy.

TOOLBOX: Enhance Climate Resilience Communication with Local Employers	
Action	Description
Leverage the Coastal Vulnerability Working Group	<p>The City of Groton has established a Coastal Vulnerability Working Group (CVWG) to inform and guide city efforts to reduce risks from Climate Change. The CVWG includes representatives from a number of local stakeholders, including major local employers like Electric Boat and Pfizer.</p> <p>Continue to support the activities and regular meetings of the CVWG. In particular, leverage the relationship-building opportunity presented by the group to maintain connections with large local employers, with a focus on mutual support around climate resilience.</p>



4.4 RESILIENCE OBJECTIVE: CREATE A FLOOD-RESILIENT SHORELINE

Coastal flooding is a concern along much of the City of Groton shoreline, with particularly susceptible areas located in the southern part of the City, as well as along Thames Street. Homes, businesses, roadways, and other infrastructure are all at risk.

To create a more resilient shoreline, the following Recommendations are put forth:

1. **Focus Development and Investment in Low-Risk Areas**
2. **Pursue Shore Avenue Resilience Strategies**
3. **Evaluate Long-term Resilience Options for Jupiter Point**
4. **Protect and Increase Coastal Open Space**

4.4.1 Recommendation: Focus Development and Investment in Low-Risk Areas

Identify and target low-risk areas of the City for future residential growth and other development, redevelopment, and investment. In the context of inland migration necessitated by rising sea levels, these areas would be “receiving areas” to which residents or businesses moving away from risk areas could relocate. Focusing development and investment in low-risk areas will also create opportunities for new property owners wary of investing in properties located in higher-risk zones.

The City already has a large inland population, and has plans in place for redevelopment of the Five Corners area.

TOOLBOX: Focus Development and Investment in Low-Risk Areas	
Action	Description
Promote Density in Low-Risk Areas	Revise Zoning Regulations to allow for increased density within target areas. Changes may include reducing density limits, setbacks, height limits, lot sizes, parking requirements, and automatic incorporation of green infrastructure in the target area.
Discourage Density in High-Risk Areas	At the same time that low-risk areas are targeted for increased density, some types of development in high-risk areas should be discouraged. Changes may include strengthening density limits, setbacks, height limits, lot size requirements, and automatic incorporation of green infrastructure. Promoting open space and water access can also decrease density while achieving other goals for the coastline.
Implement Transfer of Development Rights	One tool that both promotes density in low-risk areas and discourages density in high-risk zones is a Transfer of Development Rights program (TDR). A TDR operates by allowing landowners in a “sending area” to sell the development rights from their land for use in a “receiving area”. The land in the sending area is permanently protected through a conservation easement or a restrictive covenant. The development value of the receiving area land is enhanced by allowing for new or special uses; greater density or intensity; or other regulatory flexibility that zoning without the TDR option would not have permitted.



TOOLBOX: Focus Development and Investment in Low-Risk Areas	
Action	Description
Incentivize Inland Development	<p>Consider measures to incentivize development and redevelopment within target areas. For example, consider implementing tax credits, revolving loan funds, voluntary transfer of development rights programs, and other economic incentives to promote development in low-risk areas while acquiring or conserving property in high-risk areas.</p> <p>Review property assessment practices to ensure that assessed property values are accurately reflecting the impacts of sea level rise and coastal hazards on properties. Consideration of sea level rise in property assessment may lead to an increase in the valuation of inland property values relative to coastal properties, encouraging inland development (note that this may require action at the State level).</p>

4.4.2 Recommendation: Pursue Shore Avenue Resilience Strategies

Pursue a suite of nature-based, hybrid, or conventional coastal protection strategies along Shore Avenue and Eastern Point, including:

TOOLBOX: Pursue Shore Avenue Resilience Strategies	
Action	Description
Plant Trees on city-Owned Open Space	Plant trees in city-owned open space along Shore Avenue, in particular at the open space north of the "Fishing Pier."
Repair "Fishing Pier" Erosion Damage	Implement needed repairs of the "Fishing Pier."
Install educational signage and materials at the "Fishing Pier"	Incorporate public education signage and artwork related to climate resilience as feasible and appropriate.
Upgrade Shore Avenue Seawall	Repair the bulkhead/seawall south of the "Fishing Pier", using wave-mitigating architecture and accounting for projected sea level rise within the expected project lifespan.
Implement Nature-Based Flood Mitigation Near 160 Shore Avenue	Construct a raised, vegetated berm at the open space south of the seawall/bulkhead area to prevent flooding from overtopping the park and accessing the road; if feasible, remove the seawall in this location to create a living shoreline and facilitate inland marsh migration. Work with the property owner at 160 Shore Avenue to perform any shoreline protection actions necessary to enable the living berm to be effective.
Upgrade Shore Avenue Drainage System	Upgrade the Shore Avenue drainage system, including with installation of tide gate structures at outlets to prevent surcharging during high tide events.



TOOLBOX: Pursue Shore Avenue Resilience Strategies	
Action	Description
Living Shoreline at Cement Revetment	Replace the sloped cement revetment north of Eastern Point Beach with a living shoreline that will provide ecological and aesthetic benefits while also attenuating wave energy during storm events. This action would require continued provision of public water access and boating access space.
Pursue Living Shoreline at Eastern Point Beach Park	Explore opportunities to implement living shoreline approaches along the edges of Eastern Point Beach Park; in particular, replace cement seawalls and bulkheads with living shorelines, where feasible.
Reduce Imperviousness and Plant Trees at Eastern Point Beach Park	Identify appropriate locations for tree planting and impervious surface reduction at Eastern Point Beach Park, including within the parking lot area, along Rita Santacroce Drive, north of the Zbierski House, and around the playground near the beach. Tree planting and impervious surface reduction should be pursued in order to reduce temperatures locally and increase the availability of shade. Availability of parking and other uses of the site should be considered. Following identification, pursue implementation.

4.4.3 Recommendation: Evaluate Long-Term Resilience Options for Jupiter Point

Jupiter Point is one of the areas of the City most at-risk of flooding. Due to the high level of risk and sensitive nature of planning for long-term solutions that may involve significant changes, implementing a comprehensive, neighborhood-specific engagement, evaluation, and adaptation plan is recommended. Voluntary retreat and relocation should be considered as part of the conversation.

TOOLBOX: Evaluate Long-Term Resilience Options for Jupiter Point	
Action	Description
Jupiter Point Stakeholder Engagement	Conduct a thorough engagement campaign targeting Jupiter Point residents and property-owners in order to identify problems and acceptable and feasible adaptation options.
Cost-Benefit Analysis for Jupiter Point Options	Conduct a forward-looking cost-benefit analysis of possible adaptation and flood mitigation options for Jupiter Point. This analysis should consider long-term maintenance and operations costs for any mitigation action, as well as the effects of continued sea level rise and climate change. Costs of inaction should also be considered. Costs should be developed with community input to make sure that local concerns are considered and quantified. This type of quantitative analysis can help put hard, long-term decisions into context.
Targeted Jupiter Point Retreat Study	Conduct a study to identify areas of Jupiter Point that may be appropriate candidates for retreat; at the same time, identify possible “receiving” areas within the City where residents may relocate, if interested. The City should consider incentive options within this study.



4.4.4 Recommendation: Protect and Increase Coastal Open Space

Identify undeveloped coastline to be protected as open space, and evaluate opportunities for increasing the amount of open space along the shoreline. Facilitating inland marsh migration with sea level rise should be a particular focus of such efforts (see <https://coastalresilience.org/connecticut-first-for-future-saltmarsh-advancement-assessment-at-fine-scale-for-entire-coast/>).

TOOLBOX: Protect and Increase Coastal Open Space	
Action	Description
Identify Undeveloped Coastal Space for Protection	Assess publicly- and privately-owned properties along the City of Groton coastline to identify undeveloped areas within current and future coastal hazard zones. Develop a list of properties to be preserved, and identify next steps with regards to conservation.
Work with Private Property Owners to Conserve Coastal Open Space	Work with the owners of private open-space properties along the shoreline to conserve those spaces. The City may use tools such as conservation easements or Transfer of Development Rights to encourage such conservation. Alternatively, the City may pursue acquisition of those properties.
Evaluate Opportunities for Nature-Based Solutions	Identify locations where replacement of “hard” infrastructure with nature-based solutions is feasible and desirable. Many of these locations will likely be privately-owned.



4.5 RESILIENCE OBJECTIVE: IMPROVE RESILIENCE OF THE TRANSPORTATION NETWORK

The potential impact of climate change related hazards on transportation has been identified as a concern for the City. With only a few key roadways leading in and out of the City, limited transportation options aside from personal vehicles, and a large commuter population, increasing the reliability of the City's transportation infrastructure will be important to the City's resilience.

A resilient transportation network will achieve the following goals:

- Maintain functionality and services for the community given the likelihood of increased flooding, and changes in precipitation and temperature
- Provide essential evacuation and access routes to facilitate emergency preparation and response to climate-related hazards
- Provide all residents access to resilience services and sites, such as comfort stations or forested areas.

To achieve these goals, the following Recommendations are put forth:

- 1. Consider Climate Change in Traffic and Evacuation Planning**
- 2. Make Roadways more Flood-Resilient**
- 3. Coordinate with Regional Transit Systems**



4.5.1 Recommendation: Consider Climate Change in Traffic and Evacuation Planning

Evaluate potential climate change impacts (both with regards to acute severe weather events as well as chronic long-term changes in local conditions) on traffic flow throughout the City of Groton and between the City and surrounding communities. In particular, evaluate how climate change impacts may affect emergency access and egress.

TOOLBOX: Consider Climate Change in Traffic and Evacuation Planning	
Action	Description
Conduct a Climate-Change-Informed Traffic Study	Conduct a comprehensive traffic study for the City of Groton that specifically considers how traffic patterns will be affected by chronic climate change impacts, as well as acute climate-related events. These considerations may include more frequent closures of some roads by high-tide flooding, or more rapid degradation of pavement caused by rising temperatures and changing freeze-thaw cycles.
Improve Evacuation Route Planning	Review and formalize emergency evacuation or access routes, including backup routes, considering locations that may become blocked by flooding or other climate hazards. Raise awareness about those routes among emergency responders, municipal staff, and the public.
Develop and Increase Awareness of Evacuation Routes	The City of Groton has mapped evacuation routes connecting the northern end of the City to regional evacuation routes, but routes within the City itself are less clear. For the most part, transportation within the City is fairly straightforward; however, some key roadways are susceptible to flooding. The City's Hazard Mitigation Plan names alternative routes for use in case of flooding, but when to use the alternative routes, and how they fit in to the rest of the evacuation plan, is unclear.
Reduce Single-Passenger Vehicle Traffic	To reduce both greenhouse gas emissions and traffic congestion, work to reduce single-passenger vehicle use within the City by supporting public transportation, carpooling, shuttle buses to Park & Ride lots or other satellite parking areas, and active transportation methods (such as walking or bicycling).

4.5.2 Recommendation: Make Roadways Flood Resilient

Protect critical roadways through elevation or structural protections, make non-critical roadways flood resistant through appropriate paving materials and drainage, and establish climate-informed protocols for maintenance and upkeep. Collaborate with the Town of Groton and Connecticut DOT to implement these measures.

TOOLBOX: Make Roadways Flood Resilient	
Action	Description
Conduct Roadway Assessment	Evaluate roadways based on usage, condition, and exposure to flood and other risks, in order to identify and prioritize at-risk road segments, as well as feasible resilience measures.
Make Non-Critical Roadways Flood Resistant	In some cases, it is acceptable for roadways to be flooded on an infrequent, or even a regular, basis; in those cases, the City can use saltwater resistant paving materials and methods to improve the resilience of those roads, and ensure the drainage systems facilitate removal of water as quickly as possible after floodwater recedes.



TOOLBOX: Make Roadways Flood Resilient	
Action	Description
Protect Critical Roadways from Flooding	Critical roadways must remain open even during significant flood events to ensure evacuation or emergency access is possible. To protect a road from flooding, the road itself can be elevated, or structural protections can be installed adjacent to the road. In some cases, floodwaters access roadways not by flowing over land, but by surcharging through drainage systems. In such cases, tide gates or other check-valves should be installed on drainage outfalls.
Consider Projected Future Flood Frequencies in Public Works Planning	The City of Groton Department of Public Works (DPW) is responsible for maintenance of roadways in the City. Plans for future capital investments, staffing, and budgeting should take into account projected increases in frequency of roadway flooding, and the associated rise in maintenance needs.

4.5.3 Recommendation: Coordinate with Regional Transit Systems

A resilient transportation network requires resilient roadways as well as resilient modes of transportation. Not all residents and visitors have equal access to personal vehicles; for those individuals without, access to public transportation is important for resilience, especially during evacuation or emergency events.

Coordinate with the Southeast Area Transit District as well as public school bus programs to identify gaps and opportunities for collaboration on providing access to resilience resources both during emergency and during every-day situations.

TOOLBOX: Coordinate with Regional Transit Systems	
Action	Description
Coordinate with Southeast Area Transit District	Work with the Southeast Area Transit District to identify gaps and opportunities for providing access to resilience resources both during emergency and during every-day situations. This may include ensuring public transit routes connect at-risk populations with cooling areas and municipal services, as well as developing agreements whereby public buses are available for evacuation prior to storms.
Develop Memorandum of Understanding with Public School Buses	Work with the Town of Groton to develop a memorandum of understanding (MOU) with the regional public school bus provider, whereby the City is able to utilize buses and drivers for emergency evacuations
Coordinate with other Transportation Services	Identify and pursue opportunities for coordination with other local and regional transportation services to ensure emergency access and egress is available for all city residents. Organizations to contact may include the Eastern Connecticut Transportation Consortium and the Groton Senior Center.



4.6 RESILIENCE OBJECTIVE: INCREASE RESILIENCE OF SOCIALLY VULNERABLE POPULATIONS

Socially vulnerable groups in the City of Groton tend to have higher risk levels to climate change related hazards and disruptions. These groups often have higher exposure to climate hazards, and often have less access to resources that might help them be resilient to the direct and indirect effects of climate change and extreme weather events.

The following Recommendations are proposed to support the City’s socially-vulnerable populations:

- 1. Increase the Capacity of Community Organizations**
- 2. Build Resilience into Low-Income Housing Standards**
- 3. Conduct Education and Engagement**

4.6.1 Recommendation: Increase the Capacity of Community Organizations

Increase the resilience of socially-vulnerable populations by focusing on the organizations and institutions that already support them. These trusted community groups already have the infrastructure and connections to reach vulnerable individuals. Improve their capacities by educating them about climate risks, informing them of municipal, regional, and state protocols and resources, and providing technical and financial assistance to support their efforts.

TOOLBOX: Increase the Capacity of Community Organizations	
Action	Description
Include Local Community Organizations in the Climate Vulnerability Working Group	Invite representatives of local community organizations to participate in the Climate Vulnerability Working Group, if they are not already involved.
Work with Local Community Organizations on Continuity Planning	Taking a similar approach as is suggested for small businesses in Recommendation 3.1, work with local community organizations to help them plan and prepare for climate-related disruptions so that they can continue to provide services during and following such events, as well as develop new or modified services related to climate change and extreme weather events.
Grassroots Resiliency Networks	Encourage local community-based organizations to participate in grassroots programs such as the Communities Responding to Extreme Weather network
Community Organization Education	Conduct climate resilience education and training events for community-based organization leadership and members.



TOOLBOX: Increase the Capacity of Community Organizations	
Action	Description
Engage Youth	Engage local youth in coastal resilience planning, awareness, and action. Groups and organizations for the City to coordinate with on this effort include local K-12 schools (Sacred Heart School, Thames River Magnet School, Marine Science High School), UConn Avery Point students, and regional schools like the U.S. Coast Guard Academy in New London.

4.6.2 Recommendation: Build Resilience into Low-Income Housing Standards

Work with the Town and the State to establish and enforce low-income housing standards that consider climate change. Low-income or subsidized housing is often a source of risk for residents, as they may not meet the most recent floodplain standards, and may not provide sufficient and safe cooling.

TOOLBOX: Build Resilience into Low-Income Housing Standards	
Action	Description
Establish Low-Income Housing Standards	Identify best practices for climate-resilient housing and work with the Town of Groton and the State of Connecticut to incorporate them into low-income housing standards. Standards should address, at a minimum, flood risk and heat risk. Low-income housing in the City of Groton is overseen by the Housing Authority of the Town of Groton and by the Connecticut State Department of Housing.
Enforce Low-Income Housing Standards	Work with the Building and Zoning Department to ensure low-income housing meets any newly established climate resilience standards.

4.6.3 Recommendation: Conduct Education and Engagement

Increase awareness and understanding of climate change impacts, risks, and adaptation options through education campaigns, sustained public engagement, and specific outreach initiatives. An example could include providing risk exposure information to new residents, whether they are buying or renting a property, so they are aware of their home’s risk.

TOOLBOX: Conduct Education and Engagement	
Action	Description
Develop and Conduct Education and Engagement Campaigns	Develop and conduct climate resilience education and engagement campaigns targeting traditionally underrepresented or marginalized communities. These campaigns should bring programming to the places where the target communities live, be provided in multiple formats, and include translation when appropriate.



TOOLBOX: Conduct Education and Engagement	
Action	Description
Provide Information about Risks and Resources	Provide information to all residents about the climate-related risks relevant to their homes (such as local flood zones and/or heat concerns), as well as information about resources available to them (such as location of nearby comfort stations, public transportation for evacuations, flood insurance, actions they can take to stay safe and healthy, etc.)



4.7 RESILIENCE OBJECTIVE: LEAD BY EXAMPLE – MUNICIPAL RESILIENCE ACTIONS

Although municipal properties and assets were not specifically identified as being at elevated risk, we have included a set of recommendations for increasing the resilience of city-owned assets for two reasons:

1. It is critical for municipal operations and administration to be resilient if the community is going to be resilient.
2. Action taken at the municipal level can serve as a case study and example for further progress across the City.

The following Recommendations are put forth:

1. **Enhance the Resilience of city-Owned Assets**
2. **Enhance the Resilience of Municipal Operations**
3. **Develop a Climate-Informed and Engaged Staff**

4.7.1 Recommendation: Enhance the Resilience of city-Owned Assets

Assess the risk to, and protect municipal facilities as warranted from, climate hazards and disruptions. This includes protecting properties and assets from damage caused by climate hazards, as well as pursuing fleet electrification and local power generation (such as through solar panels) in order to reduce the potential impacts of power outages caused by worsening storms.

TOOLBOX: Enhance the Resilience of city-Owned Assets	
Action	Description
Conduct a Municipal Asset Vulnerability Assessment	Evaluate all municipal property, including real property (buildings, facilities, land) and movable property (vehicles), to develop a comprehensive understanding of the climate change vulnerabilities of the City's assets. Considerations may include exposure of facilities to flooding, operation of mechanics during extreme heat events, and impacts of saltwater exposure to vehicles driving through flooded roadways.
Implement Climate Adaptation Measures for Municipal Assets	Based on the previously mentioned vulnerability assessment, pursue and implement climate adaptation measures on municipal properties and for municipal assets. Measures may include installation of stormwater retention and detention structures, floodproofing buildings, retrofitting vehicles to withstand saltwater exposure, upgrading and/or replacing mechanics with more efficient equipment and/or heat-tolerant alternatives, and more.
Evaluate Opportunities for Local Power Generation	Evaluate opportunities for installation of local power generation, in particular through renewable energy sources such as solar panels on municipal properties. Availability of locally-generated power may reduce the risks posed by long-term power outages caused by climate hazards. Micro grid feasibility should also be considered. Backup power generation should be available for all core city functions.
Evaluate and Assess Electric Fleet Transition Opportunities	Pursue electrification of city vehicle fleets (including school buses), while simultaneously working with Groton Utilities to implement bi-directional charging at critical city facilities. This will help the City build a more reliable electric grid with short-term local power sources (EVs).



TOOLBOX: Enhance the Resilience of city-Owned Assets	
Action	Description
Evaluate Emergency Shelter Capacities and Needs	Evaluate need for increasing local emergency shelter capacity, and opportunity for creating that capacity in local municipal facilities.

4.7.2 Recommendation: Enhance the Resilience of Municipal Operations

Ensure that the City is able to maintain essential services and operations through climate change disruptions. Evaluate city administration and operations to identify vulnerabilities relevant to climate change, such as supply-chain disruption or loss of access for municipal personnel. Address identified vulnerabilities as feasible.

TOOLBOX: Enhance the Resilience of Municipal Operations	
Action	Description
Incorporate Climate Change into Municipal Planning	<p>Incorporate climate change considerations into the City’s Emergency Plan, and develop additional plans as necessary. Planning documents that help formalize climate resilience policies and practices may include:</p> <ul style="list-style-type: none"> • Emergency Plans that address preparation, evacuation, emergency operations, and recovery • Hazard Mitigation Plan • Debris Management Plans • Tree and Utility Maintenance Plans • Mitigation Project Operation and Maintenance Plans • Stormwater Infrastructure Inspection and Maintenance • Open Space Plan • Bicycle and Pedestrian Plans • Neighborhood Master Plans • Capital Improvement Plans
Establish Municipal Responsibilities	<p>Clearly lay out municipal responsibilities with regards to climate resilience. Such responsibilities should include:</p> <ul style="list-style-type: none"> • Updating maps of future hazard zones over time • Monitoring and collect sea level rise rates and projections • Identifying public assets at risk from sea level rise and coastal storms • Incorporating sea level rise and coastal resilience into planning and decision making across all departments and commissions • Improving transportation and utility infrastructure over time as sea levels rise
Conduct Energy Audit and Carbon Footprint Analysis	Determine the City’s energy use to identify opportunities for improved efficiencies; lowering energy use will increase the ability of the City to provide that energy through local generation in the event of a regional power outage. Assessing the City’s energy use and climate footprint, and reducing both, will also help reduce the City’s contribution to climate change.



TOOLBOX: Enhance the Resilience of Municipal Operations	
Action	Description
Incorporate Climate Change into Operating Procedures	<p>Develop practices and procedures to facilitate effective response to and recovery from climate change events. While some of the procedures listed below already exist in the City of Groton, it is recommended that they be reviewed, updated as necessary, and made easily accessible and useable.</p> <ul style="list-style-type: none"> • Emergency procedures (including evacuation and traffic management procedures), and procedures for serving areas at risk of isolation from flooding (examples include acquiring high-water rescue vehicles). • Identify areas for resident parking during high tide flooding. • Procedures for removing or otherwise protecting boats on moorings or docks before storm events.

4.7.3 Recommendation: Develop a Climate-Informed and Engaged Staff

Through education, collaboration, and training, improve the understanding that city staff have about climate risks and resilience, and how climate change impacts, and can be addressed by every department.

TOOLBOX: Develop a Climate-Informed and Engaged Staff	
Action	Description
Create Cross-Department Climate Resilience Working Group	Create a working group consisting of representatives of multiple municipal departments to identify the impacts of climate change on each department’s operations, the capabilities that exist within each department to mitigate the impacts of climate change, and opportunities for collaboration on adaptation efforts.
Provide Climate Resilience Training to Staff	Develop and provide regular climate resilience trainings to all staff as part of the City’s annual training and education efforts.
Designate a Climate Resilience Coordinator	Designate an individual municipal staff member who will coordinate Climate Resilience efforts across departments, and who will oversee implementation and advancement of this Plan. This role could be added to an existing position, or a new position could be created.



5 Resilience Concepts

As a first step toward taking action on Recommendations listed above, Four Resilience Concepts have been prepared for the City of Groton. These Resilience Concepts advance specific projects by providing more detailed descriptions of project features, planning-level cost estimates, and renderings and other graphics. The purpose of the Resilience Concepts is to help the City and the community hone their visions for the projects in question, and take the next step of developing design-level products for each.

The decision of which four projects would be taken to the Resilience Concept stage for this Plan was made based on a combination of factors:

- ❖ **Risk Assessment Results:** It was important to be responsive to risks identified in the risk assessment.
- ❖ **Stakeholder and Public Input:** Input gathered on the topic of Resilience Concepts, as well as throughout the project process, was considered.
- ❖ **Equity:** Social vulnerability factors were considered when determining project locations.
- ❖ **Geographic Distribution:** Projects from around the City were chosen, both inland and coastal.
- ❖ **Multi-Hazard:** The four projects together address heat, stormwater floods, and coastal floods.
- ❖ **Feasibility:** Choosing projects that are likely to be implemented relatively quickly was important so that the momentum generated by this Community Resilience Plan will build and encourage additional action. Therefore, projects with relatively few barriers were chosen. For example, projects that could be performed on city-owned properties, as well as those that aligned with existing municipal plans and goals, were prioritized.

Through consideration of the factors above, as well as collaboration with multiple municipal departments, four Resilience Concepts were developed. These are briefly summarized below.

- ❖ **Tree Planting at Washington Park**

Washington Park is located in an area identified as having a moderate degree of risk from extreme heat and a moderate level of social vulnerability; it is also highly accessible to the community and well-used by residents. For these reasons, it was selected as a good location to provide passive cooling infrastructure through nature-based solutions to help provide relief for residents and visitors during extreme heat events.

This Resilience Concept maps out possible locations for planting trees to provide shade. A tree-planting initiative here would serve as a case-study for the City to promote a more widespread street-tree planting effort that is recommended to reduce the urban heat island effect, mitigate stormwater runoff, and provide environmental and aesthetic benefits throughout the community.



❖ **Shore Avenue Coastal Resilience Strategies**

The Shore Avenue Resilience Concept focuses on a landscape design and regrading project on city-owned open space on the western side of Shore Avenue. The objective of this project would be to prevent flooding of a small section of Shore Avenue during “sunny-day” high tide events under projected sea level rise conditions by 2050.

- ❖ The project would raise the land surface to act as a vegetated coastal flood control structure, in cooperation with stormwater drainage retrofits to prevent surcharging during high tides. The project would not prevent flooding during more severe high tide events. In addition to the specific concept, mapping of other areas of resilience opportunity along Shore Avenue is provided.

Surcharge is when water flows backwards through a drainage pipe.

❖ **Birch Plain Creek Resilience Trail**

The Birch Plain Creek Resilience Trail Concept maps out a multi-use trail that links an existing trail connecting Washington Park to West Street with another existing trail at the Birch Plain Creek Open Space off Thomas Road. The trail would be walkable and bikeable, and would include educational signage throughout.

There are multiple climate resilience benefits of this concept. First, the trail would provide access to the passive cooling benefits of shaded forest areas, especially to socially vulnerable residents in the Brandegee Avenue neighborhood. Second, the trail would increase connectivity throughout the City, linking different neighborhoods and areas. Third, the trail would increase the social and economic value of the open space within flood hazard areas along Birch Plain Creek, reducing the risks of future development within those areas. Fourth, the trail would include educational information about climate change risks and resilience. Finally, public use bicycle stations are planned for the southern trailhead and at the northern end, in Washington Park. In addition to providing connectivity and sense of place, bicycle use may reduce short automobile trips across town, potentially reducing greenhouse gas emissions.

❖ **Municipal Complex Rain Gardens**

Installation of rain gardens on the municipal complex property would reduce stormwater runoff from a site with relatively high impervious surface coverage. The high visibility of these rain gardens to the public would also allow them to serve an educational purpose and help with efforts to encourage rain garden installation on private property and other key areas around the City. This concept lays out a few possible sites for rain gardens.

More detailed descriptions of each Resilience Concept, including planning-level cost estimates and graphics, are included in Appendix C. These concepts will be used not only to advance the specific projects they discuss, but other related projects around the City. While only four Resilience Concepts were developed and included in this Plan, all recommendations and actions described in Section 4 should be fully considered to determine appropriate next steps for each.



6 Next Steps

The City of Groton Community Resilience Plan describes existing plans and reports relevant to climate change resilience, lays out the City's vulnerabilities and exposure levels to climate hazards, and provides an overview of key climate change risks across geographies, hazards, and sectors. The set of seven Resilience Objectives, and the Recommendations and Actions contained within each, form a framework for advancing climate resilience using a holistic, community-centered approach. The four Resilience Concepts provide stepping-stones that the City can use to maintain the momentum developed during this planning process.

The Community Resilience Plan is intended to be a living document, and it is essential that the City continue to engage with it, and regularly revisit and update it as necessary.

The Recommendations and Actions listed in Section 4 of this plan will each require a municipal champion or lead. An internal coordination and engagement process will be necessary to identify these municipal leads, and to prioritize and select Recommendations and Actions for pursuit by those leads. Community resilience is relevant to all municipal departments; however, those that are most likely to play a role in implementation include:

- ❖ Building and Zoning
- ❖ Parks and Recreation
- ❖ Public Works
- ❖ Planning and Economic Development (PED)
- ❖ Groton Utilities

The stakeholders, residents, workers, and visitors that make up the local community are central to community resilience. Continued engagement on implementation of this plan will help secure local support, ensure the desired results are being seen, and maintain momentum for ongoing action. The Community Resilience Building framework, used for one workshop during this planning process (as well as once during a previous initiative carried out by The Nature Conservancy) is a powerful tool that can continue to be used. Key stakeholders in furthering the City's resilience planning and next steps include:

- ❖ Major Employers (e.g., Pfizer, Electric Boat)
- ❖ Academic Institutions (e.g., University of Connecticut Avery Point)
- ❖ Regional NGOs (e.g., Southeastern Connecticut Enterprise Region; seCTer)
- ❖ Environmental Nonprofits (e.g. Eastern Connecticut Conservation District)
- ❖ Local Community Groups (e.g. schools, churches, Elks Lodge)

The complex jurisdictional framework in which the City of Groton operates is somewhat unique, but the need to coordinate regionally on climate resilience efforts is global. The City will need to coordinate with the Town of Groton and the State on implementation of many of the actions listed in this Plan. Additionally, the Southeastern Connecticut Council of Governments (SCCOG) can be a very powerful resource in support of the City's efforts.



Implementing resilience actions will, in many cases, require outside funding. The City has already proven its ability to secure funding from a variety of grant sources. Possible sources for additional grants include:

- ❖ **Federal Emergency Management Agency (FEMA):** provides grants for planning and infrastructural projects with the goal of reducing economic losses from natural hazards.
- ❖ **Environmental Protection Agency (EPA):** projects that reduce stormwater runoff, and therefore mitigate pollution to water resources, may qualify.
- ❖ **National Fish and Wildlife Foundation (NFWF):** the NFWF Long Island Sound Futures Fund (LISFF) funded this plan; additional grant opportunities arise annually.
- ❖ **Housing and Urban Development (HUD):** The HUD Community Development Block Grant CDBG specifically targets low-income communities.
- ❖ **CIRCA:** The CIRCA Municipal Resilience Grant and Matching Funds Grants can sometimes be an option for small community efforts. These programs open when funding becomes available.

An immediate next step should be pursuit of opportunities to advance the four Resilience Concepts presented in this plan. The write-ups included in **Appendix C** can be used to engage decision-makers and the public around these specific projects, and to drive scoping, budgeting, and grant proposals to bring the concepts to the design phase.

To keep this Plan relevant, active, and “living,” the City will need to regularly revisit it, review progress made on Recommendations and Actions, and update the document as needed. The City should designate a “plan champion” to lead these efforts. The following steps are suggested:

- ❖ **Planning and Economic Development Review:** On an annual basis, the PED Department (unless a different department or individual is given responsibility) should review the document and identify progress on Recommendations, relevant changes within the community, and updates to climate change projections and impacts. This review will serve as a gap analysis to drive subsequent actions.
- ❖ **Municipal Staff Engagement:** On an annual basis, following the PED Department review, representatives from relevant municipal departments (specifically those put in leadership roles for specific actions) should be brought together to workshop next steps. Gaps identified through the PED Department review will be discussed, and actions to be pursued in the upcoming year identified. Specific departments and individuals will be put in lead roles for implementation of specific actions.
- ❖ **Plan Updates:** Every five years, a comprehensive update of the Community Resilience Plan is recommended.

This Community Resilience Plan sets the stage for the City of Groton to continue to grow and thrive over the coming years, adapting to changing climate conditions and building resilience to any disaster or disruption that may arise. Pursuing the actions proposed herein, continuing to collaborate with internal and external stakeholders, and revisiting the Plan regularly, will help keep the community on-track and maximize the Plan’s benefits. The people who live in, work in, and visit



the City of Groton create the community; this Community Resilience Plan will help make sure that community stays strong far into the future.

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Appendix A: Review of Existing Studies and Documents



REVIEW OF EXISTING PROGRAMS, STUDIES, AND CAPABILITIES

INTRODUCTION

The City of Groton has a long history of participating in regional and local efforts to become a more climate resilient community. Previous City plans, programs and projects have laid a strong foundation towards the ongoing work of becoming a more resilient community.

A thorough review of local and regional documents was performed to ensure that the current Community Resilience Planning effort incorporates and builds upon past efforts. Understanding how existing City and Regional planning documents address climate resilience, and identifying gaps in those documents with this regard, will also facilitate future updates that more effectively consider resilience, and will build toward a consistent local and regional planning vision with regards to resilience.

Documents reviewed for this evaluation were:

- ❖ City of Groton Zoning Regulations (2020)
- ❖ Plan of Conservation and Development (2019)
- ❖ Community Resilience Building Workshop (2019)
- ❖ Hazard Mitigation Plan (2018)
- ❖ Harbor Management Plan (2006)
- ❖ Resilience and Sustainability Task Force: Human Health and Safety Recommendations (2020)
- ❖ Intra-Regional Water Supply Response Plan (2019)
- ❖ Critical Facilities Assessment (2017)
- ❖ Historic Resources Resiliency Planning (2017)
- ❖ Southeastern Connecticut Regional Resilience Vision Project (2017)
- ❖ A Salt Marsh Advancement Zone Assessment of Groton, CT (2015)
- ❖ Preparing for Climate Change in Groton, Connecticut (2011)

Key information from each document were captured and summarized below. Following a review of each document, summary tables were created to emphasize key findings. This exercise concludes with a summary of previously identified vulnerabilities, strengths and capacities, and recommendations based on the previous plans, programs, and projects reviewed.



REVIEW OF DOCUMENTS: MUNICIPAL PLANNING DOCUMENTS

City of Groton Zoning Regulations (2020)

The City of Groton Zoning Regulations were last amended on September 2, 2020. They include a variety of preventative regulations pertinent to mitigating flooding hazards. These regulations are applied during the permitting process for new construction and during substantial improvement of existing structures.

Section 5.2 presents the Coastal Area Management Overlay Zone (CAM). The City of Groton enforces a 25-foot setback from any tidal water body or watercourse or from coastal resource areas within the Coastal Area Management Boundary defined by the Connecticut DEEP. In addition, new single-family homes cannot be constructed within 100 feet of tidal wetlands, coastal bluffs and escarpments, or beaches and dunes. All new construction (with exemptions) must undergo a Coastal Site Plan Review that evaluates potential adverse impacts of the project.

Section 5.3 of the regulations covers flood protection. The City of Groton utilizes the 1% annual chance floodplain (commonly referred to as the "100-year" floodplain) to manage development in floodplains. The 1% annual chance floodplain is depicted on the DFIRM published August 5, 2013 by FEMA and includes areas in Zone A, Zone AE, and Zone VE including floodways. The degree of protection required by this regulation is the minimum reasonable for regulatory purposes. In particular,

- Substantial Damage is defined as damage to a structure whereby the cost to repair would equal or exceed 50% of the market-value of the structure to repair, OR flood-related damages sustained by a structure on two separate occasions over a 10-year period for which the average cost of repairs of each damage event equals or exceeds 25% of the market value of the structure. In other words, one or two damage events over a 10 year period with cumulative repair costs that equal or exceed 50% of the structure value is considered Substantial Damage, triggering requirements to bring the structure up to the most recent code. Note that it appears that multiple damage events with repair costs that are each less than 25% of the structure value but cumulatively equal 50% of the structure value would *not* trigger substantial damage requirements.
- Substantial Improvement is defined as improvements to a structure with cumulative costs over a one-year period that equal or exceed 50% of the market-value of the structure. This is a relatively short "lookback period" that may allow for significant improvements to structures to be made over many years without the structure needing to be brought into compliance with the most up-to-date building code.
- All applications for building permits within the flood hazard area must include the base flood elevation data from the FIRM for the portions of the activity located within the flood hazard area. The Building Official will record as-built elevation of the lowest floor and lowest horizontal structural member (for VE zones) and keep this information on file.



- The applicant must demonstrate to the commission that the development is consistent with the need to minimize flood damage within floodprone areas and that the building sites will be reasonably safe from flooding. In addition to confirming that the design is consistent with the Connecticut Building Code, the Building Official must confirm that the development is designed and constructed so as to minimize flood damage prior to building permit approval. Electrical, heating, ventilation, plumbing, air conditioning, and other service facilities must be designed and/or located so as to prevent water from entering or accumulating within the components during flooding.
- The Planning and Zoning Commission will coordinate with neighboring communities, the Connecticut DEEP, and FEMA prior to approving any activity that alters or relocates a watercourse.
- New construction, substantial improvements, and manufactured homes must be elevated and anchored to resist floatation, collapse, or lateral movement.
- New construction and substantial improvements require that fully-enclosed areas below the lowest floor must be wet-floodproofed and used solely for the parking of vehicles, building access, or storage. The area cannot be used as furnished living space. Utilities are prohibited in the space below the base flood elevation.
- In coastal VE zones, all new construction or substantial improvement must be located landward of the reach of the mean high tide and elevated so that the bottom of the lowest supporting horizontal member is located above the base flood elevation level. Fill may not be used as a structural support.
- Encroachment in floodways is not allowed unless the applicant can demonstrate that the proposed activity will result in no net increase in flood levels during the base flood discharge. The City can require floodway data be provided for watercourses without FEMA-established floodways.
- All building utilities (electrical, heating, plumbing, HVAC, etc.) must be elevated to one foot above the BFE.
- New construction and substantial improvements to residential structures must have the lowest floor elevated to one foot above the base flood elevation.
- New construction and substantial improvements to non-residential structures must have the lowest floor elevated or floodproofed to one foot above the base flood elevation.
- New construction and substantial improvements to any structures in a VE zone must have the bottom of the lowest floor elevated to one foot above the base flood elevation.

Parking requirements are listed in Section 7.1. Parking is required for residential, institutional, marine, retail and service, office, hospitality, industrial, and other uses. Parking requirements for industrial uses (only) may be met in part by the provision of alternative transportation for employees, including shared vans or buses. Parking requirements may also be reduced for some uses if parking is available on-street or on an interconnected lot; other exemptions exist as well. Parking requirements are relevant in the context of impervious surface extent and stormwater runoff.

Section 7.7 presents Stormwater Management Regulations, specifically promoting application of Low Impact Development strategies.



- Any development with the City of Groton must implement provisions of the Connecticut Stormwater Quality Manual:
 - Pollutant Reduction
 - Groundwater Recharge and Runoff Volume Reduction
 - Peak Flood Control for 10-, 25-, and 100-year storm events.
- Stormwater management systems may utilize Low Impact Development techniques

Other hazard-mitigation related zoning regulations include:

- Roads and driveways must be adequate in width, grade, and alignment to allow access by fire, emergency, and police protection (Section 7.5)
- New utilities shall be installed underground (Section 7.5)
- Buildings meeting building-height regulations and located in the flood zone may be elevated (and thus exceed height limits) to comply with FEMA standards (Section 8.3.b.6: Flood Preparation – When a non-conforming building is located within a FEMA flood zone and is being elevated to comply with FEMA standards, it may be so elevated provided doing so does not increase its non-conformity as to yard setbacks or building coverage.)

Plan of Conservation and Development (2019)

The City’s Plan of Conservation and Development was most recently updated and adopted in 2019. This new POCD contains a new subsection, “6.1 Prepare for Climate Change And Sea Level Rise,” that presents the following list of strategies:

1. Address issues associated with climate change and sea level rise.
2. Establish a working committee to evaluate community vulnerabilities associated with climate change and sea level rise.
3. Conduct a thorough assessment of vulnerability to climate change and sea level rise including:
 - a. a database of “repetitive loss” properties; and
 - b. detailed maps showing areas subject to potential inundation in the future.
4. Create an action plan to prioritize actions relative to climate change and sea level rise including a conceptual capital improvement program to balance fiscal capacity with coastal issues/needs.
5. Continue to work with regional, state, and federal agencies and other organizations to address issues related to coastal vulnerability.
6. Consider increasing regulatory standards relative to construction in vulnerable areas:
 - a. Limiting construction of habitable structures;
 - b. Increasing “freeboard” requirements;
 - c. Applying coastal “V” zone flood standards to areas which may be subject to such flooding in the future;
 - d. Update regulations to encourage or allow for increased structural integrity to the extent consistent with FEMA standards.

Another new section in the POCD is “6.3 Promote Sustainability/Resiliency,” which includes the following strategies that “Promote Resiliency”:



3. Continue efforts to identify, avoid, reduce, mitigate, and recover from impactful events.
4. Continue to participate in updating the regional Hazard Mitigation Plan in order to address risks and obtain funding.
5. Implement the Hazard Mitigation Plan, as amended.

Community Resilience Building Workshop (2019)

The City of Groton worked with The Nature Conservancy (TNC) to organize a Community Resilience Building (CRB) Workshop in January of 2019. The workshop objectives were to:

- Define top climate-related hazards of concern for the City.
- Identify local vulnerabilities and strengths.
- Develop a list of prioritized resiliency actions for the City.

The top hazards identified by workshop participants were:

- Coastal flooding from storm surge and sea level rise
- Winter storm events (nor'easters, blizzards, etc.)
- Extreme cold temperature events
- Intense wind events

Areas of concern identified through the workshop were:

- Neighborhoods
 - a. Jupiter Point
 - b. Eastern Point
 - c. Branford Manor, Avery Heights, and Groton Estates
- Ecosystems
 - a. Eastern Point Beach Park
 - b. Washington Park
 - c. Birch Plain Creek
 - d. The city's forests
 - e. Drinking water reservoirs (not located within City of Groton)
- Transportation
 - a. Shore Ave
 - b. Eastern Point Rd
 - c. Beach Pond Rd
 - d. Jupiter Point Rd
 - e. Groton Airport
 - f. Thomas Road
 - g. Route 349
 - h. Gold Star Bridge
- Infrastructure
 - a. Bayberry Lane Boat Launch



- b. Pump Stations: Bayberry Lane, Eastern Point Beach
- c. Wastewater Treatment Plant
- d. Water Treatment Plant
- e. Thomas Road Bridge
- f. Mitchell Street stormwater drainage and downstream impacts
- g. Limited animal sheltering capacity
- Vulnerable Populations
 - a. Renters or Transient
 - b. Elderly
 - c. Developmentally Disabled
 - d. Non-English Speaking
 - e. Low Income
 - f. Working Poor

Discussion of hazard-related concerns included the following:

- Road Network Flooding: flooding on streets is caused by both storm surge and precipitation events that overwhelm the capacity of stormwater drainage systems.
- Traffic: there is concern about the ability of the City to evacuate local residents and employees in the event of a disaster. Electric Boat has about 7,000 employees, and Pfizer has about 3,500. Areas identified as potential pinch points were Thames Street, Bridge Street, I-95, and the Gold Star Bridge.
- Infrastructure: the City's emergency management communication system is of concern, specifically regarding information about evacuation routes and evacuation preparedness, as well as the ability of the city to reach the residents in the various housing complexes in the City.

Strengths and assets identified in the workshop included:

- Leadership: Responsive and committed leadership, and collaboration between leadership, at the City of Groton, Town of Groton, regional, and State levels.
- Staff: Experienced and well-resourced staff, and good coordination between departments.
- Social Services: Supportive social services and faith-based organizations
- Ledge Light Health District
- DEMHS Region 4 Regional Emergency Planning Team
- Major regional employers
- Strong backup power capabilities at critical facilities
- Natural resources and public parks

High priority recommendations included:

- Jupiter Point Flood Study: with short- and long-term assessments and recommendations, cost estimates for projects and ongoing infrastructure maintenance, and consideration of natural infrastructure.
- Citywide Drainage Study: to evaluate impacts of projected future flood and precipitation events on stormwater drainage network and the wastewater treatment plant.



- Strengthen capacities of Ledge Light Health District, NGOs, faith-based organizations, and other social services to support families in need during emergencies.
- Increase hazard resilience of the business community through education and continuity and recovery planning.
- Improve outreach and education about the city’s emergency evacuation plan, specifically focusing on housing complexes and transient populations, as well as workers who commute to the City but do not live here.
- Conduct a Traffic and Evacuation Study to identify patterns and pinch points, and to help develop a comprehensive traffic flow and parking plan to help facilitate evacuation if needed.
- Strengthen downtown area to retain businesses and attract residents.
- Conduct a tree canopy study, and incorporate zoning changes to promote planting trees in public and private spaces.
- Improve access to water treatment plant; consider relocation of facilities to higher elevation over the longer-term.
- Update the emergency check-in list of elderly and disabled residents.

Hazard Mitigation Plan (2018)

The City of Groton has participated three times in the Southeastern Connecticut Multi-Jurisdiction Hazard Mitigation Plan, with the most recent Plan (the second update) approved by FEMA in 2018. The City’s HMP documents its commitment to reducing losses caused by flooding, coastal storms, and other hazards. Mitigation actions in the document focus on preparing for, withstanding, and recovering from acute hazard events, but do not look at long-term adaptation needs in the face of future climate changes.

Vulnerabilities identified in the 2018 HMP that are relevant to climate resilience include:

- Inland (non-coastal) flooding occurs due to drainage issues on the western side of the city. Tropical Storm Arthur in 2014 flooded Thames Street and Eastern Point Road. Flooding occurs on Thames Street near Smith Street and John Street, beginning near Sacred Heart School and flowing downhill along road.
- Large parking areas lead to stormwater flooding. 30-inches or more.
- Golf Course drainage causes flooding of Shore Avenue.
- Electric Boat places steel rods on drainage pipes for security purposes – these can catch debris and clog.

Excerpt from the Hazard Mitigation Plan

“Like many communities, the City lacks existing policies and mitigation measures that are specifically designed to address sea level rise. The City participated in a resiliency planning initiative with SCCOG and TNC in 2016-2017. However, the City has not yet embarked on detailed coastal hazard planning to the degree that nearby communities like Waterford and the Town of Groton have done. Although the City of Groton does not currently have a specific plan to address sea level rise, important pieces are in place in the form of the codes and regulations cited in this HMP that have been enacted to minimize storm, erosion, and flood damage.”



- Four homes are located within Birch Plain Creek Special Flood Hazard Area (SFHA). They are located on Paul Revere Road, Madison Place, Nathan Hale Road, and Thomas Road.
- A pump station (on Madison Place) is within the SFHA.
- Flooding occurs along Poquonnock Road from Birch Plain Creek. Drainage across from breached dam site needs to be maintained.
- Basement of Groton City Hall complex can be flooded, and is often damp.
- The Public Works facility is at slight risk from riverine flooding.
- Road flooding in the southern part of the City can make evacuation difficult. Specific vulnerable locations include:
 - The southern section of Eastern Point Road.
 - Thomas Road Causeway. This is an important egress route for the area.
 - Road is low and susceptible to flooding.
 - Drainage structures are old and need repair.
 - The drainage system from Kamaha Street flows beneath railroad tracks; this is a structure of concern.
 - The downstream railroad bridge is a concern as well.
 - Some drainage structures in the area are maintained by the railroad company, and the City does not have the ability to ensure this is done.
 - Roads in Jupiter Point (Jupiter Point Rd, Pine Island Rd, and Bayberry Lane) that are in need of drainage improvements.
 - Roads in Eastern Point (Shore Ave, Tyler Ave, Beach Pond Rd, Thomas Rd, South Prospect St (a dead end)).
- Jupiter Point has many homes in the SFHA.
- Eastern Point has many homes in the SFHA, as well as a public park and beach that are vulnerable to flooding (much of this area is protected from wave action by seawalls)
- Pfizer facilities, Electric Boat facilities, and other areas along Thames Street are located near the flood source of the Thames River and therefore have risk.

City of Groton capabilities identified in the 2018 HMP that are relevant to climate resilience include:

- Prevention (Plans and Regulations)
 - Development within FEMA-mapped SFHAs is regulated (Section 2.5 in the Zoning and Subdivision Regulations of the City of Groton, (2016).
 - Alternative evacuation routes have been established in case Eastern Point Road and Thomas Road are flooded. These are Mitchell Street and Tyler Avenue.
- Structural (Infrastructure and Structural Flood Mitigation)
 - John Street Drainage Improvements in 2012 directed stormwater into the Thames River and helped mitigate flooding of Thames Street, Eastern Point Road, Mitchell Street, and John Street.
 - Various coastal protections structures exist along the coastline:
 - Small, private seawalls and bulkheads are located along residential neighborhoods



- Larger seawalls & bulkheads are located along UConn Avery Point, Eastern Point, Pfizer property, and Electric Boat property
 - Groins serve to mitigate longshore erosion at Shennecossett Beach
 - Tide gates on the outfalls of stormwater drainage systems have been upgraded, especially on Shore Ave
 - Beach Pond Road has been elevated.
- Utility Service Capabilities
 - The City has three tree wardens who monitor trees for issues and direct the DPW to remove trees or limbs at risk of falling
 - The City has a robust tree maintenance budget
 - Groton Utilities serves the City with electric, cable, and water service. The utility company is very responsive and service outages tend to be limited.

The 2018 HMP includes a set of hazard mitigation actions. A selection of those relevant to climate resilience are listed below:

- Incorporate the recently updated 1% annual chance and the 0.2% annual chance inland and coastal floodplains based on the current DFIRM into the CT Alerts Emergency Notification System to telephone warnings into potentially affected areas.
- Work with the Town of Groton to create an open space corridor along Birch Plain Creek (called the “Greenbreak”) and add land to the existing Birch Plain Creek Park.
- If property owners become interested, consider elevation or acquisition of residential properties that suffer flood damage.
- Ensure that the EOP provides up-to-date, detailed instructions regarding the timing of evacuations from the southern part of the City, since these roads will be significantly flooded or washed out by a major hurricane.
- Develop formalized guidance for culvert and bridge construction and replacement that requires utilization of the most up-to-date extreme rainfall data from <http://precip.eas.cornell.edu>
- Consider elevating Shennecossett Road immediately east of Avery Point above the 1% annual chance floodplain.
- Repair and clean the culverts near Shennecossett Beach.
- Groton City Hall: Pursue short-term recommendation that drainage improvements be designed and constructed to minimize future risks of stormwater entering the basement.
- Groton Public Works: Pursue short-term recommendation that public works buildings be wet and dry-floodproofed.
- Clearly mark Tyler Avenue as an alternate evacuation route with signage
- Post and maintain signs signifying alternate evacuation routes from coastal areas.



Harbor Management Plan (2006)

In 2006, the City of Groton Harbor Management Commission, with assistance from the Southeastern Connecticut Regional Planning Agency, developed the City of Groton Harbor Management Plan to provide guidance for the management and use of the waters and waterfront of the City.

The Plan divides the City's waterfront into the following sections:

- A. **Thames Street or Groton Bank:** This is the oldest section of the city, with historic structures, marinas, docks, and water-dependent uses. The winds blow predominantly west or southwest across the Thames River in this area and produce rough water. Water depth is very deep close to the shore here, with the main river channel very close to the shore and used by large ships and submarines. This channel is regularly dredged and maintained. The bank here is steep.
- B. **Intensive Industrial Area:** Includes Electric Boat Corporation (building nuclear-powered submarines for the U.S. Navy), Amerada Hess Corporation Oil Terminal [note: appears to now be operated by Buckeye Terminals, LLC], and Pfizer pharmaceuticals. This section of shoreline is an economic engine for the city and the region. The land here is steeply sloping, and the main ship channel is close to shore. The water between the channel and the shoreline is too deep for most marina development but too shallow for large ships.
- C. **Circle Avenue to Avery Point:** This is a residential area that includes part of the Shennecossett Golf Course and a City-owned waterfront park, which includes two masonry piers. The area includes two recreational facilities: Eastern Point Beach (City-owned) and the Shennecossett Beach Club (private). Residential area shoreline is rocky, with a few private boat moorings. The shoreline is exposed to winds and waves from the southwest. Water activities here include swimming, boating, scuba diving, fishing, lobstering, and personal watercraft activity. Two ponds/conservation areas along Shennecossett Road (one on Beach Club property and one on UConn property) perform important drainage functions and provide wildlife habitat. Avery Point consists of the UConn Avery Point campus; the campus waterfront is open to the public.
- D. **Pine Island Bay:** This area contains multiple boating facilities, including a UConn pier, UConn docking facilities (including for Project Oceanology boats, Coast Guard Research and Development Center boats, and other state research boats), Shennecossett Yacht Club, Pine Island Marina, Bayberry Lane boat launch (state-owned), and a significant mooring area. This area is the most active in the City with respect to recreational boating. The area is subject to wave action from the south and southwest.
- E. **Baker Cove:** Predominantly residential, with a number of small water-related commercial facilities scattered throughout the area. Groton Elks Club, to the north, contains a marina for small boats. Baker Cove is very shallow, and only navigable by small boats. The shores consist of low, marshy land that are an important natural resource area. There is a Public Access area on Jupiter Point Road. To the north, the railroad bridge and the Thomas Road Bridge mark the boundary of the Cove; farther north the Cove narrows to become Birch Plain Creek. Birch Plain Creek borders conservation areas of salt marshes and forests, which are accessible by way of the City-owned Birch Plain Creek Conservation Area, the City-owned



open space area at the end of Paul Revere Road and Nathan Hale Road, West Side Junior High School, and the Town of Groton-owned open space north of West Side Junior High School.

Important economic features of the City of Groton Harbor include boating resources (marinas, moorings, docks, and slips), fishery and shell fishery resources, a variety of commercial and industrial water-dependent uses, and natural resources (with recognized ecological, educational, recreational, and aesthetic values).

Important water-dependent uses identified in the Thames Street area (as of 2006) include:

- Whaling City Dredge and Dock Corporation a Division of Mohawk Northeast, Inc.
- Ken Streeter Boat Launch
- Groton Oil Co. Marina
- Groton Marine Dock
- Carolyn Green Pier
- Seabird Enterprises
- Hell-Cat Dock
- On-the-Thames Boatel
- Morgan & White Wharf
- Ed Costa Pier
- J. Garbo Seafood Operations

Other water-dependent uses are:

- Pine Island Marina
- G & S Fisheries
- Other small boatyards

The Harbor Management Plan included many relevant “Issues, Problems, and Opportunities,” such as:

- Economic revitalization is needed in the Groton Bank (Thames Street) area. From the point of view of the Harbor Management Commission, this means encouragement of water-dependent businesses.
- The Groton Bank shoreline is steep and narrow, exposed to the full width of New London Harbor and the predominant west or southwest winds (producing waves), subject to wave wash caused by passing large-vessel traffic in the main harbor channel, and the water is very deep.
- The state-owned boat launch facility under Route I-95 should be used by the general public.

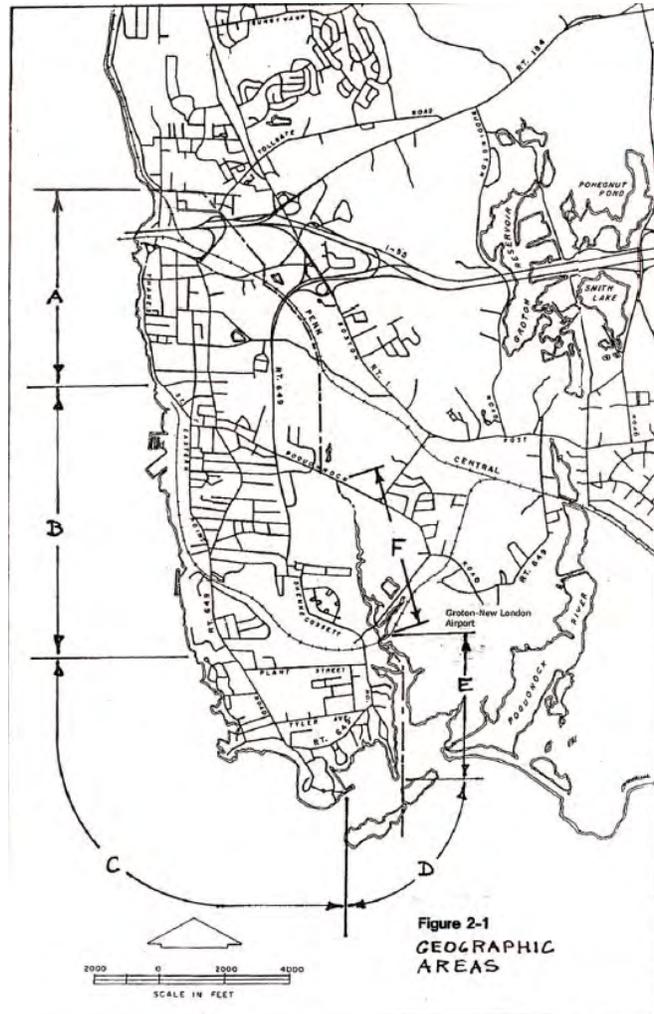


Figure 1: Harbor Management Area Divisions



- The Harbor Management Commission is concerned about the potential for hazardous material (oils and chemicals) spills occurring in the Industrial Area.
- Public access and recreational opportunities in the Eastern Point area should be enhanced.
- The City of Groton, the University of Connecticut, and the Shennecossett Yacht Club, and the Pine Island Marina cooperated in construction of a breakwater extending southeasterly from Avery Point to mitigate wave action in Pine Island Bay. There is still some risk of wave action in parts of the bay.
- Much of the Baker Cove shorefront is in the flood hazard area.
- Birch Plain Creek is a fragile and important environmental area.
- Increasing development of upland areas may be causing an increase in stormwater runoff to Birch Plain Creek, in turn changing the salinity of the creek and thus its ecological characteristics.
- The Harbor Management Commission supports increasing the size of the Thomas Road Bridge opening to increase water flow and tidal flushing [this had been recently performed when the plan was developed].

Finally, the Plan lists a number of goals, objectives, and policy recommendation relevant to climate resilience, including:

- Encourage public access and passive recreation
- Prevent oil and chemical spills and facilitate cleanup operations in the Industrial Area
- In Pine Island Bay, continue engineering studies to find a solution to wave action problems and develop potential solutions, consistent with the CT Coastal Management Act and the CT Structures, Dredging & Fill in Tidal, Coastal, or Navigable Waters Act.
- Establish conservation areas within Baker Cove
- Encourage changes to the railroad and Thomas Road bridges in order to increase water exchange



REVIEW OF DOCUMENTS: REGIONAL PLANNING DOCUMENTS

Resilience and Sustainability Task Force: Human Health and Safety Recommendations (2020)

In 2020, the Groton Resilience and Sustainability Task Force (GRAS TF) produced a report summarizing the 2019 Division of Emergency Management and Homeland Security (CT DEMHS) assessment of threats to the region due to climate change, identifying key risks to the Town of Groton. The report also included recommended resilience actions for the Town of Groton, many of which would be relevant for City of Groton.

Top threats to human health and safety identified by DEMHS were:

1. Pandemic, influenza, and insect vector borne disease
2. Hurricanes
3. Electrical failure
4. Extreme temperature events
5. Water contamination and water quality deterioration

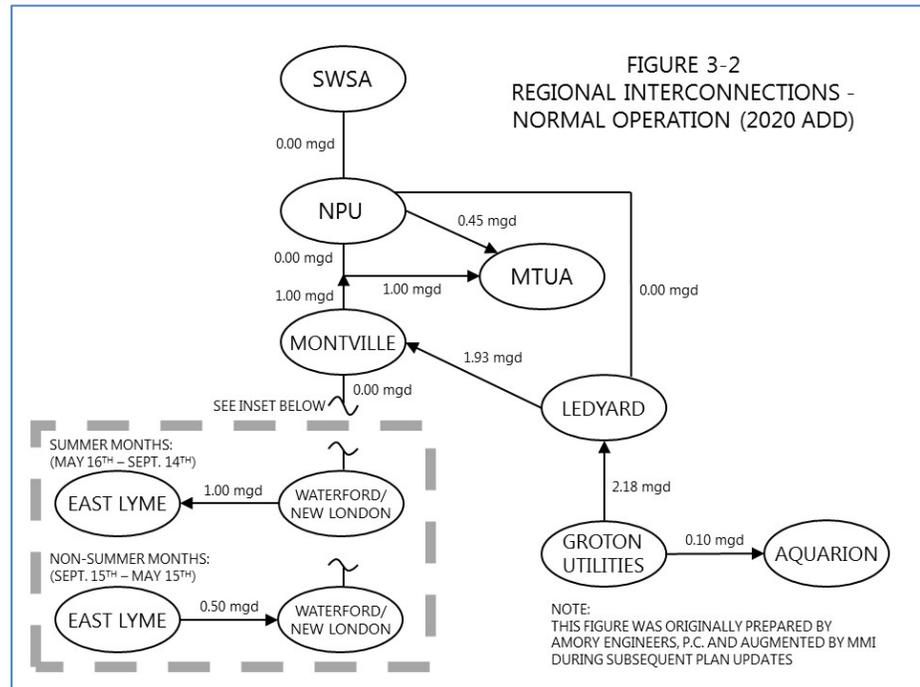
Action recommendations were categorized by threat, as listed above. These included:

- Biological disease risks:
 - a. Conduct public health education on preventative behaviors and symptom recognition
 - b. Strengthen public communication and alert mechanisms
- Hurricanes
 - a. Conduct Community Assessment for Public Health Emergency Hurricane Response (CASPER)
 - b. Distribute educational material
 - c. Survey household preparedness and set community-wide performance target
 - d. Perform evacuation and sheltering exercises
 - e. Conduct exercises to build community trust in public officials
 - f. Recruit Medical Reserve Corps and CT Red Cross recruitment
- Extreme Temperatures
 - a. Public education
 - b. Identify vulnerable populations
 - c. Activate cooling/warming centers
- Water Quality Degradation
 - a. Public education
 - b. Have water utilities communicate protection activities to the public



Intra-Regional Water Supply Response Plan (2019)

Working with other municipal and non-municipal water utilities, Groton Utilities forged a plan to interconnect all of the water utilities of southeastern Connecticut and then implemented this plan over the course of 15 years. To accompany this interconnection group of water systems, the region developed an *Intra-Regional Water Supply Response Plan*. The plan was developed



in 2005 and has been amended several times, including an amendment in 2019. The plan envisions a network of water utilities that can provide water to one another during times of unplanned outages and emergencies.

The City of Groton remains the key player in this interconnected system, as Groton Utilities has the largest and most robust supply, actively providing water to Ledyard, Montville, the Mohegan Tribe, and the Aquarion System in Mystic.

Critical Facilities Assessment (2017)

SCCOG received a grant from CIRCA in 2017 to complete an assessment of critical facilities in the region. The study focused on facilities that would otherwise not be addressed by other programs such as the Clean Water Fund (which addresses sanitary sewers) and therefore included fire stations, emergency operations centers, municipal offices, public works facilities, and the like. FEMA Elevation Certificates (ECs) were completed for most facilities along with the assessments. Two facilities in the City of Groton were included: the municipal building (city hall) and the public works facility. Some of the findings of the study, which are relevant to the City's climate resilience planning, include:

- The approximate 0.2% annual chance flood elevation associated with Birch Plain Creek is 52.8'.
- There is no 1% annual chance flood elevation associated with Birch Plain Creek.



Municipal Building

- The Municipal Building is mapped in an X zone adjacent to a 0.2% annual chance floodplain along Birch Plain Creek, indicating an assumption of minimal or negligible flood risk.
- The lowest adjacent grade at the Municipal Building is 49.54', with the lowest floor elevation at 49.62'. However, the ground surface between the 0.2% annual chance floodplain and the Municipal Building rises to 54.7', which is two feet higher than the 0.2% flood elevation of 52.8'. Therefore, Birch Plain Creek does not contribute flood risk to the Municipal Building.
- The Municipal Building and adjacent parking areas undergo nuisance site flooding which occurs on average once a year, per anecdotal reports. The Public Works building has not been flooded.
- Climate change is believed to be increasing the intensity of precipitation events and may also lead to greater overall precipitation in the state, which could increase risks along Birch Plain Creek and in the vicinity of the Municipal Building.
- Short-Term: Drainage improvements are recommended to decrease nuisance flooding at the Municipal Building. These improvements should be designed for increasing precipitation intensities.

Public Works Building

- The Public Works building is mapped in the 0.2% annual chance floodplain along Birch Plain Creek, indicating an assumption of relatively low flood risk.
- Long-Term: climate change will create slightly increased flood risks to the Public Works facilities. A combination of wet and dry floodproofing for the main building may be prudent in the future. Outbuildings could be made floodable, including the garage building located immediately north of Birch Plain Creek.
- The Public Works site likely has sufficient space for flood walls, berms, or raising grade. Specifically, a flood wall could be constructed along the southern edge of the site (refer to picture to the right), running between the garage outbuilding and Birch Plain Creek, turning north at each end to meet higher grade.

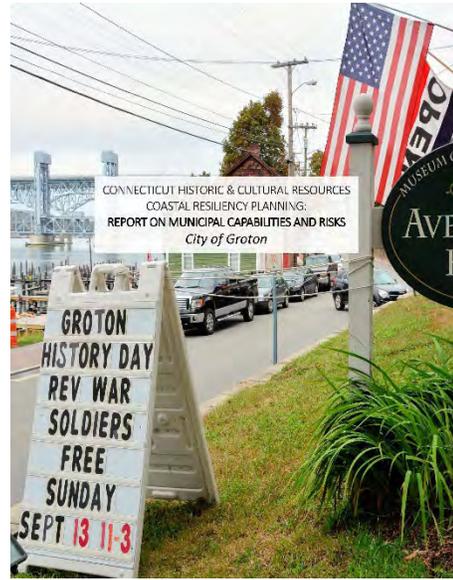


Historic Resources Resiliency Planning (2017)

Historic and cultural resources are increasingly at risk to natural hazards and climate change; furthermore, historic resources are difficult to floodproof, elevate, or relocate without potential loss of their historicity. Recognizing this challenge, the Connecticut State Historic Preservation Office (SHPO) embarked on a resiliency planning study for historic and cultural resources beginning in 2016.



SCCOG hosted a historic resources resiliency planning meeting in June 2016, with several communities attending. During winter 2016-2017, individual meetings were held with shoreline communities including City of Groton. A report was issued to the City in August 2017. This report outlines historic resources at risk, gaps in municipal planning documents with regards to addressing historic preservation in the context of natural hazards, and strategies that can be employed to make historic and cultural resources more resilient.



In the City of Groton, 64 historic structures were identified within the FEMA Special Flood Hazard Area. 13 historic structures are within an area that may be inundated on a daily basis under three feet of sea level rise, and 37 are within the area that will be inundated on a daily basis under six feet of rise. Historic sites in the City of Groton are concentrated in the Groton bank Historic District and around the Shennecosset Golf Course; both areas are near the shoreline. Despite this proximity, damage to these sites from flooding has historically been relatively limited.

Historic structures in more rural and wooded areas are at elevated risk from high winds and winter storms; however, such areas are very limited in the City of Groton.

Recommended strategies identified in the 2017 report for the City to pursue are:

- Coordinate Regionally and with the State
- Educate Regarding Historic Resources
- Incorporate Historic Preservation into Planning Documents
- Revisit Floodplain Regulations and Ordinances
- Revisit Historic District Preservation Regulations and Ordinances
- Structural Adaptation Measures
- Strengthen Recovery Planning
- Identify Historic Resources

A best practices guide for planning techniques to make historic resources more resilient was distributed in 2019. This guide can be used by all jurisdictions in Connecticut when undertaking development of hazard mitigation plans.



Southeastern Connecticut Regional Resilience Vision Project (2017)

The Nature Conservancy (TNC) conducted a series of “Risk & Vulnerability Assessment Workshops” in southeastern Connecticut, including the City of Groton, beginning in 2012. Through these efforts, TNC (in conjunction with SCCOG and the Southeastern Connecticut Enterprise Region) developed the “Southeastern Connecticut Regional Resilience Vision Project” summary of findings along with the “Southeastern Connecticut Regional Resilience Guidebook” (published March 2017). These documents seek to help southeastern Connecticut residents prepare for disaster events and a changing climate. The project notes that Groton was included, although a distinction between the City and Town was not made in the reporting materials.

The vision for the project was assembled in conjunction with municipal staff, land use and economic planners, public and private utilities, major employers, academic institutions, and other stakeholders. Stakeholders included:

- Southeastern Connecticut Council of Governments
- Southeastern Connecticut Enterprise Region
- Ledge Light Health District
- Avalonia Land Conservancy
- University of Connecticut
- Connecticut College
- Millstone Environmental Laboratory
- Uncas Health District
- New London County Food Policy Council
- Eastern Connecticut State University Institute for Sustainable Energy
- Thames River Basin partnership
- Groton Utilities
- Pfizer
- Connecticut Department of Public Health
- Connecticut Department of Energy and Environmental Protection
- Connecticut Department of Transportation
- Connecticut Department of Emergency Management and Homeland Security
- Region 4
- The Community Foundation of Eastern Connecticut
- Eastern Connecticut Conservation District

In order to prioritize major focus areas of the project, the core project team recruited a team of planners representing each municipality and boroughs within the planning area. This team derived six planning sectors that would form the framework of the resilience workshops. The six sectors identified were:

1. Water
2. Food



3. Ecosystem services
4. Transportation
5. Energy
6. Regional economy

All of these sectors were deemed important areas in which to focus the resilience efforts.

TNC held two workshops, which were used to derive the challenges facing the region, as well as possible solutions. In the first workshop, participants were given six planning sectors, listed above, and were asked to identify challenges associated with each planning sector caused by weather events, climate change, and other factors. Dialogue between the various stakeholders listed above ensured that various interests were considered when identifying challenges. In the second workshop, stakeholders were tasked with providing potential solutions to each of the challenges identified in each planning sector. The potential solutions were then consolidated into "overarching" solutions, which could have more broad application.

A summary of challenges, as well as some solutions, per sector, identified in the report are listed below.

Water:

- Nonpoint source pollution impacting surface and ground water
 - Utilize green infrastructure, including rain gardens and bioswales
 - Require septic system inspection at point of property sale
- Aging and outdated stormwater systems overburdened by intense rainfall and sea level rise
 - Cross-municipality planning
 - More efficient water use & conservation
- Infrastructure is vulnerable to storm surge
 - Managed retreat from vulnerable areas (limit development and encourage relocation)
- Rising sea water intruding into aquifers and septic systems
 - Develop long-term plan for upgrading infrastructure to reduce impacts of intrusion
- Planning for water shortages
 - Inventory private wells in the region.
 - Construct interconnections between public water systems
 - Encourage private water conservation measures
 - Develop region-specific decision & planning support process
 - Perform outreach, focusing on school classrooms
- Loss of tax base due to coastal storms

Food:

- Regulatory hurdles for local producers
 - Streamline regulatory requirements across state agencies
 - Permit and incentivize non-traditional ag practices at municipal level
- Limited infrastructure for local producers and distributors



- Cooperative funding, sourcing, and distribution models
- Large scale municipal composting
- Regional processing facility
- Food production on municipal park land
- Competition for farmland with more profitable land-uses
 - Increase housing opportunities & density in developed areas
 - Promote agricultural careers
 - Use transfer of development rights to protect farmland
- Food deserts in the City of Groton
 - Conduct food-shed mapping effort
 - Develop year-round farmers market
- Environmental threats to agriculture (pollution, etc.)
 - Encourage crop diversification, value-added products, and other on-farm uses
 - Reduce flood risks to farmers
 - Plant trees and deep-rooted perennial crops

Ecosystems

- Changing water quality and quantity on ecosystems
 - Institute mandatory water conservation policies based on land use
- Loss or alteration of ecosystem services (coastal protection, water purification)
 - Municipal championing of protections at regional scales
 - Assess monetary value of ecosystem services to inform decision making
 - Identify vulnerable, functionally-important ecosystem areas for planning
 - Restore ecosystems as coastal infrastructure moves inland
 - Enact stricter or more strictly enforce standards in hazard areas
 - Implement living shoreline techniques
 - Incorporate ecosystem services into MS4 permitting requirements
- Conflicts between built environment and natural systems
 - Identify financial mechanisms and incentives for property owners to enhance natural systems
 - Integrate natural infrastructure into zoning codes
 - Education & outreach
 - Focus on opportunities in redevelopment projects

Transportation

- Primary arterial road vulnerable to flooding, tree, and ice impacts
 - Prioritize improving roads that contribute to resilience building
 - Regional collaboration on vulnerabilities and resilience-building
 - Incorporate green infrastructure into upgrades
 - Elevate roads
 - Improve evacuation communication
 - Facilitate inland marsh migration through culverts & bridges
- Unreliable public transportation to emergency shelters and employment centers
 - Establish mutual aid agreements with inland urban centers



- Smart phone apps for real-time bus mapping
- Assess public transit capacity
- Aging Infrastructure
 - Retrofit existing and design new infrastructure for storms of the 2030s
 - Connect transportation funding with MS4 permitting needs
 - Prioritize improvements based on road runoff volumes
 - Long term assessments of regional transportation network
- Conflict between use of Thames River Amtrak Bridge and access to the Groton Submarine Base

Energy

- Insufficient preparedness and capacity to recover from flooding and high wind weather events
- Communications disconnect between energy consumers and providers
- Uncertainty surrounding inner workings of energy grid

Economy

- Effects of flooding and power outages on business continuity
 - REPT Regional Emergency Support Function 7 concerns private sector recovery and response and includes a model ordinance to establish a Recovery management Organization to help coordinate business recovery
 - Include local businesses in post-disaster recovery drills
 - Inventory businesses with generators
 - Utilize third party organizations to support businesses
 - Establish mutual aid agreements to help with permitting following a disaster
 - Inventory available space for temporary operations (share space/equipment/materials)
- Serving lower income communities with food, transportation, and shelter in emergency situations
- Limited training and testing of preparedness plans for municipalities and social services
 - Improve coordination of disaster recovery between public and private
 - Recovery drills with wider range of stakeholders
 - Identify communication and response gaps
 - Stockpile generators when lower priced
- Regional interconnectivity
- Vulnerability of tax base
 - Consider economic impacts of hazards when determining resilience funding
 - Incentivize future development inland
 - Prioritize compact mixed-use areas with infilling
 - Diversify economy and revenue generators
 - Transfer responsibility of infrastructure to homeowners and neighborhood associations
 - Mandatory evacuations pre-storm



A Salt Marsh Advancement Zone Assessment of Groton, CT (2015)

Salt marshes are important coastal ecosystems that are only viable within a narrow vertical band between low tide and slightly above high tide. As sea levels rise, salt marsh habitats will need to migrate upward vertically, or inland horizontally, in order to remain viable. This inland migration is referred to as marsh migration or marsh advancement. In 2015, TNC utilized the Salt Marsh Advancement Model (co-developed by TNC and the University of Connecticut Department of Natural Resources Management and Engineering) to assess potential future salt marsh conditions along the coastline of Groton (including the Town of Groton and the City of Groton) under projected sea level rise scenarios. The assessment considers current land cover, ground elevation, and hydrologic connectivity, among other factors. This assessment considered salt marsh advancement by 2080; specifics regarding this sea level rise scenario are not provided in the report.

Within the City of Groton, significant opportunity for salt marsh advancement is located along Birch Plain Creek and Baker Cove on the eastern border of the city, and around Jupiter Point and Eastern Point to the south. Much of the southern areas have developed land cover (buildings and pavement) that will prohibit salt marsh migration unless land cover is changed, while much of the potential marsh migration areas along Birch Plain Creek are already undeveloped. Some locations of note include:

- The Electric Boat parking lot located adjacent to Birch Plain Creek off Poquonnock Road. The southeastern portion of this area could support marsh migration if current land cover were to be changed to open space.
- Large yards located on private properties south of Shennecossett Road have the potential to support future marsh migration, provided the property owners allow for the change in land cover.
- The forested area bounded by Shore Ave, Central Boulevard, and Eastern Point Road may be able to support salt marsh in the future even though it is not directly adjacent to the shore. For salt marsh to be supported, connectivity will need to be maintained with the waters of Long Island Sound.

Preparing for Climate Change in Groton, Connecticut (2011)

The Town of Groton and the City of Groton participated in an EPA-funded climate change planning process in 2010 and 2011. While the effort was heavily skewed in favor of Town of Groton participants, former Mayor Dennis Popp participated in the planning process. The team of EPA, DEEP, and the Town of Groton organized three workshops in 2010 focusing on:

1. The climate adaptation planning process and projected global, regional and local climate changes;



2. Identification of vulnerabilities from projected changes in global and regional climate; and
3. Identification of potential actions that could be used to increase resilience towards existing and projected changes in global and regional climate.

The planning process resulted in the report “Preparing for Climate Change in Groton, Connecticut: A Model Process for Communities in the Northeast” (April 2011). The report focused on the Town, and the Town of Groton incorporated some of the findings and recommendations into its Municipal Coastal Program and Plan of Conservation and Development, both of which were updated in 2013-2014. During the workshops, participants identified the following as climate related impacts likely to affect the broader “Groton” (some are located in the City):

- More frequent river and coastal flooding;
- Increased coastal erosion;
- Increased precipitation, flooding, drought, and erosion;
- More frequent flooding that could prevent access to and reduce function of Groton-New London Airport;
- Access to state parks such as Bluff Point and Haley Farm could be hampered by flooding;
- Docks and marina facilities could be damaged by flooding and sea level rise;
- Increased economic impacts related to infrastructure replacements, loss of employment hours, additional emergency service personnel, and others arising from no action scenarios;
- Sections of Amtrak railroad could flood under certain sea level rise and storm flooding scenarios;
- Mystic River bridge may experience additional openings for smaller boats as bridge clearance diminishes with sea level rise;
- Overall quality of life, aesthetics, and enjoyment of citizens may be reduced.

Specific locations were also identified by workshop participants as vulnerable to climate change impacts such as sea level rise, increased storm frequency, and increased storm intensities:

Transportation

- Poquonnock Road
- Fort Hill Road
- Groton Long Point Road
- Route 649 Amtrak railroad underpass
- Route 117 at Route 1
- Route 1 at Fishtown Road
- Route 1 at Poquonnock Bridge
- Route 27 at Mystic River Bridge
- Mystic River Bridge



Other Town/City Infrastructure

- Reservoir and Water Treatment Plant
- Wastewater Treatment Plant and Pump Stations – 30% of pump stations are along the coastline
- Claude Chester Elementary School
- Cutler Middle School

Residential Locations

- Mumford Cove
- Groton Long Point
- Noank
- Eastern Point
- Mystic

Commercial Locations

- Downtown Mystic
- Poquonnock Bridge
- Airport Industrial Park

Ecological Resources

- Birch Plain Creek – Baker Cove
- Fort Hill Brook – Mumford Cove
- Eccleston Brook – Palmer Cove
- Groton Long Point Marshes

Emergency Services

- Police and Fire Operations
- Emergency Medical Services

Numerous adaptation strategy suggestions were developed by workshop participants:

1. Relocate/Elevate vulnerable roads and infrastructure – ensure emergency access and preservation of public safety during extreme events;
2. Develop Memorandums of Understanding with state personnel regarding funding of local police costs incurred to protect safety along vulnerable state-owned road infrastructure during and after storm, so that police can also monitor other hazardous areas;
3. Stormwater runoff reduction program designed to control peak discharges and to require post- development rates of runoff to be no greater than pre-development conditions in most circumstances;
4. Flood-proofing of existing buildings;
5. Conversion of land upriver to wetlands in order to accommodate increased sea level rise;
6. Creation of incentives for retreat zoning and/or zoning and redevelopment restrictions and building code changes or enforcement to prevent building in the most vulnerable locations;



7. Educational programs that alert residents about climate change and vulnerable areas of the Town;
8. Purchase of vulnerable land or land that will act as a buffer;
9. More stringent building and engineering design standards that anticipate future climate conditions, as opposed to just existing conditions;
10. Beach nourishment;
11. Installation of flood/tide gates at locations such as Groton Long Point and Mumford Cove;
12. Creation of a comprehensive watershed management plan for debris and culverts, in partnership with Amtrak and CTDOT;
13. Improved road condition reports during extreme events, in order to help the school district and other agencies to identify the safest transportation routes;
14. Identification of Town, State, and Federal funding available to make the improvements to infrastructure that is deemed highly vulnerable;
15. Integrate climate preparedness into the Capital Planning process, Master Plan of Conservation and Development update process, the zoning regulations revision, and streetscape project; and

Investigate the logistical challenges of incorporating climate change, adaptation, and preparedness into school curriculum.



TABLE SUMMARY OF REVIEWED DOCUMENTS

General Concerns

The following table is intended to capture climate-related concerns specifically identified in each document.

	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
FLOOD CONCERNS												
Coastal Erosion												X
Coastal Flooding	X	X	X	X		X		X	X	X		X
Drainage Overwhelmed/Clogged			X	X						X		X
Riverine Flooding	X			X				X				X
Sea Level Rise		X		X				X	X	X	X	X
EXTREME WEATHER CONCERNS												
Extreme Cold			X			X						
Extreme Heat						X						
Intense Wind			X	X		X			X			
Wildfire				X								
Winter Storm Events			X	X				X	X			



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
INFRASTRUCTURE CONCERNS												
Drinking Water Resources						X	X			X		
Emergency Communication System			X			X				X		
Evacuation & Traffic			X	X						X		X
Food Availability										X		
Power Outages						X				X		
Railroad										X		X
ENVIRONMENTAL CONCERNS												
Agricultural Impacts										X		
Biological Disease						X						
Ecosystem Damage										X		
Pollution from Runoff					X	X				X		
ECONOMIC CONCERNS												
Business Continuity										X		X
Property Damage/Values		X	X	X	X			X	X	X		X
Water-Dependent Businesses												X



Specific Vulnerabilities

The following table is intended to capture the assets, systems, or services specifically identified in each document as being at risk from climate-related hazards.

	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
PROPERTY DAMAGE OR LOSS												
Avery Heights			X									
Branford Manor			X									
Eastern Point			X	X					X			X
Groton Bank									X			
Groton Estates			X	X								
Jupiter Point			X	X	X							
GOVERNMENT FACILITIES												
City Hall Basement				X				X				
Public Works Facility				X				X				
TRANSPORTATION FACILITIES												
Bayberry Lane Boat Launch			X									
Groton Airport			X									X
Railroad Bridge over Birch Plan Creek				X								X



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
ROADWAYS & BRIDGES												
Bayberry Lane				X								
Beach Pond Rd			X	X								
Eastern Point Rd (Rt 349)			X	X								
Gold Star Bridge			X									
Jupiter Point Rd			X	X								
Pine Island Road				X								
Poquonnock Road				X								X
Route 349			X							X		
Shore Ave			X	X								
South Prospect Street				X								
Thames Street				X								
Thomas Road			X	X	X							
Tyler Ave				X								
UTILITY INFRASTRUCTURE												
Drinking Water			X				X			X		X
Drinking Water Treatment Plant			X									X
Pump Station: Bayberry Lane			X									X
Pump Station: Eastern Point Beach			X									X
Pump Station: Madison Place				X								X
Wastewater Treatment Plant			X									X



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
STORMWATER DRAINAGE												
Golf Course				X								
Mitchell Street			X									
Parking Areas				X	X							
Security Fence Blockage				X								
PARKS AND ECOSYSTEMS												
Birch Plain Creek (SLR & Runoff Impacts)			X	X	X						X	X
Eastern Point Beach Park			X								X	
Forests and Tree Canopy		X	X									
Hazardous Spills From Industrial Area					X							
Tidal Marsh Damage											X	
Washington Park			X									
SOCIAL SYSTEMS												
Animal Sheltering Capacity			X									
Developmentally Disabled			X									
Elderly			X									
Historic and Cultural Resources								X				
Low Income			X									
Non-English Speaking			X									
Renters or Transient			X									
Working Poor			X									



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
ECONOMIC SYSTEMS												
Docks and Marinas												X
Electric Boat Facilities				X	X							
Pfizer Facilities				X	X							
Thames Street Businesses				X	X				X			



Capabilities & Capacities

The following table is intended to capture strengths that exist within the City of Groton in terms of building community resilience to climate change impacts, as specifically identified in each document.

	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
MUNICIPAL OPERATIONS & SERVICES												
Groton Utilities (Electric, Cable, Water)				X			X					
Municipal Leadership and Staff			X									
Tree Wardens and Management				X								
EMERGENCY RESPONSE												
Alternative Evacuation Routes				X								
Backup Power at Critical Facilities			X			X						
COMMUNITY CAPACITY AND OTHER SERVICES												
DEMHS Region 4 Regional Emergency Planning Team			X			X						
Historic and Cultural Resources									X			
Ledge Light Health District			X									
Social Services			X			X						
BUSINESSES STRENGTHS												
Regional Employers			X									
Water-Dependent Businesses					X							



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
PROTECTION STRUCTURES												
Beach Groins (Shennecossett)				X								
Drainage Improvements (eg John Street)				X								
Seawalls (Eastern Point, Avery Point, Pfizer, EB, Private)				X	X							
Road Elevations (Beach Pond Road)				X								
Tide Gates On Stormwater Drainage (Shore Ave)				X								
REGULATIONS												
100-Foot Single-Family Home Setback	X											
25-Foot Setback from Tidal Water & Coastal Resources	X											
Coastal Site Plan Review	X											
Freeboard: 1 ft above BFE	X											
Height Allowance for Flood Elevation	X											
LID is Permitted	X											
Regulated Floodplain	X			X								
Require CT Stormwater Quality Manual	X											
Substantial Damage = 2 events over 10 Yrs > 50% Value	X											
Substantial Improvement = 50% over 1 Year	X											
Underground Utilities Required	X											



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
NATURAL SYSTEMS												
Birch Plain Creek		X	X		X						X	X
Natural Resources and Public Parks			X		X						X	
Tidal Marshes											X	



Recommended Actions

The following table is intended to list all of the climate-resilience actions specifically recommended by each document.

	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
REGULATIONS & POLICIES												
Building Codes / Standards									X			X
Flood Protection Regulations		X							X	X		X
- Increased Freeboard		X										
- V Standards in Future V Zones		X										
Green Infrastructure (codes, incentives)										X		
Open Space for Marsh Migration											X	
Stormwater Regulations										X		X
Water Conservation Policies										X		



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
STUDIES												
Community Assessment for Public Health Emergency Hurricane Response						X						
Drinking Water Interconnections							X			X		
Ecosystem Services Study										X		
Flood / Drainage / Watershed Study & Management			X									X
Historic Resource Inventory									X			
Inundation Mapping		X										
RLP Database		X										
Traffic & Evacuation Study, Planning, & Monitoring			X	X								X
Tree Study, Planning			X									
Vulnerable Population Study						X						
Water Resource Study										X		
MUNICIPAL CAPACITY												
CIP for Climate Change		X										X
Committee on Climate Change		X										
Coordination with Region, State, Fed.		X	X						X	X		X
Debris Management												X
Integrate Climate Change into Planning									X	X		X
Recovery Management Organization (ESF7)										X		



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
COMMUNITY CAPACITY												
Community Trust Building						X						
Education & Outreach			X			X			X	X	X	X
Social Service Capacities – Strengthen			X			X						
Water Conservation Measures										X		
ECONOMIC CAPACITY												
Business Recovery Planning and Outreach			X							X		
Business Resilience Analysis										X		
Diversify Economy/Revenue Generators										X		
Post-Disaster Operations Protocols/Agreements										X		
EMERGENCY RESPONSE												
Check-list of Disabled			X			X						
Emergency Alerts				X		X						
Public Transit Capacity										X		
Recovery Planning						X			X			
Warming & Cooling Centers						X						



	Zoning Regulations (2020)	POCD (2019)	CRB Workshop (2019)	HMP (2018)	Harbor MP (2006)	RSTF (2020)	Water Supply Plan (2019)	Critical Facilities (2017)	Historic Resources (2017)	Regional Vision (2017)	Salt Marsh (2015)	Preparing for Climate (2011)
NATURAL SYSTEMS												
Beach Nourishment												X
Chemical Spill Prevention					X							
Living Shorelines										X		
Marsh Migration										X	X	X
Natural Area Conservation				X	X						X	X
Tree Planting			X							X		
INFRASTRUCTURE PROTECTION												
Coastal Protection Structures					X			X				
Critical Facilities Floodproofing				X				X				X
Culvert, Bridge, & Drainage Capacity Increase				X	X			X		X	X	
Drainage Maintenance & Repair				X				X				X
Drinking Water System Infiltration Protection										X		
Green Infrastructure										X		
Road Elevations				X						X		X
Water Treatment Plant Access			X									
PROPERTY PROTECTION												
Elevations & Acquisitions				X					X			X
Retreat (Incentivize)										X	X	X
Structural Protection Measures									X			



SUMMARY TAKEAWAYS FROM DOCUMENT REVIEW

The City of Groton has produced numerous plans, participated in workshops, and been a part of regional efforts that have both directly and indirectly helped the City understand and prepare for climate change. These past efforts will contribute to and inform the City's current climate resilience planning efforts, as the City will be able to build from past efforts and lessons learned. The documents reviewed in this exercise identified a wide range of concerns and vulnerabilities, strengths and capacities, and recommendations that the City of Groton should consider in its current climate resilience plan, and as it continues to pursue resilience to climate change and extreme weather.

Concerns and Vulnerabilities

Coastal Flooding and stormwater flooding are the primary flood-related concerns discussed, with sea level rise and increasingly severe precipitation events expected to exacerbate those hazards. Riverine flooding is noted, but is a relatively minor concern; Birch Plain Creek is the only stream impacting the city, and flooding from this source is predominantly tidal in nature, rather than riverine. Coastal erosion is not a significant concern locally.

Severe weather concerns focus predominantly on intense wind and storm events, as these events tend to produce the most dramatic impacts, and have caused damage in the City in the past. Extreme temperatures (cold and heat) and wildfires are mentioned infrequently. The lack of attention to extreme heat is an important gap to address, as increasing annual average temperatures as well as longer periods of extreme heat are expected to occur across the region and could have significant impacts for the City of Groton.

Other concerns that are noted in numerous documents include:

- Vulnerability of drinking water resources to pollution (primarily from non-point sources, i.e. runoff), saltwater intrusion as sea levels rise, loss of access during high water events, and drought.
- Evacuation challenges due to the large number of commuters who travel to the City for work, exacerbated by possible obstacles to egress routes from flooding, erosion, or downed tree limbs and power lines. Related to this are other concerns related to the City's emergency response and recovery protocols.
- Damage to coastal ecosystems (particularly the Birch Plain Creek tidal wetland) from the compounding stressors of sea level rise and both non-point source (runoff) and point source (leaks from industrial facilities along the Thames River) pollution.
- Damage to properties and an associated decrease in property values and loss of essential tax revenue.

Key gaps within existing documents include a lack of the following:

- Evaluation of extreme heat risks
- Evaluation of risks to local small businesses



- Evaluation of risks to vulnerable populations
- Evaluation of the potential for increased frequency of future power outages due to the impacts of heat, increased demand, and worsening storm events.

Strengths and Capacities

Based on review of these documents, the City of Groton has many strengths that can be leveraged and expanded on for the purpose of the City's climate resilience planning.

Groton Utilities, its reliable delivery of electricity and water, and its ability to rapidly respond to outages and interruptions, is clearly an essential strength of the City. Other municipal and regional services, including municipal leadership and staff, the Ledge Light Health District, and DEMHS Regional 4 Regional Emergency Planning Team, are also noted as capabilities. Local businesses (small and large) are also identified as important partners that the City can leverage to build resilience.

Local community-based organizations or community-service organizations, including religious institutions and vulnerable-population service-providers, are not identified as capabilities in most of the documents reviewed. Identifying these organizations, increasing their capacities to respond to climate change impacts, and including them in resilience planning efforts and conversations, will be essential to building community resilience.

Other capabilities identified include past structural flood-protection projects, and comprehensive zoning regulations. Natural systems are also generally identified as important capabilities, including tidal marshes and public parks, and Birch Plain Creek, specifically.

An important gap in the identification of strengths presented in the reviewed documents is that the impacts of sea level rise and other climate-change effects on the effectiveness of existing flood-protection projects and zoning regulation is not directly addressed.

Recommended Actions

Resilience actions recommended in the documents reviewed include adopting regulations and policies to limit hazard exposure, performing studies to better understand risks and adaptation options, improving municipal and community capacities to prepare and respond to climate-related hazard events, increasing the resilience of the City's businesses, preserving natural systems in the face of changing environmental conditions, and protecting and maintaining essential infrastructure and properties.

Specific recommendations identified by multiple documents include:

- Strengthening and Enforcing Flood Protection Regulations
- Conducting Flood and Drainage Studies
- Conducting Traffic and Evacuation Studies
- Coordinating with Regional, State, and National Stakeholders



- Integrate Climate Change Across Municipal Planning Efforts
- Conduct Community Engagement, Education, and Outreach
- Conserve Natural Areas
- Utilize Living Shorelines and Green Infrastructure
- Increase the Capacities of, and Adequately Maintain, Culverts, Bridges, and Drainage Infrastructure
- Floodproof Critical Facilities
- Elevate Roads
- Protect Residences through Elevation or Managed Retreat



Appendix B: Climate Risk Assessment



**CITY OF GROTON 2022 COMMUNITY RESILIENCE PLAN
CLIMATE RISK ASSESSMENT REPORT**



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ACRONYMS

ACS	AMERICAN COMMUNITY SURVEY
AZ	ASSESSMENT ZONE
BFE	BASE FLOOD ELEVATION
CBG	CENSUS BLOCK GROUP
CDC	CENTERS FOR DISEASE CONTROL AND PREVENTION
CIRCA	CONNECTICUT INSTITUTE FOR RESILIENCE & CLIMATE ADAPTATION
CT DEEP	CONNECTICUT DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION
CT DOT	CONNECTICUT DEPARTMENT OF TRANSPORTATION
CT ECO	CONNECTICUT ENVIRONMENTAL CONDITIONS ONLINE
DFIRM	DIGITAL FLOOD INSURANCE MAP
DPW	DEPARTMENT OF PUBLIC WORKS



FEMA	FEDERAL EMERGENCY MANAGEMENT AGENCY
GIS	GEOGRAPHICAL INFORMATION SYSTEM
NFIP	NATIONAL FLOOD INSURANCE PROGRAM
NWS	NATIONAL WEATHER SERVICE
POCD	PLAN OF CONSERVATION AND DEVELOPMENT
SFHA	SPECIAL FLOOD HAZARD AREA
SLOSH	SEA, LAKE, AND OVERLAND SURGE FROM HURRICANES
SLR	SEA LEVEL RISE
SVI	SOCIAL VULNERABILITY INDEX
UConn	UNIVERSITY OF CONNECTICUT
UHI	URBAN HEAT ISLAND
USACE	UNITED STATES ARMY CORPS OF ENGINEERS
WPCA	WATER POLLUTION CONTROL AUTHORITY

GLOSSARY

Adaptive Capacity	Describes how a community, asset, or feature can prepare, respond, and/or recover from a natural hazard event.
Climate Hazard	Extreme weather natural events, such as flooding or hurricanes, which can cause varying degrees of damage and may be exacerbated by climate change impacts.
Exposure	A measurement of the likelihood a climate hazard will impact a community feature.
Flood Zones	<p>The Federal Emergency Management Agency (FEMA) has delineated Special Flood Hazard Areas (SFHAs) which are the areas susceptible to inundation during the base flood. The base flood is the 1% annual chance (100-year) flood and includes zones A, AE, and VE. Zones in Groton City include:</p> <p>A & AE: These zones are the 100-year base flood areas. AE zones have delineated flood depths while A zones do not. There are also “floodways” associated with these ones. A floodway is a regulatory channel that is reserved for flow discharge; communities must regulate development in these areas.</p> <p>VE: Velocity zones are adjacent to the coast. These zones have flood depths and have the highest wave activity.</p> <p>X (0.2% annual chance): this is considered the 500-year flood zone. While not considered part of the SFHA, this zone is considered a moderate flood hazard area.</p>
Risk	The combination of a community, asset, or population’s vulnerability and exposure to a given climate hazard.
Sensitivity	Describes how a feature or asset could be impacted or affected by a climate hazard.
Vulnerability	The extent to which a climate hazard may damage or harm people, structures, systems, or other community features.



INTRODUCTION

The City of Groton faces increasing threats from climate-related hazards as climate change leads to rising sea levels, worsening storms, more severe high temperature and drought events, and other acute and chronic changes. These threats pose a risk to the City’s infrastructure; parks, open spaces, and coastline; cultural and community resources; and operations and services. Climate change has the potential to directly and indirectly impact City residents, employees, and visitors.

This report presents the results of a thorough and detailed climate risk assessment performed as part of the City of Groton’s Community Resilience Planning effort. This risk assessment will form one part of a comprehensive Community Resilience Plan.

Because the climate risk assessment requires a certain amount of background information and supporting context to be fully understood, the Climate Risk Assessment Report includes information that, in the final comprehensive Community Resilience Plan, will be organized into different sections. In order to explain this context, an initial Table of Contents for the complete Community Resilience Plan has been provided, below:

COMMUNITY RESILIENCE PLAN INITIAL TABLE OF CONTENTS

- 1. Executive Summary**
 - 1.1. Priority Recommendations
- 2. Introduction**
 - 2.1. Community Overview
 - 2.2. Defining Climate Risk and Community Resilience
 - 2.3. Need for Community Resilience Planning in Groton
- 3. Community Resilience Planning Process**
 - 3.1. Review of Existing Studies and Documents
 - 3.2. Stakeholder and Public Input
 - 3.2.1. Engagement Process
 - 3.2.2. Summary of Takeaways
 - 3.3. GIS Analysis
- 4. Climate Risk Assessment**
 - 4.1. Climate Risk Assessment Approach
 - 4.2. Climate Risk Assessment Results
- 5. Climate Resilience Strategies**
 - 5.1. Approaches to Climate Resilience
 - 5.2. Recommended Climate Resilience Strategies
 - 5.3. Prioritization and Implementation
- 6. Concept Designs**
- 7. References**

The Climate Risk Assessment that follows has been organized to align with this table of contents, recognizing that many sections are not included at this point.



COMMUNITY OVERVIEW

ASSESSMENT ZONES

For the purposes of this Community Resilience Plan, the City was divided into six Assessment Zones (AZ). These AZ are used to identify discrete geographic areas where certain climate hazards are a concern, and certain resilience approaches are appropriate.

AZ were mapped to align with specific areas identified in the City of Groton 2019 Plan of Conservation and Development (POCD)¹, the 2006 City of Groton Harbor Management Plan (Harbor Plan), and 2010 Census Block Group (CBG) geographies² (referenced above in Table 1), in order to facilitate consistency across planning efforts.

The six AZ are shown in Figure 1 and summarized below:

❖ **Thames Street Assessment Zone**

This is the oldest section of the city, with historic structures, marinas, docks, and water-dependent uses along the shoreline. This AZ covers the Thames Street Action Area identified in the 2019 POCD, aligns with Harbor Plan area A, and is identical to the area of CBG #24002. The Zone is bounded by Grove Avenue to the north; North Street and Mitchell Street to the east; Baker Avenue to the south; and the Thames River to the west. It includes the Groton Bank Historic District and Fort Griswold Battlefield State Park.

❖ **Technology Campus**

This area consists of the Electric Boat and Pfizer campuses (Pfizer Groton campus, and the Pfizer West campus), as well as a number of other primarily industrial land uses. The AZ shares the borders of the Technology Campus along Eastern Point Road identified in the 2019 POCD. It also aligns with Harbor Plan area B. Although this AZ includes portions of CBG #25002 and #26001, it has no residential use, and so demographic data from the census cannot be applied.

❖ **Five Corners**

Five Corners, as defined in this Risk Assessment, encompasses the Five Corners Action Zone identified in the 2019 POCD, as well as surrounding residential areas. The area is considered the city center, and includes retail and other commercial uses, single and multi-family residential buildings (including a number of larger apartment buildings), and schools and other community resources; it also includes numerous large parking lots. The Five Corners AZ includes all of the residential uses within CBG #25002, as well as a large portion of CBD #24003. It does not include any shoreline. The northern boundary of the AZ is Baker Avenue and the northern edge of the Sacred Heart School property. The AZ is then

¹ Relevant maps within the 2019 POCD include the Community Form Plan (POCD p. 9) and the Economic Development Plan (POCD p. 25).

² Decennial 2020 Census data was not yet available at the time of plan development; 2019 five-year estimates used for the project utilize 2010 geographies.



bounded by Brandegee Ave to the east, Shennecossett Road to the South, and Eastern Point Road to the west.

❖ **South Shore**

The South Shore refers to the portion of the city to the south of the Pfizer campuses. The northern boundary follows the Pfizer campus edges and then Shennecossett Road and Thomas Road. The AZ aligns with Harbor Plan areas C, D, and E, and mostly aligns with CBG 26001. South Shore is largely residential and includes the Shennecossett Golf Course, Eastern Point Beach, the Shennecossett Beach Club, two wetland areas along Shennecossett Road, and the University of Connecticut (UConn) Avery Point campus.

Smaller neighborhoods encompassed by the South Shore include:

- **Eastern Point:** residential area with public parks and water access points, and part of the Shennecossett Golf Course
- **Avery Point:** hosts the UConn Avery Point campus (non-residential university campus)
- **Pine Island Bay:** residential area interspersed with boating facilities: Shennecossett Yacht Club, Pine Island Marina, and Bayberry Lane Boat Launch.
- **Jupiter Point and Baker Cove:** low-lying residential area with some water-related commercial facilities.

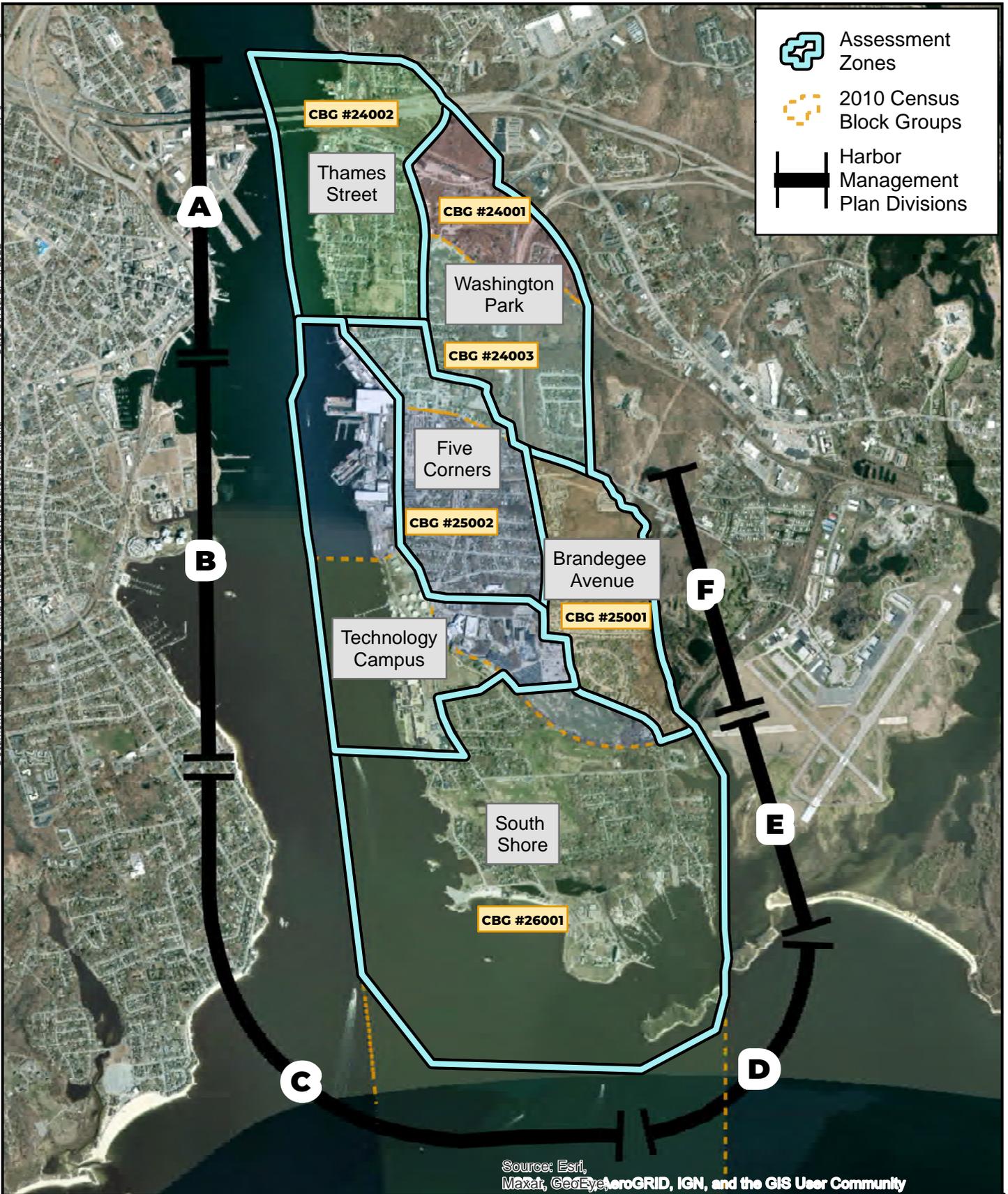
❖ **Brandegee Avenue**

The area described as Brandegee Avenue borders Birch Plain Creek between Thomas Road and Poquonnock Road (Route 649). The western edge of the AZ is marked by Brandegee Ave. This AZ aligns with Harbor Plan area F and CBG #25001. It includes Birch Plain Creek, conservation areas of salt marshes and forests, and large apartment complexes.

❖ **Washington Park**

The Washington Park AZ is north of Poquonnock Road on the eastern side of the city and includes the City municipal building campus and Washington Park, the Old Farm Road neighborhood, and a mix of residential and commercial properties. The area is not included in Harbor Plan; though, it largely aligns with CBG #24001 and #24003. The AZ is bounded to the west by North Street and Mitchell Street; Poquonnock Road to the south; Birch Plain Creek to the east of Mira Drive; and the railroad to the north and northeast.





Assessment Zones

2010 Census Block Groups

Harbor Management Plan Divisions

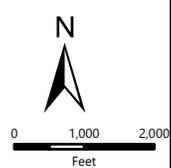
Source: Esri, Maxar, GeoEye, AeroGRID, IGN, and the GIS User Community

SLR

99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

CITY WIDE ASSESSMENT ZONES
CITY OF GROTON COMMUNITY RESILIENCE PLAN

295 Meridian Street
Groton, CT 06340



SCALE 1" = 2,731'

DATE 3/23/2022

141.12536.00015
PROJ. NO.

FIG. 1

CLIMATE RISK ASSESSMENT

As a significant component of the City of Groton’s 2021-2022 Community Resilience Plan, a Preliminary Risk Assessment was conducted in consideration of how different potential climate variables would affect the City. This section of the Plan details the methodology used in conducting the climate risk assessment, including a climate vulnerability assessment and exposure analysis, as well as the results of the detailed assessment of the City’s climate-risks.

CLIMATE RISK ASSESSMENT APPROACH

Climate risk is defined in this climate risk assessment as the combination of **vulnerability** and **exposure** to a given climate hazard (Figure 2).

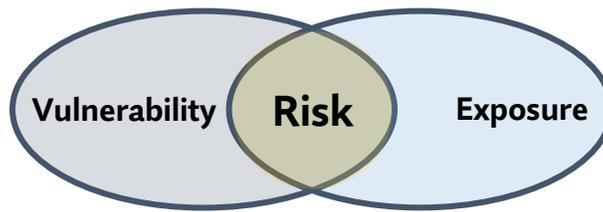


Figure 2: Conceptual Model of Climate Risk.

Vulnerability is defined here as the extent to which a climate hazard may damage or harm people, structures, systems, or other community features. Vulnerabilities can be viewed in the context of primary and secondary impacts. Primary impacts describe direct damages to building and infrastructure, while secondary impacts can include disruptions to commerce, isolation of areas from emergency services, and other indirect effects.

Vulnerability depends on the following:

- ❖ **Sensitivity:** how bad would it be if the feature were impacted by a climate hazard?
- ❖ **Adaptive Capacity:** how well can the feature prepare, respond, and recover from a hazard event?

Critical infrastructure, care facilities, socially vulnerable populations, or rare habitats may have **high vulnerability**. Open spaces and adapted buildings or infrastructure may have **low vulnerability**.

Exposure is a measurement of the likelihood a climate hazard will impact a community feature.

Exposure depends on the following:

- ❖ **Frequency and Severity:** How often does a climate hazard of a given severity occur?
- ❖ **Physical Characteristics:** Topography, land cover, and other factors inform the ability of a given climate hazard to impact a community feature.

A home in a low-lying area next to the shoreline may have **high exposure** to flood hazards. Power lines near tall trees may have **high exposure** to wind.



Climate hazards include both acute events and chronic conditions related to precipitation, wind, and temperature, which cause damage or disruption to the built environment, the economy, social systems, and public health. Global climate change caused by anthropogenic greenhouse gas emissions is increasing average global temperatures and changing climate hazard profiles around the world. While occurring globally, the effects of climate change are being felt at the local level and may vary depending on geographic location. In the City of Groton, historic and projected changes as a result of climate change include:

- ❖ Rising average and maximum annual temperatures, and increasing frequency of extremely hot days
- ❖ Rising average and maximum annual precipitation amounts, and increasing severity of extreme precipitation events
- ❖ Increasing frequency and severity of drought periods
- ❖ More frequent and severe storm events, including severe wind events
- ❖ Acceleration of rising sea levels

Based on a review of historic events and municipal experience, along with stakeholder input, the following list presents the climate hazards of concern for the city:

- ❖ **Coastal Flooding** from storm surge
- ❖ **Stormwater Flooding** during severe precipitation events
- ❖ **Sea Level Rise**, and the stresses and inconveniences it will cause in the long term
- ❖ **Extreme Heat**, and its negative health impacts
- ❖ **Severe Storms**, including high winds, severe rain or snowfall, and the combined effects of winds, precipitation, and storm surge

CHANGING CONDITIONS AND CHANGING RISK

In planning for long-term community resilience, the City of Groton must consider changing levels of both vulnerability and exposure. Both climate change and human activities can lead to changes in each:

- ❖ **Development** within hazardous areas places community assets at risk, increasing both the exposure and vulnerability of the community. Conversely, development designed with climate resilience in mind can minimize the risk to assets and to the community.
- ❖ **Impervious Surface** expansion can increase runoff from precipitation events and raise local temperatures, increasing the severity of (and potentially exposure to) those hazards. Conversely, reducing impervious surfaces can reduce the severity of those hazards.
- ❖ **Climate Change** will increase the frequency and severity of weather and climate events such as severe precipitation, high wind events, extreme hot days, and coastal flooding. This will increase overall climate risk to the City, unless the City acts to reduce vulnerabilities.



This section describes the sources and methods used to identify and classify vulnerabilities, exposure levels, and degree of risk faced by the City of Groton from climate change. The section discusses the following topics:

- ❖ **Vulnerability Assessment Methodology:** this subsection discusses the criteria and datasets used to identify assets and resources present throughout the City of Groton.
- ❖ **Exposure Analysis Methodology:** this subsection presents the data sources used to evaluate exposure levels throughout the City of Groton to a variety of climate hazards.
- ❖ **Risk Assessment Methodology:** this subsection explains how the vulnerability assessment and exposure analysis were combined to assess risk within the City of Groton.

Following this methodology section, a detailed description of the results of the vulnerability assessment, exposure analysis, and risk assessment are presented.



VULNERABILITY ASSESSMENT METHODOLOGY

The level of sensitivity and the adaptive capacity of different parts of the city was evaluated through analysis of social and physical infrastructure criteria. The specific categories of vulnerability assessed were:

- ❖ Social
- ❖ Residential
- ❖ Commercial
- ❖ Critical Facilities and Infrastructure
- ❖ Community Resources
- ❖ Natural Systems

This section describes the criteria and data sources used to evaluate vulnerability levels for each of these six categories.

SOCIAL VULNERABILITY CRITERIA

Social vulnerability refers to social and economic conditions that increase vulnerability levels of certain populations and areas. According to the Centers for Disease Control and Prevention (CDC), factors including socioeconomic status, household composition, disability, minority status, language barriers, housing conditions, and vehicle access, can all affect the capacity of individuals to anticipate, confront, repair, and recover from climate hazards (CDC, 2021; Flanagan, et. al., 2018).

Figure 3 shows a breakdown of factors used to calculate the CDC Social Vulnerability Index (SVI). The SVI quantifies social vulnerability at the census-tract scale nation-wide, allowing for analysis and comparison of relative vulnerability levels of different populations.

Higher social vulnerability levels, either overall or within any one of the categories identified by the CDC, may cause or correlate with less access to resources and assistance needed to be resilient to climate hazards.

For this climate risk assessment, the census-tract-scale of the CDC SVI was considered insufficient to meaningfully analyze difference in social vulnerabilities across the City of Groton. Instead, a selection of CDC SVI factors, available at the census block-group scale, were considered:

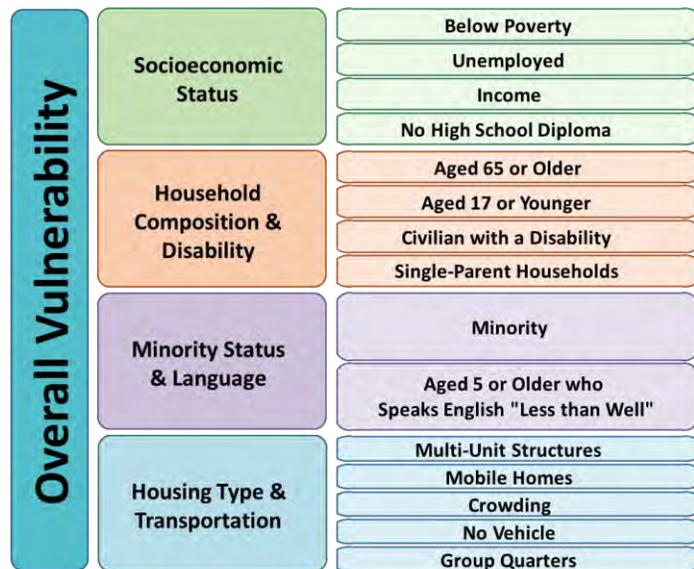


Figure 3: CDC Social Vulnerability Index Factors



- ❖ **Socioeconomic Status: Per-Capita Annual Income**
- ❖ **Residents with Limited English**
- ❖ **Residents with a Disability**
- ❖ **Households without a Vehicle Available**
- ❖ **Percent Non-White**

Socioeconomic and demographic data was sourced from the United States Census 2019 American Community Survey (ACS) 5-year estimates dataset. Table 1 below summarizes social vulnerability criteria for each census block group (CBG) within City of Groton, as well as citywide totals.

Table 1: Demographic Data for City of Groton (by Census Block Group)

Census Block Group	Population	Per-capita Income	% Limited English	% of Households with one or more persons with a disability	Vehicles Per Person	% Non White
901170 24001	1,109	\$47,182	1.26%	17.59%	0.57	25.07%
901170 24002	1,096	\$35,935	0.00%	25.68%	0.50	8.03%
901170 24003	1,366	\$32,685	1.02%	27.29%	0.42	62.88%
901170 25001	1,949	\$20,548	4.62%	20.99%	0.55	48.90%
901170 25002	2,438	\$26,041	0.00%	18.12%	0.45	29.08%
901170 26001	1,072	\$49,028	0.56%	39.52%	0.47	8.40%
Citywide	9,030	\$32,386	1.37%	23.30%	0.49	32.97%

RESIDENTIAL VULNERABILITY CRITERIA

Residential vulnerability specifically captures attributes of the residential built-environment that may impact community vulnerability. Housing density was the primary factor considered, with increasing density of housing units or of housing occupancy (for example, a multi-family apartment has a higher occupancy density than a single-family house) translating to a higher vulnerability level.

This category of vulnerability provides a measure of how the people who live in the City of Groton will be directly affected by climate hazards; the more individuals who live in a given area, the more people that are present to experience the impacts of a hazard event. Additionally, damages that occur to residences will directly impact the lives and finances of City of Groton citizens.

Data about housing density and occupancy was sourced from building GIS shapefiles (provided by the City of Groton from the Southeastern Connecticut Council of Governments), parcel GIS shapefiles (extracted from the Town of Groton GIS database), and Google Earth.

COMMERCIAL VULNERABILITY CRITERIA

This category of vulnerability specifically captures attributes of the commercial built-environment that may impact community vulnerability. The presence of commercial uses and the types of businesses present in an area are considered when assessing commercial vulnerability.

Climate hazards may impact businesses by direct damage to facilities, interruption of operations (for example, through loss of utility services or supply chain function), and disruption of client engagement (for example, through loss of access or decreases in visitor populations). Businesses



serve essential roles in supporting a functioning community, and business recovery following a climate hazard is often a first step to broader community recovery (Kim, 2018; McKay, 2018).

Parcel GIS shapefiles from the Town of Groton GIS database, Google Earth, the City of Groton 2019 Plan of Conservation and Development, and data provided by municipal staff and collected through field reconnaissance was used to identify commercial uses.

CRITICAL FACILITIES AND INFRASTRUCTURE VULNERABILITY CRITERIA

Critical facilities and infrastructure assets include facilities essential to municipal operations, emergency services, and utility providers. Climate hazards that impact these resources may not only cause direct damage to those assets but may interfere in the city's capacity to engage in recovery efforts, and may even lead to cascading impacts and damages (for example, if loss of utility assets leads to loss of electricity and refrigeration capacity at a restaurant). Assets considered include:

- ❖ Emergency Services
- ❖ Care Facilities
- ❖ Municipal Administration and Operations Facilities
- ❖ Utilities

Critical facility locations were sourced from U.S. Department of Homeland Security publicly available GIS datasets. Roadway GIS shapefiles were downloaded from a Connecticut Department of Transportation (CT DOT) database. Other essential facilities and infrastructure assets were identified using input from city staff and community stakeholders.

COMMUNITY RESOURCE VULNERABILITY CRITERIA

Sites and services important to community identity and function were also identified. These assets play an essential role in supporting the city's community, identity, health, and wellness. Assets considered include:

- ❖ Schools and Daycare Centers
- ❖ Religious Sites
- ❖ Historic and Cultural Resources
- ❖ Community Organizations

Community resources were identified using Google Earth as well as input from city staff and community stakeholders

NATURAL SYSTEM VULNERABILITY CRITERIA

Natural systems provide important benefits to quality of life and community character, while also serving to mitigate the impacts of many climate hazards. Natural systems evaluated in this risk assessment include:



- ❖ Forests and Trees
- ❖ Tidal Wetlands
- ❖ Beaches
- ❖ Managed Parks and Open Space

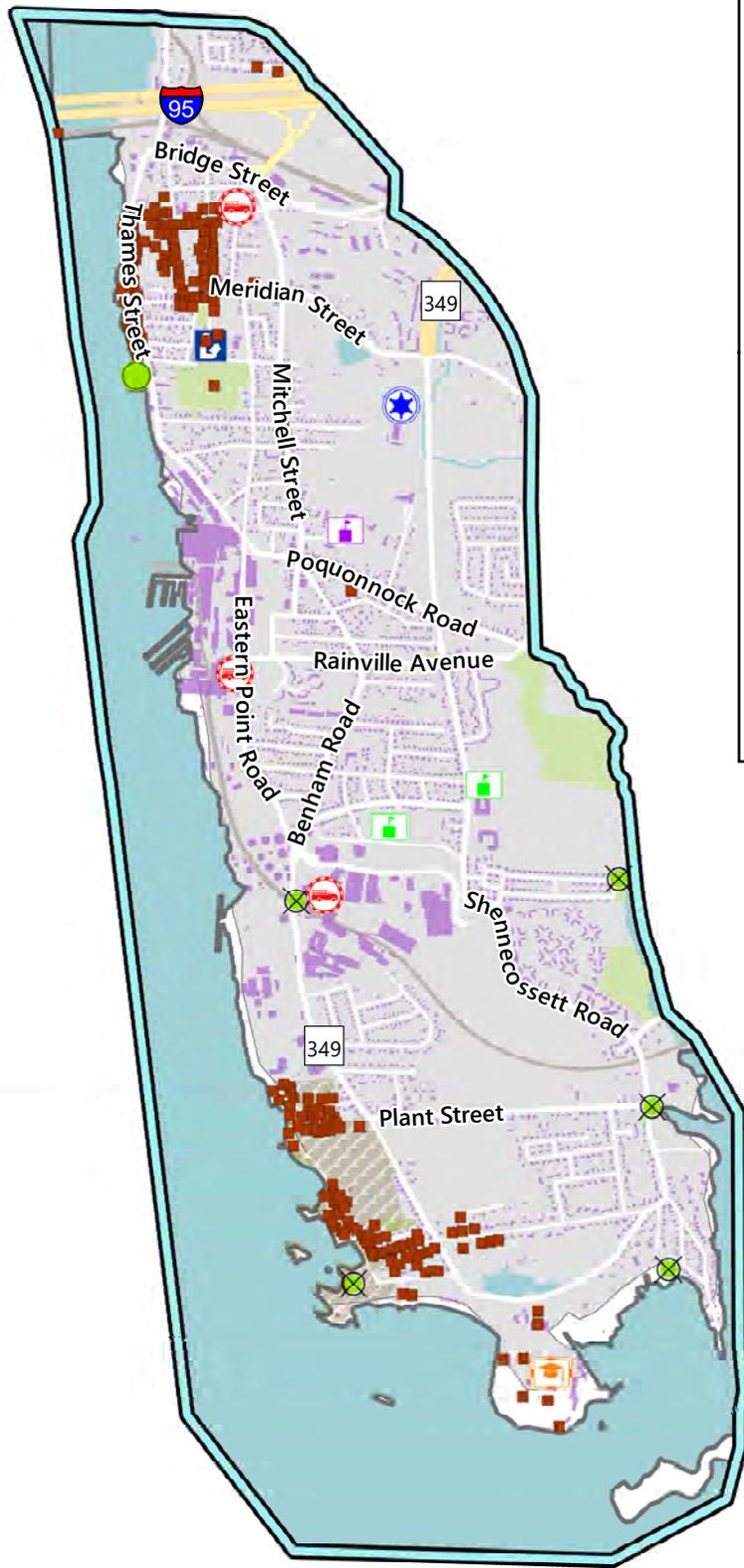
Natural systems were identified using 2016 Connecticut Environmental Conditions Online (CT ECO) land cover maps and aerial imagery.

VULNERABILITY ASSESSMENT METHODOLOGY CONCLUSION

The six vulnerability categories discussed in this section (social, residential, commercial, critical facilities and infrastructure, community resources, and natural systems) were evaluated to determine the types of assets and resources present throughout the city. In the next section, we discuss the analysis performed to determine the level of exposure the city has to climate hazards. The risk assessment was conducting by evaluating the intersection of vulnerabilities and exposure.

Figure 4, on the following page, depicts some of the critical sites and resources throughout the City, as discussed above.



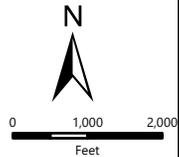


-  Assessment Zone Boundary
-  Police Station
-  Fire Station
-  Pump Station
-  Water Abatement Facility
-  CT Historic Resources
-  Colleges and Universities
-  Public Schools
-  Private School
-  Public Library
-  Historic District



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CITY WIDE
 CRITICAL FACILITIES
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 DATE 3/23/2022
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FIG. 4

EXPOSURE ANALYSIS METHODOLOGY

Exposure to climate hazards was assessed using the following sources:

- ❖ Public and stakeholder input
- ❖ Review of existing reports and studies
- ❖ Geographic Information System (GIS) analysis

Public and stakeholder participation was ongoing at the time this preliminary risk assessment was being developed and is not fully incorporated into the document.

The review of existing reports and studies is summarized in Section 3.1 of this City of Groton Community Resilience Plan, and discussed in detail in a separate report.

The GIS analysis evaluated the community features identified in the previous section with regard to their proximity to spatially specific climate hazard zones. Each of these climate hazard zones is described below along with accompanying maps depicting where the climate hazard zone exists within City of Groton.

FEMA SPECIAL FLOOD HAZARD AREAS

The 1% annual chance (100-year) flood has been adopted by the Federal Emergency Management Agency (FEMA) as the *base flood*. Special Flood Hazard Areas (SFHAs) are the areas susceptible to inundation during the base flood, as delineated as part of the National Flood Insurance Program (NFIP). FEMA uses a variety of flood zones to delineate areas of annual chance flood hazard, as shown below in Figure 5.

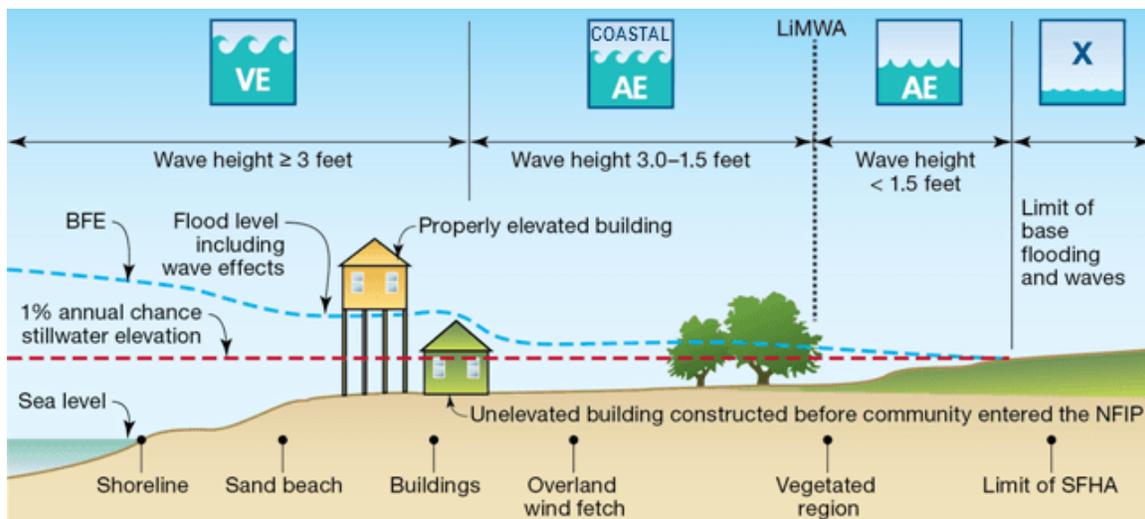


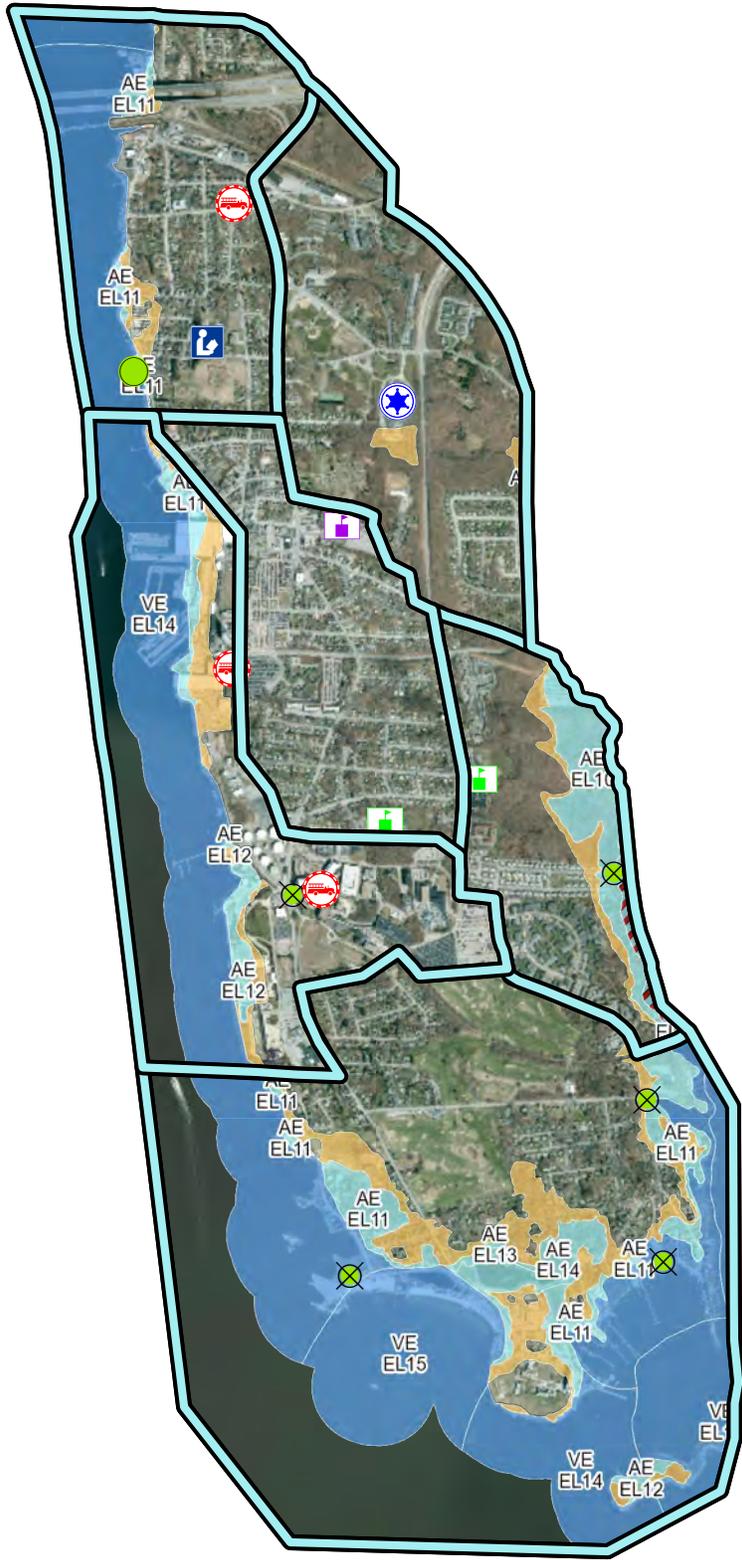
Figure 5: Conceptual Model of FEMA Flood Zones (Source: FEMA)

FEMA flood zones in the City of Groton are shown in Figure 6. The most recent Digital Flood Insurance Rate Map (DFIRM; effective August 5, 2013) for the City of Groton was used in this risk assessment.



Floodzones

-  Zones A and AE; 1% annual chance flood hazard
-  Zone AE; Floodway; 1% annual chance flood hazard
-  Zone VE; 1% annual chance flood hazard
-  Zone X; 0.2% annual chance flood hazard

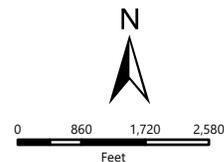


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CITY WIDE
FEMA FLOOD HAZARD AREAS
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FIG. 6

HURRICANE STORM SURGE

The US Army Corps of Engineers has created Sea, Lake, and Overland Surge from Hurricanes (SLOSH) maps for each Connecticut coastal community. The SLOSH model, developed by the National Weather Service, maps expected flood extents caused by storm surge associated with multiple hurricane magnitudes. The model accounts for atmospheric pressure, size, forward speed, and storm track data for historical, hypothetical, and predicted hurricanes.

Hurricane inundation maps for the City of Groton are presented in Figure 7.

This resource provides an additional tool beyond FEMA maps for evaluating storm surge flood exposure. Note that FEMA mapping also accounts for precipitation-caused flooding, which SLOSH maps do not.

SEA LEVEL RISE

The impact of projected sea level rise on both storm surge and daily tides was evaluated using the Connecticut Sea Level Rise and Storm Surge Viewer developed by the Connecticut Institute for Resilience & Climate Adaptation (CIRCA). This tool depicts flood extents given 20 inches of sea level rise and the following tidal conditions:

- ❖ Mean Higher-High Water (average highest daily high tide) – see Figure 8
- ❖ 10-Year Flood Event (10% annual-chance flood) – see Figure 9
- ❖ 30-Year Flood Event (3% annual-chance flood) – see Figure 10
- ❖ 100-Year Flood Event (1% annual-chance flood) – see Figure 11

CIRCA's report (O'Donnell, 2019) on Connecticut sea level rise provided the basis for the sea level rise projection chosen. The planning threshold of 20 inches (0.5 meters) of sea level rise, considered likely by 2050, was formalized in 2018 in Connecticut Public Act 18-82, *An Act Concerning Climate Change Planning and Resiliency*.

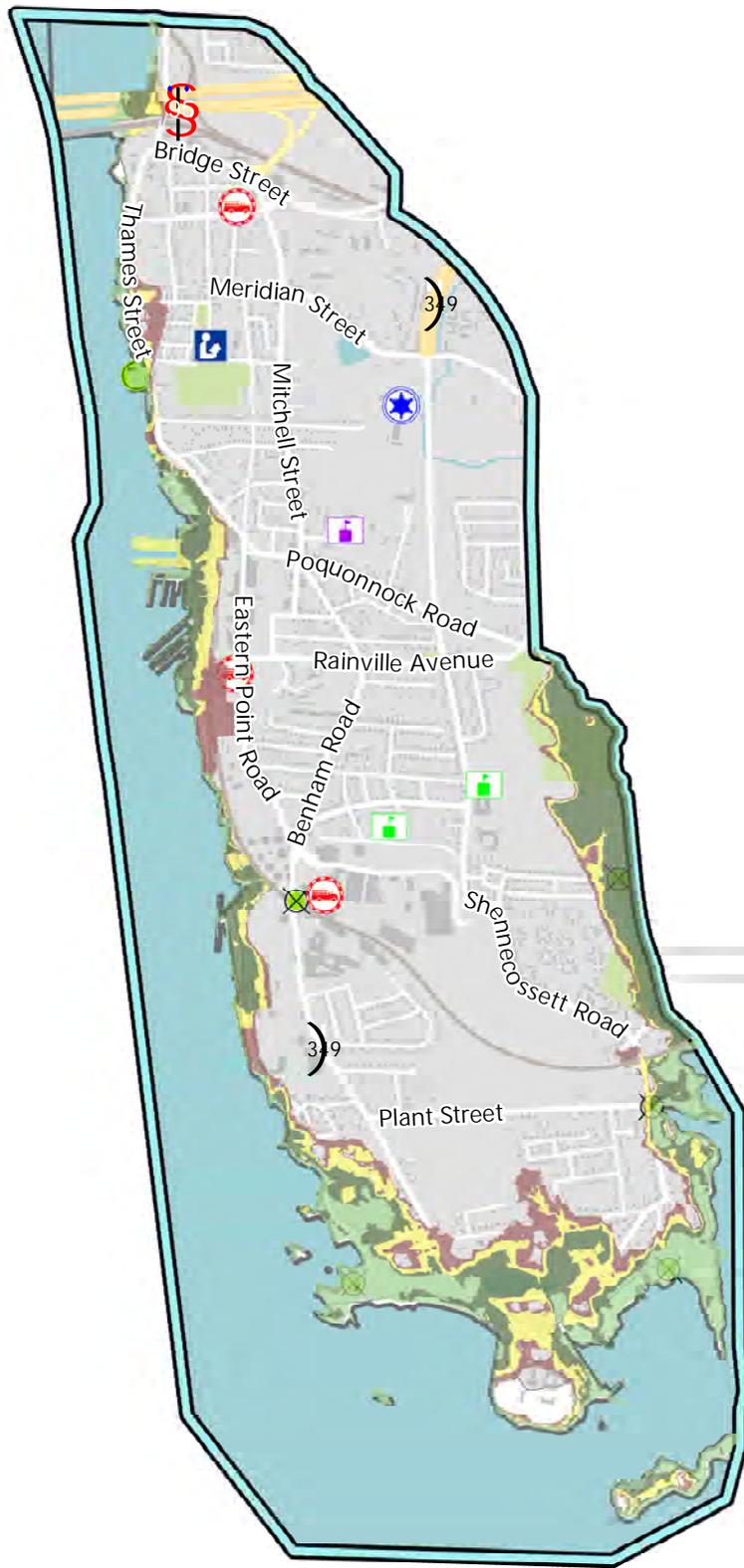
EROSION

Erosion can be caused by waves or flowing water, and can occur during flood events or under normal conditions. Importantly, erosion can impact community features located above flood levels by undermining the ground below them; therefore, reviewing flood zone maps alone is not sufficient to understand this additional hazard.

Erosion hazards were evaluated using two sources:

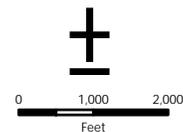
- ❖ The Connecticut Erosion Susceptibility Map (CT DEEP, 2005; https://cteco.uconn.edu/guides/Erosion_Susceptibility.htm)
- ❖ The Connecticut Shoreline Change Analysis Database (O'Brien, et. al. 2014; <https://shorelinechange.uconn.edu>)





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CITY WIDE
 HURRICANE SURGE INUNDATION
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FIG. 7



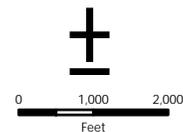
Mean Higher High Water Plus 20 inches SLR

- Low-lying Areas
- Inundated Areas



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CITY WIDE MEAN HIGHER HIGH WATER
 WITH 20 INCHES SEA LEVEL RISE
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 Groton, CT 06340



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FIG. 8

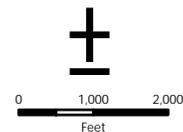


 Inundated Areas



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CITY WIDE TEN-YEAR FLOOD
WITH 20 INCHES SEA LEVEL RISE
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295 Meridian Street
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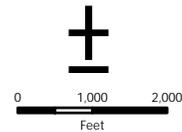
FIG. 9

Inundated Areas



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CITY WIDE THIRTY-YEAR FLOOD
WITH 20 INCHES SEA LEVEL RISE
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295 Meridian Street
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SCALE	1" = 2,558'
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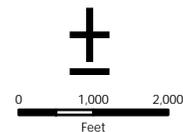
FIG. 10

Inundated Areas



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CITY WIDE ONE-HUNDERED-YEAR FLOOD
WITH 20 INCHES SEA LEVEL RISE
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295 Meridian Street
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FIG. 11

The Connecticut Erosion Susceptibility GIS layer, published by the Connecticut Department of Energy and Environmental Protection (DEEP) in 2005, combines soil type and surficial geology to classify soil erosion susceptibility as follows:

Most Susceptible to Erosion
Highly Susceptible to Erosion
Surficial Materials Susceptible to Erosion
Soils Susceptible to Erosion

Areas with “Surficial Materials Susceptible to Erosion” and “Soils Susceptible to Erosion” are identified within the City of Groton; no areas classified as “Highly Susceptible to Erosion,” and only one small area classified as “Most Susceptible to Erosion,” are found within the city.

The Connecticut Shoreline Change Analysis program analyzed how the state’s shoreline changed between the late 1800’s and 2006 based on aerial imagery and detailed shoreline maps. A GIS dataset was produced showing net shoreline change, as well as short-term and long-term average shoreline change rates.

Figure 13, on the following page, shows a map of the city with both Connecticut Erosion Susceptibility and Connecticut Shoreline Change Analysis data mapped.

IMPERVIOUS SURFACES

Evaluation of impervious surface distribution across the city can provide valuable insight into both the occurrence of stormwater runoff flooding and severe heat events.

Impervious surfaces are those that water cannot penetrate, such as concrete and asphalt, causing increased rates of runoff that accumulate pollutants and increase in temperature before reaching a wetland or waterway.

Figure 12 depicts the differences between natural ground cover and impervious surface on the local water cycle. This increase in stormwater volume can lead to street or property flooding, cause disruptions and damage, and can overwhelm drainage systems.

These sealed surfaces also absorb sunlight (unless light-colored materials or coatings are used to mitigate this effect), and as they heat up, they warm the surrounding air, contributing to the urban heat island effect.

For this assessment, the CT DEEP Connecticut Environmental Conditions Online (CT ECO) 2015 Land Cover GIS layer was used (see Figure 14).

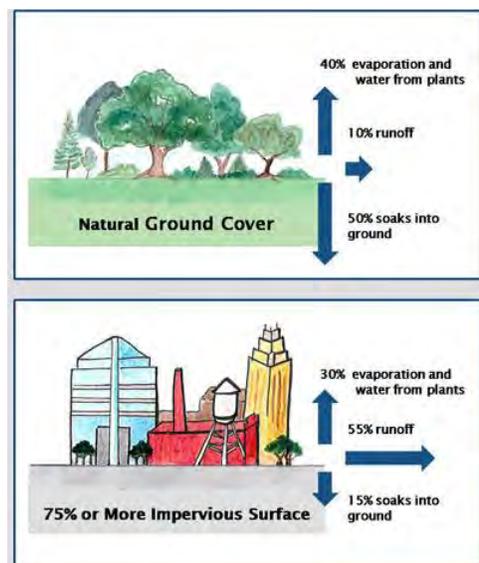
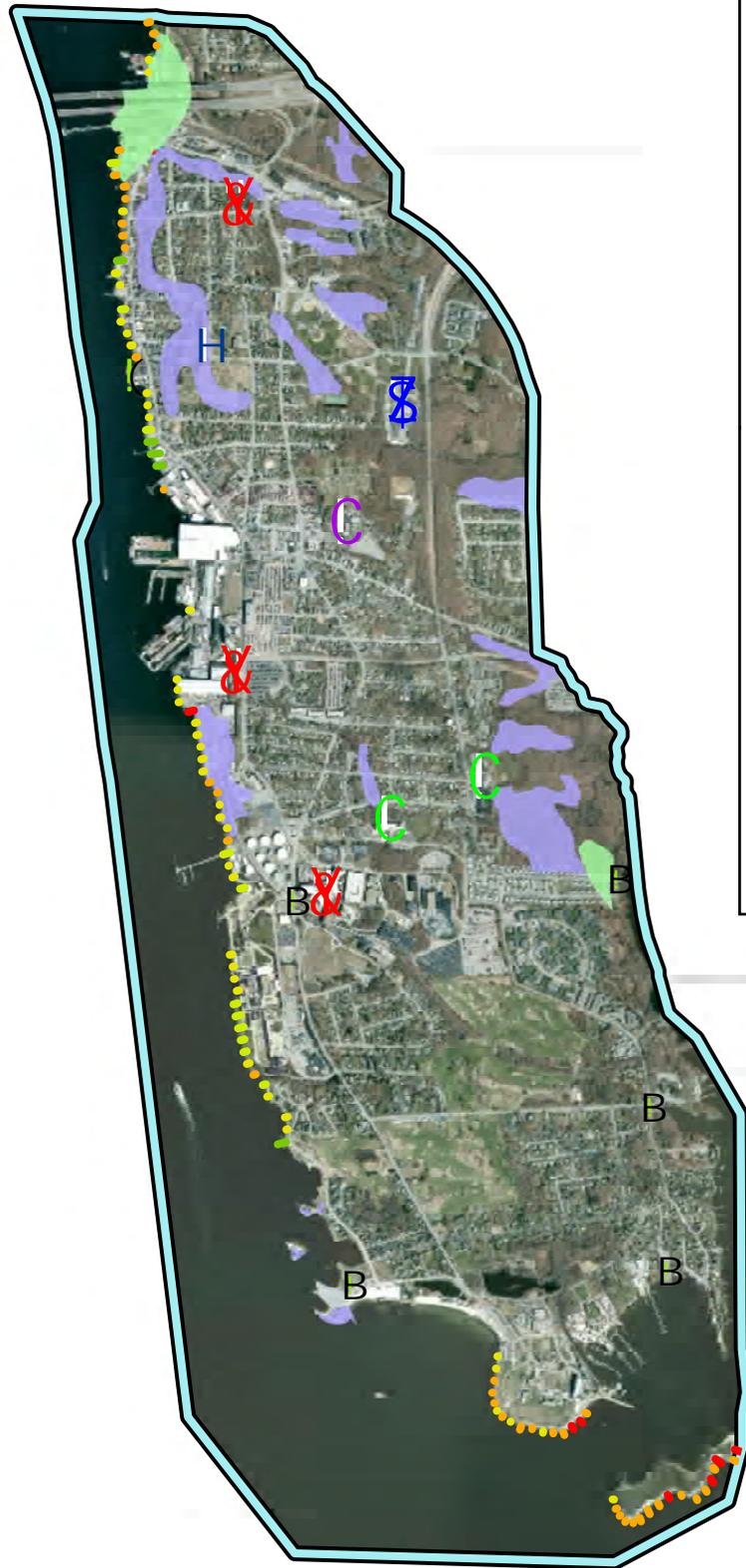


Figure 12: Effects of Impervious Surfaces on Infiltration, Evaporation, and Runoff
 From: City of Durham, NC.
<https://durhamnc.gov/864/Impervious-Surface>





Short-Term Shoreline Change Rate

- > 0.5 m/yr Erosion
- > 0.0 m/yr Erosion
- < 0.5 m/yr Accretion
- < 1.0 m/yr Accretion
- < 5.0 m/yr Accretion
- > 5.0 m/yr Accretion

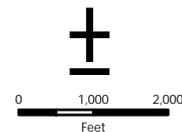
Erosion Susceptibility

- Most Susceptible to Erosion
- Highly Susceptible to Erosion
- Surficial Materials Susceptible to Erosion
- Soils Susceptible to Erosion



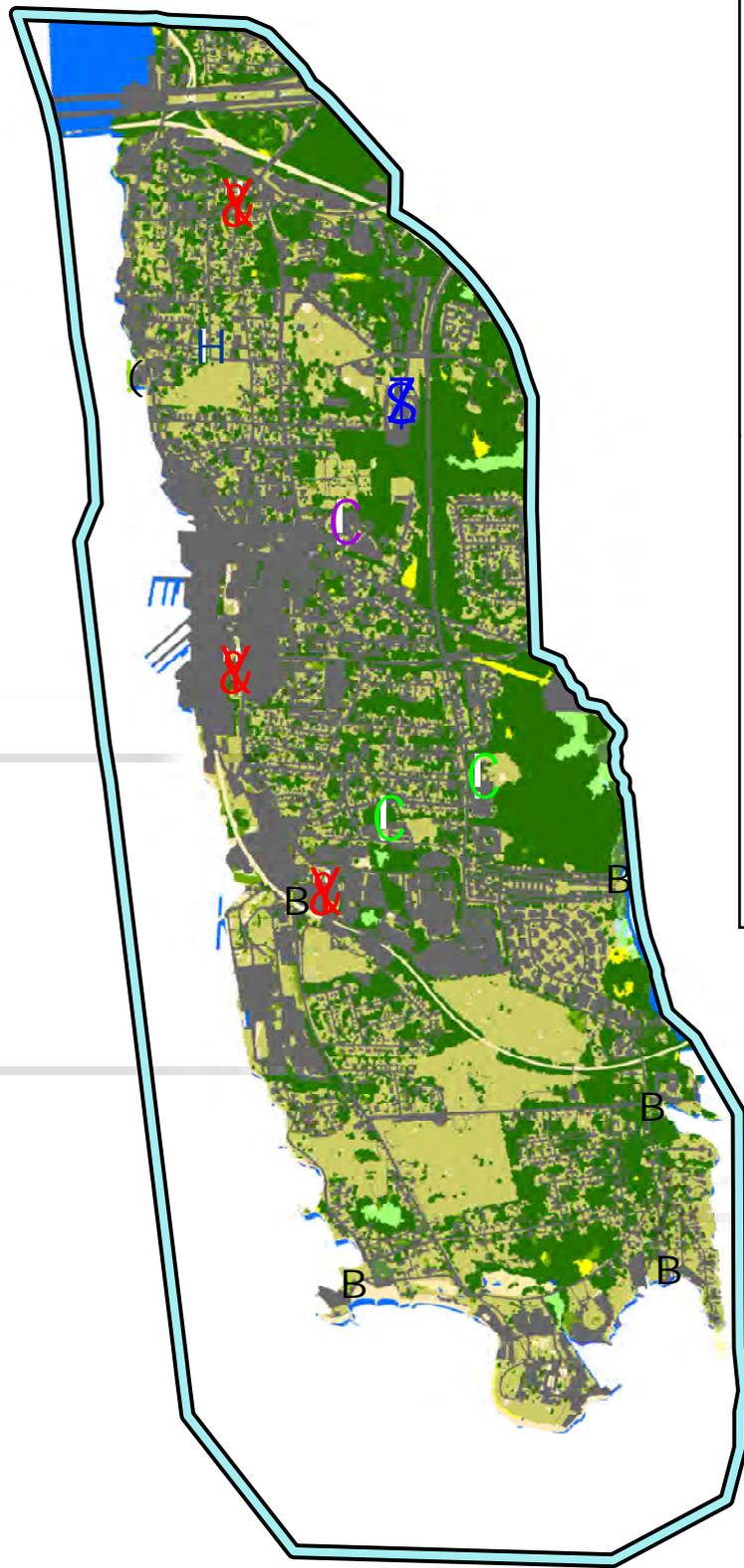
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CITY WIDE
 EROSION SUSCEPTIBILITY
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
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FIG. 13

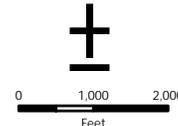


-  Impervious
-  Developed Open Space
-  Grassland
-  Mixed Forest
-  Scrub/Shrub
-  Palustrine Forested Wetland
-  Palustrine Scrub/Shrub Wetland
-  Palustrine Emergent Wetland
-  Estuarine Scrub/Shrub Wetland
-  Estuarine Emergent Wetland
-  Unconsolidated Shore
-  Bare Land
-  Open Water
-  Palustrine Aquatic Bed



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CITY WIDE
 LAND COVER
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
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FIG. 14

URBAN HEAT ISLAND EFFECT

A more direct method for evaluating localized heat variations is available through the Trust for Public Lands “Urban Heat Island Severity for U.S. Cities” GIS dataset. Figure 15 demonstrates how temperatures are relatively higher in urban centers than in areas with other, less developed areas. The map in Figure 16 was developed using satellite imagery

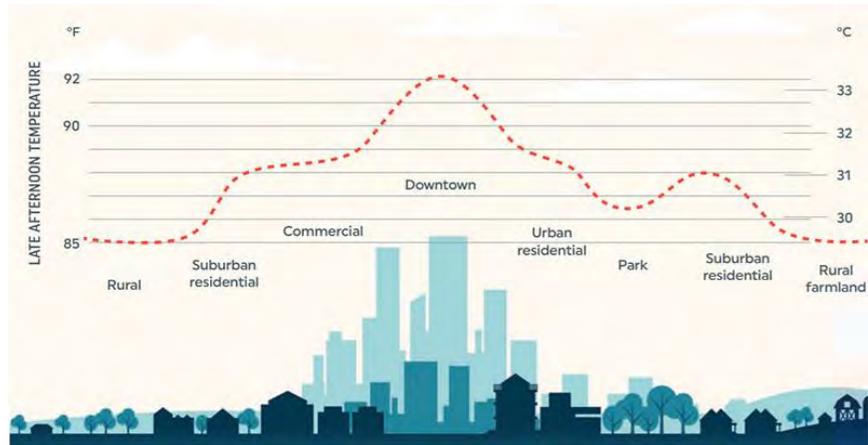
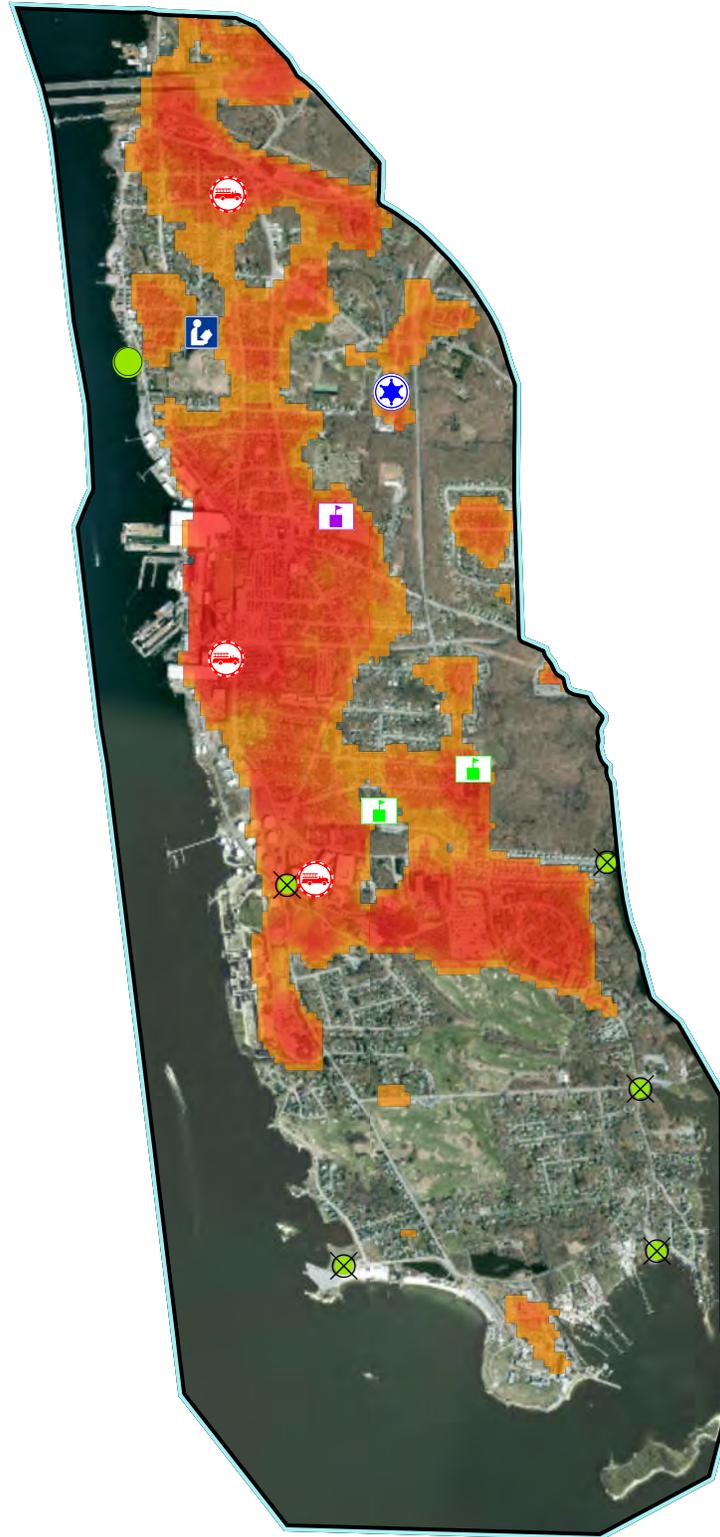


Figure 15: Urban Heat Island Profile.
From: Urban Land Institute

(Landsat 8 Imagery Band 10 data; ground-level thermal sensor) collected during the summers of 2019 and 2020. Areas within each evaluated city that are hotter than the average temperature of the city as a whole are identified, with relative heat severity values assigned on a scale of one (temperatures are slightly above the city average) to five (temperatures are significantly above the mean for the city). This relative ranking allows for evaluation of localized hot-spots.



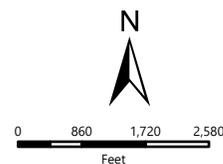


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CITY WIDE
URBAN HEAT ISLAND EFFECT
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FIG. 16

EXPOSURE ANALYSIS METHODOLOGY CONCLUSION

The five sources of climate hazard data described in this section (FEMA Flood Maps, Hurricane Surge Models, Sea Level Rise Models, Erosion Susceptibility Maps, Impervious Surface Maps, and Urban Heat Island Maps) were used to analyze the level of climate hazard exposure across the City of Groton. The four specific categories of climate hazard evaluated were:

- ❖ **Flood Hazard:** coastal or riverine flooding; based on FEMA, hurricane surge, and sea level rise maps.
- ❖ **Erosion Hazard:** exposure to erosion that may undermine an area or cause damaging deposition of eroded material onto an area; based on the presence of soils susceptible to erosion as well as historic shoreline change.
- ❖ **Stormwater Flood Hazard:** flooding in urban areas away from coastal or riverine flood sources, caused by runoff from precipitation; based on impervious surface extent and other land cover considerations.
- ❖ **Heat Hazard:** severe heat that may impact health or cause other damage; based on land cover, the presence of tree cover for shading, and mapped urban heat island effect.

In the next section, we discuss the methodology used to intersect vulnerabilities and exposure to assess risk.



CLIMATE RISK ASSESSMENT METHODOLOGY

Climate risk for the City was determined by combining the results of the vulnerability assessment and the exposure analysis. Figure 17, along with the list below, demonstrate how vulnerability and exposure levels were combined to determine risk:

- ❖ **High** Vulnerability and **High** Exposure = **High** Risk
- ❖ **High** Vulnerability and **Low** Exposure = **Moderate** Risk
- ❖ **Low** Vulnerability and **High** Exposure = **Moderate** Risk
- ❖ **Low** Vulnerability and **Low** Exposure = **Low** Risk

Climate hazard vulnerability and exposure throughout the city were determined as described in the preceding section.

The results of the climate vulnerability assessment, exposure analysis, and subsequent climate risk assessment, are presented in the following section.

Vulnerability ↑	High	Moderate	High
	Low	Low	Moderate
		Low	High
		→ Exposure →	

Figure 17: Illustrative Vulnerability-Exposure Risk Matrix



CLIMATE RISK ASSESSMENT RESULTS

The following section presents the results of the vulnerability assessment, exposure analysis, and climate risk assessment for the City of Groton. Vulnerabilities for each AZ were evaluated based on the criteria described in the Vulnerability Assessment Methodology section. Exposure of each AZ to climate hazards was then evaluated based on map overlays of the different hazards, as identified, and described in the Exposure Analysis Methodology section. Vulnerabilities and Exposure were given a classification of low, moderate, or high for each AZ. These scores were then combined to create a Climate Risk score for each AZ.

Vulnerability, exposure, and risk classifications for each AZ were each determined in comparison to other areas of the City of Groton; classifications are not intended for comparison to areas outside the City.

This section presents the Vulnerability Assessment, Exposure Analysis, and Climate Risk Assessment results for each AZ. Climate Risk is then then summarized for the entire City.



THAMES STREET RISK ASSESSMENT

Vulnerabilities, hazard exposure, and overall climate change risks to the Thames Street Assessment Zone (AZ) are described in this section.

THAMES STREET VULNERABILITIES

The following assets and features were identified as potential vulnerabilities within the Thames Street AZ.

Social Vulnerabilities

According to the 2019 ACS 5-year estimates, this area has a per-capita income (\$35,935 for the CBG covering the area) slightly higher than the city average of \$33,605. It is almost 92 percent white and has no residents with limited English (compared to 1.37 percent city-wide). Vehicle availability is relatively high (one vehicle for every two residents). Over 25 percent of households include at least one individual with a disability.

Overall, these factors show that social vulnerabilities are relatively low for this AZ when compared to the other five, with potential additional attention needed for residents with disabilities in the face of a climate hazard.

Social Vulnerability for the Thames Street AZ is classified as **Low**.

Residential Vulnerabilities

The Thames Street AZ consists primarily of single-family homes, with a handful of two- or three-family buildings and no major population centers that would present elevated vulnerabilities. Residential vulnerabilities are relatively low compared to other AZ, with a relative low density of residents and properties.

Residential Vulnerability for the Thames Street AZ is classified as **Low**.

Commercial Vulnerabilities

Thames Street itself is home to numerous local businesses and is an economic development interest area for the city. Many of these local businesses are retail, restaurant, and experience providers that attract visitors to the city. Many of these businesses are water-dependent, such as:

- ❖ Thames River Heritage Park Water Taxi
- ❖ Thames Inn and Marina
- ❖ Hel-Cat II Fishing Parties
- ❖ Osprey Sport Fishing Charters
- ❖ Mohawk Northeast

Because of the importance of the Thames Street commercial corridor to City development goals, commercial vulnerabilities are considered relatively high in this AZ.

Commercial Vulnerability for the Thames Street AZ is classified as **High**.



Critical Facilities and Infrastructure Vulnerabilities

The Groton City Fire Department is located at 140 Broad Street, at the northeastern edge of the AZ.

The City of Groton Water Treatment Plant is located on the water in this AZ, at 311 Thames Street. The ongoing, successful, uninterrupted operation of this facility is critical for the health and safety of the city's population, as well as downstream habitats and water users.

Essential roads, utility lines, and other infrastructure passes through this AZ, including:

- ❖ Thames Street
- ❖ Mitchell Street
- ❖ Fairview Avenue (one of the only northern access points to the city)
- ❖ Bridge Street
- ❖ Amtrak railroad
- ❖ Providence and Worcester railroad
- ❖ Interstate 95 Gold Star Memorial Bridge.

A major stormwater pipe runs under Thames Street, draining the Five Corners neighborhood. Water and sewer also run underground throughout the AZ, and power lines are above ground.

There are no public bus stops in this area.

The vulnerabilities to critical facilities and infrastructure are high; the AZ includes two critical facilities essential to health and safety, as well as many important infrastructure elements.

Critical Facility and Infrastructure Vulnerability for the Thames Street AZ is classified as **High**.

Community Resource Vulnerabilities

In many ways, this area is the cultural heart of the City of Groton. Important community resources located in this AZ include:

- ❖ Submarine Veterans of World War II National Memorial (Thames Street & Bridge Street)
- ❖ Local 1302 (171 Thames Street)
- ❖ Post Office (202 Thames Street)
- ❖ Groton Bank Historic District (including many historic structures in the neighborhood)
- ❖ Islamic Center of New London (18 Pleasant Street)
- ❖ Bill Memorial Library (240 Monument Street)
- ❖ Groton Heights Baptist Church (72 Broad Street)
- ❖ Groton Congregational Church (162 Monument Street)
- ❖ Community Speaks Out (214B Thames Street)

The KE Streeter Boat Launch, a public boat launch, is located in the northern end of the AZ, north of the railroad tracks and below the Route 95 Gold Star Memorial Bridge.



Finally, the area contains important local and regional park and historic sites, including:

- ❖ Fort Griswold Battlefield State Park
- ❖ Groton Monument
- ❖ Thames View Park
- ❖ Thames River Heritage Park

Community Resource Vulnerability for the Thames Street AZ is classified as **High**.

Natural System Vulnerabilities

Because the AZ is highly developed, natural habitats are extremely limited in the area. Nevertheless, there is a fair amount of managed open space (as noted by the park areas identified above) that are designated parks or otherwise conserved, and therefore at low risk of being developed. There are also some small, forested areas (including about two acres of Town of Groton-owned forest between Meridian Street and Broad Street next to North Street, open space at the Bill Memorial Library, as well as pockets of forested private property). The hardened Thames River shoreline is not conducive to significant coastal habitats.

Both the extent of natural areas, and the likelihood of them being diminished in the future, are limited.

Natural System Vulnerability for the Thames Street AZ is classified as **Low**.

Thames Street Vulnerability Summary

Given the vulnerabilities described above, the overall climate vulnerability for the Thames Street AZ is summarized in Figure 18.

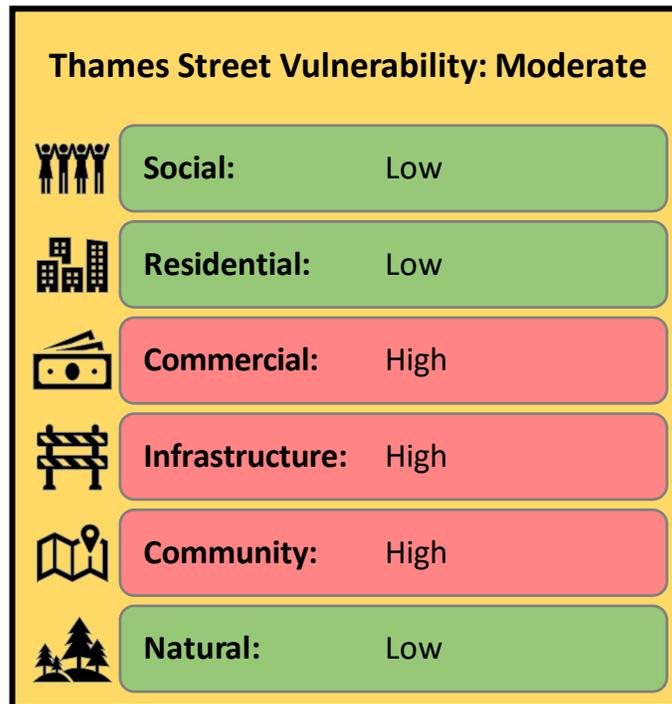


Figure 18: Thames Street Vulnerability Summary



THAMES STREET EXPOSURE

The exposure of the Thames Street AZ to flooding, erosion, stormwater flooding, and high heat hazards is described below.

Flood Exposure

The shoreline of this AZ consists of steep banks rising to developed areas located at relatively high elevations; coastal flooding is mostly limited to the immediate shoreline and does not extend far inland. An exception is in the area of School Street, Pleasant Street, Latham Street, and Fort Street, where mapping shows flood risk extending inland past Thames Street (see Figure 19: Map of Thames Street FEMA Flood Hazard Zones, Figure 20: Map of Thames Street Hurricane Surge Inundation, and Figure 21: Map of Thames Street Sea Level Rise Inundation). Importantly, substantial development has occurred immediately adjacent to the Thames River, and some development has occurred on fill that has extended into the waterway itself; thus, even in areas where flood hazards are limited to the shoreline, exposure to flooding is considerable.

Overall, despite the relatively narrow mapped flood risk zone, flood exposure is considered moderate, relative to other areas of the City.

Flood Exposure in the Thames Street AZ is classified as **Moderate**.

Erosion Exposure

A map of erosion exposure in the Thames Street AZ is presented in Figure 22.

The Connecticut Erosion Susceptibility Map (CT DEEP, 2005) identifies a crescent-shaped section of the Thames River coastline as being “Somewhat Susceptible To Erosion.” This crescent encompasses the Mohawk Northeast area, running from just south of the Fairview Avenue overpass over the railroad (near Grove Ave), following the curve of the railroad under Route 95 and then extending south through the Fairview Avenue and Bridge Street intersection to the northern edge of Osprey Sport.

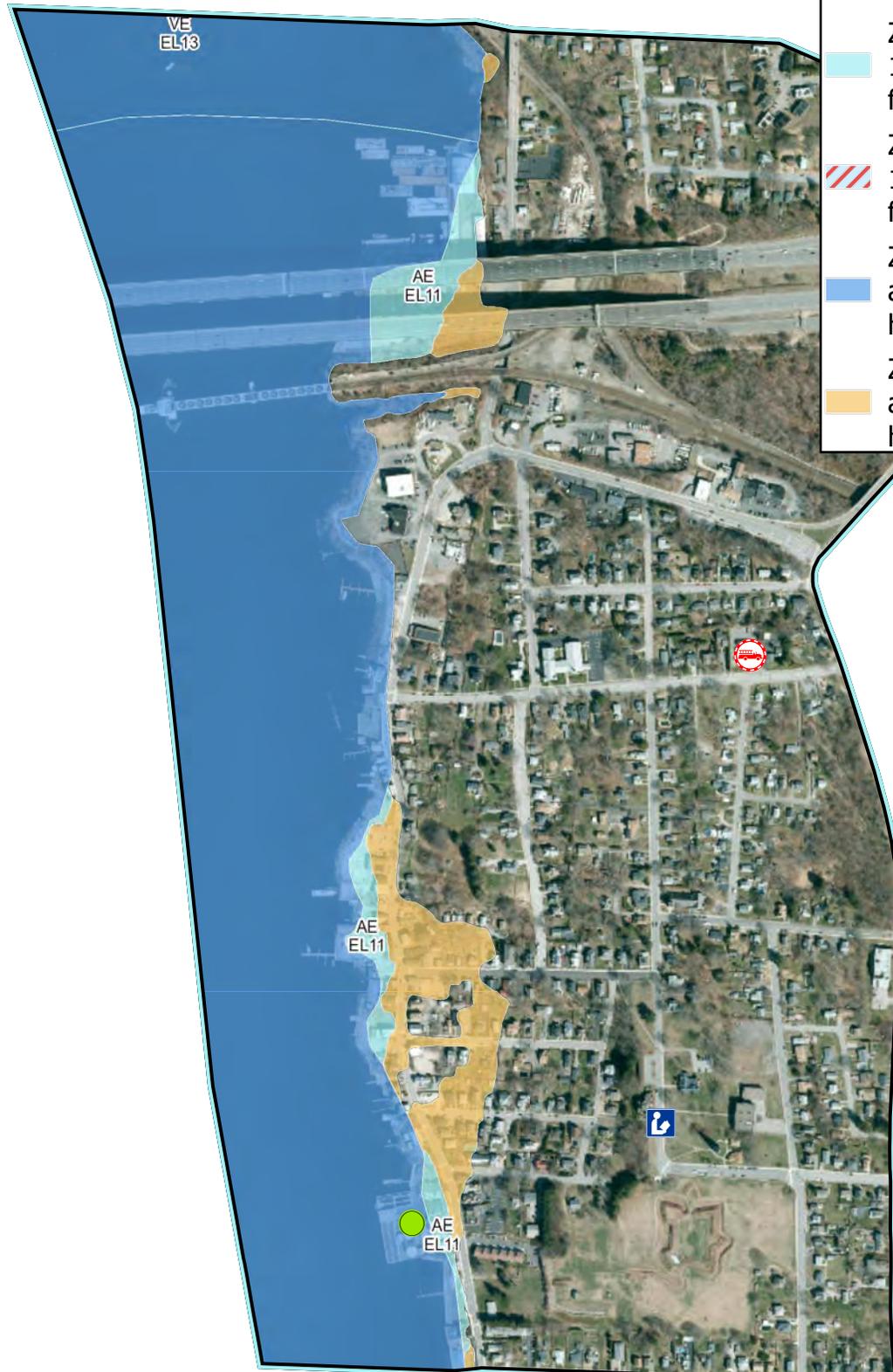
Other locations, designated as “Soils Susceptible to Erosion,” are identified in more inland areas, where conditions that would cause erosion of these soils are unlikely to occur.

The Connecticut Shoreline Change Analysis (O’Brien, et. al. 2014) supports the conclusion that parts of the Thames Street shoreline are somewhat susceptible to erosion. This dataset shows that net erosion from 1983 to 2006 occurred at a rate of over 0.25 feet per year along the shoreline north of Mohawk Northeast, as well as to the west of Bridge Street (the southern part of the susceptible area identified above). Most of the rest of the Thames Street shoreline is shown to have been accreting since 1983.

The surficial materials of this AZ make some areas somewhat susceptible to erosion, and shoreline change trends show that erosion has occurred; however, the location along the tidal Thames River means that this area is relatively protected from the type of waves or currents that could cause significant erosion.

Erosion exposure in the Thames Street AZ is classified as **low**.





Floodzones

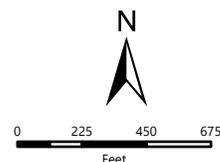
- Zones A and AE;
1% annual chance flood hazard
- Zone AE, Floodway;
1% annual chance flood hazard
- Zone VE; 1%
annual chance flood hazard
- Zone X; 0.2%
annual chance flood hazard

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99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

THAMES STREET
FEMA FLOOD HAZARD ZONES
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



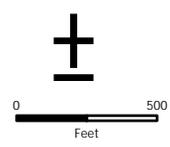
SCALE	1" = 667'
DATE	3/31/2022
PROJ. NO.	141.12536.00015

FIG. 19



SLR
 99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

**THAMES STREET
 HURRICANE SURGE INUNDATION**
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE	1" = 681'
DATE	3/24/2022
PROJ. NO.	141.12536.00015
FIG. 20	

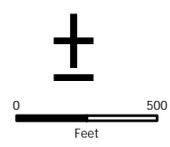


Mean Higher High Water Plus 20 inches SLR

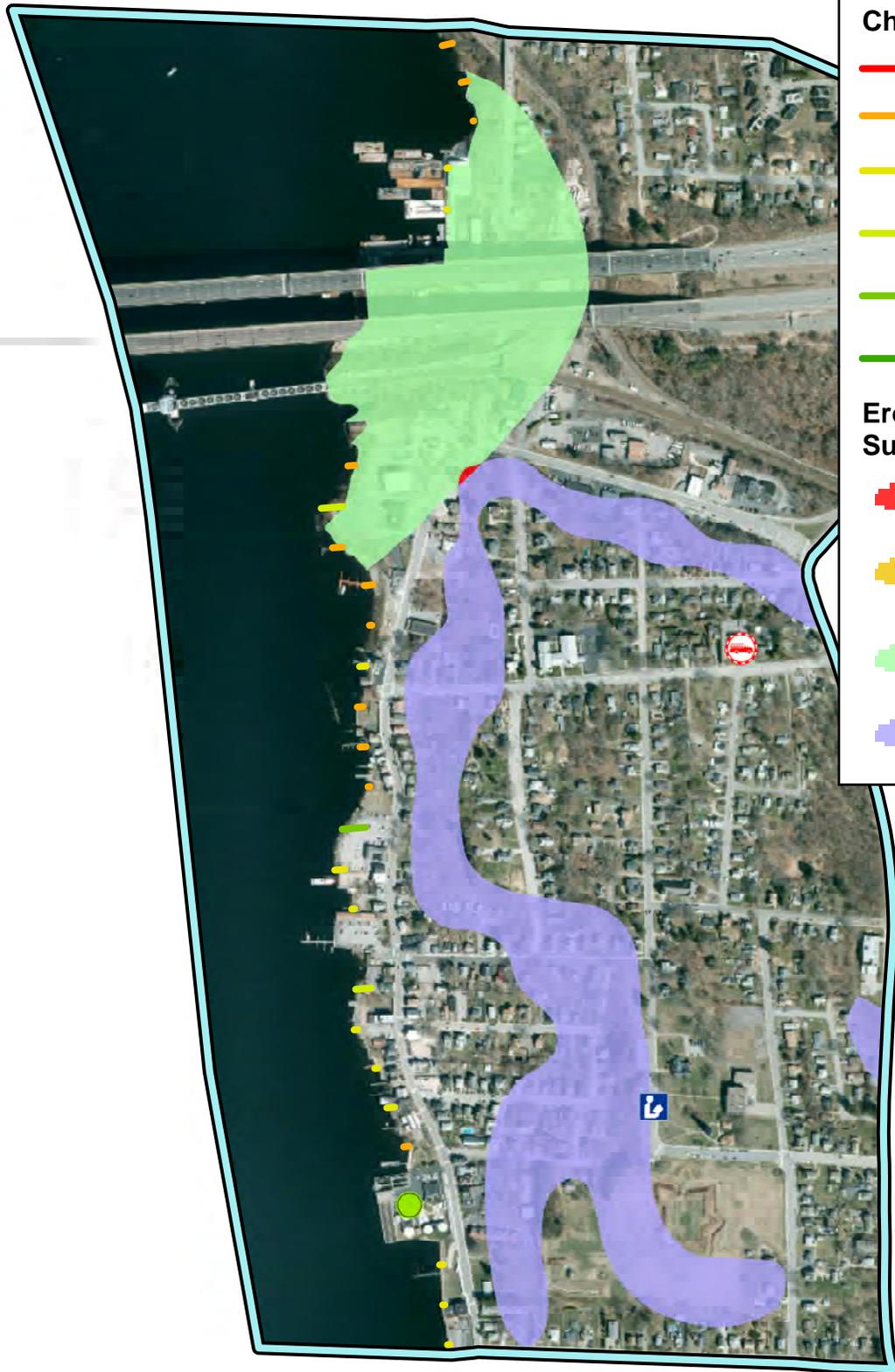
- Low-lying Areas
- Inundated Areas

SLR
 99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

THAMES STREET MEAN HIGHER HIGH
 WITH 20 INCHES OF SEA LEVEL RISE
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 681'
 DATE 3/24/2022
 141.12536.00015
 PROJ. NO.
FIG. 21



CT Shoreline Change Transects

- > 0.5 m/yr Erosion
- > 0.0 m/yr Erosion
- < 0.5 m/yr Accretion
- < 1.0 m/yr Accretion
- < 5.0 m/yr Accretion
- > 5.0 m/yr Accretion

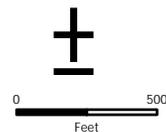
Erosion Susceptibility

- + Most Susceptible to Erosion
- + Highly Susceptible to Erosion
- + Surficial Materials Susceptible to Erosion
- + Soils Susceptible to Erosion



99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

THAMES STREET
EROSION SUSCEPTIBILITY
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 681'
DATE 3/24/2022
141.12536.00015
PROJ. NO.

FIG. 22

Stormwater Flood Exposure

Relatively dense impervious surfaces are present along the shoreline (Thames Street) and Bridge Street, including at Mohawk Northeast, the boat launch area, and some parking lots. Inland residential areas, especially around Groton Bank Historic District, have relatively low-density impervious surfaces.

Because inland areas have relatively low imperviousness, they are expected to have relatively low contributions to stormwater flooding in the AZ.

Stormwater Flood exposure in the Thames Street AZ is classified as **moderate**.

Heat Exposure

Heat is a concern in the densely impervious areas near the shoreline. While significant tree cover is present on private properties on side streets, there are few street trees providing shade on the roads. Areas with particularly low tree coverage are:

- ❖ Thames Street
- ❖ The Submarine Veterans Memorial
- ❖ The Bridge Street - North Street intersection
- ❖ Monument Street
- ❖ Park Avenue
- ❖ Parts of Baker Avenue

Urban Heat Island (UHI) mapping shows a “hot zone” along Bridge Street (see Figure 23).

Overall, this AZ has moderate heat risk due to both a lack of street trees and the relative density of imperviousness (especially in the identified tree-poor areas above).

Heat exposure in the Thames Street AZ is classified as **moderate**.



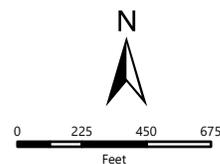


State of Connecticut, Maxar



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 CHESHIRE, CT 06410
 203.271.1773

THAMES STREET
 URBAN HEAT ISLAND EFFECT
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 667'
 DATE 3/30/2022
 141.12536.00015
 PROJ. NO.

FIG. 23

Thames Street Exposure Summary

The Exposure Analysis of the Thames Street AZ, when compared to the exposure levels of other areas of the City of Groton, shows the overall climate hazard exposure for this AZ as follows in Figure 24:

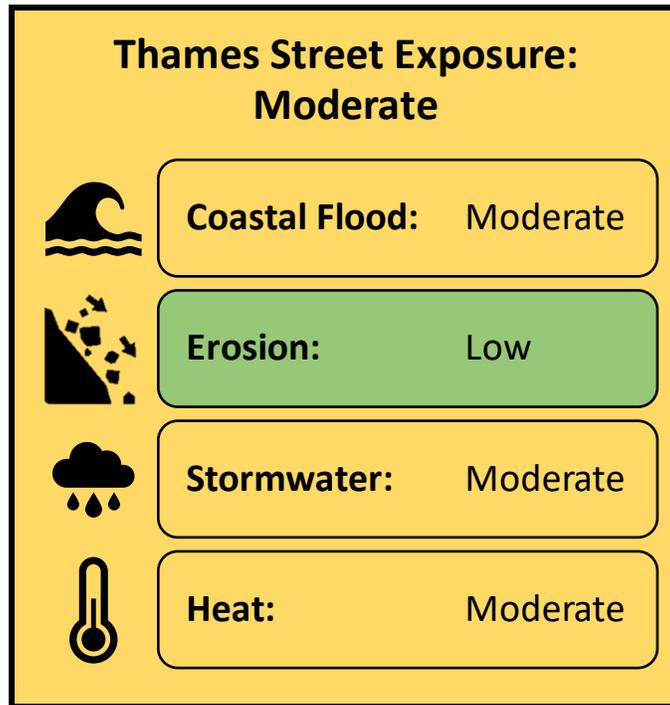


Figure 24: Thames Street Exposure Summary



THAMES STREET CLIMATE RISKS

By combining the vulnerabilities identified in the Thames Street AZ with the climate hazard exposure levels for the area, the level of climate risk faced by this part of the City can be determined. Risk levels are provided below for each identified climate hazard based on how the hazard may affect identified vulnerabilities.

Flood Risk

Flood hazard mapping (see Figure 19, Figure 20, and Figure 21) shows the following specific areas within the AZ susceptible to coastal flooding:

- ❖ **Mohawk Northeast, Inc. Groton Marine Terminal:** the storage and staging areas for this water-dependent business are located in the FEMA-mapped AE Zone (11-foot BFE), with docks and some features in the mapped VE Zone (14-foot BFE). Flooding of this area would pose a risk of damage to the facility itself, as well as a risk of contamination and debris to surrounding areas. The CIRCA Sea Level Rise viewer shows that the site is expected to experience minor flooding during a 30-year flood event at current sea levels; with 20 inches of sea level rise, moderate to significant flooding would occur even during a ten-year event.
- ❖ **West of Thames Street:** A number of properties on the west side of Thames Street (both commercial and residential uses, with some water-dependent businesses) are mapped as being located within the FEMA VE Zone (14-foot BFE). These properties have first-floors located at street-level, above the BFE, so only lower-levels, yards, or outbuildings are susceptible to flooding. Many of these properties include docks.

The CIRCA Sea Level Rise viewer shows that 20 inches of sea level rise will cause some back yards to experience flooding during daily high tide events; a ten-year storm on top of 20 inches of rise is shown to inundate parking lots and some building areas (including the Hel-Cat II Fishing Parties parking lot, the Thames Inn & Marina parking lot and building, and waterfront parks).

The VE-zone extends slightly inland at Thames Street and Broad Street, so that about seven buildings, as well as a portion of Thames Street itself, are mapped within the VE-zone.

Between about 143 Thames and the Water Pollution Control Authority (WPCA) plant, an AE zone (11-foot BFE) is present in addition to the VE zone, encompassing parking lots and parts of some commercial buildings. The Thames Inn and Marina is almost entirely within this AE zone, with a portion of the building extending into the VE zone. Additionally, a 0.2%-chance flood zone is mapped extending farther inland into residential areas here.



- ❖ **Water Pollution Control Facility:** The WPCA facility at 311 Thames Street is located entirely within FEMA flood zones (both an AE zone with an 11-foot BFE and a VE zone with a 14-foot BFE). The facility has structural protection measures in place (floodwalls, floodproofed structures, and elevated structures), but these are not reflected in the FEMA flood map.

The CIRCA Sea Level Rise viewer shows that a ten-year flood event would likely impact the western end of the facility under current sea levels. With 20 inches of sea level rise, the mapping shows that the entire facility would be susceptible to inundation.

Given the specific risk areas identified above, as well as the results of the Thames Street AZ vulnerability assessment and the flood hazard exposure analysis, Table 2 summarizes flood risk in the Thames Street AZ.

Table 2: Thames Street Flood Risks

Vulnerability Category	Flood Risk
Social	Low
Residential	Low
Commercial	High
Infrastructure	High
Community	High
Natural	Low
Overall Risk	Moderate

Both coastal flood exposure and overall vulnerability in this AZ are classified as moderate; therefore, the Thames Street AZ has a moderate risk rating to coastal flooding.

Erosion Risk

While the northern portion of the AZ has some exposure to erosion risks, this exposure is relatively minor, and vulnerabilities in this area are few. The Providence & Worcester railroad runs north along the water at the very northern tip of the AZ (continuing north along the shoreline of the Town of Groton); there is some erosion risk to this important piece of infrastructure.

Given these specific risk areas, as well as the results of the vulnerability assessment and the exposure analysis, Table 3 summarizes erosion risk in the Thames Street AZ.

Table 3: Thames Street Erosion Risks

Vulnerability Category	Erosion Risk
Social	Low
Residential	Low
Commercial	Moderate
Infrastructure	Moderate
Community	Low
Natural	Low
Overall Risk	Low



Erosion exposure in this AZ is classified as low, and vulnerability as moderate; therefore, the erosion risk rating for Thames Street AZ is low.

Stormwater Risk

Stormwater flooding exposure is classified as moderate in this area. Stormwater flooding has been reported as an issue on Thames Avenue, although the problem appears to mostly affect the southern portion of Thames and Mitchell within the Five Corners Assessment Zone. The walkway between Monument Street and Slocomb Terrace has also been identified as a site where stormwater flooding occurs.

Stormwater runoff that makes its way into the city’s wastewater system is a particular concern at the WPCA Facility.

Table 4 summarizes stormwater risk in the Thames Street AZ.

Table 4: Thames Street Stormwater Risks

Vulnerability Category	Stormwater Risk
Social	Moderate
Residential	Moderate
Commercial	Moderate
Infrastructure	High
Community	Moderate
Natural	Low
Overall Risk	Moderate

Combining the moderate vulnerability and moderate exposure gives Thames Street AZ a moderate stormwater risk rating.

Heat Risk

Heat exposure is classified as moderate throughout this AZ, though concern is elevated along Bridge Street and, to a lesser extent, Thames Street. High heat events may impact the health of residents (especially those who are socially vulnerable) and workers, and discourage visits to local businesses.

Table 5 summarizes heat risk in the Thames Street AZ.

Table 5: Thames Street Heat Risks

Vulnerability Category	Heat Risk
Social	Moderate
Residential	Moderate
Commercial	Moderate
Infrastructure	Low
Community	Low
Natural	Low
Overall Risk	Moderate



Combining heat vulnerability and exposure gives the Thames Street AZ a moderate risk rating.

Thames Street Risk Summary

Table 6 below summarizes the risk assessment results for the Thames Street Assessment Zone. In addition to the analysis presented above, an overall risk classification is assigned to each vulnerability category based on the risk classification determined for each of the four hazards assessed.

Table 6: Thames Street Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	Moderate	Moderate	Low
Residential	Low	Low	Moderate	Moderate	Low
Commercial	High	Moderate	Moderate	Moderate	High
Infrastructure	High	Moderate	High	Low	High
Community	High	Low	Moderate	Low	Moderate
Natural	Low	Low	Low	Low	Low
Overall Risk	Moderate	Low	Moderate	Moderate	Moderate

The overall risk level for the Thames Street AZ is moderate, with higher risks facing commercial and infrastructural assets, as well as community resources. Risks are focused along the Thames Street corridor, which is susceptible to all four identified climate hazards. The Bridge Street corridor is another area of elevated risk, primarily from heat and stormwater.



TECHNOLOGY CAMPUS RISK ASSESSMENT

Vulnerabilities, hazard exposure, and overall climate change risks to the Technology Campus Assessment Zone (AZ) are described in this section.

It is recognized that large portions of this AZ are privately-owned, and opportunities for City intervention may be limited.

TECHNOLOGY CAMPUS VULNERABILITIES

The following assets and features were identified as potential vulnerabilities within the Technology Campus AZ.

Social Vulnerabilities

This AZ consists entirely of commercial and industrial uses; there are no residents. There are, however, many workers who spend time within this AZ, and may be exposed to climate hazards. Given the fact that workers are only present on a temporary basis, arriving and leaving every day, social vulnerability in this AZ is classified as low.

Social Vulnerability for the Technology Campus AZ is classified as **Low**.

Residential Vulnerabilities

This AZ does not include any residential uses. Residential vulnerability measures, therefore, do not apply to this AZ, and residential vulnerability is classified as Not Applicable.

Residential Vulnerability for the Technology Campus AZ is classified as **Not Applicable**.

Commercial Vulnerability

The area includes major businesses and employment centers for the City and the region, such as:

- ❖ Electric Boat Corporation
- ❖ Buckeye Terminals, LLC
- ❖ Pfizer Research and Development Groton Laboratories Campus
- ❖ Pfizer West Campus

Electric Boat, Buckeye Terminals, and Pfizer West are all water-dependent businesses located on the Thames River. The AZ also includes smaller businesses, including the Ice Cube Building offices.

The presence of these important economic drivers within this AZ creates a high level of sensitivity to climate hazards; damage to or disruption of these businesses could have significant impacts to the City. At the same time, the size and strength of these companies (such as Electric Boat and Pfizer), likely means that the ability of these businesses to adapt to and recover from climate hazard events is relatively high. Taking both the sensitivity and adaptive capacity described here into consideration, the commercial vulnerability of this AZ is classified as moderate.

Commercial Vulnerability for the Technology Campus AZ is classified as **Moderate**.



Critical Facilities and Infrastructure Vulnerabilities

This AZ includes critical facilities important to health and safety, as well as many important infrastructure and utility elements.

Both Electric Boat and Pfizer operate their own fire departments, (The Electric Boat Fire Department is located at 185 Eastern Point Road; the Pfizer Fire Department is located at the Pfizer headquarters building).

A sewer pump station is located at 500 Eastern Point Road.

Essential roads, utility lines, and other transportation infrastructure exist in this AZ, including Eastern Point Road (Route 349).

Additionally, major stormwater pipes run underground throughout the area, along with water and sewer. Power lines are above ground.

Critical Facility and Infrastructure Vulnerability for the Technology Campus AZ is classified as **high**.

Community Resource Vulnerabilities

This AZ does not include any community resources, as defined in the Vulnerability Assessment Methodology section. Community resource vulnerabilities are therefore considered Not Applicable.

Community Resource Vulnerability for the Technology Campus AZ is **Not Applicable**.

Natural System Vulnerabilities

This AZ is highly developed and includes only very minor natural or open-space areas. There are forested sections of private properties (such as between Virginia Avenue and Warner Street), and some forested pockets of the Pfizer campus. Unforested, managed open space is present on the Pfizer campus and the Marine Science Magnet High School campus.

Much of the area consists of paved parking lots, primarily serving Electric Boat employees. Pfizer also has extensive parking, though these lots tend to have more vegetated surfaces incorporated.

The hardened shoreline is not conducive to coastal ecosystems.

The presence of natural features in this area is extremely limited, and the features that do exist are on private property and therefore may face development pressure in the future.

Natural System Vulnerability for the Technology Campus AZ is classified as **high**.



Technology Campus Vulnerability Summary

Given the vulnerabilities described above, in comparison to vulnerabilities of the other areas of the City of Groton, the overall climate vulnerabilities for the Technology Campus AZ are summarized in Figure 25.

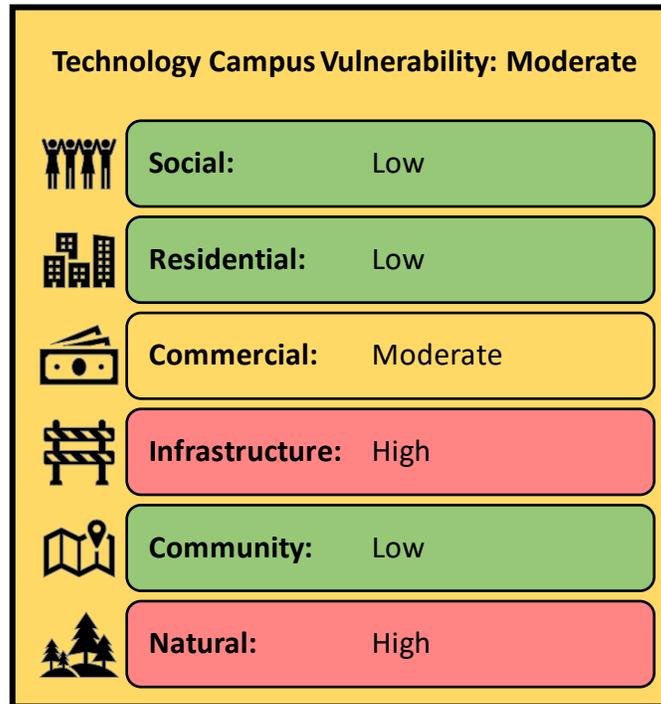


Figure 25: Technology Campus Vulnerability Summary



TECHNOLOGY CAMPUS EXPOSURE

The exposure of the Technology Campus AZ to coastal flooding, erosion, stormwater flooding, and heat hazards is described below.

Flood Exposure

As noted previously, the shoreline of this AZ is dominated by the water-dependent, industrial operations of Electric Boat, Buckeye Terminals, and Pfizer West Campus. Significant portions of these properties are located at lower elevations and fall within FEMA flood zones. The ground elevation rises rapidly toward the east, however, so coastal flood risk does not extend far inland.

See Figure 26: Map of Technology Campus FEMA Flood Hazard Zones, Figure 27: Map of Technology Campus Hurricane Surge Inundation, and Figure 28: Map of Technology Campus Sea Level Rise Inundation. Because much of this highly developed shoreline is susceptible to coastal flooding, flood exposure is classified as high.

Flood exposure for the Technology Campus AZ is classified as **high**.

Erosion Exposure

A map of erosion exposure in the Technology Campus AZ is presented in Figure 29.

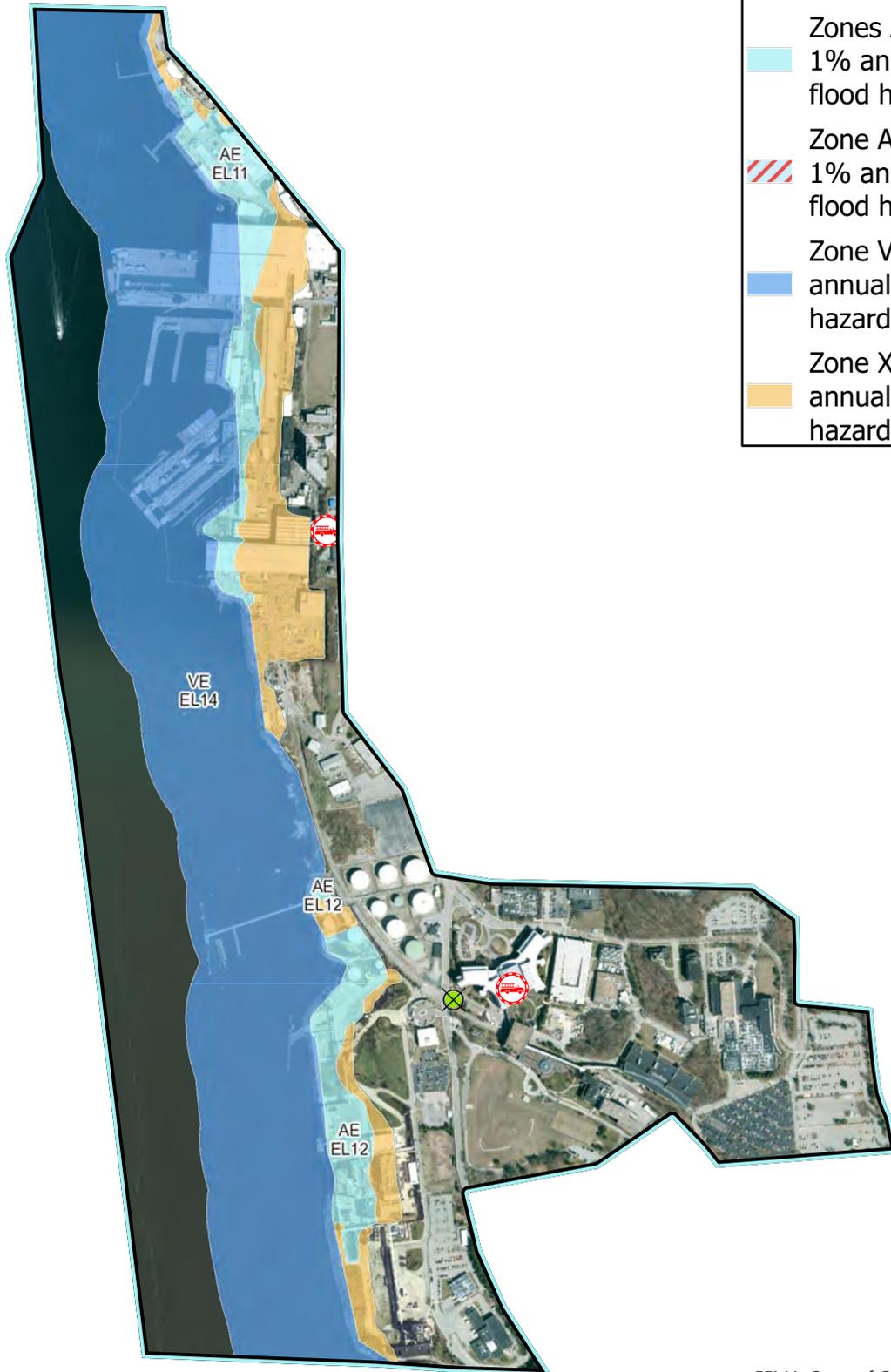
A section of land along the Thames River west of Eastern Point Road, with its northern end roughly aligned with Burgess Place and its southern end roughly aligned with Morse Avenue, is identified as having “Soils Susceptible to Erosion” by the Connecticut Erosion Susceptibility Map (CT DEEP, 2005). This indicates that shallow soils lying on bedrock are present and may be removed relatively easily. It does not appear that more extensive erosion of deeper materials is likely.

The Connecticut Shoreline Change Analysis (O’Brien, et. al. 2014) shows a small section just south of the Electric Boat dock area where net erosion occurred from 1983 to 2006 at a rate of greater than 0.25 feet-per-year. Most of the rest of the shoreline in this area is shown to have been accreting since 1983.

While some evidence of minor erosion susceptibility is present, erosion is of minimal concern in this AZ.

Erosion exposure for the Technology Campus AZ is classified as **low**.





Floodzones

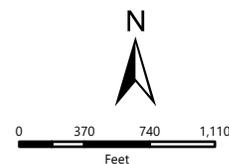
- Zones A and AE;
1% annual chance flood hazard
- Zone AE, Floodway;
1% annual chance flood hazard
- Zone VE; 1% annual chance flood hazard
- Zone X; 0.2% annual chance flood hazard

FEMA, State of Connecticut, Maxar



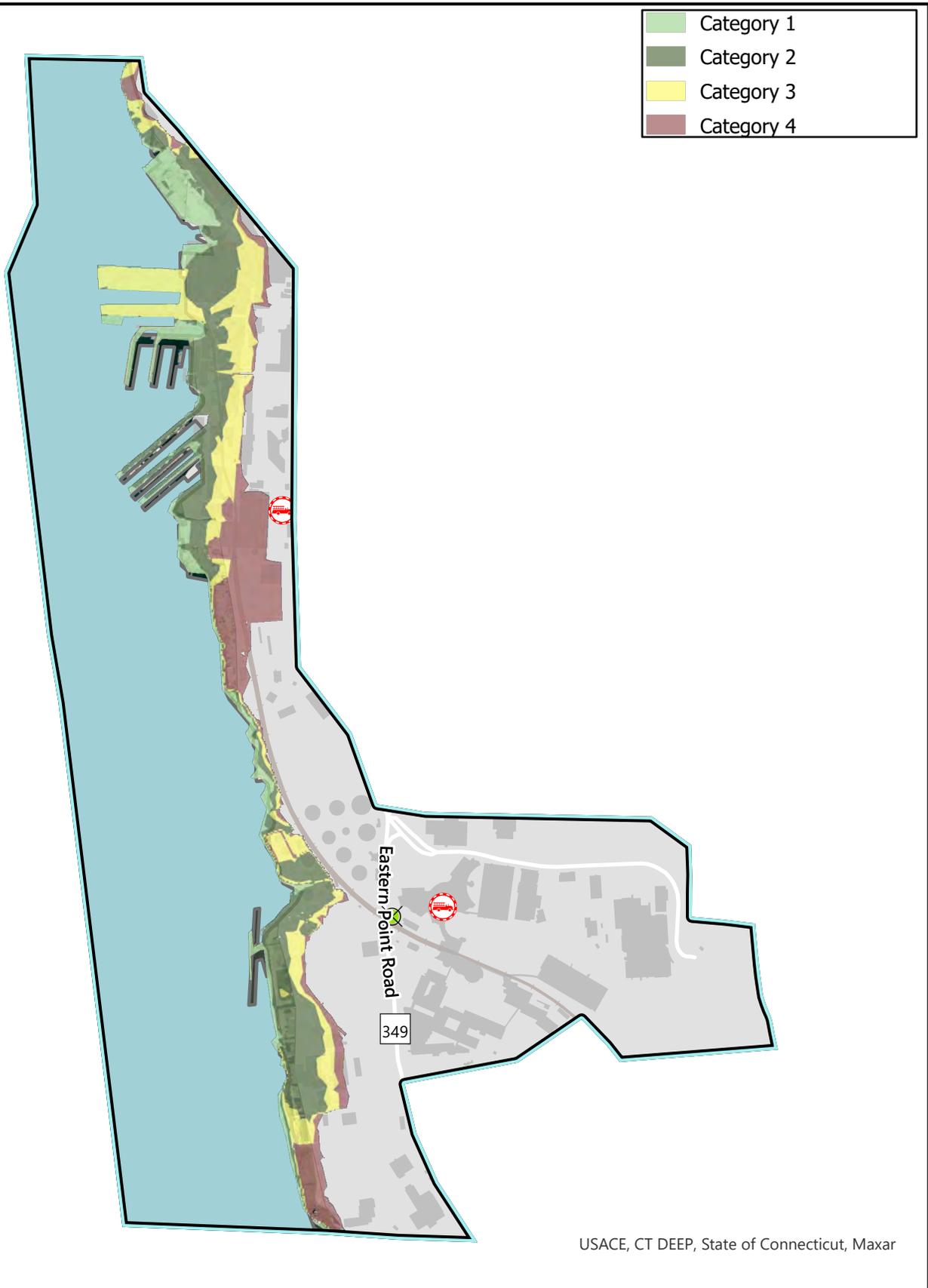
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

TECHNOLOGY CAMPUS
FEMA FLOOD HAZARD ZONES
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 1,083'
DATE 3/31/2022
141.12536.00015
PROJ. NO.

FIG. 26

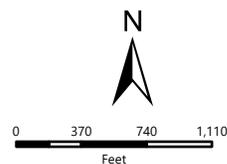


USACE, CT DEEP, State of Connecticut, Maxar



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TECHNOLOGY CAMPUS
HURRICANE SURGE INUNDATION
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 1,083'
DATE 3/31/2022
141.12536.00015
PROJ. NO.

FIG. 27

Mean Higher High Water Plus 20 inches SLR

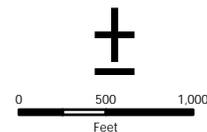
- Low-lying Areas
- Inundated Areas



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TECHNOLOGY CAMPUS MEAN HIGHER HIGH WATER
 WITH 20 INCHES SEA LEVEL RISE
 CITY OF GROTON COMMUNITY RESILIENCE PLAN

295 Meridian Street
 Groton, CT 06340



SCALE 1" = 1,097'

DATE 3/24/2022

141.12536.00015
 PROJ. NO.

FIG. 28



CT Shoreline Change Transects

- > 0.5 m/yr Erosion
- > 0.0 m/yr Erosion
- < 0.5 m/yr Accretion
- < 1.0 m/yr Accretion
- < 5.0 m/yr Accretion
- > 5.0 m/yr Accretion

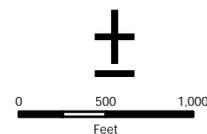
Erosion Susceptibility

- + Most Susceptible to Erosion
- + Highly Susceptible to Erosion
- + Surficial Materials Susceptible to Erosion
- + Soils Susceptible to Erosion



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TECHNOLOGY CAMPUS
EROSION SUSCEPTIBILITY
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295 Meridian Street
Groton, CT 06340



SCALE 1" = 1,097'
DATE 3/24/2022
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FIG. 29

Stormwater Flooding Exposure

Severely dense impervious surfaces are present over most of this AZ, both along the shoreline and inland. This includes both structures and pavement areas. Some managed open space and forested areas are present on the Pfizer campus; Pfizer parking areas also have impervious surface mitigation measures in place such vegetated medians and parking dividers.

The high amount of impervious surface in this AZ would be expected to generate large amounts of stormwater runoff. Because much of the impervious surface area is located immediately adjacent to the shoreline, this runoff would not flood downstream developed areas; instead, it would flow directly into the Thames River. It is important to note that, while this would not impact developed areas, it may negatively impact marine ecosystems.

Considering both the high chance of stormwater runoff generation, as well as the likelihood that most stormwater runoff flows into the Thames River before impacting developed areas, a moderate stormwater flood exposure classification is assigned to this AZ. More information about where stormwater flooding has or has not occurred on these private properties is needed to accurately classify stormwater flood exposure.

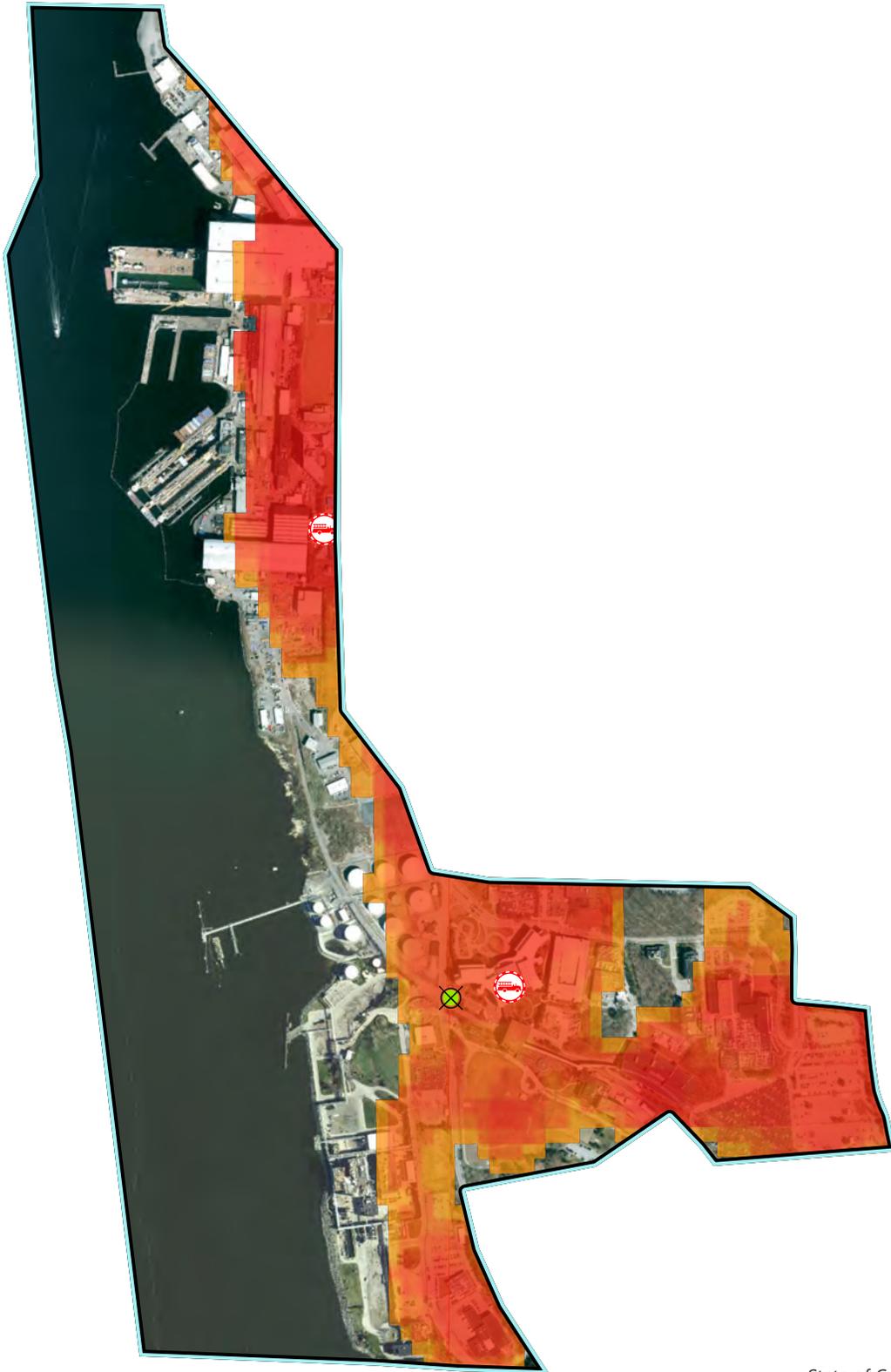
Stormwater Flood exposure in the Technology Campus AZ is classified as **moderate**.

Heat Exposure

In addition to being largely impervious, as described above, the Technology Campus AZ has relatively low tree coverage. The shoreline is impervious and with few trees for the entirety of the AZ. Impervious surfaces decrease and tree coverage increases to the east, on the Pfizer campus; forested areas are located on the Pfizer campus, and vegetated buffers are present in Pfizer parking areas.

UHI mapping shows severe heat island effect in the area of Electric Boat, running south through the Pfizer campus and Buckeye terminals. See



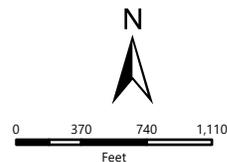


State of Connecticut, Maxar



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TECHNOLOGY CAMPUS
URBAN HEAT ISLAND EFFECT
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 1,083'
DATE 3/30/2022
141.12536.00015
PROJ. NO.

FIG. 30

In Figure 30 , the darker red colors indicate relatively severe UHI effect, the lighter colors indicate relatively mild UHI, and no coloring indicates temperatures are at or below the average for the city.

The high amount of impervious surface, coupled with UHI mapping showing severe heat island effect, lead to classification of heat exposure in this AZ as high.

Heat exposure in the Technology Campus AZ is classified as **high**.

Technology Campus Exposure Summary

The Exposure Analysis of the Technology Campus AZ, when compared to the exposure levels of other areas of the City of Groton, shows the overall climate hazard exposure for this AZ as follows in Figure 31.

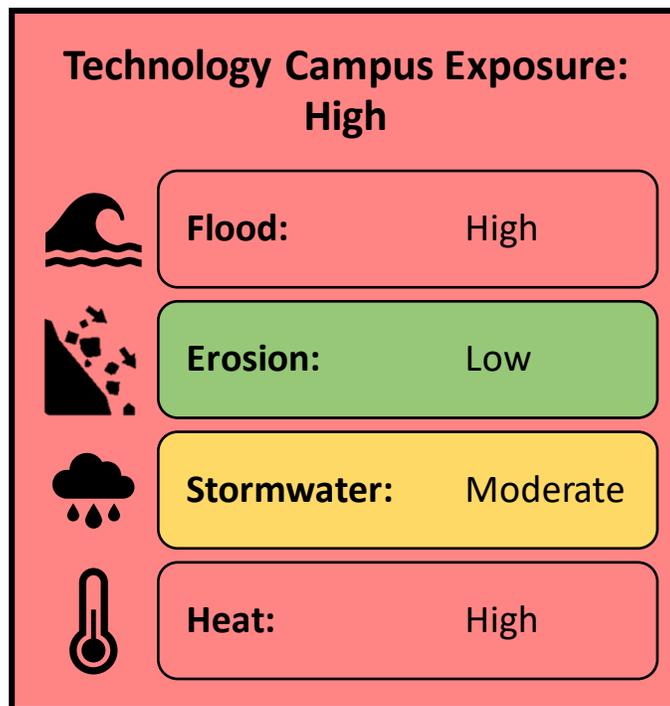


Figure 31: Technology Campus Exposure Summary



TECHNOLOGY CAMPUS CLIMATE RISKS

By combining the vulnerabilities identified in the Technology Campus AZ with the climate hazard exposure levels, the level of climate risk faced by this part of the City can be determined. Risk levels are provided below for each identified climate hazard based on how the hazard may affect identified vulnerabilities.

Flood Risk

Flood hazard mapping (see Figure 26, Figure 27, and Figure 28) shows the following areas are susceptible to coastal flooding:

- ❖ **Electric Boat:** Large portions of the Electric Boat facility are located within VE zones (14-foot BFE), AE zones (11-foot BFE), and 0.2% annual-chance flood zones. The CIRCA Sea Level Rise viewer shows that 20 inches of sea level rise may lead to flooding of some areas of the facility (particularly at the northern end) during a ten-year flood event. Other than that northern section, the rest of the facility appears to be protected even from a 100-year flood event with 20 inches of sea level rise.

The facility includes wet- and dry-docks that extend over 750-feet into the Thames River. Flooding of the facility would pose a major risk of damage and disruption to business operations, as well as of debris and contamination to surrounding areas.

- ❖ **Buckeye Terminals:** Fuel storage tanks located to the west of the railroad fall within AE-zones (12-foot BFE) and a 0.2% annual-chance zone. Levees and floodwalls mitigate some flood risks here. CIRCA Sea Level Rise mapping shows the site as protected even against a 100-year flood event with 20 inches of sea level rise. Fuel lines extend around 700 feet into the Thames River. Flood damage to the facility would pose a major risk of pollutant release.
- ❖ **Pfizer West Campus:** Large portions of this property are located within an AE zone (12-foot BFE) and 0.2% annual-chance flood zone. Levees and floodwalls mitigate some flood risks here; the VE-zone does not extend inland of the coastal flood protection structures. Sections of the facility, including storage tanks and critical buildings, are shown to have flood exposure under a ten-year flood event with 20 inches of sea level rise scenario.

Flood damage to the facility would pose a risk of pollutant release.

Given the specific risk areas identified above, as well as the results of the Technology Campus AZ vulnerability assessment and the flood hazard exposure analysis, Table 7 summarizes flood risk in the Technology Campus AZ.



Table 7: Technology Campus Flood Risks

Vulnerability Category	Flood Risk
Social	Low
Residential	N/A
Commercial	High
Infrastructure	High
Community	N/A
Natural	High
Overall Risk	High

Flood exposure in the Technology Campus AZ is classified as high, and overall vulnerability is classified as moderate. Flood risk for the Technology Campus AZ is classified as high.

Erosion Risk

Erosion exposure in this AZ is classified as low. Areas exposed to potential erosion include the Electric Boat facility, a critical economic asset. Erosion at this site poses a slightly elevated risk.

Table 8 summarizes erosion risk in the Technology Campus AZ.

Table 8: Technology Campus Erosion Risks

Vulnerability Category	Erosion Risk
Social	Low
Residential	N/A
Commercial	Moderate
Infrastructure	Low
Community	N/A
Natural	Low
Overall Risk	Low

Combining the overall AZ vulnerability classification of moderate with the low erosion exposure gives a low erosion risk rating.

Stormwater Risk

Stormwater flooding exposure is classified as moderate in this area. Stormwater flooding has been identified as a significant issue at the intersection of Thames Street and Smith Street; floodwaters have flowed over a retaining wall into Electric Boat property and caused damage to that retaining wall. Stormwater generated uphill has been observed “sheet flowing” down Poquonnock Road into this intersection. This specific stormwater flood issue is addressed in the Five Corners Assessment Zone as well.

Stormwater picks up contaminants and debris along its flow path. Direct input of stormwater into the Thames River from the impervious surfaces in this AZ represent a significant risk to coastal and marine ecosystems.



Table 9 summarizes stormwater risk in the Technology Campus AZ.

Table 9: Technology Campus Stormwater Risks

Vulnerability Category	Stormwater Risk
Social	Low
Residential	N/A
Commercial	Moderate
Infrastructure	Moderate
Community	N/A
Natural	High
Overall Risk	Moderate

Combining the moderate vulnerability and moderate exposure gives a moderate stormwater risk rating.

Heat Risk

Heat exposure is classified as high, especially at the Electric Boat campus. This is an area with a high concentration of workers; these workers are directly at risk from exposure to extreme heat events. It is also possible that extreme heat conditions may impact operations at these industrial facilities. Prolonged heat waves may impact the already vulnerable natural systems in this AZ.

Table 10 summarizes heat risk in the Technology Campus AZ.

Table 10: Technology Campus Heat Risks

Vulnerability Category	Heat Risk
Social	Moderate
Residential	N/A
Commercial	High
Infrastructure	Moderate
Community	N/A
Natural	High
Overall Risk	High

Combining heat vulnerability and exposure in this AZ gives a high risk-rating for heat.



Technology Campus Risk Summary

Table 11 below summarizes the risk assessment results for the Technology Campus Assessment Zone. In addition to the analysis presented above, an overall risk classification is assigned to each vulnerability category based on the risk classification determined for each of the four hazards assessed.

Table 11: Technology Campus Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	Low	Moderate	Low
Residential	N/A	N/A	N/A	N/A	N/A
Commercial	High	Moderate	Moderate	High	High
Infrastructure	High	Low	Moderate	Moderate	Moderate
Community	N/A	N/A	N/A	N/A	N/A
Natural	High	Low	High	High	High
Overall Risk	High	Low	Moderate	High	High

The Technology Campus AZ has a high level of risk. The primary hazards of concern are flooding (from the Thames River) and high heat; stormwater flooding is also a risk. The role this AZ plays as an economic driver is a primary concern. The resilience of the managed and unmanaged open spaces and natural resources in this area – especially considering the role they can play to mitigate heat and stormwater runoff hazards – is another top concern.



FIVE CORNERS RISK ASSESSMENT

Vulnerabilities, hazard exposure, and overall climate change risks to the Five Corners Assessment Zone (AZ) are described in this section.

FIVE CORNERS VULNERABILITIES

The following assets and features were identified as potential vulnerabilities within the Five Corners AZ.

Social Vulnerabilities

The Five Corners AZ includes all of the residential uses within CBG #25002, as well as a large portion of CBD #24003.

According to the 2019 ACS 5-year estimates, these CBGs have per-capita incomes of \$26,041 and \$32,685, respectively. Considering both figures, this income level is low compared to the city average of \$33,605. Nearly 63-percent of residents in CBG #24003 and 30-percent of residents in CBG #25002 identify as non-white; overall this is a relatively large minority population percentage compared to the citywide average of 33% non-white. Very few residents have limited English (about 1 percent for CBG #24003 and zero-percent in CBD #25002). Over 27 percent of households in CBG #24003 and about 18-percent of households in CBG #25002 include one or more individuals with a disability. About 0.45 vehicles are available per person; vehicle availability is lower in the two CBGs included in this AZ than anywhere else in the City.

Overall, these factors show that social vulnerabilities are relatively high for this AZ, as income and vehicle access is relatively low, and the percentage of non-white residents and the number of residents with disabilities is relatively high. These measures indicate that residents will potentially face challenges accessing important resources, may need additional attention to prepare and assist those with disabilities, and may have barriers to evacuation, in the face of a climate hazard.

Social Vulnerability in the Five Corners AZ is classified as **High**.

Residential Vulnerabilities

The Five Corners AZ includes single-, two- and three-family homes, as well as multi-family buildings and complexes, such as:

- ❖ The River View Apartments (Bishop Lane)
- ❖ Avery / Boardsen Place (245 Benham Road)

The population density in this area is high compared to other portions of the city; for this reason, residential vulnerability is also considered high.

Residential Vulnerability in the Five Corners AZ is classified as **High**.



Commercial Vulnerability

This AZ includes the Five Corners Action Zone, as well as a General Commercial Zone, and the majority of the AZ falls within an Enterprise Zone where economic development and job creation are encouraged (according to the 2019 POCD Zoning Map). Many businesses, including local small businesses, currently exist in this AZ, including retail stores, restaurants, hotels, gas stations, banks, pharmacies, auto repair shops, and offices. These businesses are concentrated along Thames Street, Smith Street, Poquonnock Road, and Mitchell Street, but businesses are present in other locations as well, including:

- ❖ Poquonnock Road near West Street.
- ❖ The southern end of Benham Road.

The City's POCD calls for continued future growth of the business sector in the Five Corners area.

An important economic activity in this AZ is the operation of privately-owned pay-to-park lots, which reportedly predominantly serve Electric Boat employees and visitors.

Electric Boat also operates out of some facilities in this AZ and owns large parking lots here.

Small businesses are particularly vulnerable to climate hazards and tend to have limited adaptive capacities to recover from damage or disruptions. Because of the high number of businesses in this AZ, the fact that many of the businesses here are small and local, and the importance of this area to the City's economic development plans, commercial vulnerability is classified as high.

Commercial Vulnerability in the Five Corners AZ is classified as **High**.

Critical Facilities and Infrastructure Vulnerabilities

This AZ includes critical facilities important to health and safety, as well as many important infrastructure and utility elements. The Eastern Point Fire Department operates out of 416 Benham Road, near the Pfizer campus. A Groton Utilities Water Tank and drinking water treatment and distribution facility is located at 135 Brandegee Avenue, on the eastern edge of the AZ.

Essential roads, utility lines, and other transportation infrastructure exist in this AZ, including:

- ❖ Eastern Point Road (Route 349)
- ❖ Benham Road
- ❖ Mumford Ave and Rainville Ave (Route 349 and essential connectors to Interstate 95 and other commuter routes)
- ❖ Numerous Southeast Area Transit District bus stops (Route 11, on Benham Road)

Additionally, major stormwater pipes run underground throughout the area, along with water and sewer. Power lines are above ground.

Overall, the critical facility and infrastructure vulnerability level in this AZ is considered moderate, due to the presence of a fire department and a number of key transportation assets

Critical Facility and Infrastructure Vulnerability in the Five Corners AZ is classified as **Moderate**.



Community Resource Vulnerabilities

Important community resources located in this area include:

- ❖ Riverfront Childrens Center (Daycare; 476 Thames Street)
- ❖ Sacred Heart Parish: this facility includes a Church, a school, and the Thomas J. Sullivan Employment Transition Center. The Employment Transition Center is part of The Arc of Eastern Connecticut, an organization partnering with people living with intellectual and developmental disabilities.
- ❖ Marine Science Magnet High School of Southeastern Connecticut (130 Shennecossett Road)

These facilities all contain concentrated populations of children during operational hours. As children under 17 years of age are considered to be a vulnerable population, these community resources are considered to have relatively high sensitivity levels. At the same time, the presence of these community resources represents a source of adaptive capacity for the local community, as they can leverage their relationships with children and families (as well as the facilities themselves) to provide support and assistance to the community.

Similarly, the Arc of Eastern Connecticut Employment Transition Center is a resource that can support community resilience through its relationships with people living with intellectual and developmental disabilities, which is another vulnerable population.

Despite the sensitivity represented by these community resources, the adaptive capacity they provide to the AZ leads to a low community resource vulnerability classification.

Community Resource Vulnerability in the Five Corners AZ is classified as **Low**.

Natural System Vulnerabilities

This AZ is highly developed but does include some natural or open-space areas. There are forested sections of private properties (such as between Virginia Avenue and Warner Street). Unforested, managed open space is present on the Marine Science Magnet High School campus.

Significant portions of the AZ consist of paved parking lots, primarily serving Electric Boat employees.

The AZ does not include any shoreline.

The presence of natural features in this area is relatively limited, and the features that do exist are on private property and therefore may face development pressure in the future.

Natural System Vulnerability for the Five Corners AZ is classified as **high**.



Five Corners Vulnerability Summary

Given the vulnerabilities described above, in comparison to vulnerabilities of the other areas of the City of Groton, the overall climate vulnerabilities for the Five Corners AZ are summarized in Figure 32.

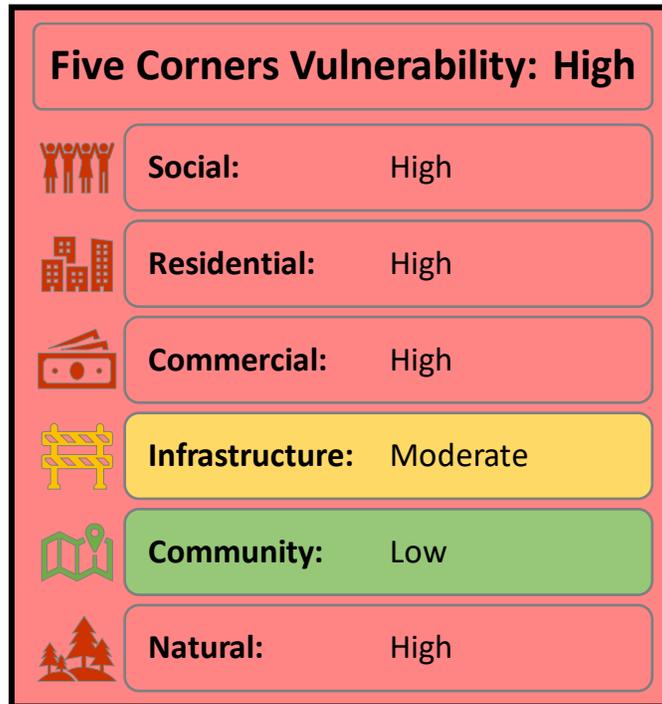


Figure 32: Five Corners Vulnerability Summary



FIVE CORNERS EXPOSURE

The exposure of the Five Corners AZ to coastal flooding, erosion, stormwater flooding, and heat hazards is described below.

Flood Exposure

This AZ does not include any shoreline area and does not have any mapped flood exposure (see Figure 6 through Figure 11). Even a CIRCA-mapped 100-year flood event with 20 inches of sea level rise is not expected to impact this AZ.

Flood Exposure for the Five Corners AZ is classified as **Low**.

Erosion Exposure

According to the Connecticut Erosion Susceptibility Map (CT DEEP, 2005), an area along White Street, extending north into the 46 Hynes Ave apartment complex, is classified as “Soils Susceptible to Erosion.” This indicates that shallow soils lying on bedrock are present and may be removed relatively easily. It does not appear that more extensive erosion of deeper materials is likely. Additionally, the topography and land use (developed, with drainage infrastructure) of this area make it very unlikely that conditions conducive to erosion of this soil will occur.

There is no shoreline included in this AZ, so Connecticut Shoreline Change Analysis (O’Brien, et. al., 2014) results do not apply.

Erosion exposure for this AZ is low. A map of erosion exposure in the Five Corners AZ is presented in Figure 33.

Erosion Exposure for the Five Corners AZ is classified as **Low**.

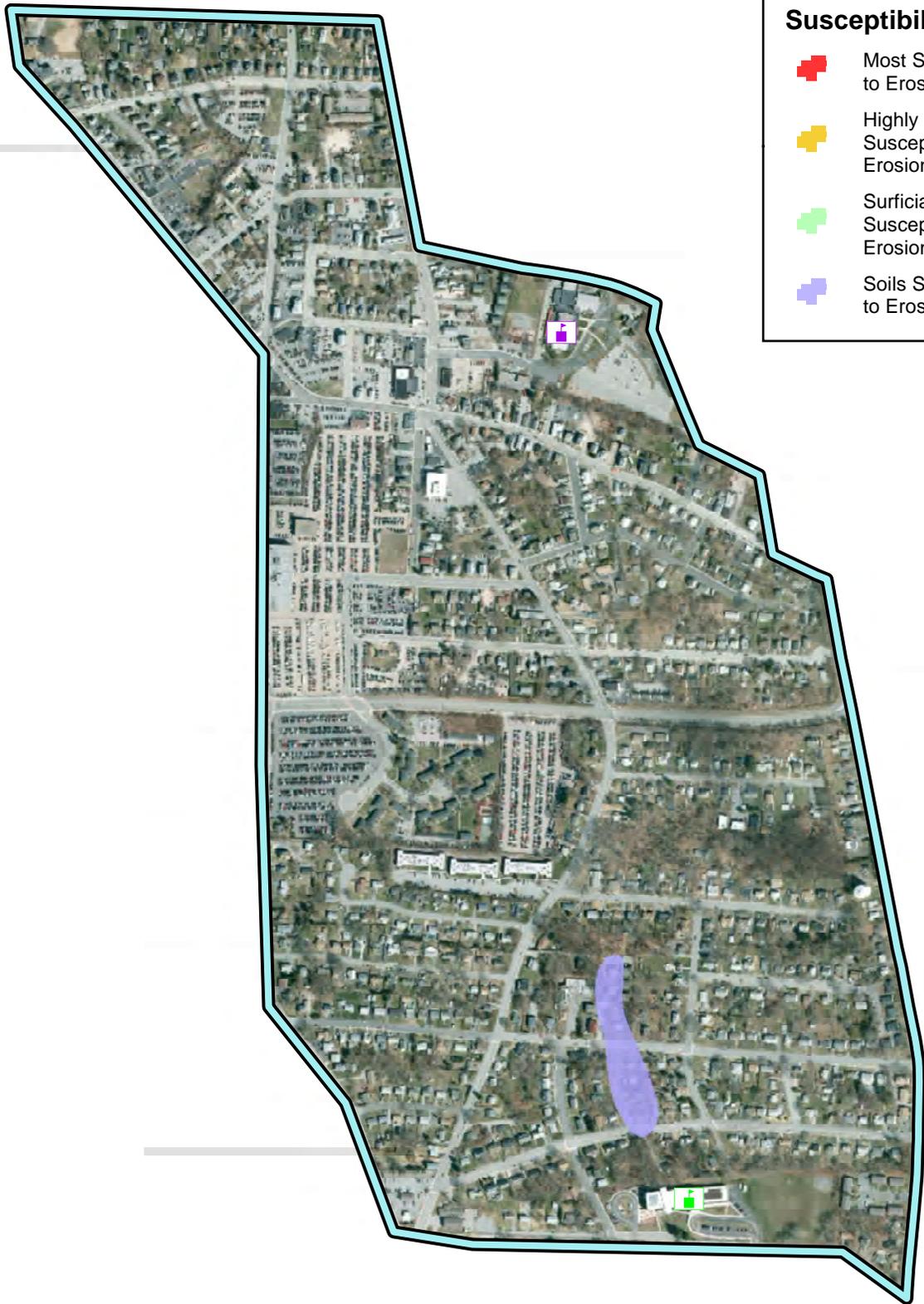
Stormwater Flooding Exposure

Severely dense impervious surfaces are present over most of this AZ, especially in the Five Corners area and near Electric Boat. Impervious surfaces include both structures and parking areas, including several very large parking areas.

The high amount of impervious surface in this AZ would be expected to generate large amounts of stormwater runoff. This is verified by reports of stormwater flooding, particularly at the intersection of Thames Street and Eastern Point Road. Stormwater runoff generated within this AZ may also impact adjacent, downstream areas, such as the Technology Campus AZ.

Stormwater Flooding Exposure for the Five Corners AZ is classified as **High**.





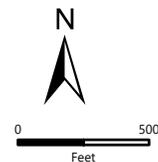
Erosion Susceptibility

-  Most Susceptible to Erosion
-  Highly Susceptible to Erosion
-  Surficial Materials Susceptible to Erosion
-  Soils Susceptible to Erosion



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FIG. 33

Heat Exposure

As described above, the Five Corners AZ has very high impervious surface concentration near the five corners intersection and Electric Boat; these areas also have very low tree coverage and shading. Farther south, as well as east of Benham Road, impervious surfaces decrease, and tree coverage increases. Tree cover is low along streets but higher on private properties, especially to the south and east.

UHI mapping shows severe heat island effect in the area of Electric Boat and the five corners intersection. See Figure 35. In this figure, the darker red colors indicate relatively severe UHI effect, the lighter orange colors indicate relatively mild UHI, and no coloring indicates temperatures are at or below the average for the city.

High imperviousness, low tree coverage, and high UHI effect according to mapping, leads to classification of heat exposure in this AZ as high.

Heat Exposure in the Five Corners AZ is classified as **High**.

Five Corners Exposure Summary

The Exposure Analysis of the Five Corners AZ, when compared to the exposure levels of other areas of the City of Groton, shows the overall climate hazard exposure for this AZ as follows in Figure 34.

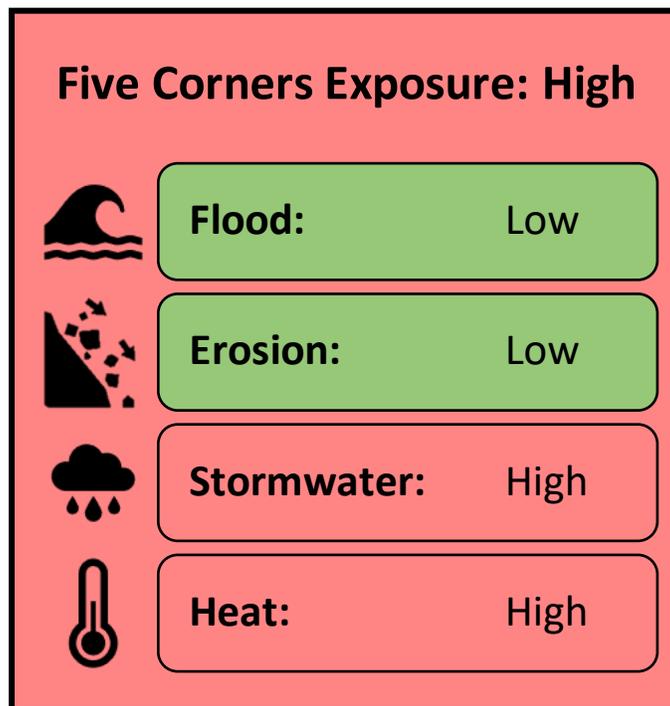
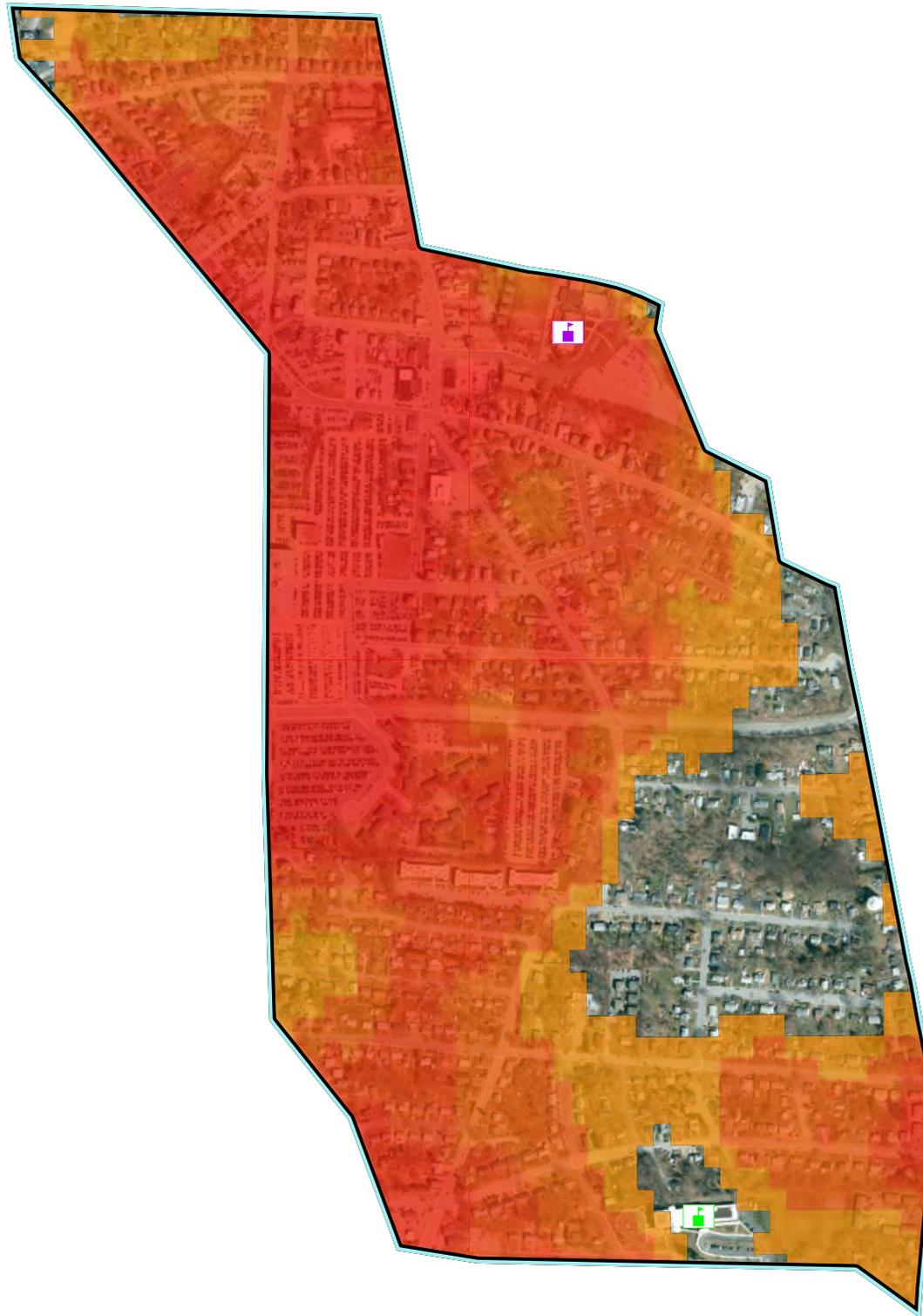


Figure 34: Five Corners Exposure Summary



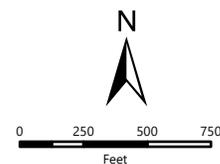


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FIVE CORNERS
 URBAN HEAT ISLAND EFFECT
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SCALE 1" = 750'
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FIG. 35

FIVE CORNERS CLIMATE RISKS

By combining the vulnerabilities identified in the Five Corners AZ with the climate hazard exposure levels, the level of climate risk faced by this part of the City can be determined. Risk levels are provided below for each identified climate hazard based on how the hazard may affect identified vulnerabilities.

Flood Risk

As noted in the Exposure section, there is no mapped flood hazard exposure in this AZ. Therefore, flood risk is classified as low. Table 12 summarizes flood risk in the Five Corners AZ.

Table 12: Five Corners Flood Risks

Vulnerability Category	Flood Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Low
Community	Low
Natural	Low
Overall Risk	Low

Erosion Risk

Erosion exposure in this AZ is classified as low, with no notable areas of concern. Table 13 summarizes erosion risk in the Five Corners AZ.

Table 13: Five Corners Erosion Risks

Vulnerability Category	Erosion Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Low
Community	Low
Natural	Low
Overall Risk	Low

Stormwater Risk

Stormwater flooding exposure is classified as high in this area. Stormwater flooding has been identified as a significant issue at the intersection of Thames Street and Smith Street; floodwaters have flowed over a retaining wall into Electric Boat property and caused damage to that retaining wall; this affected Eastern Point Road, which is located within this AZ. Stormwater generated uphill has been observed “sheet flowing” down Poquonnock Road into this intersection.



The General Commercial Zone is located to the north of the Thames Street and Smith Street intersection. The small businesses in this location may be particularly at risk from stormwater flooding, both from direct impacts to property as well as disruptions to business, deliveries, and customer access due to roadway flooding.

The Riverfront Childrens Center is located on Thames Street, downhill of some of the stormwater runoff generating sources described above. While stormwater flooding has not specifically been reported here, the risk of direct impact or loss of access to the facility while children are on site is of particular concern (leading to an elevated social and community resource risk classifications).

Table 14 summarizes stormwater risk in the Five Corners AZ.

Table 14: Five Corners Stormwater Risks

Vulnerability Category	Stormwater Risk
Social	High
Residential	Moderate
Commercial	High
Infrastructure	High
Community	Low
Natural	Moderate
Overall Risk	High

Combining the high vulnerability and high exposure gives a high stormwater risk rating.

[Heat Risk](#)

Heat exposure is classified as high, near the center of the Five Corners Action Area. This is an area with a high concentration of residents, workers, and visitors, indicating that a high level of vulnerability exists within this high exposure zone. Heat hazards tend to disproportionately affect socially vulnerable populations. High heat events may also impact the businesses in the neighborhood by preventing customer visits, impacting workers, or disrupting operations.

The presence of strong community resources may mitigate some of the heat risk to the community by providing locations that can serve as cooling centers or providing other assistance to residents.

Heat exposure is likely exacerbated by the high amount of vehicular emissions from traffic. It is worth noting that cars overheating in the parking lots, as well as the need for commuters to walk distances between parking spots and their destinations, increase exposure to the impacts of severe heat events.

Prolonged heat events may negatively impact the sensitive natural resources that exist in the AZ.



Table 15 summarizes heat risk in the Five Corners AZ.

Table 15: Five Corners Heat Risks

Vulnerability Category	Heat Risk
Social	High
Residential	High
Commercial	High
Infrastructure	Moderate
Community	Moderate
Natural	High
Overall Risk	High

Combining heat vulnerability and exposure in this AZ gives a high risk-rating for heat.

Five Corners Risk Summary

Table 16 below summarizes the risk assessment results for the Five Corners Assessment Zone. In addition to the analysis presented above, an Overall Risk classification is assigned to each vulnerability category based on the risk classification determined for each of the four hazards assessed.

Table 16: Five Corners Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	High	High	High
Residential	Low	Low	Moderate	High	Moderate
Commercial	Low	Low	High	High	High
Infrastructure	Low	Low	High	Moderate	Moderate
Community	Low	Low	Low	Moderate	Low
Natural	Low	Low	Moderate	High	Moderate
Overall Risk	Low	Low	High	High	High

The Five Corners AZ has a relatively high risk-level. Although risks from flooding and erosion are low, due to the low level of exposure, the high risks presented by stormwater flooding and high heat events are of high concern. Stormwater and heat risks are given extra weight in the overall risk analysis (resulting in an overall risk of high, rather than moderate) because of the significant impacts on the public health and economic sustainability of the entire city.



SOUTH SHORE RISK ASSESSMENT

Vulnerabilities, hazard exposure, and overall climate change risks to the South Shore Assessment Zone (AZ) are described in this section.

SOUTH SHORE VULNERABILITIES

The following assets and features were identified as potential vulnerabilities within the South Shore AZ.

Social Vulnerabilities

According to the 2019 ACS 5-year estimates, this area has a per-capita income of \$49,028, which is about 45% higher than the city average of \$33,605. The AZ is almost 92% white. Only 0.56% of residents have limited English. There are 0.47 vehicles per person in the AZ (not quite one vehicle for every two residents, and slightly lower than the city average). A relatively large percentage of households (almost 40%), compared to the city average, include one or more individuals with a disability.

The high number of residents with disabilities is a source of social vulnerability for this AZ; additional attention may be needed to prepare and assist these residents in the face of a climate hazard. All of the other measures indicate a low level of social vulnerability for this AZ. Overall, social vulnerability is considered moderate for this AZ.

Social Vulnerability in the South Shore AZ is classified as **Moderate**.

Residential Vulnerabilities

The South Shore area consists primarily of single-family homes. There are no major population centers that would present elevated vulnerabilities. Residential vulnerabilities are relatively low, with a relatively low density of residents and properties.

Residential Vulnerability for the South Shore AZ is classified as **Low**.

Commercial Vulnerabilities

The South Shore's residential areas are interspersed with boating facilities and other water-dependent uses, including:

- ❖ Pine Island Marina (916 Shennecossett Road)
- ❖ Shennecossett Yacht Club (1010 Shennecossett Road)

This AZ has few businesses overall; nevertheless, those that exist are important for attracting visitors to the City. The small number of important businesses leads to a commercial vulnerability classification of moderate.

Commercial Vulnerability for the South Shore AZ is classified as **Moderate**.



Critical Facilities and Infrastructure Vulnerabilities

The AZ includes a number of important infrastructure assets. There are no emergency response facilities in the AZ.

There are three sewer pump stations in the area:

- ❖ Eastern Point Sewer Pump Station (1 Beach Pond Road)
- ❖ Bayberry Lane Sewer Pump Station (84 Bayberry Lane)
- ❖ Plant Street Sewer Pump Station (10 Shennecossett Rd)

There are two roadways that are essential to access and egress in this AZ:

- ❖ Eastern Point Road
- ❖ Shennecossett Road

Because there are limited alternative egress options if these roads were to be damaged or blocked, the vulnerability of these assets is considered high.

The rail line cutting through the northern portion of the AZ is essential to the operations of Pfizer, Buckeye Terminals, and Electric Boat.

Additionally, important underground utilities run throughout the area, including along coastal roads like Shore Avenue. Power lines are above ground.

Southeast Area Transit District public bus stops (route 11) are located along Shennecossett Road on the eastern side of the AZ, down to Avery Point campus.

The presence of three critical pump stations in this AZ, the essential roadways, and railways (coupled with the lack of emergency response facilities within the AZ, which increases the importance of the roadways), as well as other important infrastructure assets, leads to classification of the area as having a high level of critical facility and infrastructure vulnerability.

Critical Facility and Infrastructure Vulnerability for the South Shore AZ is classified as **High**.

Community Resource Vulnerabilities

Important community resources located in this area include:

- ❖ Elks Lodge 2163 (700 Shennecossett Rd): includes parking, indoor programming space, outdoor open space, and a marina.
- ❖ Bayberry Lane Boat Launch (98 Bayberry Lane): public water access.
- ❖ UConn Avery Point (1084 Shennecossett Rd): commuter campus that includes marine science and climate change research, and houses Project Oceanology.

The AZ encompasses numerous public parks and recreational spaces, including:

- ❖ Eastern Point Beach
- ❖ Shore Avenue public space
- ❖ Shennecossett Golf Course
- ❖ Shennecossett Beach



- ❖ Avery Point Beach
- ❖ Jupiter Point Beach (residents only)
- ❖ Julia Chase Drive Public Coastal Access

Eastern Point also contains the Eastern Point Historic District, an important cultural resource.

These assets serve an important role in defining community character and creating community identity, as well as attracting visitors and generating economic gains. Damage to these assets due to climate hazards would potentially have a significant impact on the community, leading to a high sensitivity classification for the AZ.

UConn Avery Point and the Elks Lodge also represent sources of adaptive capacity for the local community. These facilities are able to leverage their buildings and connections to provide support and assistance to the community in the face of climate hazards. Additionally, UConn Avery Point provides meaningful research and tools to help the City prepare for and respond to climate change impacts, and is a major climate resilience asset to the community, region, and state.

Given the high levels of both sensitivity and adaptive capacity within the community resources located in this AZ, community resource vulnerability is classified as moderate.

Community Resource Vulnerability in the South Shore AZ classified as **moderate**.

Natural System Vulnerabilities

This AZ includes many coastal ecosystem areas, including Eastern Point Beach, Shennecossett Beach, Avery Point Beach, and Jupiter Point Beach. There are also a number of tidal wetland features, including south of Beach Pond Road, just north of Avery Point campus, and on Jupiter Point. Forested areas are present between Shennecossett Road and Tyler Ave (to the east), along the coast near the Shennecossett Yacht Club and the Elks Lodge, in pockets on the edges of the Shennecossett Golf Course, and on private properties.

Many of these natural resources are vulnerable to climate change and sea level rise. The relatively large extent of natural areas, however, indicates that there is resilience within these systems; some of the tidal wetland features may have space to migrate inland with sea level rise, and the relatively healthy forests here have more capacity to adapt than the urban forests in other parts of the city. This adaptive capacity reduced the overall vulnerability of natural systems.

Natural System Vulnerability in the South Shore AZ classified as **moderate**.



South Shore Vulnerability Summary

Given the vulnerabilities described above, in comparison to vulnerabilities of the other areas of the City of Groton, the overall climate vulnerabilities for the South Shore area are summarized in the graphic below.

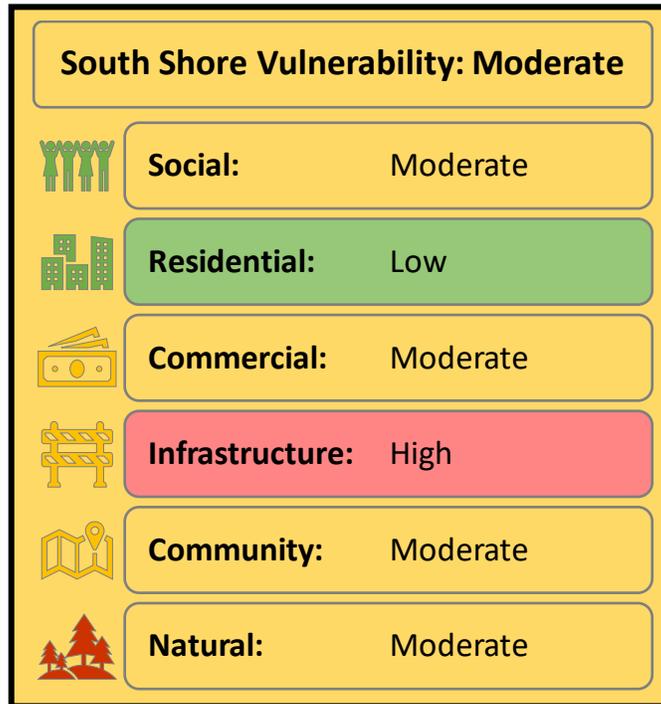


Figure 36: South Shore Vulnerability Summary



SOUTH SHORE EXPOSURE

The exposure of the South Shore AZ to coastal flooding, erosion, stormwater flooding, and high heat hazards is described in this section.

Flood Exposure

The South Shore area is the lowest elevation in the city, and therefore has the most extensive mapped flood exposure (see Figure 37 through Figure 39).

. Many residential properties fall within FEMA AE-zones; a significantly larger area falls within FEMA 0.2% annual-chance flood zones. Areas within flood hazard zones include roadways and infrastructure, residential buildings, parks and recreational areas, forests and wetlands, marinas and boating facilities, and portions of the UConn Avery Point campus.

Due to the large extent of mapped flood zones, flood exposure is high compared to other areas of the City.

Flood Exposure for the South Shore AZ is classified as **High**.

Erosion Exposure

A map of erosion exposure in the South Shore AZ is presented in Figure 40.

The Connecticut Erosion Susceptibility Map (CT DEEP, 2005) shows that the lawn at Eastern Point Beach, south of the parking lot, is identified as having “Soils Susceptible to Erosion.” This indicates that shallow soils lying on bedrock are present and may be removed relatively easily. It does not appear that more extensive erosion of deeper materials is likely here. No other portions of this AZ are identified as having erodible soils or surficial materials.

The Connecticut Shoreline Change Analysis (O’Brien, et. al. 2014) shows that almost no erosion or accretion has occurred along most of the shoreline in this area, though this analysis was only conducted on the western and southern ends of the peninsula (analysis continues along Pine Island and Bushy Point). The analysis does show that net erosion occurred at the Avery Point peninsula from 1983 to 2006; net erosion rates range from zero feet-per-year to greater than 0.25 feet-per-year, with rates tending to increase moving eastward along the shoreline.

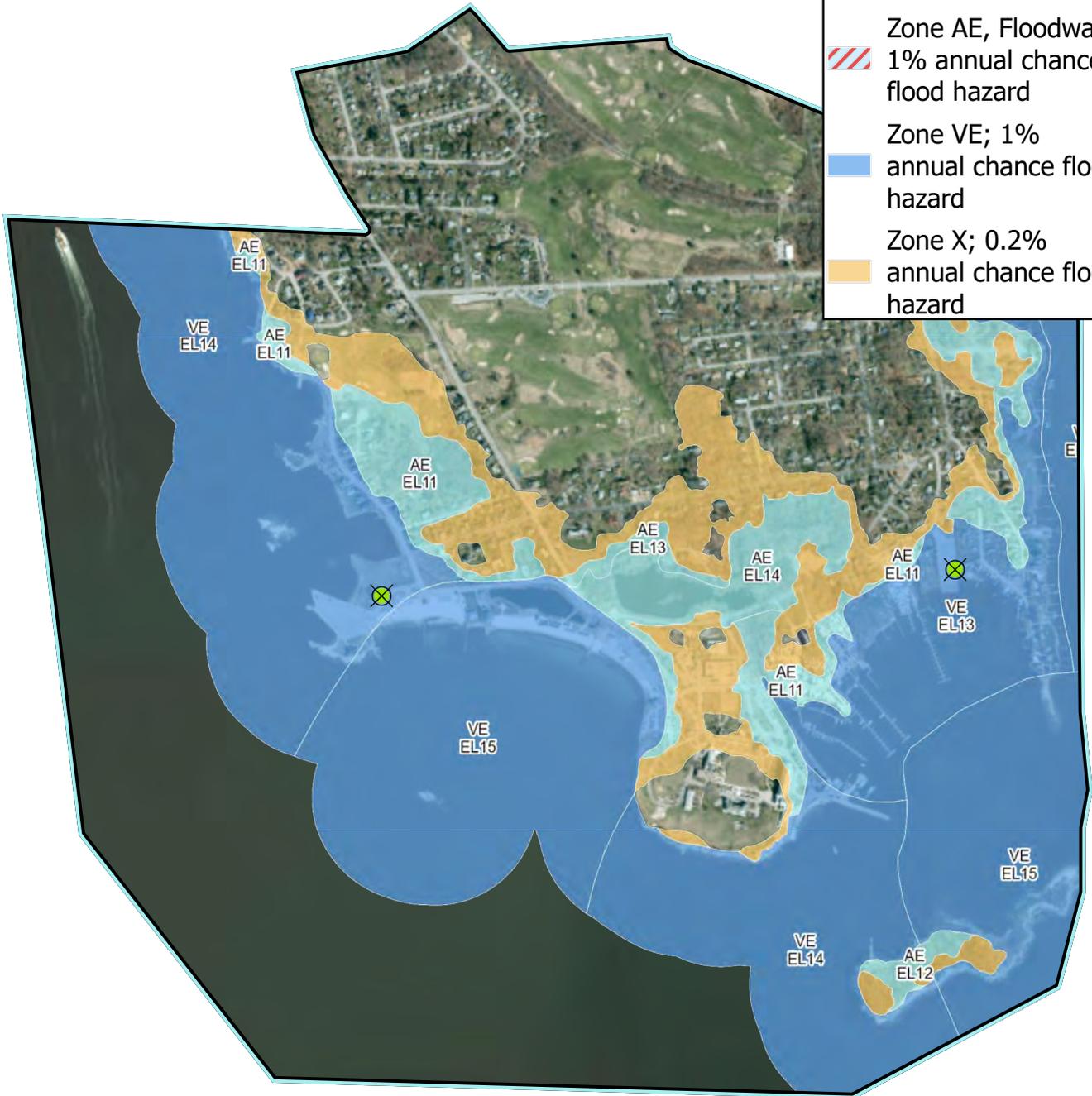
The two sources reviewed above show minimal exposure to erosion in this AZ.

Erosion Exposure in the South Shore AZ is classified as **Low**.



Floodzones

-  Zones A and AE;
1% annual chance flood hazard
-  Zone AE, Floodway;
1% annual chance flood hazard
-  Zone VE; 1%
annual chance flood hazard
-  Zone X; 0.2%
annual chance flood hazard

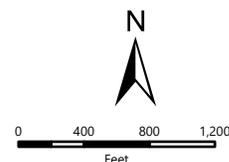


FEMA, State of Connecticut, Maxar



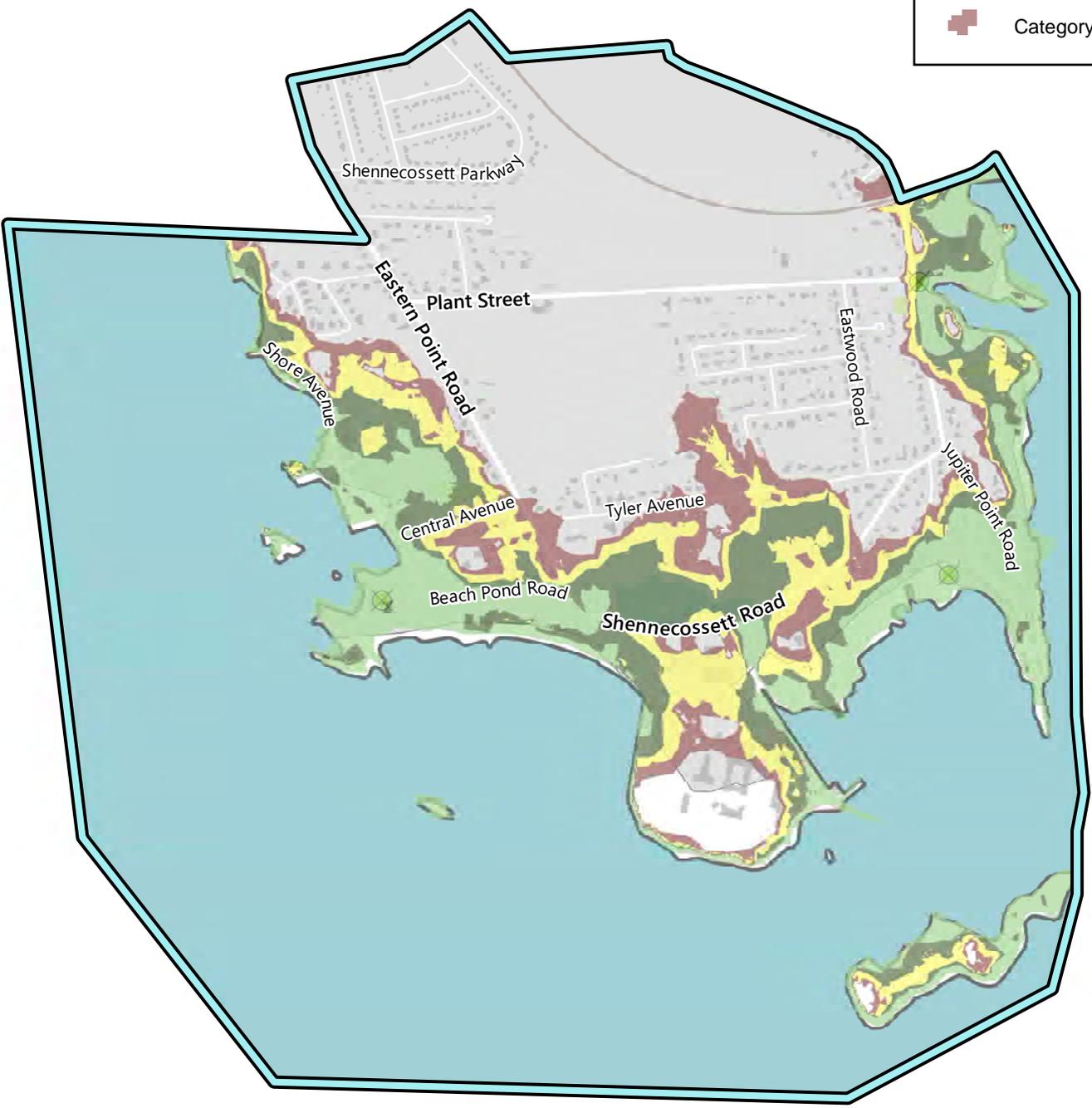
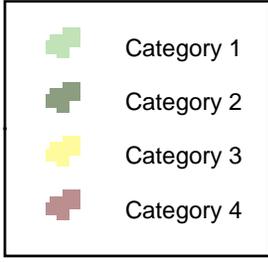
99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

SOUTH SHORE
FEMA FLOOD HAZARD ZONES
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



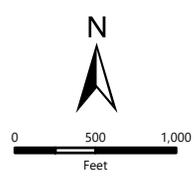
SCALE	1" = 1,167'
DATE	3/31/2022
PROJ. NO.	141.12536.00015

FIG. 37



SLR
 99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

**SOUTH SHORE
 HURRICANE SURGE INUNDATION**
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 1,186'
 DATE 3/24/2022
 PROJ. NO. 141.12536.00015

FIG. 38

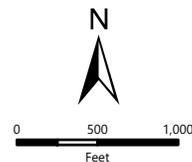
Mean Higher High Water Plus 20 inches SLR

- Low-lying Areas
- Inundated Areas



99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

**SOUTH SHORE MEAN HIGHER HIGH WATER
 WITH 20 INCHES SEA LEVEL RISE**
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 1,186'
 DATE 3/24/2022
 141.12536.00015
 PROJ. NO.

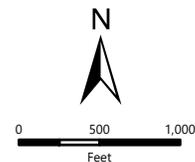
FIG. 39

CT Shoreline Change Transects	Erosion Susceptibility
> 0.5 m/yr Erosion	Most Susceptible to Erosion
> 0.0 m/yr Erosion	Highly Susceptible to Erosion
< 0.5 m/yr Accretion	Surficial Materials Susceptible to Erosion
< 1.0 m/yr Accretion	Soils Susceptible to Erosion
< 5.0 m/yr Accretion	



99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

**SOUTH SHORE
 EROSION SUSCEPTIBILITY**
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 1,186'
 DATE 3/24/2022
 141.12536.00015
 PROJ. NO.

FIG. 40

Stormwater Flooding Exposure

For most of South Shore, impervious surface density is low. Impervious surfaces of significant size do exist at larger parking lots:

- ❖ Eastern Point Beach
- ❖ Avery Point campus
- ❖ Marinas and boat-launches on Pine Island Bay

While the parking areas identified above would be expected to generate stormwater runoff, their locations near the shoreline mean that stormwater would not flood downstream developed areas; instead, it would flow directly into the waterbodies of the Thames River, Eastern Point Bay, Pine Island Bay, and Baker Cove.

Overall, there are few areas in this AZ where stormwater is generated in large quantities, and no stormwater flood issues have been reported (although stormwater pollution has been identified as a concern in Baker Cove). Overall exposure is classified as low.

Stormwater Flooding exposure in the South Shore AZ is classified as **low**.

Heat Exposure

As noted above, impervious surface density is low in this AZ, with the exception of the parking areas previously identified.

Tree coverage is variable, with relatively high coverage on many of the private residential properties, and forested pockets in some portions of the Shennecossett Golf Course, south of Tyler Avenue, and near Baker Cove. Few trees are present on and adjacent to the golf course, at Eastern Point Beach, on the UConn Avery Point campus, and at the marinas and boat launches.

UHI mapping shows no or minimal urban heat island effects in the South Shore AZ. See Figure 41. In this figure, the darker red colors indicate relatively severe UHI effect, the lighter orange colors indicate relatively mild UHI, and no coloring indicates temperatures are at or below the average for the city.

Overall, heat exposure in the South Shore AZ is low. Some moderate exposure areas are located at the Eastern Point Beach and along the roads adjacent to the Shennecossett Golf Course.

Heat exposure in the South Shore AZ is classified as **low**.



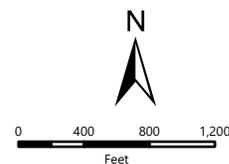


State of Connecticut, Maxar



99 REALTY DRIVE
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 203.271.1773

SOUTH SHORE
URBAN HEAT ISLAND EFFECT
CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 1,167'
 DATE 3/30/2022
 141.12536.00015
 PROJ. NO.

FIG. 41

South Shore Exposure Summary

The Exposure Analysis of the South Shore AZ, when compared to the exposure levels of other areas of the City of Groton, shows the overall climate hazard exposure for this AZ as follows in Figure 34.

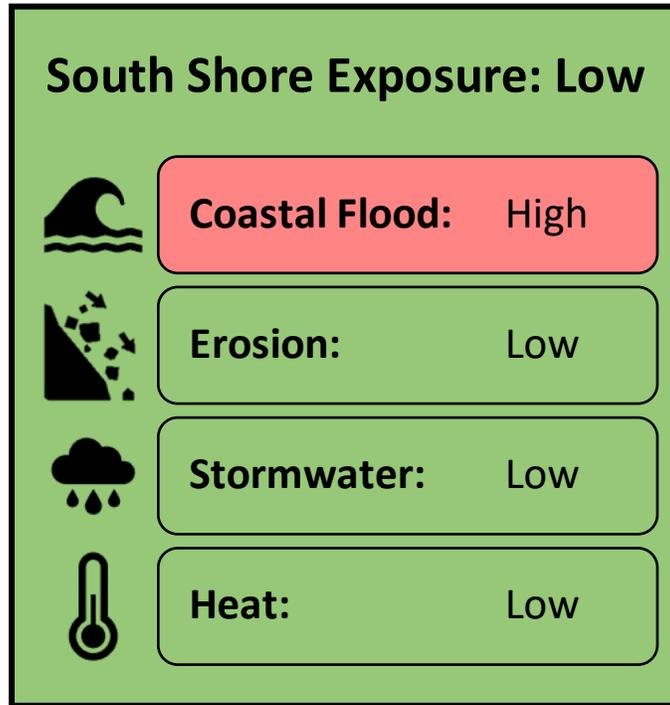


Figure 42: South Shore Exposure Summary



SOUTH SHORE RISKS

By combining the vulnerabilities identified in the South Shore AZ with the climate hazard exposure levels for the area, the level of risk faced by this part of the City can be determined. Risk levels are provided below for each identified climate hazard based on how the hazard may affect identified vulnerabilities.

Flood Risk

Flood hazard mapping (see Figure 37 through Figure 39) shows the following areas susceptible to flooding:

- ❖ **Eastern Point:** around thirteen properties off Shore Avenue and Circle Avenue are located entirely or partially within a FEMA VE-zone (14-foot BFE). Shore Avenue itself is within the VE zone for much of its length. An AE-zone (11-foot BFE) extends inland along Central Boulevard and Beach Pond Road to encompass another dozen properties. A 0.2% annual-chance zone covers land even farther inland, including areas of Tyler Avenue and part of Eastern Point Road. These properties are mostly large, single-family homes. Some privately-owned shoreline structures mitigate some flood risk (mainly from more minor flood events or from wave action).

The CIRCA Sea Level Rise viewer highlights a low point along Shore Avenue where 20 inches of sea level rise may lead to daily high-tide waters crossing City-owned open space and flooding the road near South Prospect Street. At current sea levels, a ten-year flood event would impact three or four homes on the east side of Shore Avenue, with floodwaters accessing the area from that same City-owned open space. With 20 inches of sea level rise, a ten-year flood event is expected to impact a much larger area, with multiple access points; such an event will impact one property on Circle Ave, more than ten properties on both sides of Shore Ave in the area of South Prospect Street, and another five or so properties in the rest of the Eastern Point neighborhood. The area projected to be impacted by a ten-year event with 20 inches of sea level rise is slightly larger than the area expected to be impacted by a 30-year flood event at current sea levels.

The area of Eastern Point projected to be impacted by a ten-year event with 20 inches of sea level rise is slightly larger than the area expected to be impacted by a 30-year flood event at current sea levels.

Eastern Point Beach and Shennecossett Beach are both located entirely within VE flood zones (14-foot and 15-foot BFE). The Eastern Point Pump Station is within the 15-foot BFE flood zone; it is not expected to be impacted by a ten-year flood at current sea levels, but is projected to be impacted by such an event with 20 inches of sea level rise.

- ❖ **Avery Point:** most of the buildings on campus are located outside of the 1% annual-chance AE and VE flood zones; these hazard zones are primarily used for parking or open space. CIRCA sea level rise mapping shows that some coastal parking areas are susceptible to



flooding from a 30-year event at current sea levels, or a ten-year event with 20 inches of sea level rise.

Shennecossett Road at the west entrance to campus, as well as part of the campus road, falls within a VE zone (15-foot BFE). While these roadways are mapped by CIRCA as dry during a 30-year storm at current sea levels, significant flooding is expected along Eastern Point Road during a ten-year event with 20 inches of sea level rise.

Project Oceanology Street on the east side of campus is almost entirely within an AE zone (11-foot BFE). The southeast corner of campus, at the boat docks and associated buildings, is shown by CIRCA sea level mapping to be susceptible to a thirty-year flood at current sea levels, or a ten-year flood with 20 inches of sea level rise.

Around 13 buildings (most buildings on campus), including the Cogeneration Plant, fall within a 0.2% annual-chance flood zone.

- ❖ **Tyler Avenue:** the area between Tyler Avenue and Shennecossett Avenue falls within AE zones (14-foot and 13-foot BFE); these AE zones cover much of Shennecossett Avenue and extend north to just behind many structures on Tyler Avenue. A 0.2% annual-chance zone extends further north to cover much of Tyler Avenue itself, as well as around 20 properties on Tyler Avenue and Pennsylvania Avenue.
- ❖ **Pine Island Bay:** AE (11-foot BFE) and VE (13-foot BFE) zones cover large portions of the marinas and other boating facilities in this area. Some residential structures (five total) fall within the VE zone. A 0.2% annual-chance flood zone is present as well. The Bayberry Lane Pump Station is within the VE Zone. Many of the yards and boat launch areas nearest the shore are shown by the CIRCA sea level rise viewer to be susceptible to flooding from a ten-year storm event at current sea levels; few permanent structures are at risk, though two homes on Bayberry Lane are shown to be within the flooded area. With 20 inches of sea level rise, significant portions of properties are mapped within the flooded area, with three homes on Bayberry Lane, and several outbuildings on other properties, affected. The Bayberry Lane Pump Station is also shown as being impacted by such an event.
- ❖ **Jupiter Point & Baker Cove:** Most of Jupiter Point (about 40 properties) is within a VE zone (13-foot BFE), with the southern, undeveloped tip extending south into at 15-foot BFE zone. Properties not within the VE zone (about 16 properties) mostly fall within an AE-zone (11-foot BFE). A 0.2% annual chance flood zone extends even farther inland. Jupiter Point Road and Pine Island Road are also within these flood zones.

A small tidal channel crosses through a culvert under Pine Island Road near the bend in the road, and small tidal wetland is present on the eastern side of the road. CIRCA mapping shows flooding of the road at this site during mean higher high water with 20 inches of sea level rise. A commercial property on the eastern side of the peninsula, on Jupiter Point Road,



is also shows to be flooded under those conditions. A ten-year flood event at current sea levels floods most of the southern portion of Jupiter Point, with floodwaters extending northward with 20 inches of rise.

A number of private shoreline protection measures are in place. Private piers and docks also extend into the water. Home elevation appears to be inconsistent, with some homes elevated, some homes elevated to VE-zone standards, and some not elevated at all.

Northward along Shennecossett road, many properties along the shoreline are within a VE-zone (13-foot BFE) or AE zone (11-foot BFE). CIRCA mapping shows only one or two properties at risk of flooding even during a ten-year flood with 20 inches of sea level rise. The AE zone extends inland to cover a sliver of Shennecossett Road near Bakers Cove Lane. CIRCA mapping does not show this location as being susceptible to flooding.

The Elks Lodge and the Plant Street Pump Station are within the AE zone. Though portions of the Elks Lodge parking area and an out-building are shown to be susceptible to flooding during a ten-year flood event with 20 inches of sea level rise, the main buildings, as well as the Plant Street Pump Station, are not shown to be impacted by flooding.

Much of Shennecossett Road falls within a 0.2% annual-chance flood zone. A particular location of concern is the Shennecossett Road railway underpass, which is within the 0.2% annual-chance flood zone. A small stream channel crosses under the road just south of the underpass, presenting a potential access point for floodwaters. Flooding of this underpass would isolate areas to the south.

Given the specific risk areas identified above, as well as the results of the South Shore AZ vulnerability assessment and the flood hazard exposure analysis, Table 17 summarizes flood risk in the South Shore AZ.

Table 17: South Shore Flood Risks

Vulnerability Category	Flood Risk
Social	Moderate
Residential	High
Commercial	Moderate
Infrastructure	High
Community	High
Natural	High
Overall Risk	High

Overall vulnerability levels in this AZ are classified as moderate, while coastal flood exposure is classified as high. Combining vulnerability and exposure gives a high risk-rating.



Erosion Risk

Erosion exposure in this AZ is classified as low. Connecticut Shoreline Change Analysis shows that some erosion has occurred along the Avery Point peninsula. Avery Point is currently protected from erosion by large riprap revetments, mitigating much of this erosion exposure; additionally, the locations where net erosion is identified are adjacent to parking lots and open space (rather than essential infrastructure or buildings), so vulnerabilities in those areas are low.

Erosion may become more of an issue at sensitive coastal ecosystems as sea levels continue to rise.

Table 18 summarizes erosion risk in the South Shore AZ.

Table 18: South Shore Erosion Risks

Vulnerability Category	Erosion Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Moderate
Community	Low
Natural	Moderate
Overall Risk	Low

Combining the overall AZ vulnerability classification of **moderate** with the **low** erosion exposure gives a low-moderate erosion risk rating. Because of the low vulnerability levels in the erosion exposure areas, as noted above, we have classified erosion risk in this AZ as **low**, rather than low-moderate.

Stormwater Risk

Stormwater flooding exposure is classified as low in this area, and no locations of concern have been identified. Damage to sensitive coastal and marine ecosystems from stormwater-carried pollutants is a concern for the Thames River, Eastern Point Bay, Pine Island Bay, and Baker Cove.

Table 19 summarizes erosion risk in the South Shore AZ.

Table 19: South Shore Stormwater Risks

Vulnerability Category	Stormwater Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Low
Community	Low
Natural	Moderate
Overall Risk	Low

Combining the moderate vulnerability and low exposure gives a low overall risk rating.



Heat Risk

Heat exposure is classified as low. Potential heat exposure areas, based on impervious surfaces, are located at the Shennecossett Golf Course, Eastern Point Beach, UConn Avery Point, and the boating facilities; these locations are mostly located away from population centers and are generally considered to create a low level of risk.

Eastern Point Beach is, however, a potential area of concern. Here, a large parking area, along with a beach and lawn area with few trees or other shade sources, leads to elevated heat exposure. Because the beach is most frequently used in the summer months, when extreme high temperature events are most likely to occur, this exposure is considered to be even further elevated. Eastern Point Beach is, therefore, a community resource with elevated heat risk.

Prolonged heat events may negatively impact the natural resources that exist in the AZ.

Table 20 summarizes erosion risk in the South Shore AZ.

Table 20: South Shore Heat Risks

Vulnerability Category	Heat Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Low
Community	Moderate
Natural	Moderate
Overall Risk	Low

Overall, combining heat vulnerability and exposure in this AZ gives a low risk-rating.



South Shore Risk Summary

Table 21 below summarizes the risk assessment results for the South Shore Assessment Zone. In addition to the analysis presented above, an Overall Risk classification is assigned to each vulnerability category based on the risk classification determined for each of the four hazards assessed.

Table 21: South Shore Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Moderate	Low	Low	Low	Low
Residential	High	Low	Low	Low	Moderate
Commercial	Moderate	Low	Low	Low	Low
Infrastructure	High	Moderate	Low	Low	Moderate
Community	High	Low	Low	Moderate	Moderate
Natural	High	Moderate	Moderate	Moderate	Moderate
Overall Risk	High	Low	Low	Low	Moderate

Climate Risks in the South Shore AZ are relatively low overall. Coastal flood risks are relatively high due to the large area exposed to coastal flooding; however, the low-density and high socioeconomic status of the area means vulnerabilities are relatively low. The area does host important natural resources that may be at risk from rising seas and coastal flood events.

The primary risks facing this AZ are flood risks to residential properties, important infrastructure and transportation networks, community resources, and natural systems.



BRANDEGEE AVENUE RISK ASSESSMENT

Vulnerabilities, hazard exposure, and overall climate change risks to the Brandegee Avenue Assessment Zone (AZ) are described in this section.

BRANDEGEE AVENUE VULNERABILITIES

The following assets and features were identified as potential vulnerabilities within the Brandegee Avenue AZ.

Social Vulnerabilities

According to the 2019 ACS 5-year estimates, this area has a per-capita income of \$20,548, about 60% of the city average of \$33,605. The AZ is about 49% non-white (a relatively large non-white population relative to the city average), and 4.6% of residents have limited English (a significantly higher percentage than any other area of the City). Nearly 21% of households include one or more individuals with a disability, which is slightly below-average for the City. Vehicle availability is comparatively high at slightly more than one vehicle for every two residents).

Overall, these factors show that social vulnerabilities are relatively high for this AZ when compared to the other areas of the City. With comparatively low income-levels, and comparatively high percentages of non-white residents and residents with limited English, residents in this AZ may potentially face challenges accessing important resources and information.

Social Vulnerability in the Brandegee Avenue AZ is classified as **High**.

Residential Vulnerabilities

The area consists primarily of large apartment complexes, including:

- ❖ Groton Estates (260 Shennecossett Road)
- ❖ Branford Manor Apartments (37 Mather Ave) – Subsidized Housing
- ❖ Groton Townhouse Apartments (126 Litton Ave)
- ❖ Boardsen Place Apartments (Kamaha Street)
- ❖ Soundbreeze Condominiums (584 Shennecossett Road)
- ❖ Avery Heights Apartments (300 Brandegee Ave) – Subsidized Housing
- ❖ Sutton Place Apartments (Sutton Place)

These major population centers present an elevated level of vulnerability for residents.

Residential Vulnerability in the Brandegee Avenue AZ is classified as **High**.

Commercial Vulnerabilities

There are no businesses located within this AZ; therefore, commercial vulnerabilities are low.

Commercial Vulnerability in the Brandegee Avenue AZ is classified as **Low**.



Critical Facilities and Infrastructure Vulnerabilities

This AZ contains a small number of important infrastructure assets.

A sewer pump station is located at 252 Paul Revere Road.

Thomas Road is a critical access and egress point for the South Shore. Poquonnock Road (Route 349) is another essential roadway, and Brandegee Avenue is an important north-south route.

Southeast Area Transit District public bus stops (route 11) are located along Brandegee Avenue, Shennecossett Road, and Thomas Road.

Critical Facility and Infrastructure Vulnerability in the Brandegee Avenue AZ is classified as **Moderate**.

Community Resource Vulnerabilities

Important community resources located in this AZ include:

- ❖ Thames River Magnet School (250 Brandegee Ave; previously the West Side Junior High School)

Few community resources are identified in this AZ; this means that there are few community assets at risk (low sensitivity), but also few community resources to support resilience (low adaptive capacity). Combining these two factors leads to a **moderate** community vulnerability designation.

Community Resource Vulnerability in the Brandegee Avenue AZ is classified as **Moderate**.

Natural System Vulnerabilities

The area contains important local parks and open space, including:

- ❖ Birch Plain Creek Wildlife Area (Thomas Road)
- ❖ Open Space at the eastern end of Groton Estates (10 Madison Place)

These large natural areas exist largely on Town- or City-owned land and are relatively unlikely to face development pressures in the near future. The health of these systems also indicates a high adaptive capacity in the face of climate stressors.

Birch Plain Creek itself is another important natural system in this AZ. The creek is a tidal waterbody, and home to tidal wetland features. These sensitive systems are extremely vulnerable to sea level rise, as well as pollution from stormwater runoff. Given the protected open space surrounding Birch Plain Creek, there is land available for inland marsh migration, as well as buffers to mitigate pollutant loading. The adaptive capacity of this ecosystem, therefore, is also considered to be relatively high.

Overall, both the level of sensitivity and the level of adaptive capacity of natural systems in this AZ are high. Natural system vulnerability is therefore classified as moderate.

Natural System Vulnerability in the Brandegee Avenue AZ is classified as **Moderate**.



Brandegee Avenue Vulnerability Summary

Given the vulnerabilities described above, in comparison to vulnerabilities of the other areas of the City of Groton, as identified for this risk assessment, the overall climate vulnerabilities for the Birch Plain Creek area are summarized in the graphic below.

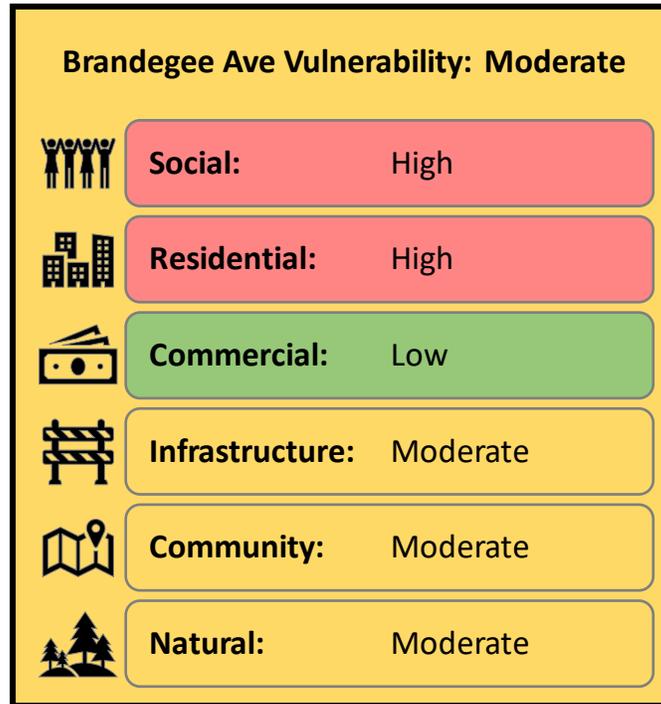


Figure 43: Brandegee Avenue Vulnerability Summary



BRANDEGEE AVENUE EXPOSURE

The exposure of the Brandegee Avenue AZ to flooding, erosion, stormwater flooding, and high heat hazards is described in this section.

Flood Exposure

The Birch Plain Creek area includes AE-zones and 0.2% annual-chance flood zones associated with Birch Plain Creek. Flood exposure here is created by a combination of tidal and riverine flooding (when high precipitation levels cause water to overtop the stream banks) and does not come with the significant waves and currents possible in VE zones. CIRCA sea level rise mapping shows that this area is unlikely to experience significant flooding during non-storm events now or in the future; a 100-year event at current sea levels or a thirty-year flood event with 20 inches of sea level rise are the lowest-severity storms expected to produce significant flooding in this AZ.

Maps of flood exposure in the Brandegee Avenue AZ are presented in Figure 44 through Figure 46.

Overall, flood exposure is considered to be moderate relative to other areas of the City.

Flood exposure in the Brandegee Avenue AZ is classified as **Moderate**.

Erosion Exposure

A map of erosion exposure in the Brandegee Avenue AZ is presented in Figure 47.

The forest north of Paul Revere Road and west of Brandegee Avenue, as well as a strip of land just south of Poquonnock Road near Birch Plain Creek, is identified as having “Soils Susceptible to Erosion.” This indicates that shallow soils are present and may be removed relatively easily.

A small patch of “Surficial Materials Susceptible to Erosion” underlies the eastern end Groton Estates, extending northward. Much of this area falls within flood hazard zones. Additionally, there is a very narrow strip of land north of Paul Revere Road classified as “Most Susceptible to Erosion.” This strip is located at the edge of the 0.2% Annual-Chance floodplain.

Because of this area’s location along Birch Plain Creek, which would not be expected to produce significant waves or flow currents even under storm conditions, it is relatively unlikely that this area will experience conditions that would cause erosion, even given the susceptibility of surficial materials. That said, the eastern end of Groton Estates is considered to have elevated erosion exposure because of the confluence of susceptible surface materials and flood hazard exposure.

Overall, erosion exposure is considered to be moderate in this AZ.

Erosion exposure in the Brandegee Avenue AZ is classified as **Moderate**.





Floodzones

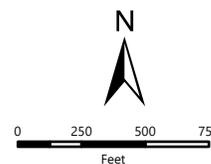
- Zones A and AE;
1% annual chance flood hazard
- Zone AE, Floodway;
1% annual chance flood hazard
- Zone VE; 1%
annual chance flood hazard
- Zone X; 0.2%
annual chance flood hazard

FEMA, State of Connecticut, Maxar



99 REALTY DRIVE
CHESHIRE, CT 06410
203.271.1773

BIRCH PLAIN CREEK
FEMA FLOOD HAZARD ZONES
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE 1" = 750'

DATE 3/31/2022

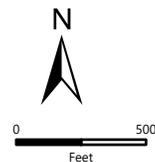
141.12536.00015
PROJ. NO.

FIG. 44



99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

BIRCH PLAIN CREEK
HURRICANE SURGE INUNDATION
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 736'
 DATE 3/24/2022
 141.12536.00015
 PROJ. NO.

FIG. 45



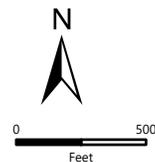
Mean Higher High Water Plus 20 inches SLR

- Low-lying Areas
- Inundated Areas



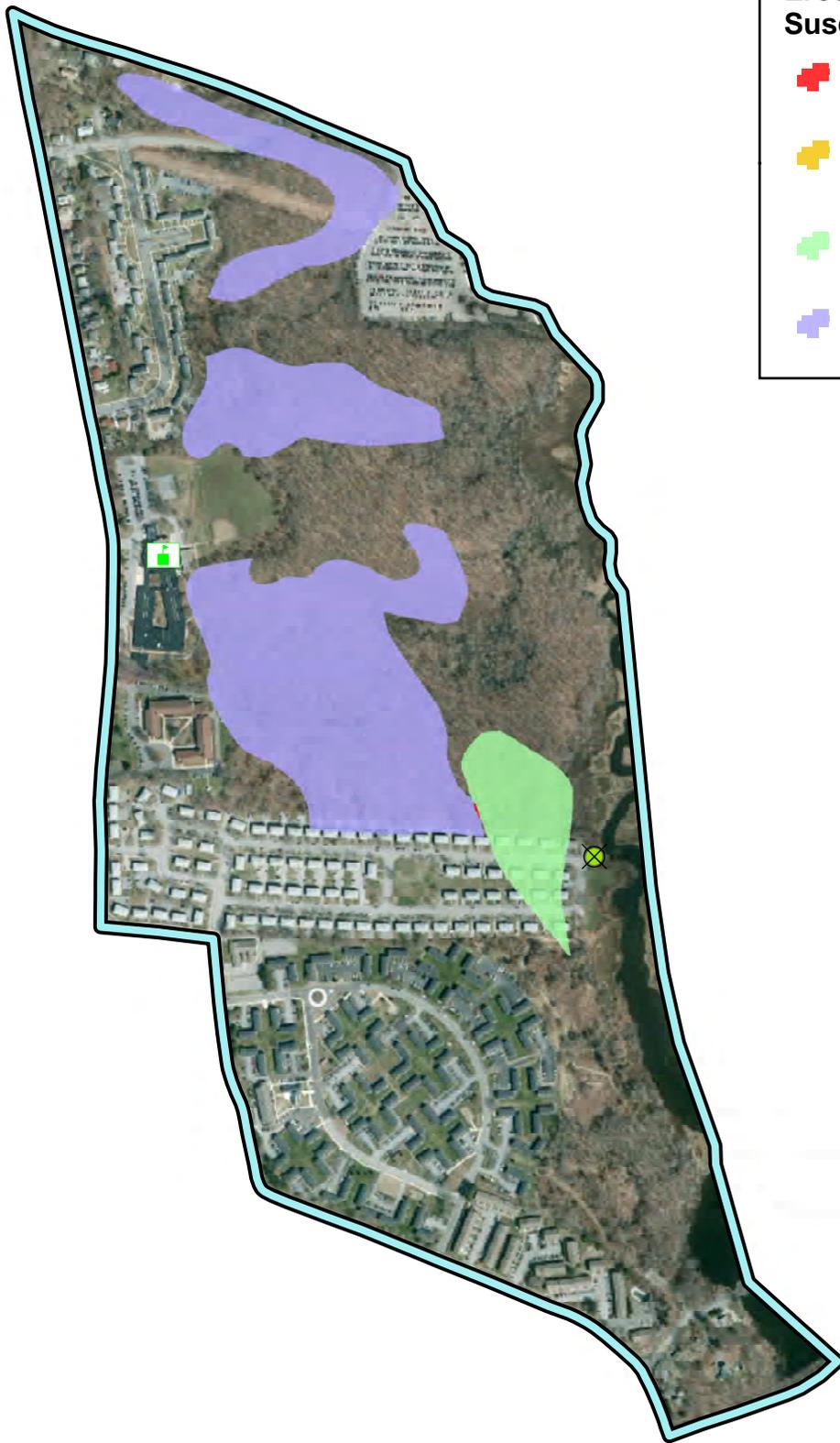
99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

**BIRCH PLAIN CREEK MEAN HIGHER HIGH WATER
 WITH 20 INCHES SEA LEVEL RISE**
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 736'
 DATE 3/24/2022
 141.12536.00015
 PROJ. NO.

FIG. 46

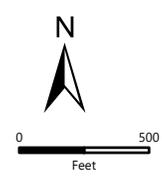


Erosion Susceptibility

- + Most Susceptible to Erosion
- + Highly Susceptible to Erosion
- + Surficial Materials Susceptible to Erosion
- + Soils Susceptible to Erosion

SLR
 99 REALTY DRIVE
 CHESHIRE, CT 06410
 203.271.1773

**BIRCH PLAIN CREEK
 EROSION SUSCEPTIBILITY**
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 736'
 DATE 3/24/2022
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 PROJ. NO.
FIG. 47

Stormwater Flooding Exposure

Impervious surface coverage is relatively low in this AZ, and no stormwater flooding issues have been reported. Electric Boat Lot M generates stormwater, but it is captured and managed on-site.

Overall, stormwater flooding exposure in this AZ is considered to be low.

Stormwater Flooding exposure in the Brandegee Avenue AZ is classified as **Low**.

Heat Exposure

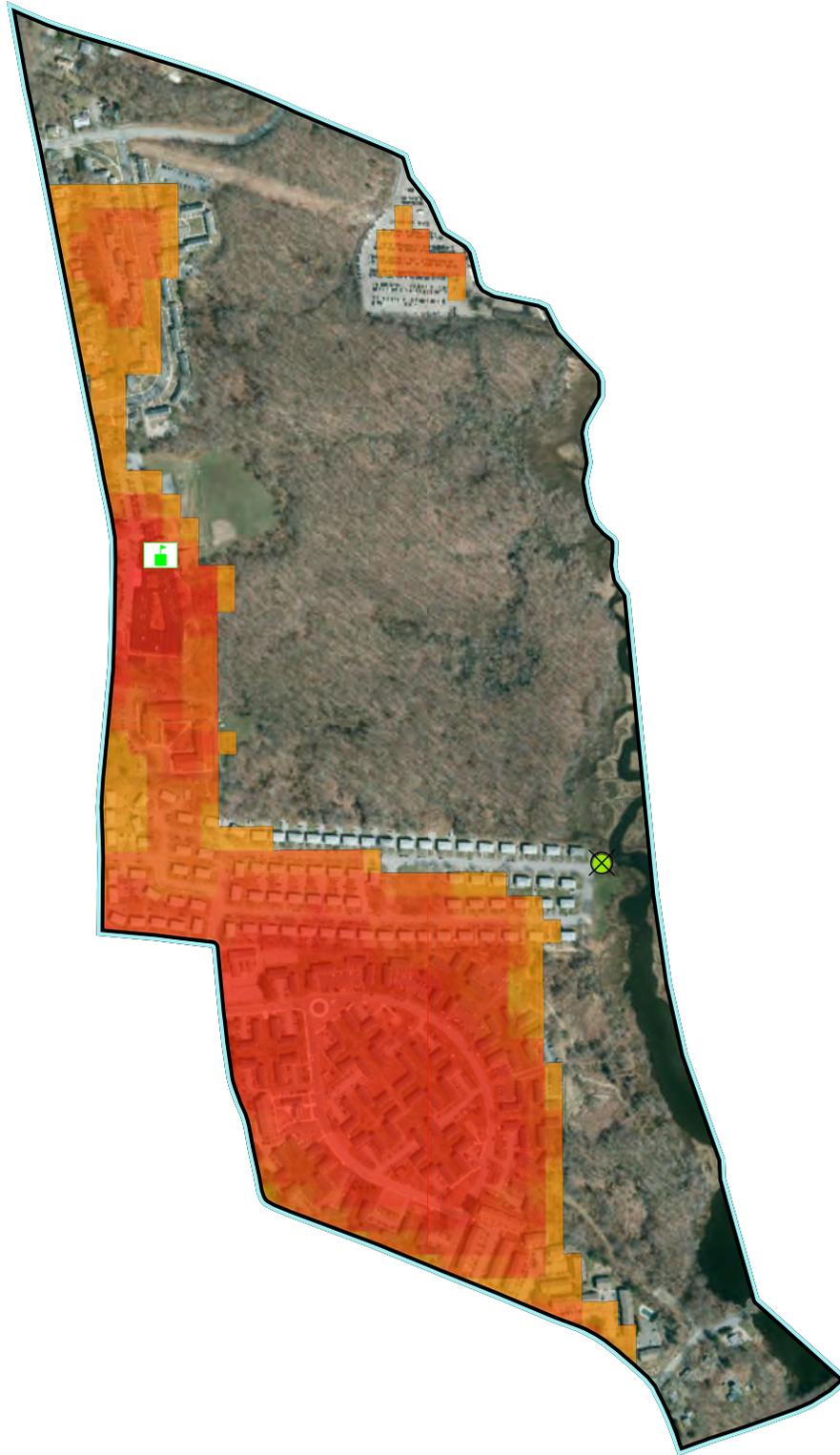
In addition to having relatively low impervious surface coverage, overall tree coverage in this AZ is relatively high. Large forest areas are present at the Birch Plain Creek Open Space, and east of the Thames River Magnet School.

Despite these large, forested areas, tree coverage is relatively low, and impervious surface density relatively high, at the apartment and condominium complexes in the area. Sound Breeze Condominiums and Branford Manor have almost no tree coverage. UHI mapping shows a strong heat island effect at Groton Estates, and an even stronger effect at Branford Manor. In this figure, the darker red colors indicate relatively severe UHI effect, the lighter orange colors indicate relatively mild UHI, and no coloring indicates temperatures are at or below the average for the city.

Overall heat exposure is classified as being high in this AZ, despite the forested areas, because of the heat island effect shown in the UHI mapping, as well as the fact that these high heat areas are located at the population centers and therefore are likely to impact residents.

Heat exposure in the Brandegee Avenue AZ is classified as **High**.



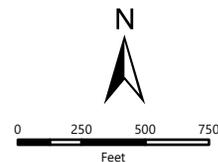


State of Connecticut, Maxar, Microsoft



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 203.271.1773

BIRCH PLAIN CREEK
URBAN HEAT ISLAND EFFECT
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 750'
 DATE 3/30/2022
 141.12536.00015
 PROJ. NO.

FIG. 48

Brandegee Avenue Exposure Summary

The Exposure Analysis of the Brandegee Avenue AZ, when compared to the exposure levels of other areas of the City of Groton, shows the overall climate hazard exposure for this AZ as follows in Figure 49.

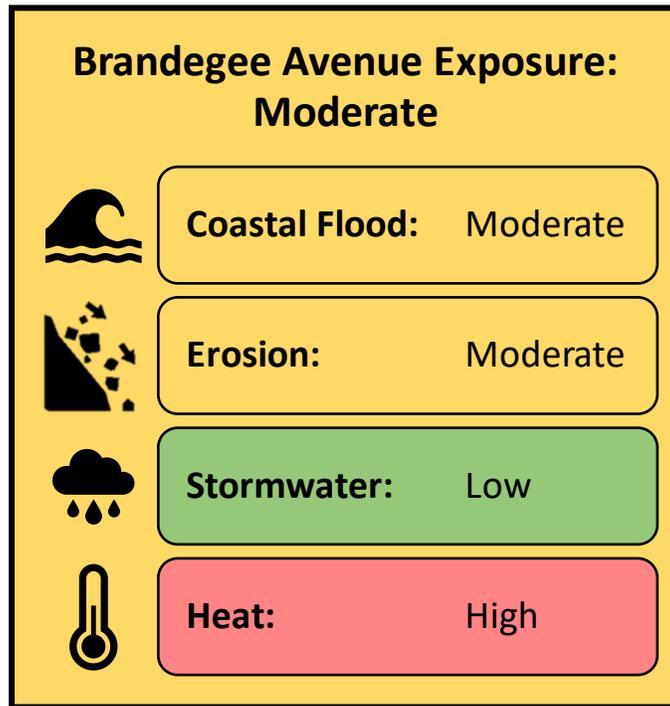


Figure 49: Brandegee Avenue Exposure Summary



BRANDEGEE AVENUE RISKS

By combining the vulnerabilities identified in the Brandegee Avenue AZ with the climate hazard exposure levels for the area, the level of climate risk faced by this part of the City can be determined. Risk levels are provided below for each identified climate hazard based on how the hazard may affect identified vulnerabilities.

Flood Risk

Most of the land in this area that falls within mapped flood zones is open space (forests and wetlands); the Electric Boat Parking M-Lot is also in the flood zone.

Flood hazard mapping (see Figure 44 through Figure 46) Figure 46: Map of Brandegee Avenue Sea Level Rise Inundation

)show the following areas susceptible to flooding:

- ❖ **Thomas Road:** This road is an essential access and egress route for the southern portion of the city and is within FEMA AE (10-foot BFE) and 0.2% annual-chance flood zones. CIRCA mapping shows that a 30-year flood at current sea levels would flood the road.
- ❖ **Groton Estates:** the eastern end of the Groton Estates apartment complex (four structures) is located within the FEMA-mapped AE zone (10-foot BFE). An additional eight structures are in the 0.2% annual-chance flood zone. CIRCA sea level rise mapping shows a thirty-year flood event with 20 inches of sea level rise impacting Madison Place roadway.
- ❖ **Paul Revere Road Pump Station:** the sewer pump station at the end of Paul Revere Road is located in the 10-foot BFE AE zone. CIRCA mapping shows a 100-year event with 20 inches of sea level rise impacting the structure.
- ❖ **Groton Utilities Sub Station:** just across Birch Plain Creek from the Electric Boat M-Lot, in the Town of Groton, is a Groton Utilities Sub Station (525 Poquonnock Road). Though outside of the city itself, this facility is a critical piece of infrastructure, and is located in an AE zone (10-foot BFE). CIRCA mapping shows a 30-year event with 20 inches of sea level rise impacting the site.
- ❖ **Electric Boat Storage Areas:** as noted above, the Electric Boat M-Lot off Poquonnock Road is located in the AE zone (10-foot BFE). Just north of the lot, across the street at 456 Poquonnock Road, is another Electric Boat lot that appears to be used for storage or equipment staging. This area is located within the Birch Plain Creek floodway, indicating elevated hazard exposure, including to stronger currents and flow velocities that can be particularly damaging. This area is outside of the City of Groton municipal boundary.
- ❖ **Poquonnock Road:** This is an important road connecting the City to points east. It is within FEMA AE (10-foot BFE) and 0.2% annual chance flood zones. CIRCA mapping shows a 30-year event with 20 inches of sea level rise impacting the road.



More broadly, rising sea levels will impact the health of the Birch Plain Creek wetland habitat.

Given the specific risk areas identified above, as well as the results of the Brandegee Avenue AZ vulnerability assessment and the flood hazard exposure analysis, Table 22 summarizes flood risk in the Brandegee Avenue AZ.

Table 22: Brandegee Avenue Flood Risks

Vulnerability Category	Flood Risk
Social	High
Residential	Moderate
Commercial	Low
Infrastructure	Moderate
Community	Moderate
Natural	Moderate
Overall Risk	Moderate

Overall vulnerability levels in this AZ are classified as moderate, while coastal flood exposure is classified as moderate. Combining the high vulnerability and moderate exposure gives a moderate risk rating.

Erosion Risk

Erosion exposure in this AZ is classified as **moderate** due to the presence of erosion-susceptible soils within or near flood zones (see Figure 47). Most of these susceptible areas are located in forested locations, away from vulnerable assets; however, there is some erosion susceptibility at the eastern end of Groton Estates, which includes a critical sewer pump station, and which has been identified as a socially vulnerable location.

Erosion of forested locations is not considered a risk to natural systems.

Table 22 summarizes flood risk in the Brandegee Avenue AZ.

Table 23: Brandegee Avenue Erosion Risks

Vulnerability Category	Erosion Risk
Social	Moderate
Residential	Moderate
Commercial	Low
Infrastructure	Moderate
Community	Low
Natural	Low
Overall Risk	Moderate

Combining the overall AZ vulnerability classification of moderate with the moderate erosion exposure give a moderate erosion risk rating.



Stormwater Risk

Stormwater flooding exposure is classified as low in this area. No specific areas of concern have been identified. Damage to sensitive ecosystems from stormwater-carried pollutants is a concern for Birch Plain Creek.

Table 24 summarizes flood risk in the Brandegee Avenue AZ.

Table 24: Brandegee Avenue Stormwater Risks

Vulnerability Category	Stormwater Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Low
Community	Low
Natural	Moderate
Overall Risk	Low

Combining the moderate vulnerability and low exposure gives a low risk-rating.

Heat Risk

Heat exposure is classified as high. This exposure overlaps with elevated residential and social vulnerabilities in the AZ, especially at Sound Breeze Condominiums and Branford Manor Groton Estates.

Heat risks are not a major concern for the healthy ecosystems in this AZ.

Table 25 summarizes heat risk in the Brandegee Avenue AZ.

Table 25: Brandegee Avenue Heat Risks

Vulnerability Category	Heat Risk
Social	High
Residential	High
Commercial	Low
Infrastructure	Moderate
Community	Moderate
Natural	Low
Overall Risk	High

Combining the high vulnerability of the AZ and the moderate heat exposure would give a moderate risk rating. Heat tends to be a more significant concern for marginalized populations who may have underlying health risks or reduced access to air conditioning. Social vulnerabilities are classified as high in this AZ; for this reason, we have chosen to classify heat risks as high, rather than moderate.



Brandegee Avenue Risk Summary

Table 26 below summarizes the risk assessment results for the Brandegee Avenue Assessment Zone. In addition to the analysis presented above, an Overall Risk classification is assigned to each vulnerability category based on the risk classification determined for each of the four hazards assessed.

Table 26: Brandegee Avenue Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	High	Moderate	Low	High	High
Residential	Moderate	Moderate	Low	High	Moderate
Commercial	Low	Low	Low	Low	Low
Infrastructure	Moderate	Moderate	Low	Moderate	Moderate
Community	Moderate	Low	Low	Moderate	Low
Natural	Moderate	Low	Moderate	Low	Moderate
Overall Risk	Moderate	Moderate	Low	High	Moderate

The Brandegee Avenue AZ has a moderate level or risk from climate hazards. While overall risk is moderate, the AZ has a high level of Social Vulnerability, and relatively high exposure to heat hazards. The high-population centers and socially vulnerable communities in this AZ face elevated risks from climate hazards.

Birch Plain Creek itself is an essential natural resource for the community and the region. This ecosystem is both at-risk itself (particularly from sea level rise and flooding, as well as stormwater pollution), as well as a resource that mitigates risk levels in the area.



WASHINGTON PARK RISK ASSESSMENT

Vulnerabilities, hazard exposure, and overall climate change risks to the Washington Park AZ are described in this section.

WASHINGTON PARK VULNERABILITIES

The following assets and features were identified as potential vulnerabilities within the Washington Park AZ.

Social Vulnerabilities

According to the 2019 ACS 5-year estimates, this area has a per-capita income between \$32,685 (the figure for CBG #24003, which covers the southern portion of the AZ) and \$47,182 (the figure for CBG #24001, which covers the northern portion of the AZ). These income levels are similar to (in the case of CBG #24003) or significantly higher than (in the case of CBG #24001) the city average per-capita income of \$33,605. The AZ has a non-white population between 25% (in CBG #24001) and 63% (in CBG #24003), compared to the city average of 33%. Around 1% of residents have limited English, and vehicle availability is around 1 vehicle for every two people (0.42 or 0.57 vehicles per person in CBG #24003 and #24001, respectively). Over 27% of households in CBG #24003, and only 18% of households in CGB #24001, include one or more individuals with a disability.

Taken together, the demographic data from the two CBGs that are included in this AZ show, for the most part, that social vulnerability indices are comparable with, or show less vulnerability than, citywide averages. Income levels, number of residents with limited English, vehicle availability, and presence of individuals with a disability, all indicate that social vulnerabilities are low to moderate, relative to other areas. Racial minorities appear to make up a somewhat larger-than-average proportion of the population, relative to other parts of the City; this reflects an elevated social vulnerability level.

Overall, these factors show that social vulnerabilities are moderate for this AZ, with potential barriers to assistance and resources existing for non-white residents.

Social Vulnerability in the Washington Park AZ is classified as **Moderate**.

Residential Vulnerabilities

The Washington Park AZ consists of single-family homes, as well as large apartment complexes that may present elevated vulnerabilities due to the higher concentration of residents.

Large apartment complexes in this area include:

- ❖ Kinnesbrook Apartments (360 Meridian Street)
- ❖ Peppertree Apartments (278 Meridian Street)
- ❖ Groton Towers (39 Broad Street)
- ❖ Northfield Commons (North Street)
- ❖ Bridgewater Estates (Bridge Street)
- ❖ Park Place Condominiums



Additionally, the Old Farm Road residential development houses hundreds of residents off Poquonock Road near Birch Plain Creek; the development has a single mode of egress (Old Farm Road).

The presence of many high population centers (in the form of large apartment complexes), as well as the specific access concern associated with Old Farm Road, leads to a high residential vulnerability classification.

Residential Vulnerability in the Washington Park AZ is classified as **High**.

Commercial Vulnerabilities

There are a number of local businesses located along commercial corridors and nodes:

- ❖ 210 Bridge Street: a mall area that includes retail, car repair, a brewery, and more.
- ❖ North Street from Meridian Street to Bridge Street.

This AZ has a relatively high number of businesses, though the area has fewer businesses and is less economically significant than some other parts of the city, such as Five Corners. For this reason, commercial vulnerability is classified as moderate.

Commercial Vulnerability in the Washington Park AZ is classified as **Moderate**.

Critical Facilities and Infrastructure Vulnerabilities

this AZ includes critical facilities essential to ongoing municipal operations, as well as to public health and safety. It also includes important infrastructure and utility elements.

The Groton Municipal Campus is located in this AZ. This facility houses municipal administrative offices, the City of Groton Police Department, and the Department of Public Works.

Route 349 (Clarence B Sharp Highway), Bridge Street, and the I-95 on-ramp are all essential transportation routes located in this AZ. The Amtrak railroad forms the northern and northeastern boundary of the AZ.

Southeast Area Transit District public bus stops are located along Mitchell Street (route 11) and Bridge Street (routes 2, 3, 11, and 108)

Critical Facilities and Infrastructure vulnerability the Washington Park AZ is classified as **High**.



Community Resource Vulnerabilities

A small number of important community resources are located in this AZ. Community assets include:

- ❖ Colonel Ledyard Cemetery
- ❖ Washington Park

The Municipal Building is also considered a community resource, as well as a critical facility. This facility provides community services, and serves as a location for community gatherings, in addition to serving as an administration and operations center.

The community resources in this AZ are sensitive to climate hazards, while also providing adaptive capacity to the community. Overall, the balance of these two aspects of vulnerability lead to a classification of community resource vulnerability as moderate in this AZ.

Community Resource Vulnerability in the Washington Park AZ is classified as **Moderate**.

Natural System Vulnerabilities

This AZ includes significant swaths of natural areas, including forested land south of the Municipal Campus, throughout Washington Park, east of Route 349, and interspersed with the large apartment complexes north of Meridian Street. These forested areas are an important community asset, and the forest south the Municipal Campus even includes a community walking trail. Other managed open space is present at Washington Park and Colonel Ledyard Cemetery.

Much of the natural systems area in this AZ is owned and managed by the City and have high adaptive capacity levels. Some areas are on private property and may face development pressure. Overall, natural system vulnerability is classified as low.

Natural System Vulnerability in the Washington Park AZ is classified as **Low**.



Vulnerability Summary

Given the vulnerabilities described above, in comparison to vulnerabilities of the other areas of the City of Groton, as identified for this risk assessment, the overall climate vulnerabilities for the Washington Park area are summarized in Figure 50.

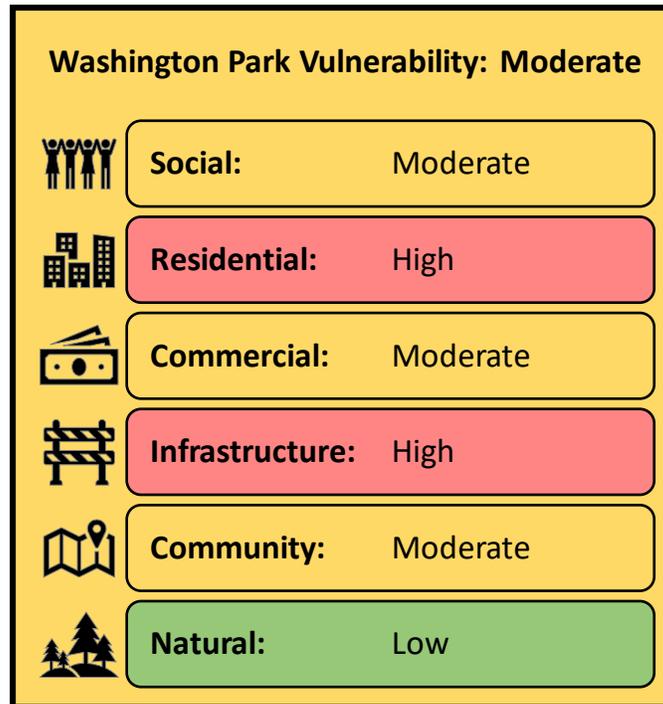


Figure 50: Washington Park Vulnerability Summary



WASHINGTON PARK EXPOSURE

Exposure of the Washington Park AZ to flooding, erosion, stormwater flooding, and high heat events is described in this section.

Flood Exposure

FEMA mapping (see Figure 51) shows limited flood exposure in this part of the City. The Birch Plain Creek flood zone is entirely riverine (not affected by tides), and only 0.2% annual-chance zones are mapped within the City of Groton. Hurricane surge flooding maps do not show hazard zones in this area.

Sea level rise will not impact exposure levels in this AZ.

Overall, flood exposure is not a significant concern in this AZ.

Flood exposure for the Washington Park AZ is classified as **Low**.

Erosion Exposure

The Connecticut Erosion Susceptibility Map (CT DEEP, 2005) identifies the area around Mira Drive, and between Mira Drive and Birch Plain Creek, as having “Soils Susceptible to Erosion” based on soils and surficial geology. This indicates that shallow soils lying on bedrock are present and may be removed relatively easily. It does not appear that more extensive erosion of deeper materials is likely. This area does not appear to fall within the Birch Plain Creek flood zone, despite its proximity; because of this, conditions conducive to eroding this soil are considered relatively unlikely.

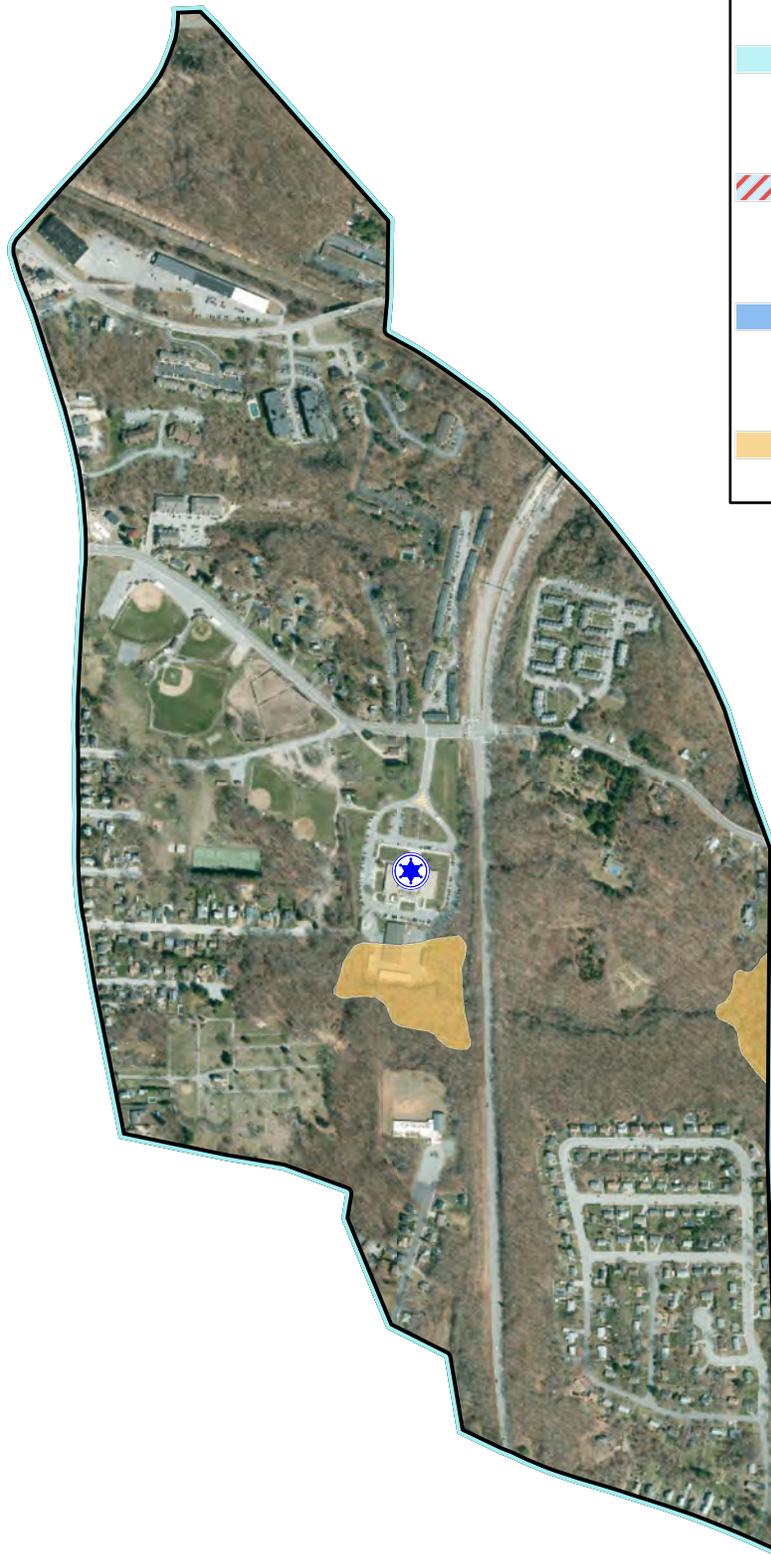
Other areas designated “Soils Susceptible to Erosion” are identified in more inland areas, where conditions that would cause erosion of these soils are even less likely to occur.

A map of erosion exposure in the Washington Park AZ is presented in Figure 52.

Overall, erosion exposure is not a significant concern in this AZ.

Erosion exposure for the Washington Park AZ is classified as **Low**.





Floodzones

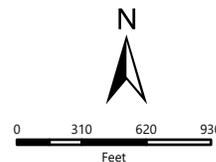
- Zones A and AE;
1% annual chance flood hazard
- Zone AE, Floodway;
1% annual chance flood hazard
- Zone VE; 1%
annual chance flood hazard
- Zone X; 0.2%
annual chance flood hazard

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NORTHEAST CORNER
FEMA FLOOD HAZARD ZONES
CITY OF GROTON COMMUNITY RESILIENCE PLAN
295 Meridian Street
Groton, CT 06340



SCALE	1" = 917'
DATE	3/31/2022
PROJ. NO.	141.12536.00015

FIG. 51

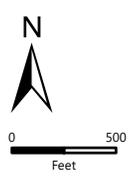


Erosion Susceptibility

-  Most Susceptible to Erosion
-  Highly Susceptible to Erosion
-  Surficial Materials Susceptible to Erosion
-  Soils Susceptible to Erosion

SLR
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 CHESHIRE, CT 06410
 203.271.1773

**NORTHEAST CORNER
 EROSION SUSCEPTIBILITY**
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 918'
 DATE 3/24/2022
 141.12536.00015
 PROJ. NO.
FIG. 52

Stormwater Flooding Exposure

Impervious surface density is relatively low in this AZ, in part because of the large park areas and forested open space. The Municipal Campus and the 210 Bridge Street mall are two areas with somewhat higher amounts of impervious surface. Stormwater runoff is likely to be generated on these impervious surfaces, but is not a significant concern throughout the AZ.

Some stormwater exposure is mitigated by nature-based stormwater detention and retention systems. The Lake George stormwater detention basin is able to capture and slow large quantities of stormwater runoff (the system is not currently operating at maximum efficiency, and the City is pursuing improvements). A number of “tree boxes” installed at the Municipal Building parking lot capture runoff; the water is then taken up by the tree or filtered through soil before entering the storm drainage system.

Overall, a limited extent of impervious surfaces, coupled with the presence of stormwater detention and retention systems, gives this AZ a low stormwater exposure classification.

Stormwater exposure for the Washington Park AZ is classified as **Low**.

Heat Exposure

As noted above, this AZ has relatively low impervious surface density. It also generally has a high amount of tree cover. Areas that have relatively low levels of tree coverage include:

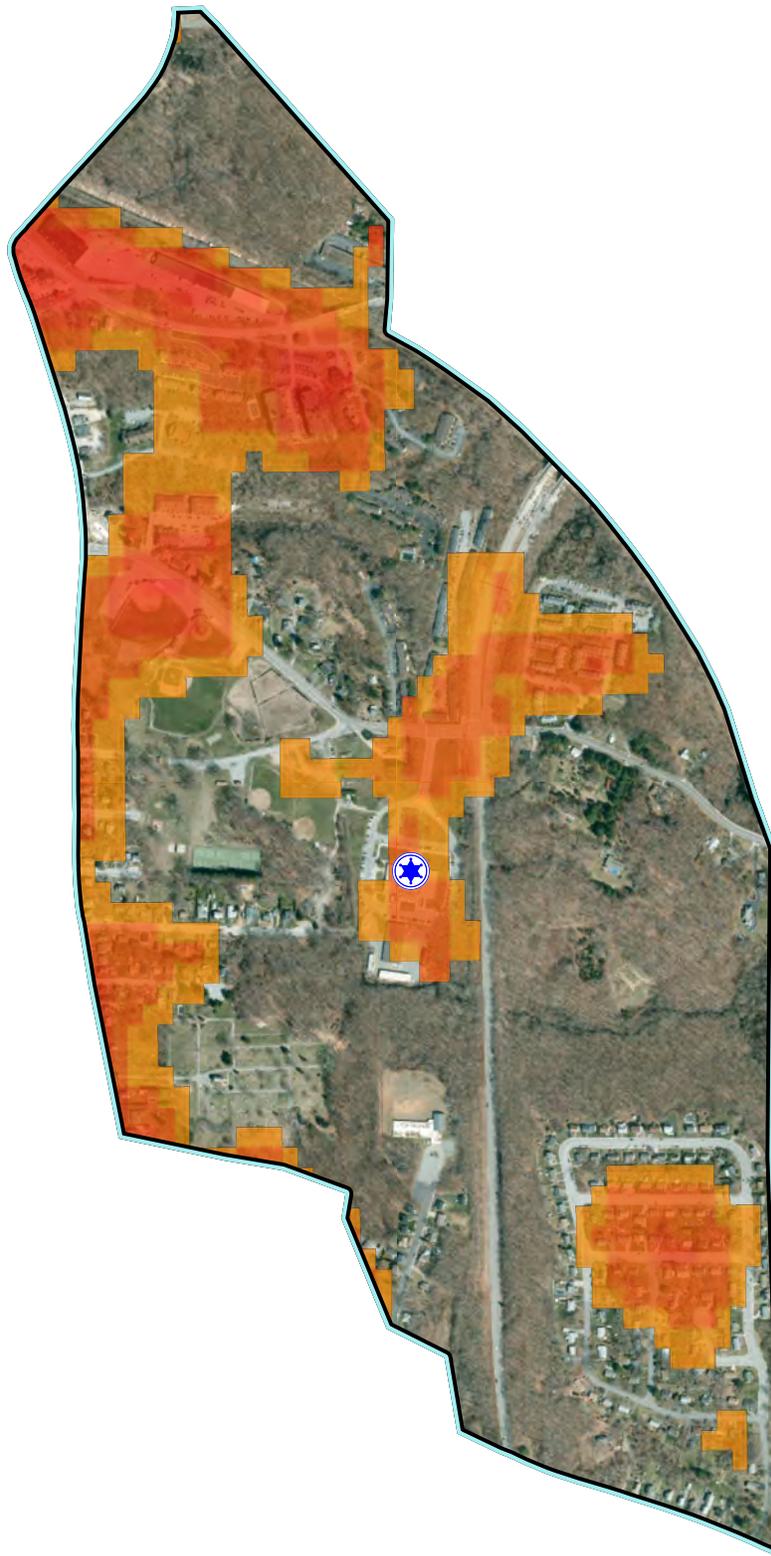
- ❖ The fields of Washington Park
- ❖ The Municipal Building Campus
- ❖ Colonel Ledyard Cemetery
- ❖ The North Street – Bridge Street intersection
- ❖ Mitchell Street
- ❖ Meridian Street

UHI mapping shows an elevated urban heat island effect east of Fort Griswold State Park, at Washington Park, and at the Municipal Building Campus. Though elevated, the urban heat island effect mapped here is not as severe as in other areas of the City. See Figure 53. In this figure, the darker red colors indicate relatively severe UHI effect, the lighter orange colors indicate relatively mild UHI, and no coloring indicates temperatures are at or below the average for the city.

Overall, heat exposure is relatively low in this AZ; however, there are pockets of concern that elevate the heat exposure classification to moderate.

Heat exposure for the Washington Park AZ is classified as **Moderate**.



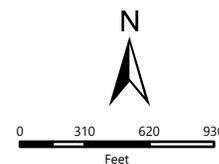


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NORTHEAST CORNER
URBAN HEAT ISLAND EFFECT
 CITY OF GROTON COMMUNITY RESILIENCE PLAN
 295 Meridian Street
 Groton, CT 06340



SCALE 1" = 917'
 DATE 3/30/2022
 141.12536.00015
 PROJ. NO.

FIG.53

Exposure Summary

The Exposure Analysis of the Washington Park AZ, when compared to the exposure levels of other areas of the City of Groton, shows the overall climate hazard exposure for this AZ as follows in Figure 54.

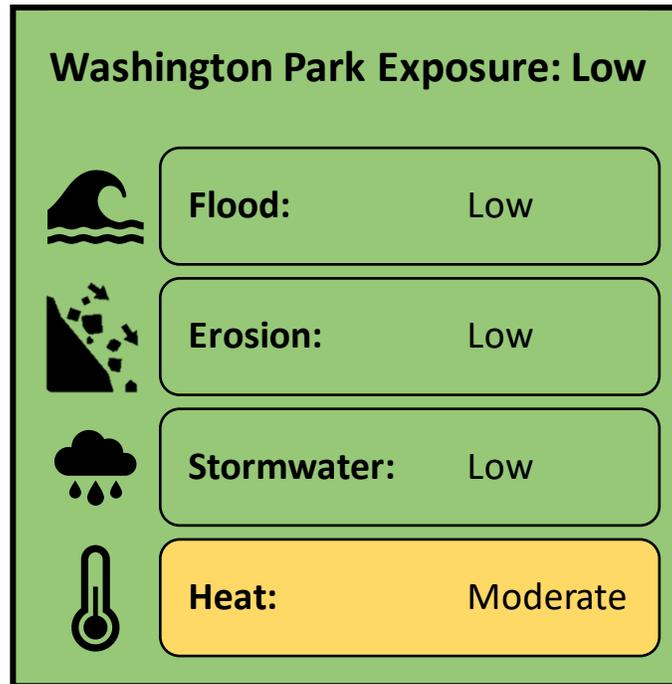


Figure 54: Washington Park Exposure Summary



WASHINGTON PARK RISKS

By combining the vulnerabilities identified in the Washington Park AZ with the climate hazard exposure levels for the area, the level of risk faced by this part of the City can be determined. Risk levels are provided below for each identified climate hazard based on how the hazard may affect identified vulnerabilities.

Flood Risk

Flood hazard mapping (see Figure 51) shows minimal exposure to flooding in this AZ. Assets in this AZ identified as being at-risk from flooding include:

- ❖ The Old Farm Road Neighborhood: this area is adjacent to the Birch Plain Creek floodplain (including an AE zone and a Floodway); however, no properties fall within the mapped zones of risk, and flooding has not been reported as a problem here. If flooding were to occur on Old Farm Road, it would isolate the entire neighborhood.
- ❖ The Municipal Campus: Flooding has been identified as a hazard of concern in this area, including at the DPW building, as well as in the basement of the Municipal Building. The DPW building, located at the south end of the municipal campus, falls within a 0.2% annual chance flood zone.

While flood exposure is very low, it does pose a risk to two critical facilities, and there is a chance flooding could isolate a large residential neighborhood. These two higher-risk factors elevate the overall AZ flood risk vulnerability classification to moderate.

Given the specific risk areas identified above, as well as the results of the Washington Park AZ vulnerability assessment and the flood hazard exposure analysis, Table 27 summarizes flood risk in the Washington Park AZ.

Table 27: Washington Park Flood Risks

Vulnerability Category	Flood Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Moderate
Community	Moderate
Natural	Low
Overall Risk	Moderate



Erosion Risk

Erosion exposure in this AZ is classified as low; no assets are identified as being exposed to erosion hazards. Combining the high vulnerability and low exposure would give a moderate risk rating; however, given the lack of identified exposure, a low risk-rating has been assigned.

Table 28 summarizes erosion risk in the Washington Park AZ.

Table 28: Washington Park Erosion Risks

Vulnerability Category	Erosion Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Low
Community	Low
Natural	Low
Overall Risk	Low

Stormwater Risk

Stormwater flooding exposure is classified as low. Stormwater flooding has been reported as a minor issue at the Municipal Campus; this is understandable, given the high level of impervious surfaces at this site. The critical facility and community resource represented by the Municipal Campus is therefore assigned a moderate stormwater risk classification.

Overall stormwater risk in the Washington Park AZ is classified as moderate.

Table 29 summarizes erosion risk in the Washington Park AZ.

Table 29: Washington Park Stormwater Risks

Vulnerability Category	Stormwater Risk
Social	Low
Residential	Low
Commercial	Low
Infrastructure	Moderate
Community	Moderate
Natural	Low
Overall Risk	Moderate



Heat Risk

Heat exposure is classified as moderate. This exposure overlaps with vulnerabilities at the Municipal Building Campus and Washington Park, and along North Street, Bridge Street, Mitchell Street, and Meridian Street. These areas include critical facilities, community resources, and commercial uses.

Heat tends to be a more significant concern for marginalized populations who may have underlying health risks or reduced access to air conditioning. Social vulnerabilities are classified as moderate in this AZ.

Prolonged heat events may negatively impact the natural systems that exist in the AZ; these systems are classified as having low vulnerability levels.

Table 30 summarizes erosion risk in the Washington Park AZ.

Table 30: Washington Park Heat Risks

Vulnerability Category	Heat Risk
Social	Moderate
Residential	Moderate
Commercial	Moderate
Infrastructure	Moderate
Community	Moderate
Natural	Moderate
Overall Risk	Moderate

Combining the moderate vulnerability of the AZ and the moderate heat exposure gives a moderate risk-rating.



Washington Park Risk Summary

Table 31 below summarizes the risk assessment results for the Washington Park Assessment Zone. In addition to the analysis presented above, an Overall Risk classification is assigned to each vulnerability category based on the risk classification determined for each of the four hazards assessed.

Table 31: Washington Park Risk Summary

Vulnerability Category	Flooding	Erosion	Stormwater	Heat	Overall Risk
Social	Low	Low	Low	Moderate	Low
Residential	Low	Low	Low	Moderate	Low
Commercial	Low	Low	Low	Moderate	Low
Infrastructure	Moderate	Low	Moderate	Moderate	Moderate
Community	Moderate	Low	Moderate	Moderate	Moderate
Natural	Low	Low	Low	Moderate	Low
Overall Risk	Moderate	Low	Moderate	Moderate	Moderate

The presence of large apartment complexes, critical facilities, and important infrastructure makes the overall risk level in this AZ “moderate,” rather than “low”, despite the relatively low exposure levels. The primary hazard of concern is high heat, followed by stormwater flooding.



RISK ASSESSMENT SUMMARY

This report identifies climate risks across different sectors and areas within the City of Groton. The results can be used to identify, develop, and prioritize climate resilience actions and opportunities. Six key risk-factors identified through this assessment are:

1. Stormwater Flooding and Impervious Surfaces

The primary hazard of concern for the City, based on the risk assessment, is stormwater-related flooding, exacerbated by the large extent of impervious surfaces. The level of exposure to stormwater flooding will rise in the future as climate change leads to an increase in annual precipitation as well as extreme precipitation events; exposure will increase further if the amount of impervious surface increases within and around the city. The primary AZs at risk from stormwater flooding are Five Corners, the Technology Campus (especially at Electric Boat), and Thames Street.

2. Severe Heat and Lack of Shade

High heat is a hazard of concern, with elevated risk areas in parts of the City with high-density of development, a large extent of impervious surfaces, relatively few trees and vegetation, and a lack of access to shade. Highest-risk areas are the Five Corners AZ, The Technology Campus AZ, and at the large housing complexes in the Brandegee Avenue AZ.

High heat tends to have disproportionately significant negative health effects on individuals with low incomes, lower-quality housing, and preexisting health issues. The City has a large population of such socially vulnerable residents and will need to pay particular attention to this risk.

3. Local Business Exposure to Climate Risks

Local businesses, small and large, are at risk from climate hazards. Flooding is a particular concern, especially along the Thames River. Small local businesses in the Thames Street AZ are susceptible to property damage and business disruption from flood events. Large industrial uses in the Technology Campus AZ (like Electric Boat, Pfizer, and Buckeye Terminals) have high exposure as well. Disruption or damage to these businesses poses a risk of cascading negative impacts to the community and local economy.

4. South Shore Flooding

Coastal flooding is primarily a concern in the southern portion of the City. Risks are highest for the mostly single-family residential properties in this area; in addition to posing a threat to homeowners, this risk may be a concern for the City's tax-base. Coastal flooding also threatens some of the sensitive coastal habitats on the South Shore, including Birch Plain Creek.

5. Vulnerable Roadways and Transportation Network

Some of the key roadways throughout the City, including Thames Street, Eastern Point Road, Shennecossett Road, and Thomas Road, are vulnerable to flooding. Flooding or erosion of these roads pose a risk of isolation or delayed access and egress for residents and emergency services.



Additionally, public transportation is limited in some cases, meaning that not all residents have equal access to important resilience resources (such as cooling centers).

6. Vulnerable Population Exposure

Socially vulnerable populations exist throughout the City, with higher concentrations in the Brandegee Avenue AZ and Five Corners AZ. These populations face higher levels of risk to climate hazards and disruptions because of their elevated vulnerabilities, and particular care is needed to support them.



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Appendix C: Resilience Concepts



**Concept 1:
Washington Park Shade Tree
Plantings**



Washington Park Shade Tree Plantings

Background

Washington Park is located in the central western portion of the Washington Park Assessment Zone (AZ) and directly to the west of the City of Groton Municipal Building Complex and Lake George. It sits at the corner of Meridian Street to the north and Mitchell Street to the west.

Based on the vulnerability assessment discussed earlier in the Resilience Plan, both the overall vulnerability of the Washington Park AZ and the vulnerability of community resources—that includes Washington Park—is moderate. The exposure analysis and overall risk assessment found that low impervious surfaces and low tree coverage in Washington Park, other nearby facilities, and paved streets, show that heat exposure and risk is moderate. Based on this hazard setting, a resilience project concept was developed to improve tree coverage in Washington Park. The details described below are done at a planning level to convey the general concept. The concept may need additional design along with a full cost estimate.



Figure 1. A concept image of tree plantings near the parking lot of Washington Park off of Meridian Street

The concept involves planting several large shade trees at five key sites throughout Washington Park. The sites were selected with input from the City of Groton Planning, Public Works and Parks and Recreation departments. The trees would help reduce the urban heat island effect and improve the overall quality of the open space. The concept supports the resilience objective to mitigate the increasing urban heat island effect impacts as well as the following two recommendations described earlier in the Resilience Plan:

- **Recommendation 4.2.2:** Develop a Citywide, Healthy Urban Forest
- **Recommendation 4.2.3:** Provide Public Access to Cooling Areas

Figure 2 shows the location of Washington Park.



Figure 2. A Map Depicting Washington Park (blue star) situated in the Washington Park Assessment Zone

Concept Description

The tree-planting project proposed at Washington Park is an effort to build resilience through enhanced shading options. Washington Park is approximately 32 acres and includes three baseball fields, two softball fields, a playground, tennis courts, outdoor fitness circuit, volleyball area, picnic areas, basketball hoops, and outdoor pavilions. The park is near single-family homes, apartment buildings, and the City of Groton Municipal Building – and is accessible via bus on Mitchell Street. It is a significantly important community space for the City of Groton.

The project would consist of planting approximately 30 young or mature red maple trees (~8 feet in height). Red maples are medium to fast growing trees that are native to the area and mature to heights of 40-60 feet. They do well in full sun to partial shade, which is representative of the sun exposure in Washington Park. It does well in a variety of soils, including sandy soils which are common for the area, although soil testing would be required in order to confirm viability. The trees would be interspersed within and around the perimeter of the park, including at Lake George, Mitchel Street, and Meridian Street. The proposed site and planting locations are depicted in Figure 2.



Figure 2: Map of proposed locations for tree planting in Washington Park with depictions of each in various seasons

The initial phase would include tree and site selection. Considerations for siting would include climate and weather considerations, safety (e.g., utilities, sidewalks obstructions), areas to allow for growth (several feet in between plantings to allow maintenance access), maintenance requirements, and soil conditions. In addition, trees that would maximize shading would be a key criterion. Final tree selection will be a native tree species identified as adaptable to potential pests and diseases while requiring little to no maintenance due to it being native to the area. The planning process will also include determining the extent and costs of the minimal maintenance requirements, such as pruning and irrigation during dry periods.

In line with the City's aims to expand its urban forest, the proposed project could kick off a citywide urban forestry initiative, which could consist of further plantings, a citywide tree inventory, and annual tree evaluations. To maximize placemaking and use of trees, future projects could include new seating around trees.

Benefits/Resilience Outcomes

The proposed project would serve multiple benefits, as outlined below:

- Help the City of Groton better adapt to the increasing hot days by providing more usage of the park's community spaces;
- Enable social cohesion and encourage physical activity;
- Protect the park's ecological functions, such as biodiversity and habitat;
- Reduce stormwater runoff by creating soil conditions that promote the infiltration of water into the soil;
- Kick off a citywide urban forestry effort;
- Improve the park's aesthetics with an oval shape tree form that turns a deep red or yellow color in the fall and boasts red stems during the winter.

Increased park usage, community physical activity, and reduced heat exposure all have been found to have financial benefits. Modeling and further research will be required to estimate more specific benefits. This could include estimated economic benefits that result from all the above benefits.

Costs

Costs for this proposed project are comprised of administrative time to finalize siting decisions, the purchase of trees, and slight increases in park maintenance. Soil testing may also be necessary for final tree selection. Assuming costs for about 8-foot trees are approximately \$700 each, planting 30 trees would amount to approximately \$21,000 in materials and labor. With a contingency cost included, a cost of \$30,000 can be expected. Maintenance costs are expected to be minimal.

Alternatives

During the initial project design phases, alternatives will need to be assessed to design the proposed project in ways that meets the hazard, climate risks, and specific community vulnerabilities. There are tradeoffs, as outlined in the Table 1.

Table 1: Alternatives Analysis

ALTERNATIVES	ANTICIPATED OUTCOMES	REASONS WHY NOT TO CHOOSE
Shaded Infrastructure (e.g., gazebos)	<ul style="list-style-type: none"> • Improved shading and heat resilience. • More community spaces usable on hot days. • No benefit to ecological function. 	<ul style="list-style-type: none"> • Lack of co-benefits from trees, such as air and water quality • More expensive • Longer time horizons to build
No action	<ul style="list-style-type: none"> • Lack of shading, heat resilience • Fewer community spaces usable on hot days • Fewer protections of the park's ecological functions • No progress made to urban forestry effort. 	<ul style="list-style-type: none"> • No added benefits

Conclusion

The proposed project has relatively low costs and addresses a key resilience risk – heat in an area with high visibility. The effort could be viewed as an initial step to increasing the City’s Urban Forest.

**Concept 2:
Birch Plain Creek Resilience
Trail**



Birch Plain Creek Resilience Trail

Background

The Birch Plain Creek Resilience Trail is planned to run the length of the Brandegee Avenue Assessment Zone (AZ) as well as the southern portion of the Washington Park AZ. It would run roughly parallel to Brandegee Avenue, cross Poquonnock Road, and continue north up Wall Street toward Park Avenue.

As outlined in the vulnerability assessment discussed earlier in the Resilience Plan, the overall vulnerability of both the Washington Park and Brandegee Avenue AZs is moderate. Exposure is low and moderate in the AZs, respectively, and exposure to heat and flood are among the top concerns. The southern part of the trail would traverse near socially vulnerable residential communities and help address inequities through added connectivity to more northern areas and transportation and recreational opportunities that address the area's moderate heat exposure. .



Figure 1. A concept image of an educational park near Groton Estates that would be along the trail

Based on this hazard setting, a resilience project concept was developed to create a surface permeable, multi-use trail that links an existing trail connecting Washington Park to West Street with another existing trail at the Birch Plain Creek Open Space off Thomas Road. The trail would be walkable and bikeable and would include educational signage throughout. Natural systems alongside Birch Plain Creek, including tidal marshes and public parks, are important components of the local community infrastructure. They offer important opportunities to build resiliency. The details described below are at a conceptual planning level. To further the general concept, additional engineering design, permitting assessment and a more detailed cost estimate will be required.

The concept supports the following resilience objectives and recommendations:

- **Resilience Objective 4.2:** mitigate increasing urban heat island effect impacts
 - Recommendation 4.2.3: Provide Public Access to Cooling Areas
- **Resilience Objective 4.5:** Improve resilience of the transportation network
 - Recommendation 4.5.1: Consider Climate Change in Traffic and Evacuation Planning
- **Resilience Objective 4.6:** Increase resilience of socially vulnerable populations
 - Recommendation 4.6.3: Conduct education and engagement
- **Resilience Objective 4.7:** Lead by example – municipal resilience actions
 - Recommendation 4.7.1: Enhance the resilience of city-owned assets

Figure 1 depicts the proposed Birch Plain Creek Resilience Trail and concept design features at select locations.



Figure 2. A Map Depicting the proposed Birch Plain Creek Trail and concept designs for select locations

Concept Description

The proposed project is a multi-use trail that connects to two existing trails—one connecting Washington Park to West Street and the other at the Birch Plain Creek Open Space off Thomas Road. The path would be constructed with permeable materials to allow for drainage and tie in with the addition of trees in Washington Park to maximize the cooling benefits of the project.

The trail, as designed, would be approximately 3.2 miles in length, 10 feet wide to allow for two-way passing, walking and bicycle use. The trail will have minor to moderate grades. Constructing the trail requires site planning, clearing, grading, laying of base and top coat materials, and drainage improvements. The trail would be unpaved to allow water to continue to percolate into the ground as needed. Crushed gravel is propose as the final surface treatment.

Additional design features would include native vegetation, signage for education and wayfinding, and a rentable bicycle facility with a self-service kiosk to enable more people to use the trail.

Green Space Trail

The crushed gravel trail is designed to traverse through about 2.5 miles worth of green space. Some of the trail already exists. There are existing trails at Birch Plain Creek Open Space and the Municipal Building Complex/Washington Park, however, these trails have not been reliably maintained. This design conservatively assumes that costs to create these trails would be similar to the cost of new trail creation. About 2 miles of the green space trail would be located in the gently sloping land near Birch Plain Creek south of Poquonnock Road, and a half-mile would be located in the relatively level terrain near the City of Groton Municipal Building.

Roadside Bike Path

The trail crosses Poquonnock Road, then runs parallel to Poquonnock Road and West Street before connecting to green space and Washington Park. This necessitates about a half-mile of roadside travel. Curbside bike-lane development, markings, and signage have been included for a bi-directional bike lane on the westbound side of Poquonnock Road and the northbound side of West Street. An engineer may find that two bike lanes are possible (one for each direction of automobile traffic), resulting in an adjusted cost estimate. All curbside bike lane design elements were made in accordance with the American Association of State Highway Transportation Officials standards.

Legal, Permitting, and Review Considerations

Most of the trail would be on public land. It would travel across 5 parcels of City-owned land, 3 parcels of Town-owned land, and 2 privately-owned parcels, as shown in Table 2. To construct the trail, easements (where an individual retains ownership yet allows the City to use a portion of the land for the trail) or right-of-way acquisitions are necessary for all non-City-owned parcels. Relying on outside parties has the potential to delay the project, so utilizing the City’s land was prioritized during planning. For this design, easements were assumed to be viable on all non-City-owned property. Maintenance responsibilities can also be negotiated through the legal process. This concept provides general maintenance activities and costs that can be expected, but creative agreements with parcel owners and community groups should be explored during the next phase to minimize the City’s costs.

Table 1. Parcel Impact Summary

PARCEL DESCRIPTION/OWNER FROM SOUTH TO NORTH	TRAIL LENGTH	TRAIL TYPE	EASEMENT/ACQUISITION REQUIRED?
Birch Plain Creek Open Space	2500ft	Upgrade	No
Branford Manor Preservation LP ⁺	1000ft	New	Yes
City of Groton	400ft	New	No
Birch Plain Properties LLC ⁺	500ft	New	Yes
Thames River Magnet School ⁺⁺	3100ft	New/Upgrade	Yes
Town of Groton ⁺⁺	3500ft	New	Yes
Poquonnock Road	2300ft	Upgrade/Retrofit	No
West Street	1100ft	Upgrade/Retrofit	No

Colonel Ledyard School**	1000ft	New	Yes
Municipal Building/Washington Park	1400ft	New/Upgrade	No
Total:	16,800 ft (3.2 mi)	---	---

+ Privately Owned

** Owned by the Town of Groton

Permits will be needed for the entire length of the trail. This design assumes the permitting process will be relatively simple, but funding sources can complicate review requirements. Federally funded projects can require National Environmental Policy Act (NEPA) documentation which typically comes with added costs. Costs can be significant if an Environmental Impact Statement is required. Based on the land in question, if federal funding is utilized, a categorical exclusion is the most likely outcome, and costs could remain around \$20,000. This cost has been excluded from the planning-level cost estimate as it is assumed state funding will be sought first.

Amenities

One of the benefits of the multi-use trail is increasing connectivity between the northern and southern neighborhoods of the City. To prioritize equity, especially with the socially vulnerable residential communities near the start of the trail in the Birch Plain Creek Open Space area, low-cost bike share stations would be installed at either end of the trail including traditional bike racks. Along the trail, trash and recycling receptacles and benches would be installed to cover basic user needs.

Educational signage would provide information about climate change risks and resilience, such as the value of riparian buffers, rain gardens, stormwater retention ponds, resilient transportation networks, and bicycling to reduce greenhouse gases. Signs would be interspersed along the path in at least four key locations to tell a place-based story. The target locations are the Birch Plain Creek Open Space trailhead, the educational park near Groton Estates, the retention pond, and the Washington Park trailhead.

Maintenance

Since the trail design calls for crushed gravel, periodic maintenance requirements will be higher than if they were asphalt or concrete. Additionally, the trail runs along Birch Plain Creek where water will be draining from the higher ground near Brandegee Avenue in the west toward the Creek, crossing the crushed gravel paths along the way. This may cause ruts to form, erosion issues, and issues with softness, but there would not be expected maintenance costs for potholes and cracks that would occur due to freeze/thaw cycles in solid trails. With these factors in mind, expected routine maintenance will include minor repairs, vegetation management, trash removal, drainage maintenance, education and safety signage maintenance, bike station maintenance, flood damage repair, and minor regrading.

Maintenance considerations for this concept are included as a yearly assumed cost by the City, but options that include maintenance responsibilities into easements or other creative alternatives should be explored. Potential revenue from the rental bike stations could contribute to maintenance costs.

Resilience Outcomes / Benefits

There are multiple climate resilience benefits of this concept. First, the trail would provide access to the passive cooling benefits of shaded forest areas, especially to socially vulnerable residents in the Brandegee Avenue neighborhood. Second, the trail would increase connectivity throughout the City, linking different neighborhoods and areas (including socially vulnerable communities with higher heat and flood risks to those with lower risk levels). Third, the trail would increase the social and economic value of the open space within flood hazard areas along Birch Plain Creek, reducing the risks of future development within those areas. Fourth, the trail would include educational information about climate change risks and resilience. Finally, public-use bicycle stations are planned for the southern trailhead and at the northern trailhead in Washington Park. In addition to providing connectivity and a sense of place, bicycle use may reduce short local automobile trips, potentially reducing greenhouse gas emissions and increasing the overall resilience and sustainability of the transportation network.

Modeling and further research would be required to estimate more specific benefits of the trail. This could include estimated economic benefits that result from all the above factors.

Costs

The considerations and features mentioned above are shown in Table 3 with planning-level estimates of their expected costs. Routine maintenance for the first year is included.

Table 2. Materials Summary and Costs

ITEM	QUANTITY	UNIT COST	TOTAL COST
Crushed gravel path <i>Materials, construction, site clearing, erosion control, grading and drainage improvements</i>	2.5 miles	\$500,000	\$1,250,000
Safety Signage <i>R3-17, R4-4 signs</i>	6	\$50	\$300
Roadside pavement markings <i>5" white retroreflective pavement marking and green pavement markings</i>	2,356 ft	\$20	\$47,120
<i>Bike lane symbols</i>	120 ft ²	\$20	\$2,400
Other features <i>Educational signs</i>	10	\$500	\$5,000
<i>Bench, installation</i>	4	\$1,000	\$4,000
<i>Trash/recycling, installation</i>	4	\$2,500	\$10,000
Bike features <i>10-Bike stations, installation, rental kiosks, bikes</i>	4	\$1,800	\$7,200
<i>Bike rack, installation</i>	2	\$30,000	\$60,000
Legal Costs <i>city-owned parcels</i>	2	\$1,500	\$3,000
<i>Easements: town-owned parcels</i>	5	0	\$0
<i>Easements: privately-owned parcels</i>	3	\$800	\$2,400
Routine maintenance	2	\$2,500	\$5,000
Design & permitting	3.2 miles	\$2,100	\$6,720
	<i>15% of construction costs</i>		\$209,721
		Subtotal	\$1,607,861
		+ 20% contingency	\$321,572
		Total	\$1,929,433

The cost estimate above is a planning-level estimate to provide a rough order-of-magnitude cost. An engineer-backed cost estimate based on a finalized design is required before further actions are taken. The planning-level cost estimate does not include considerations for extensive surveying or mitigation work, complex permitting or environmental review, costs above and beyond simple easements and rights-of-way acquisitions, user amenities such as lighting or water fountains, or special site remediation. A 20% contingency was added to cover unanticipated conditions and costs. Maintenance beyond year one is not included.

Alternatives

During the initial project design phase, alternatives were considered to ensure an appropriate project selection that addresses the hazard setting and specific community vulnerabilities. The alternatives, anticipated outcomes, and decision reasonings are outlined in Table 1.

Table 3. Alternative Descriptions

ALTERNATIVE DESCRIPTION	ANTICIPATED OUTCOME(S)	REASON(S) WHY NOT CHOSEN
Traditional bike lane along existing roadways	<ul style="list-style-type: none"> Broader construction impacts and delays 	The value of the green space would

	<ul style="list-style-type: none"> • Increased construction costs due to road widening (both lanes, more roads) • Increased traffic and safety issues • Higher transportation usage; higher greenhouse gas reduction • Limited flood filtration benefits • No reduction in heat risk • No educational signage • No improvement of green space value 	remain unchanged, and there would be no resilience benefits regarding heat risk
Do Nothing	<ul style="list-style-type: none"> • Risk of development and loss of green infrastructure and associated benefits, such as water quality from natural filtration and tree cooling • No effect on traffic and associated greenhouse gas reduction • Maintain limited connectivity • No educational benefit 	No resilience benefits

Conclusion

The Birch Plain Creek Trail concept would provide resilience benefits that address the City’s social and residential vulnerabilities while also reducing its heat and flood exposure. It would build on and improve the existing green space to create a multi-functional recreational feature that would attract residents and visitors from the surrounding areas for hiking, biking, and general transportation uses.

**Concept 3:
Municipal Building
Campus Rain Gardens**



Municipal Building Campus Rain Gardens

Background

The City of Groton Municipal Building campus is located in the southwestern portion of the Washington Park Assessment Zone (AZ) and directly to the east of Washington Park itself. It sits at the corner of Meridian Street to the north and Clarence B Sharp Hwy (Route 349) to the east.

Based on the vulnerability assessment discussed earlier in the Resilience Plan, the overall vulnerability of the Washington Park AZ is moderate, but the infrastructure vulnerability—that includes the municipal complex—is high. The risk assessment found that flooding and stormwater issues result in a moderate risk to the infrastructure in the AZ, with the second-highest hazard of concern for the area being stormwater flooding. Based on this hazard setting, a resilience project concept was developed to advance stormwater mitigation in the parking lot of the City of Groton Municipal Building. The details described below are at a planning level to convey the general concept. The concept will need engineered design along with a full cost estimate prior to construction.



Figure 1. A concept image of a rain garden on the west side of the Municipal Building entrance

The concept involves three rain gardens on the north side of the Municipal Building that would capture rain runoff from the surrounding parking lot pavement and allow the water to percolate into the ground. Installation of rain gardens on the municipal complex property would reduce stormwater runoff from a site with relatively high impervious surface coverage. The high visibility of these rain gardens to the public would also allow them to serve an educational purpose and help with efforts to encourage rain garden installation on private property and other key areas around the city. The concept supports the resilience objective to reduce stormwater flooding from impervious surfaces as well as the following two recommendations described earlier in the Resilience Plan:

- **Recommendation 4.1.3:** Fund Municipal Stormwater Reduction Efforts: Raise funds for stormwater reduction projects by establishing a Stormwater Authority, pursuing grants, and securing public support for municipal spending
- **Recommendation 4.1.5:** Implement Retention, Detention, and Infiltration Techniques: Slow or reduce the flow of stormwater into stormwater drainage pipes through installation of cisterns, swales, ponds, and other measures, focusing on the use of green-infrastructure. This will reduce the stress on drainage systems and the risk of flooding, while creating additional environmental co-benefits.

Figure 1 shows the general location of the Municipal Campus.



Figure 2. A Map Depicting the City of Groton Municipal Building Complex (blue star) situated in the Washington Park Assessment Zone

Concept Description

The resilience concept consists of three rain gardens (approximately 300, 400, and 1000 sq.ft). They would complement the existing five tree filters and nine catch basins in the parking lot. Two of the rain gardens would complement existing tree filters that are already in the planned garden locations. The tree filters function as self-contained water treatment systems that use natural processes to help clean stormwater by filtering it through a specially designed soil mixture to remove pollutants. The rain gardens would help expand the nature-based filtration capacity in the parking lot to help treat water that contains non-point source pollution from the pavement, encourage water percolation and reduce the demand placed on the existing stormwater infrastructure. Figure 2 shows the proposed locations of the three gardens. Figures 3, 4 and 5 show concepts of how the rain gardens may appear.



Figure 2: Map of proposed locations for rain gardens in the parking lot of the City of Groton Municipal Building parking lot



Figure 3: Rain garden A concept



Figure 4: Rain garden B concept



Figure 5: Rain garden C concept

The rain gardens would be built into the existing curb-surrounded grassy areas and would require the selected areas to be depressed by approximately six inches for the two smaller rain gardens and approximately ten inches for the larger bioretention area. One to two cutouts per garden area (based on future engineering determinations) would be created in the curb to facilitate the flow of rainwater and snowmelt from the parking lot into the garden. The cutout entrance would be met with stones to minimize erosion from the flow of runoff and reduce maintenance requirements. The stones would continue through the central portion of the garden to form an inlet for excess water.

Plants adapted to rain garden-like conditions would be planted starting at the edges of the stones and up the slope of the garden which would gradually increase at a low grade towards the curb edges and away from the cutouts. A 3:1 side slope is ideal. The garden would be planted with resilient, native perennials to the greatest extent possible that are tolerant to drought flooding, and exposure to high salt concentrations. The plants in Table 2 were selected for this concept.

Table 1. Plant Summary

NAME	TYPE	HEIGHT	BLOOM	FALL COLOR	SUN CONDITIONS
Sweet pepperbush (clethra alnifolia)	Shrub	6 ft	July/August (six weeks)	Yellow-gold	Full sun – partial shade
Blue flag iris (Iris versicolor)	Grass-like	2-3 ft	May – June (blue, lavender)	Green	Full sun – partial shade
Sweet fern (comptonia peregrina)	Shrub	2-4 ft	April – May (green, yellow)	Green	Full sun – partial shade
Red chokeberry (aronia arbutifolia)	Shrub	6 ft	February – May (red)	N/A	Full sun – partial shade
Bearberry (arctostaphylos uva-ursi)	Bush	6-12 in	April – May (white, light pink flowers, red fruits)	Burgundy-bronze	Full sun
Virginia wildrye (elymus virginicus)	Grass	2-4 ft	March – May (yellow)	Green – silvery blue	Partial shade
Bluejoint (calamagrostis canadensis)	Grass	3-6 ft	Juen – August (green)	Green	Sun – full shade
Service berry (amelanchier arborea)	Shrub/Tree	15 ft	April – May (white flowers, red-purple berries in summer)	Red, purple	Sun – full shade

Soil testing will determine the current soil type and nutrient content. The area is likely to have sandy soil which is porous and has high absorption capabilities which would be very suitable for rain gardens.¹ It would need to percolate the water within 48 hours (72 hours maximum) to adequately handle the runoff, support the plants, and prevent mosquito breeding. Planting soil depth would generally be at least 18 inches for herbaceous plant species, but the soil depth for the bio-retention area would be increased to accommodate trees and woody shrubs in the design. Soils would be supplemented with a composted organic material. This typically includes 20-30 percent compost and 70-80 percent soil base/topsoil. To accommodate better pollutant absorption, soils should have a pH of between 5.5 and 6.5.

Maintenance of the rain gardens will include twice-yearly evaluations and as-needed pruning and weeding of the plants. The topsoil, mulch, and stones should be re-spread as-needed if significant erosion occurs. A full mulch/topsoil replacement may be required every 2-3 years.

Resilience outcomes / Benefits

The goal of the resilience concept is to mitigate stormwater runoff, and it is estimated that this project will reduce stormwater volumes from ponding on the pavement or entering preexisting stormwater infrastructure by at least 592 ft³. Rain garden A would have a surface storage volume of 75 ft³, garden B of 100 ft³, and garden C of 417 ft³, based on the estimated bed areas and designed water depths (Surface Storage Volume (CF) = Bed Area (ft²) x Average Design Water Depth)

The overall storage volume depends on the infiltration volume, but specific soil characteristics would be needed to calculate the true volume reduction. Garden C, which is designed as a larger bioretention, would have a drainage area of about 5,968 sqft according to a study conducted by the Stormwater Corps course at the University of Connecticut. After a final design, a more complete analysis of benefits can help to calculate volume reduction and water quality benefits at the Municipal Building.

Water quality improvements would be another outcome of the project. These can be tailored to the specific pollutants that are being targeted, for example, creating a sump in the bottom of the area to achieve nitrogen removal. In general, nitrogen, phosphorous, and suspended solids can be reduced by

¹ <https://cteco.uconn.edu/guides/Soils.htm>

56-86%.² Reductions in pollutants will help protect local surface waters, such as nearby Birch Plain Creek. On an annual basis, garden/bio-retention C is estimated to treat 157,127 gallons of runoff, reduce nitrogen by 1.63 lb N/yr, and reduce phosphorous by 0.207 lb P/yr according to the study done by the University of Connecticut.

Other benefits, such as erosion prevention, biodiversity improvements, and minimal watering and maintenance once established, are also expected.

Costs

Professionally installed rain gardens typically range from \$10 to \$20 dollars per square foot. A planning-level cost estimate for the project is \$20,000-\$30,000. This assumes garden sizes of 300 sqft, 400 sqft, and 1000 sqft; depths of 6-10" based on garden size and water retention needs; about 18 inches between plants, a moderate garden slope; and sandy soil. Variations from these assumptions are expected to affect costs, potentially substantially if extensive soil replacement is required. The use of City labor and equipment could significantly reduce this cost. The cost of annual maintenance will be similar to the lower end of traditional landscaping, and it is estimated to be about \$4 per square foot(\$6,800 annually).

Alternatives

After the hazard setting was analyzed, resilience concepts were brainstormed as an initial step in determining the most suitable option. The alternatives to the rain gardens are described in Table 1.

Table 2. Alternatives Summary

ALTERNATIVE	ANTICIPATED OUTCOMES	REASON NOT PURSUED
Bioretention pond	<ul style="list-style-type: none"> • Temporary surface storage of runoff, including partial evaporation • Provides educational, aesthetic, and biodiversity benefits. • Larger space would be devoted to the bioretention pond 	Site does not have larger volumes of stormwater runoff that would benefit from a bioretention pond relative to the alternative. A rain garden can be designed to handle the site's typical volumes of runoff while also providing aesthetic, educational, and biodiversity benefits.
Expand stormwater management infrastructure	<ul style="list-style-type: none"> • No educational benefit, including ones that would encourage other rain garden installations in other areas of the city. • No aesthetic and biodiversity improvements. • May be designed to accommodate a larger volume of runoff. 	Long planning horizon, more expensive, and more required maintenance
No action	<ul style="list-style-type: none"> • Potential for stormwater infrastructure in parking lot to become overwhelmed and ponding to occur 	Stormwater runoff is one of the top hazards of concern and mitigating it would reduce risk to vulnerable infrastructure

Conclusion

Overall, the concept is designed to mitigate runoff, be low maintenance and cost-effective, especially when compared to the alternatives. Specifics of this concept are dependent on eventual engineered studies and designs and can be modified to achieve specific stormwater mitigation and water quality improvement benefits.

² https://mostcenter.umd.edu/sites/default/files/bioretention_illustrated.pdf

**Concept 4:
Shore Avenue Resilience
Projects**



Shore Avenue Resilience Projects

Background

The sites of the Shore Avenue resilience projects are located in the southwestern portion of the South Shore Assessment Zone (AZ). They follow almost the entirety of Shore Avenue from Eastern Point Beach to the western tip of Shennecossett Golf Course.

Based on the vulnerability assessment discussed earlier in the Resilience Plan, the overall vulnerability is moderate, but the infrastructure vulnerability—which includes critical roads and utilities in Eastern Point and along Shore Avenue—is ranked as high. The South Shore AZ has the most widespread mapped coastal flood exposure extent, especially along Shore Avenue in the south. The Connecticut Institute for Resilience & Climate Adaptation (CIRCA) Sea Level Rise and Storm Surge Viewer shows the mean higher high-water level plus 20 inches of sea-level rise as highly likely to inundate Shore Avenue during a non-storm setting, by 2050, as shown in Figure 1. Based on this hazard setting, several resilience projects were suggested along Shore Avenue to help mitigate risk from coastal flood hazards, and one project has been chosen to highlight through a full concept.



Figure 1. A before resilience projects (left) and after resilience project (right) view of the mean high-water level plus 20-inches of sea-level risk flooding that CIRCA models as highly likely by 2050

The Shore Avenue projects (with full-concept projects **bolded**) include:

- Plant trees on city-owned open space
- Repair “fishing pier” erosion damage
- Install educational signage and materials at the fishing pier
- Upgrade shore avenue sea wall (plans underway)
- **Implement nature-based flood mitigation near 160 Shore Avenue**
- **Upgrade Shore Avenue drainage system**
- Living Shoreline at Cement Revetment
- Pursue Living Shoreline at Eastern Point Beach Park
- Reduce Imperviousness and Plant Trees at Eastern Point Beach Park

The highlighted Shore Avenue resilience concept focuses on a landscape design and regrading project on City-owned open space on the western side of Shore Avenue. The project would raise the land surface to act as a vegetated coastal flood control structure, in cooperation with stormwater drainage retrofits to prevent surcharging through the drainage system during high tides. The objective of this

project is to prevent flooding of a small section of Shore Avenue during “sunny-day” high tide events under projected sea-level rise conditions by 2050. The project would not prevent flooding during more severe high tide events. In addition to the specific concept, mapping of other areas of resilience opportunity along Shore Avenue is provided. The details described below are at a conceptual planning level to convey the general vision. The concept will require an engineering design, flood modeling, and a full cost estimate.

The concept supports the resilience objective to create a flood-resilient shoreline as well as the recommendation to pursue Shore Avenue resilience strategies described earlier in the Resilience Plan. Figure 2 depicts the locations of the various resilience features under consideration, including the one addressed by this concept.



Figure 2. A Map depicting the Shore Avenue vegetated berm and drainage upgrade project

Concept Description

The vegetated berm will be approximately 150 feet long and run parallel to Shore Avenue across the street from 160 Shore Ave before turning west toward the water, running down the entire length of the City-owned parcel, and finally turning south onto the privately-owned parcel for the final 25 feet (Figure 3).



Figure 3. The vegetated berm concept with red chokeberry shrubs

Vegetated Berm Construction

With a grade change of +3 feet from the existing ground surface for the 2050 design flood elevation (DFE), the berm is expected to have at least a 30-year useful life. It may be feasible to incrementally extend the berm farther south to block the future flooding pathway over time to extend the project's useful life. The design slope is 5:1 (horizontal: vertical) on the waterside (3:1 on the inland side) for concept planning purposes which will facilitate ease of maintenance. The berm is designed with a crest setback of about 45 feet which will allow the open space immediately next to the water to flood as needed during high-tide, sunny day flooding events.

The vegetated berm will use a clay core as its highly dense, low permeability material to prevent seepage on the inland side. It will also have 15 feet of feathering (width) to support the same goal. If necessary, horizontal drainage/filter layers may be needed to further prevent seepage. A vegetated (grass-covered) top layer will help protect the clay core.

Three to four native, perennial shrubs will be added to the green space to increase aesthetic appeal and value. For this design, red chokeberries (*aronia arbutifolia*) were selected. They can expect to grow to about six feet in height and are commonly used in rain gardens due to their salt and temporary inundation tolerances. Red chokeberries will bloom sometime between February and May with a vibrant red color. They do best in full sun to partial shade, which is what the project area calls for. They will need to be placed at least 15 feet away from the berm out of an abundance of caution to prevent their root systems from uprooting during a high-flow water flow event and causing a breach.

Shore Avenue Drainage Upgrades

Although currently consistently submerged underwater, there are presumed to be two stormwater outfalls coming out of the sea wall along the parcel of land where the majority of the berm will be located on. They are assumed to be approximately 3 to 4 feet in diameter. These outfalls will require a full inspection to better understand their exact locations, specification, and conditions. For the purposes of this concept design, their conditions are assumed to be poor which would necessitate partial replacement.

The replacement structures will maintain the same 3- to 4-foot diameter but will be outfitted with tide gates to prevent surcharging during high tides. The new locations on the sea will also be adjusted to prevent constant submergence.

Due to the non-permeable characteristic of the berm, there will likely be a requirement for stormwater management additions (pumping stations) on the eastern, inland side of the nature-based structure to prevent ponding due to current and future precipitation levels. Additionally, the pumping stations should be designed to handle excess capacity due to the overtopping of the berm during large storm surge events. The necessity, noise concerns, and aesthetic considerations would ultimately be decided during the engineering design phase.

Legal, Permitting, and Review Considerations

The majority of the berm will be located on property owned by the City of Groton. However, the last 25 feet at the end closest to the water will need to be on privately-owned property to adequately tie into higher grade to prevent the high-tide flooding that is predicted to occur by 2050 according to the CIRCA Sea Level Rise and Storm Surge Viewer. This will require either acquisition or an easement, and this planning-level design and cost estimate assumes the latter. There are minimal expected complications with securing the easement since the outcome of the project will ultimately improve the quality of the surrounding land due to flood mitigation benefits. The total value of the vacant parcel (per City land assessor records) is \$342,500, so if it were to be acquired, it would add significant costs to the project.

Permits for the project will be for the vegetated berm construction, the potential current stormwater infrastructure removal, and the installation of the two new tide gates. Local and/or state funding is preferred to keep permitting and environmental review concerns to a minimum. Extensive environmental review (i.e., anything triggering NEPA compliance) could increase project costs by \$15,000+. Permitting for the new outfalls, tide gates, pump stations, and berm are all expected to be intensive and will require considerable time and money to accomplish, especially if completed using federal funding.

Operations & Maintenance

Maintenance is expected to be mainly inspections on an annual basis and before an upcoming major storm event that poses a risk of overtopping or breaching due to weak points in the berm developing over time. Erosion, sinkholes, vegetative encroachments, seepage, drainage issues, and settlement are among the top concerns during inspections. The outfalls and tide gates should also undergo regular inspections with debris removal happening when the stormwater volume is noticeably affected.

Other more common maintenance activities include mowing the grass and attending to red chokeberry plantings. Small repairs may be expected approximately every 5-years and can cause several thousand dollars.

Resilience Outcomes / Benefits

The threat of high tide, sunny-day flooding is real, and the risk will only increase as time goes by. To prevent the highly likely Shore Avenue inundation issues, the nature-based and drainage system improvements described above will be implemented to increase the resilience of Shore Avenue utilities, transportation, and residential properties. The improvements will also help prevent the encroachment of erosion that has been slowly depleting the current sea walls and surrounding land. The preexisting stormwater management systems in place are regularly submerged in water, so surcharging is a real issue that leads to high-tide flooding issues and poor stormwater management inland. Outfitting the replacement outfalls with tide gates will help with this issue now and in the future as the 20 inches of expected sea-level rise changes the coastal hazard landscape. Finally, the nature-based solution will maintain the value of the City-owned open space and water views for the residential homeowners across Shore Avenue.

Costs and Permitting

The considerations and features mentioned above are shown in Table 1 with planning-level estimates of their expected costs. Expected operations and maintenance costs—such as annual/storm inspections,

vegetation maintenance, and stormwater infrastructure maintenance—are estimated to be \$20,000 annually.

Table 1. Materials and Work Summary with Costs

ITEM	QUANTITY	UNIT COST	TOTAL COST
Vegetated berm/earthen levee <i>Materials, construction, monitoring</i>	150ft	\$2000	\$300,000
Stormwater pumping station <i>Materials, construction</i>	1	\$250,000	\$250,000*
Shrubs <i>Materials, installation</i>	3	\$100	\$300
<i>Clearing of vegetation too close to the berm</i>	--	--	\$2,000
Tide gates <i>Materials, installation</i>	2	\$500,000	\$1,000,000
<i>Old stormwater outfall removal</i>	2	\$50,000	\$100,000
<i>Stormwater outfall replacement materials and construction</i>	2	\$300,000	\$600,000
Legal Costs <i>Privately-owned parcel easement</i>	1	\$2,500	\$2,500
Engineering, design & permitting	<i>15% of construction costs</i>		\$338,220
		Subtotal	\$2,593,020
		+ 20% contingency	\$518,604
		Total	\$2,773,404

*Need for pumping station to be determined during modeling and design phase

The cost estimate above is a planning-level estimate to provide a rough order-of-magnitude cost. Price of berm construction varies dramatically based on engineering design. Stormwater outfall construction needs are unknown without further investigation. An engineer-backed cost estimate based on a finalized design would be required before further actions are taken. A 20% contingency was added to cover unanticipated conditions and costs, such as needing to overbuild the berm due to soil conditions and settlement.

Alternatives

During the initial project design phase, alternatives were considered to ensure an appropriate project selection that addresses the hazard setting and specific community vulnerabilities. The alternatives, anticipated outcomes, and decision reasonings are outlined in Table 2.

Table 2. Alternative Descriptions

ALTERNATIVE DESCRIPTION	ANTICIPATED OUTCOME(S)	REASON(S) WHY NOT CHOSEN
Do Nothing	<ul style="list-style-type: none"> Sunny day flooding is not prevented and roads continue to flood, affecting residential properties on Shore Avenue 	Transportation issues from flooding would persist in the future
Raise the height of the existing sea wall	<ul style="list-style-type: none"> Sunny day flooding is prevented Residential property owners likely opposed Reduced quality of open/green space Ponding issues during rain events – pumping infrastructure required 	A nature-based solution is preferred, and homeowner approval is higher with a method that improves the quality of open space
Floodable open space & grade of the road raised by 12-18"	<ul style="list-style-type: none"> Sunny day flooding is prevented in roadway Quality of open space not improved Increased project costs 	The project costs would likely be higher

Conclusion

A nature-based solution will provide the place-based values that local residents prioritize while also protecting critical infrastructure now and into the future as sea-level rise increases the risk of flooding across Shore Avenue and in nearby residential properties. The tide gates will complement the vegetative berm by preventing surcharging and allowing for efficient stormwater management farther inland.