GZA GeoEnvironmental, Inc.

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Town of Westbrook Natural Hazard Mitigation Plan Update

Westbrook, Connecticut

Local Natural Hazard Mitigation Plan Update

Prepared in accordance with the requirements presented in the 44 Code of Federal Regulations (CFR) Part 201.6, FEMA Local Mitigation Plan Review Guide and the Local Mitigation Handbook

Prepared by:
GZA GeoEnvironmental, Inc.

Prepared For:
The Town of Westbrook Connecticut
Land Use Department

December 3, 2019

GZA GeoEnvironmental, Inc.

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TOWN OF WESTBROOK
NOEL BISHOP, FIRST SELECTMAN

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Certificate of Adoption Resolution
Town of Westbrook, Connecticut
BOARD OF SELECTMEN

A RESOLUTION ADOPTING THE WESTBROOK MULTI-HAZARD MITIGATION PLAN UPDATE

WHEREAS, the Town of Westbrook recognizes the threat that natural hazards pose to people and property within the Town of Westbrook; and

WHEREAS, the Town of Westbrook established a Local Planning Team to prepare the Multi-Hazards Mitigation Plan Update; and

WHEREAS, the Town of Westbrook has prepared a multi-hazard mitigation plan, hereby known as the WESTBROOK MULTI-HAZARD MITIGATION PLAN UPDATE dated December 3, 2019 in accordance with the Disaster Act of 2000; and

WHER3EAS, the WESTBROOK MULTI-HAZARD MITIGAION PLAN UPDATED dated December 3, 2019 identifies mitigation goals and several potential future projects to mitigate impacts from natural hazards including climate related hazards in the Town of Westbrook; and

WHEREAS, a duly noticed public hearing meeting was held by the Town of Westbrook on June 19, 2019 for the public and municipality to review prior to consideration of this resolution; and

WHEREAS, adoption by the BOARD OF SELECTMEN demonstrates their commitment to the hazard mitigation and achieving the goals outlined in the WESTBROOK MULTI-HAZARD MITIGATION PLAN UPDATE dated December 3, 2019 and

WHEREAS, the Town of Westbrook authorizes responsible departments to execute their responsibilities demonstrated in the plan; and

NOW, THEREFORE, BE IT RESOLVED that the Town of Westbrook BOARD OF SELECTMEN formally approves and adopts the WESTBROOK MULTI-HAZARD MITIGATION PLAN UPDATE, in accordance with MGI c 40.

ADOPTED AND SIGNED this 27th day of February 2020.

WESTBROOK BOARD OF SELECTMEN

By: _____
Noel Bishop, First Selectman

By: _____
John Hall, Selectman

By: _____
Hiram Fuchs, Selectman

Add FEMA formal approval letter here

QUICK PLAN REFERENCE GUIDE

The following provides a Quick Reference Guide to the Town of Westbrook Natural Hazard Mitigation Plan Update:

STEP 1: UNDERSTAND THE PLANNING PROCESS

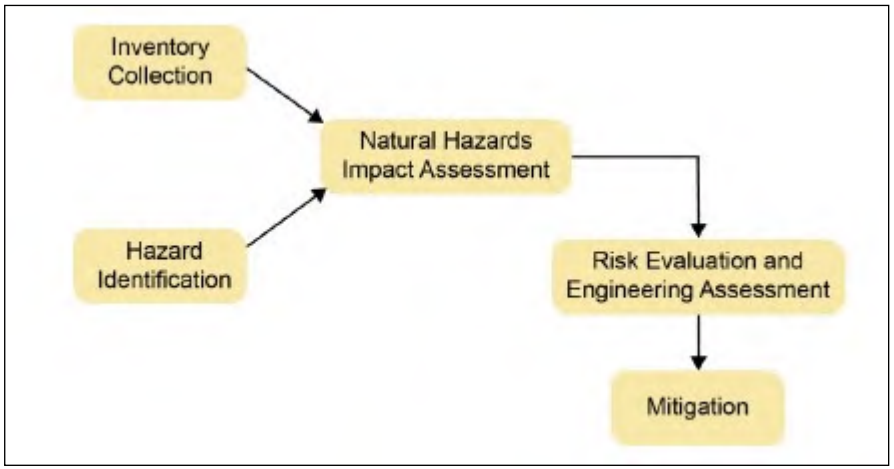
Section 2 - Planning Process describes the planning process and identifies the members of the Local Planning Team (LPT) that participated in the Plan development. **Attachment 6** presents public meeting documentation for the two public meetings.

STEP 2: INVENTORY TOWN ASSETS (COMMUNITY PROFILE)

Section 3 - Community Profile presents a brief overview of the Town assets. **Attachment 1** provides a detailed description of these assets, including the Town population, and an inventory of Essential and Lifeline Systems, High Potential Loss Facilities, Transportation Infrastructure, and Town Facilities and Zoning Districts and General Building Stock.

STEP 3: IDENTIFY NATURAL HAZARDS

Section 4 - Natural Hazard Risk identifies and summarizes the natural hazards applicable to the Town. **Attachment 2** provides the detailed description of relevant natural hazards. The hazards are characterized including past hazard events and expected probability of occurrence. Future climate-related changes to severe weather and climate-related hazards are also presented based on the current available science.



Conceptual Steps in Assessing and Mitigating Losses due to Natural Hazards (FEMA)

STEP 4: ASSESS NATURAL HAZARD IMPACTS AND RISK

Section 4 - Natural Hazard Risk also presents the results of an assessment of the vulnerability of the Town to the natural hazards. **Attachment 3** provides a detailed hazard vulnerability assessment. FEMA HAZUS-MH simulations were performed for Hurricane (probabilistic), flood (1% and 0.2% Annual Exceedance Probability [AEP] floods), and earthquake (2% in 50 years). The simulation results are presented in **Attachment 4**.

STEP 5: MITIGATION PLAN AND IMPLEMENTATION

Sections 5, 6 and 7 present mitigation strategies and actions, regional and intercommunity considerations and plan implementation details. **Attachment 3** provides the basis for ranking natural hazard priorities. **Attachment 5** presents state and federal hazard mitigation and response grant funding sources. References and resources, and key contacts are presented in **Attachments 7** and **8.**

UNDERSTANDING NATURAL HAZARD RISK

This Natural Hazard Mitigation Plan Update is intended to provide the Town of Westbrook with a risk-based approach to making planning decisions. In simple terms...

Risk = the probability of an event occurring x the consequences of that event

Risk can be assessed qualitatively or quantitatively. The evaluation of the risks associated with the Westbrook natural hazards required: 1) identifying the type of natural hazard(s) applicable to Westbrook vicinity; 2) evaluating their probability of occurrence; and 3) evaluating their consequences. For example, a coastal flood could impact Westbrook resulting in damage to property, injury or death and/or other economic or natural resource impacts. Different coastal flood conditions (water level, limit of flooding, wave height, etc.) are associated with different probabilities of occurrence and different degrees of consequences. By characterizing the hazard, evaluating its probability and evaluating the consequences, the likelihood that these consequences will be experienced is determined. Once the consequences are understood in this way, value and risk-based planning decisions can be made.

Quantitative Risk Assessment

Quantitative assessment of natural hazard risk typically defines hazard probability in terms of Annual Exceedance Probabilities (AEP). The AEP refers to the probability that an event (e.g. , a specific flood water level) will be experienced or exceeded in any given year. For example, the 1% AEP event has a 1 in 100 chance of being met or exceeded in any given year. This probability is often described in terms of a recurrence interval. The recurrence interval is also a statistical indication of the probability of an event and can be considered as the "expected" frequency of an event, on average and over a long period of time. The 100-year recurrence interval is consistent with a 1% AEP. Estimates of AEP are typically presented as "mean" values and have uncertainty represented by lower and upper bounds.

Quantitative estimates of natural hazard probabilities, to be statistically meaningful, require long periods of record of actual historical hazard data or use of other statistical methods. Certain natural hazards such as coastal flooding and earthquakes have been defined quantitatively by the federal government (FEMA, USGS and/or the US Army Corps of Engineers), and these values have been used for this Plan. For other natural hazards (e.g., Hail), this Plan has used limited historical data to extrapolate probabilities. While not statistically valid, the extrapolated estimates are useful in categorizing likelihood of occurrence (e.g., high to very low). Even though these "quantitative" value are presented in the Plan, the reader should be aware that they are not statistically meaningful due to the limited period of record of historical data.

Evaluating Consequences

This Plan Update evaluates the consequences associated with natural hazards in several different ways. The FEMA HAZUS-MH software is used to calculate losses (e.g. building damage) associated with Hurricanes (high winds), Coastal Flooding and Earthquakes. For the other natural hazards, the consequences were extrapolated from available historical data. Similar to the estimated probabilities for these hazards, this approach is not statistically valid; however, it is useful for categorizing the consequences (minor to catastrophic).

Risk Over Time

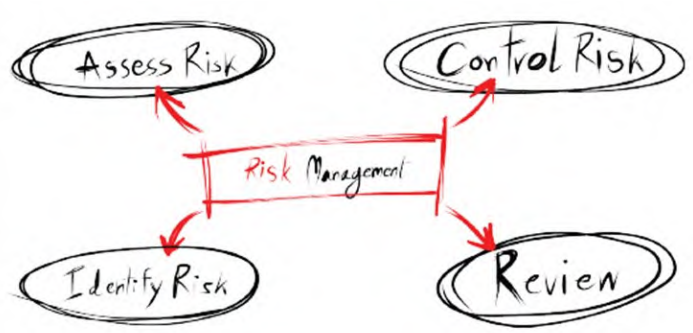
While AEPs and recurrence intervals define the annual risk (i.e., risk in any given year), the risk of experiencing that same hazard event at least once will increase when longer periods of time are considered. For example, the 1% AEP flood has a 1 in 4 chance (25%) of occurring at least once over a 30-year period.

Climate Change

Climate change can effect the risk of severe weather and climate-related hazards. For example, a flood level that has a 1% AEP today may have a much higher probability of occurrence in the future due to sea level rise.

Low Probability is not the Same as Impossible

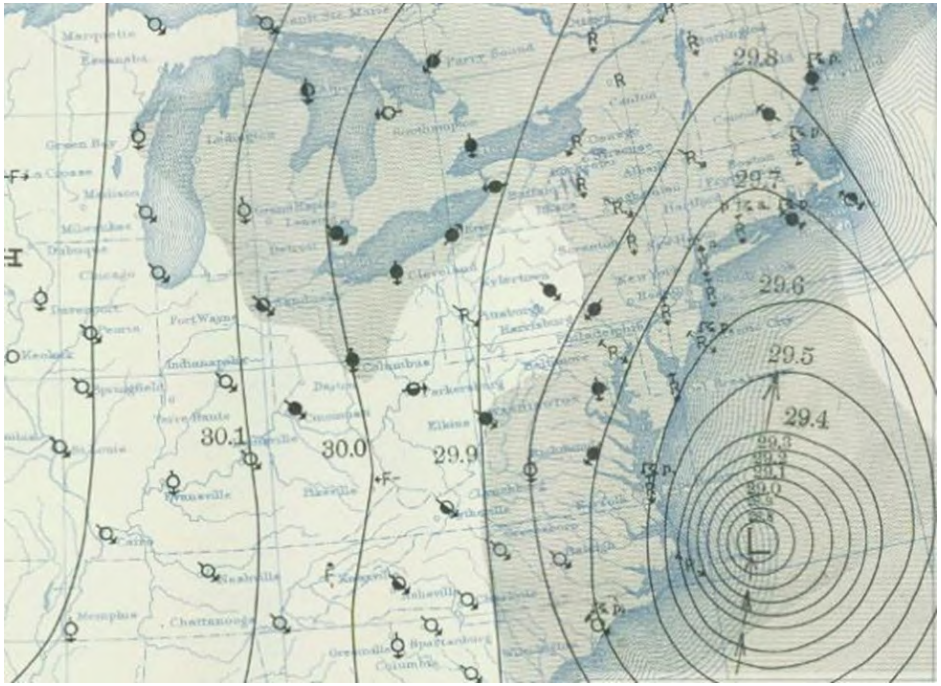
Even though a hazard is predicted to have a low probability of occurrence, that does not mean it cannot happen. For example, a major tornado is unlikely to occur at Westbrook based on the available historical data, but it could happen - it is just predicted to be a low probability for planning purposes.



Risk Management Planning Process

Section 1: Plan Introduction

SECTION 1- INTRODUCTION



Historical Surface Weather Map of the Hurricane of 1938 on September 9, 1938

PURPOSE OF PLAN UPDATE

The following presents the Natural Hazard Mitigation Plan (NHMP) Update for the Town of Westbrook, Connecticut. The Town is a coastal waterfront community that is home to about 7,000 residents, located in southeastern Connecticut on Long Island Sound. Westbrook is 29 miles east of New Haven and 23 miles west of New London. The Town is bordered by Old Saybrook to the east, by Essex and Deep River to the north, by Killingworth to the northwest, and by Clinton to the west.

As a coastal New England town, Westbrook is vulnerable to coastal storms, intense rainfall and extreme wind. The Town is also vulnerable to other severe weather hazards, climate-related hazards (e.g., extreme heat and cold) and geologic hazards (e.g., earthquakes). The Town have developed this NHMP Update to update the risks and vulnerabilities associated with natural disasters and to develop near– and long-term strategies for protecting people and property from future hazard events. Ultimately, the goal of the Plan Update is to enable action to reduce loss of life and property by lessening the impact of natural disasters.

The development of the Plan enables the Town to:

- Increase education and awareness about the Town's vulnerability to natural hazards;
- Build partnerships for risk reduction involving government, organizations, businesses, and the public;
- Identify long-term, broadly-supported strategies for risk reduction;
- Align risk reduction with other state, regional, tribal, or community objectives;
- Identify implementation approaches that focus resources on the greatest risks and vulnerabilities; and
- Communicate priorities to potential sources of funding.

PLAN REQUIREMENT

In addition, FEMA requires state, tribal, and local governments to develop and adopt hazard mitigation plans as a condition for receiving certain types of non-emergency disaster assistance, including funding for mitigation projects. Jurisdictions must update their hazard mitigation plans and re-submit them for FEMA approval every five years to maintain eligibility.

The State of Connecticut encourages local municipalities to take ownership of the multi-hazard mitigation planning process by pursuing and developing local multi-hazard mitigation plans (MHMP).

Section 2: Planning Process

SECTION 2 - PLANNING PROCESS

The FEMA planning process includes the following steps:

1. Organize the Planning Process and Resources

At the start, focus on assembling the resources needed for a successful mitigation planning process. This includes securing technical expertise, defining the planning area, and identifying key individuals, agencies, neighboring jurisdictions, businesses, and/or other stakeholders to participate in the process. The planning process for local and tribal governments must include opportunities for the public to comment on the plan.

2. Assess Natural Hazard Risks

Identify the characteristics and potential consequences of hazards. It is important to understand what geographic areas each hazard might impact and what people, property, or other assets might be vulnerable.

3. Develop Mitigation Strategies

Develop long-term strategies for avoiding or minimizing the undesired effects of disasters. The mitigation strategy addresses how the mitigation actions will be implemented and administered.

4. Adopt and Implement the Plan

Once FEMA has received the adoption from the governing body and approved the plan, the state, tribe, or local government can bring the mitigation plan to life in a variety of ways, ranging from implementing specific mitigation projects to changing aspects of day-to-day organizational operations. To ensure success, the plan must remain a relevant, living document through routine maintenance. The state, tribe, or local government needs to conduct periodic evaluations to assess changing risks and priorities and make revisions as needed.

The Town of Westbrook followed this process, including:

- Organizing a diverse local planning team.
- Retaining GZA to provide technical and planning expertise.
- Providing opportunities for the public to comment on drafts of the plan prior to final plan approval.
- Providing opportunities for neighboring communities and local and regional agencies involved in natural hazard mitigation activities that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process.
- Reviewing and incorporating applicable existing plans, studies, reports, and technical information into the plan.

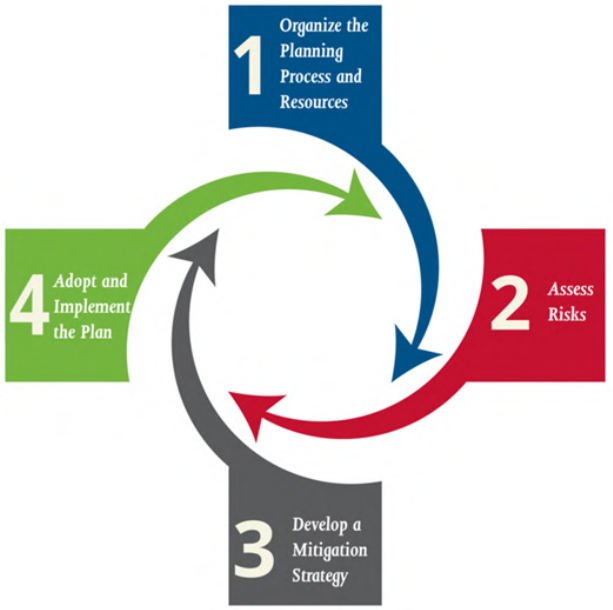


Figure credit FEMA/Jenny Burmester – Aug 21, 2017

The Town assembled a Local Planning Team (LPT) with critical Town, neighboring municipalities, State and Academic leadership responsibilities. The LPT was tasked with providing oversight and guidance in developing the Plan.

LOCAL PLANNING TEAM MEMBERS

Town of Westbrook

- Land Use Department, Eric Knapp, Planning, Zoning and Development Coordinator
- Board of Selectmen, Noel Bishop, First Selectman
- Planning Commission– Marilyn Ozols, Commissioner, Chair
- Economic Development Commission— James Crawford , Chair
- Emergency Management – Donald Izzo, Director
- Health Department— Sonia Marino, Director
- Water Pollution Control Office, Shirley Mickens, Environmental Health Technician

SECTION 2 - PLANNING PROCESS cont.

The Local Planning Team (LPT) conducted four working group meetings to provide input and guidance in developing the plan throughout the planning process. The meetings were held on 4/10/2019, 04/30/2019, 07/23/2019 and 09/13/2019. The purpose each working group meeting is summarized below:

- Working Group Meeting No. 1: Reviewed and discussed the inventory of Town assets as presented in Section 3 and **Attachment 1**. LPT members also provided details on previous natural hazard occurrences that impacted the Town.
- Working Group Meeting No. 2: Reviewed and finalized the inventory of Town assets as presented in Section 3 and **Attachment 1**. Conducted site visits to areas of town vulnerable to natural hazards and photo-documented assets in these areas.
- Working Group Meeting No. 3: Reviewed and discussed natural and climate change related hazard characterizations and preliminary risk assessment results with respect to Westbrook as presented in Section 4 and **Attachment 2 and 3**. The LPT also reviewed and provided feedback on the Draft 1st Public Meeting Presentation.
- Working Group Meeting No. 4: Reviewed, discussed and finalized the new goals and actions for the town's hazard mitigation strategy that are consistent with the State of 2019 Connecticut's Natural Hazards Mitigation Plan Update. The LPT also reviewed and provided feedback on the Draft 2nd Public Meeting Presentation.

The Town conducted two public meetings that provided residents, community stakeholders, business, neighboring communities, state agencies, regional planning authorities, and Town officials, including the LPT members the opportunity to participate during the planning process. The purpose of these meetings was to solicit input during the planning process for consideration and integration into the development of the Plan. The meetings were held at the Town Hall and publicized on the Town's website and through a formal press release.

At the first public meeting, a presentation was given to provide background on Hazard Mitigation Planning and to describe the Town's assets inventory, hazards characterization, and preliminary risk assessment. At the second public meeting, a presentation was given to provide the final risk assessment results and the Town's revised Mitigation Strategy that included updated goals and actions. The presentation materials for both public meetings are included in **Attachment 6**. The Town hosted the meetings on the following dates: July 29, 2019 and September 16, 2019.

EXISTING PLAN REVIEW

Several existing plans, reports and regulatory programs were reviewed by GZA and relevant details (e.g. future development areas as outlined in the Westbrook Master Plan) were incorporated as part of this Natural Hazard Mitigation Plan, including:

- State of Connecticut Natural Hazard Mitigation Plan Update (January 2019)
- Stormwater Management Plan (2017)
- Town Center Vision Plan (2015)
- Local Natural Hazard Mitigation Plan Update (2014)
- Harbor Management Plan (2014)
- A Salt Marsh Advancement Zone Assessment of Westbrook, Connecticut (2014, Nature Conservancy)
- Local Plan of Conservation and Development (2011)
- Coastal Zone Management Act
- Federal and state flood regulations
- Westbrook Zoning regulations, effective May 1, 2019
- Federal Coastal Barriers Act
- National Flood Insurance Program
- State and federal permits related to natural hazard mitigation, resilience and adaptation measures

A brief overview of relevant town details is also provided in Section 3 and **Attachment 1.**

Section 3: Community Profile

SECTION 3 - COMMUNITY PROFILE OVERVIEW

Location: Westbrook is located within Middlesex County in south-central Connecticut along the northern shore of Long Island Sound. The Town is bordered by Old Saybrook to the east, by Essex and Deep River to the north, by Killingworth to the northwest, and by Clinton to the west as shown on **Figure 1**.

Characteristics: Westbrook has the typical physical characteristics of a Long Island Sound coastal town, with uplands bordered by low-lying areas, tidal wetlands, salt marshes, tidal flats, and beaches. The total area of Westbrook is about 21 square miles. The areas to the south of Interstate 95 (I-95) are low-lying, consisting mostly of tidal marsh and coastal plain. The area to the north of I-95 consists of rolling hills of bedrock and glacial till, with a network of valley streams and inland wetlands. Westbrook has over 16 square miles of land and 5 square miles of water. Westbrook's southern coastal shoreline has resulted from the reworking of glacial sand and gravel deposits left after the retreat of the last glacial event over 10,000 years ago.

Beaches: As presented in the Town's May, 2014 Harbor Management Plan (2014 HMP) n some areas of Westbrook, beaches have formed along coastal plain areas while in other areas beaches were formed as spits through longshore drifting of sediment. The shoreline includes two promontories, a bedrock ridge identified as Old Kelsey Point and the sedimentary deposits at the mouths of the Patchogue and Menunketesuck Rivers. The Westbrook Council of Beaches was formally organized on June 28, 1972 as a 503(c)(4) non-profit corporation that consists of 17 member associations. The Council's mission is to listen to our members needs, to work with each beach association and its members. to cooperate with the Town of Westbrook, to cooperate with other organizations, and to advocate on our behalf.

Marshes and Rivers: The extensive tidal marshes located on the Patchogue and Menunketesuck Rivers extend north of Route 1 and, in some areas, extend 1,000 feet from the adjacent uplands. As noted in the 2014 MHP, a Federal channel within the Patchogue River exists south of Route 1 and must be dredged periodically.

Harbors: The Westbrook Harbor as addressed in the Town's May, 2014 Harbor Management Plan, lies between Chapman Beach/Kelsey Point at the Old Saybrook town line on the east and Grove Beach at the Clinton town line to the west. Westbrook is home to over 2,000 shipping vessels located at 12 separate facilities as well as at approximately 175 to 200 town moorings.

The Town is governed by a three-member Board of Selectmen, First Selectman and traditional New England Open Town Meeting. The Town is also one of seventeen member towns within the Lower Connecticut River Valley Council of Governments (RiverCOG), supporting regional land use, transportation, economic and natural resource management planning.

Attachment 1 provides a detailed description of Town's community profile including population, land use, essential facilities, lifeline systems, support, high occupancy and vulnerable populations, historic properties and natural resources. The following pages provide a brief overview.

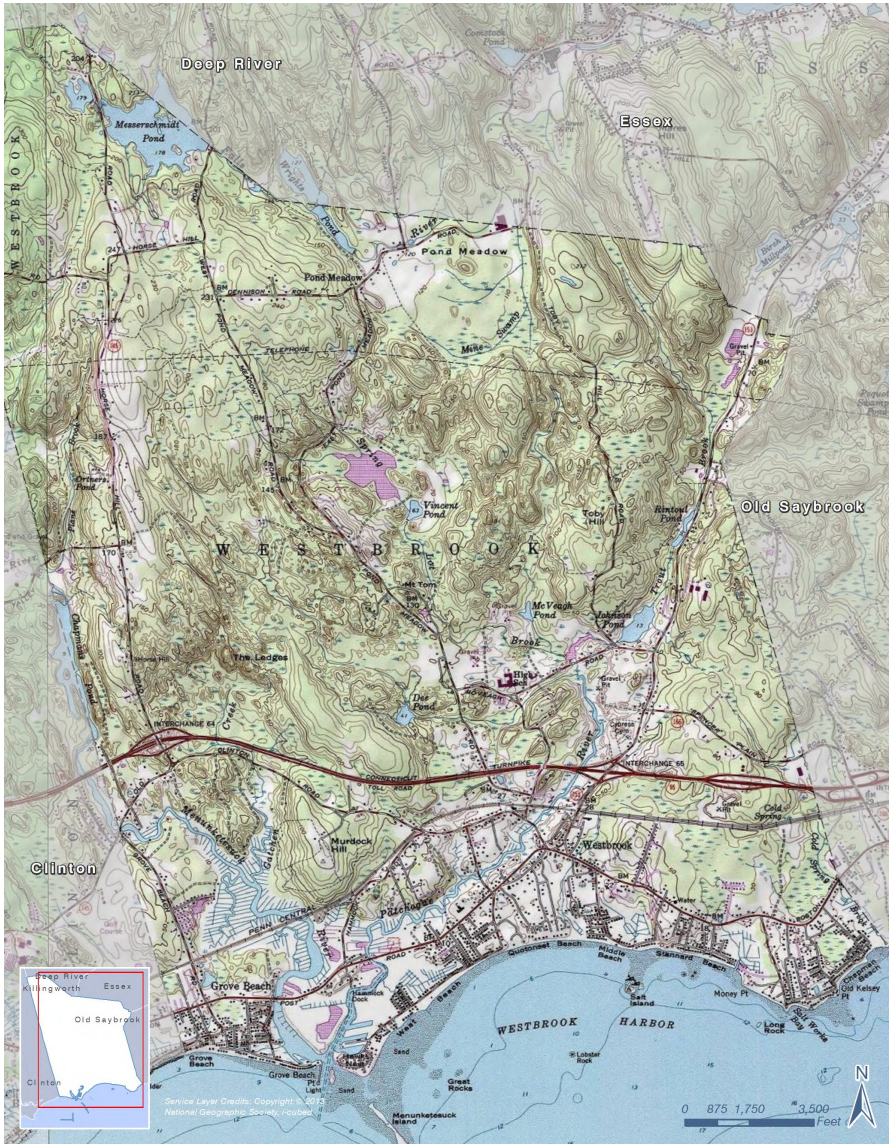


Figure 1: Westbrook Site Locus & Town Limits

Community Profile Snapshot:

Per the 2010 United States Census and 2013-2017 American Community Survey (ACS) (https://www.census.gov/quickfacts/oldsaybrooktownmiddlesexcountyconnecticut):

Age and Sex:

Population:	6,956
Population change since 2000:	+10.6%
Percent female/male:	49.9%/50.1%
Age:	
persons <5 years:	188
persons <18 years:	890
persons ≥ 65 years:	1,488

Race:

White alone:	94.7%
Black or African Amer. alone:	1.0%
American Indian and Alaska Native	0%
Asian alone:	0.2%
Two or more races:	1.5%
Hispanic or Latino:	4.6%

Health:

With disability, under 65 years:	10.2%
Persons w/o health insurance, under 65 years:	8.8%

Education:

High school graduate or higher, greater 25 years:	91%
Bachelor's degree or higher, greater 25 years:	42.6%

Economy:

In civilian labor force, total, greater 16 years+:	66.9%
In civilian labor force, female, greater 16 years:	64.7%

Income and Poverty:

Median household income:	$95,583
Per capita income:	$58,608
Persons in poverty:	7.8%

Family and Living Arrangements:

Households (ACS 2013 to 2017):	2,873
Persons per Household:	2.37
Language spoken at home other than English, greater than 5 years:	9.8%

Housing:

Median house cost:	$378,900
Median gross rent:	$2,117/month
Percent owner-occupied:	77.1%

Population Density:

439.6/sq. mile

Social Vulnerability Index:

Westbrook's Overall Social Vulnerability: medium with no Social Vulnerability Flags.

Community Profile Snapshot:

Building Stock: 3,913 Buildings

- 72.2% Residential (building exposure: $923.2M)
- 17.94% Commercial (building exposure: $229.3M)
- 5.7% Industrial (building exposure: $72.9M)
- 4.14% Agricultural/Religion/Government/Education (building exposure: $45.2M)
- Total building exposure: $1.28B (2014 Dollars) (see **Attachment 4** for more details)

Support, High Occupancy and Vulnerable Population Facilities:

- 32 Facilities including but not limited to Daycare, Assisted Living, Nursing Homes, Schools, Community Centers, Religious Institutions, Primary Care, Gas Stations, Hotels, Town Administration Buildings

Land Use:

- 27 % Residential
- 7 % Business (i.e., commercial/industrial)
- 19 % Open Space/Agriculture
- 5% Town Land/Institutional
- 6% Transportation
- 36% Vacant/Undeveloped Land

Zoning & Districts:

- Residential: High Density Residential; Low Density Residential; Medium Density Residential; Planned Residential; Rural Residential
- Commercial: Commercial Boating; Commercial; Commercial Town Center; Neighborhood Commercial
- Coastal Conservation
- Housing Opportunity
- Industrial
- Light Industrial
- Turnpike Interchange

Future Development:

- 1,163 Potential New Single-Family Units
    - New Units on New Lots would primarily be north of I-95
- 398 Conversion of Restricted Seasonal Units

Historic Districts:

- 24 properties on the State Register of Historic Properties
- 1 historic district (Westbrook Town Center Historic District) and 4 properties on National Register of Historic Places

Transportation Infrastructure:

- 16.87 miles of State Roads
- 45.86 miles of Town Roads
- 13 Bridges
- Regional and Amtrak Rail

Essential Facilities:

- 1 Emergency Management Facility
- 2 Healthcare Facilities
- 2 Police Facilities (1 local, 1 state)
- 3 Fire and Rescue Facilities
- 1 Designated Shelter
- 1 Back-up Shelter

Lifeline Systems:

- Town Water Supply System (Connecticut Water Company, Guilford Water System (wells and reservoirs), Individual wells)
- Sanitary Wastewater Treatment (All On-Site Sewage Disposal Systems)
- Electricity (Eversource)
- Natural Gas (Mid-State Mechanical)
- Telecommunications (Comcast and Verizon)
- Separate Stormwater and Sanitary Infrastructure

Hazardous Materials:

- 6 HazMat Category IV Facilities

High Potential Loss Facilities:

- 3 Dams

Natural Resources:

- Local watersheds (Patchogue River, Menunketesuck River, South Central Shoreline, Oyster River and Falls River)
- Wildlife Areas (Stewart B. McKinney and Salt Meadow National Wildlife Areas)

Section 4: Natural Hazard Risk

SECTION 4 - NATURAL HAZARD RISK OVERVIEW

A Natural Hazard Risk Assessment was conducted by GZA to evaluate the potential consequences of natural hazards to the people, economy, and built and natural environments of the Town of Westbrook. The FEMA Multi-Hazard HAZUS-MH program was used to evaluate economic losses due to seismic, flood and hurricane hazards. The HAZUS-MH simulation results are presented in **Attachment 4**. The hazards were ranked (on a scale with 1 being the top ranking and 9 the lowest) using a scoring system based on the likelihood/frequency, severity/magnitude, and potential impact area (see **Table 1**). Each hazard category was provided a score based on the criteria shown in **Attachment 3**. For each hazard, the product of the points from each category was determined and the hazards ranked from highest value to lowest. The details of the risk assessment and how the hazards were ranked are presented in **Attachments 2 and 3.** The top ranked hazards include:

- Flooding due to Coastal Storm Surge

  The extent of coastal storm surge impacts a large area of shoreline and low-lying areas of Town south of Interstate 95, making it the top-ranked hazard due to: 1) impacts to Town Hall; 2) impacts to transportation infrastructure, including Route 1 and bridges with lower deck elevations; 3) impacts to the lifeline systems including on-site wastewater management system 4) impacts to Marinas and beach Associations 5) impacts to natural resources including the inland tidal marshes along the Patchogue and Menunketesuck Rivers and beaches. Extensive damage to the Transportation Infrastructure would result in significant impacts to residents due to loss of access to key roadways and loss of emergency response services (at least temporarily) to some areas of town due to impassable roadways. It would also result in economic impact including effecting the Town's municipal bond rating.

- Sea Level Rise

  Sea level rise is the 2nd ranked hazard due to the increasing extent and depth of flooding, as well as the worsening effects of waves resulting principally to rising sea levels. This will in turn result in greater impacts to even larger extents of shoreline and increasing the vulnerability of major transportation, essential facilities, lifeline systems, residential and commercial properties as well as increasing the size of regularly flooded marshes while further eroding the beaches.

- Hurricanes/Tropical Storms

  Severe wind, and related damages during hurricanes is ranked third due to its relatively high probability of occurrence, its coincidence with coastal flooding and its potential for wide-spread damage. In particular, a hurricane strike at or near Westbrook with a 1% probability of occurrence (100-year recurrence interval) would be catastrophic (similar to the 1938 and 1954 hurricanes). In addition to high winds, hurricanes will also create large storm surges and waves and heavy rainfall.

Severe Weather Hazards:	**Rank**
Severe Wind:	
Hurricanes/Tropical Storms	**3**
Thunderstorms	6
Tornadoes	5
Lightning	8
Intense Rainfall	5
Hail	7
Flood:	
Storm Surge	**1**
Sea Level Rise	**2**
Urban Drainage Flooding	5
Riverine Flooding	5
Severe Winter Weather:	
Snowfall	4
Ice Storms	6
Climate-Related Hazards:	
Extreme Temperature:	
Heat	8
Cold	8
Drought	7
Wildfire	9
Geologic Hazards:	
Earthquake	7
Landslides	0
Tsunami	0
Secondary Hazard:	
Dam Failure	**4**

Table 1: Westbrook Natural Hazard Ranking based on the hazard frequency of occurrence, severity and extent of impact area.

SECTION 4 - NATURAL HAZARD RISK OVERVIEW

Table 2 presents a summary of the predicted hazard likelihood of occurrence/frequency, severity/magnitude and impact area for each natural hazard that is relevant to Westbrook. The hazard probability of occurrence (frequency) is characterized as:

Frequency:

Very Low: Events that occur less frequently than once in 1,000 years (less than 0.1% per year).

Low: Events that occur from once in 100 years to once in 1,000 years (0.1% to 1% per year)

Medium: Events that occur from once in 10 years to once in 100 years (1% to 10% per year).

High: Events that occur more frequently than once in 10 years (greater than 10% per year).

The hazard impact in part is characterized as follows:

Severity:

Minor: Limited and scattered property damage; no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e., 1 or 2 communities); essential services (utilities, hospitals, schools, etc.) not interrupted; no injuries or fatalities.

Serious: Scattered major property damage (more than 50% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services are briefly interrupted; some injuries and/or fatalities.

Extensive: Consistent major property damage; major damage to public infrastructure (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and fatalities.

Catastrophic: Property and public infrastructure destroyed; essential services stopped, thousands of injuries and fatalities.

Climate change will have an effect on Severe Weather Hazards and Climate-Related Hazards. **Table 3** compares key components of Westbrook's climate today to changes predicted by the year 2050. The impact of certain climate change effects on the Town such as sea level rise and coastal flooding are predictable. The impact of other effects such as the increase in the frequency and duration of Heat Waves are less predictable. However, these Climate-Related hazards are predicted to become a high priority for Westbrook over the next decade.

Natural Hazard	Likelihood/Frequency	Severity/Magnitude	Impact Area
SEVERE WEATHER HAZARDS			
Severe Wind: Hurricanes/Tropical Storms/ Nor'easters	• High Wind Warning (>40mph): +/- 100% AEP (1-year recurrence interval); **High** • Hurricane Wind Warning (>74mph): 1% AEP (100-year recurrence interval); **Medium to Low** • Extreme Wind Warning (>115 mph) <0.2% AEP (>500-year recurrence interval); **Very Low**	Minor Extensive Catastrophic	Town-wide
Thunderstorms (wind >58 mph)	• Within Middlesex County: 56% AEP or minimum of 1-year to 2-year recurrence interval (29 years with 1 or more events over 52 years); Probability of occurrence within Westbrook is likely lower; **Medium to High**	Minor	Town-wide or portions of Town
Tornadoes	• Tornadoes within Middlesex County: 12% AEP or 8-year recurrence interval (8 years with 1 or more events over 68 years); **Medium** • Major tornado within Middlesex County: 1.5% AEP or 70-year recurrence interval; **Low** • Based on the proportional land area, the Westbrook tornado AEP is about 0.2% and the Westbrook major tornado AEP is very low (less	Serious to Catastrophic	Town-wide or portions of Town
Lightning	• Events resulting in fatality, injury and/or damage within Middlesex County: 38% AEP or 3-year recurrence interval; **High** • Within Westbrook: 5% AEP or 20-year recurrence interval); **Medium to High**	Minor (fatality risk is very low)	Town-wide or portions of Town
Intense Rainfall	• 4% AEP or 25-year recurrence; **High**	Minor Major (potential impacts to 3	Town-wide or portions of Town
Hail (≥ 3/4 inch)	• 31% AEP or 3-year recurrence interval (17 years with 1 or more events over 55 years); Probability of occurrence within Westbrook is likely low-	Minor to Serious	Town-wide or portions of Town

Table 2: Westbrook Natural Hazard Overview

Natural Hazard	Likelihood/Frequency	Severity/Magnitude	Impact Area
SEVERE WEATHER HAZARDS			
Flooding:			
Coastal Flooding			
	• Stillwater elevation (SWEL) = 5.6 feet NAVD88: 10% AEP (10-year recurrence interval); **Medium**	Minor to Serious	Portions of Town
	• Stillwater elevation (SWEL) = 7.7 feet NAVD88: 2% AEP (50-year recurrence interval); **Medium to Low**	Serious	
	• Stillwater elevation (SWEL) = 9.2 feet NAVD88: 1% AEP (100-year recurrence interval); **Low**	Serious to Catastrophic (2% of buildings)	Town-wide south of I-95
	• Stillwater elevation (SWEL) = 14.9 feet NAVD88: 0.2% AEP (500-year recurrence interval); **Very Low**	Catastrophic (3.5% of buildings including the Police Station, several 100s of on-site septic systems)	Town-wide south of I-95
Urban Flooding			Town-wide or portions of Town
	• 4% AEP or 25-year recurrence; **High**	Minor to Serious	

Town impact due to coastal flooding:

- 73 buildings are predicted to be impacted during to the 1% AEP flood. This number represents 2% of the total number of Westbrook buildings.
- 136 buildings are predicted to be impacted during to the 0.2% AEP flood. This number represents 3.5% of the total number of Westbrook buildings.
- No Lifeline Systems are predicted to be impacted during to the 1% AEP flood.
- 1 Lifeline Systems (1 Fire Police Station) is predicted to be impacted during to the .2% AEP flood.
- 60+ of Town/State Roads impacted. Large Sections of Route 1 during floods of <1% AEP (>100-year recurrence interval).
- Several Town Commercial Boating, High-Density Residential, Medium Density Residential, and Neighborhood Commercial districts and neighborhoods impacted during to the 1% AEP and 0.2% AEP flood including the low-lying residences located within the 17 beach associations and Town Beach.
- Widespread impacts to on-site septic systems during to the 1% AEP and 0.2% AEP flood.

Table 2 cont.: Westbrook Natural Hazard Overview

Natural Hazard	Likelihood/Frequency	Severity/Magnitude	Impact Area
SEVERE WEATHER HAZARDS			
Severe Winter Weather:			
Snowfall	• 86% AEP or 1-year recurrence interval Heavy Snowfall; **High**	Minor to serious	Town-wide
Ice Storms	• The data indicate that the probability of Ice Storms at and near Westbrook is low. Available data is insufficient to estimate probabilities. **Medium to Low**	Minor to serious	Town-wide or portions of Town

Town snowfall estimates (upper bound monthly snowfall estimates)*:

- 8 to 10 snow days per year
- Average annual snowfall of 26 inches
- 90% AEP or 1 year recurrence interval Heavy Snowfall (19 years with 1 or more events over 22 year record)
- Reasonable estimate of average monthly snowfall: 6 to 8 inches
- Reasonably conservative monthly snowfall upper bound: 40 inches (maximum monthly upper bound of 60 inches)

* Used data from the Groton/New London, CT National Weather Service (NWS) local forecast office which is the nearest office to Westbrook with relevant historical data.

Table 2 cont.: Westbrook Natural Hazard Overview

Natural Hazard	Likelihood/Frequency	Severity/Magnitude	Impact Area
CLIMATE-RELATED HAZARDS			
Extreme Temperatures:			
Heat	• Excessive Heat (multi-day period with higher than normal Heat Index) near Westbrook (Middlesex County): 30% AEP or 1 event every 3 years. **Medium**	Minor to Serious (in particular for more vulnerable populations)	Town-wide
Cold	• Available data is insufficient to estimate probabilities. **Assumed Medium**	Minor	Town-wide
Drought	• Drought Warnings are expected in the Connecticut Drought Southeast Region which includes Westbrook 5% to 10% AEP or 15 to 20-year recurrence interval; **Low** to **Medium** • Connecticut experiences extended, multi-year droughts about every 25 years; **Low** to **Medium**	Minor (due to limited agricultural economy in Town; could be Serious if affects Town Water Supply)	Town-wide
Wildfire	• The historical data indicates that the probability of wildfire within Westbrook is low. Quantitative probabilities of occurrence are not available. **Low**	Minor	20% of Town area is open space and forest

Town climate considerations:

Periods of colder temperatures occur at Westbrook and can cause wind chill conditions. Wind chill conditions example:

- 0° F and 25 mph sustained wind speeds, 30-minute exposure
- 5° F and 55 mph sustained wind speeds, 30-minute exposure

The severity and magnitude of extreme heat events at Westbrook is, in part, dependent upon: 1) demographics; and 2) the capability of residents to get cool (e.g. air conditioners in homes). Westbrook's demographic data indicates that about 32% of the population may be at a greater than average vulnerability as outlined below.

- 21% of Westbrook's population is older than 65 years
- 3% of Westbrook's population is less than 5 years
- 8% of Westbrook's population is at the poverty level

Table 2 cont.: Westbrook Natural Hazard Overview

Natural Hazard	Likelihood/Frequency	Severity/Magnitude	Impact Area
GEOLOGIC HAZARDS			
Earthquake	• 2% in 50 years PGA (2,500-year recurrence interval; Maximum Considered Earthquake) in the vicinity of Westbrook is 0.13g **Very Low**	Serious	Town-wide
	• 10% in 50 years PGA (500-year recurrence interval) in the vicinity of Westbrook is 0.03g **Very Low**	Minor	Town-wide
Landslide	Landslide conditions do nor exist within the Town. Local areas of shoreline bluff may experience sloughing or slope stability failure due to coastal erosion. **Low to Medium (only local shoreline bluff failures)**	Minor	Town-wide
Tsunami	The probability of a significant tsunami affecting Westbrook is **Very Low.***	Minor to Catastrophic	Town-wide

*2019 Connecticut Natural Hazards Mitigation Plan Update excluded Tsunami from the State's list of natural hazards due to their low probability of occurrence.

About earthquakes and tsunamis at Westbrook:

1. The direct earthquake risk to Westbrook is due to the ground motion that results during the earthquake. The Seismic Design Category for the majority of Westbrook is A or B indicating a low seismic hazard. The 10% in 50 years (500-year recurrence interval) ground motion would be experienced as light to moderate perceived shaking and none to very light damage. The 2% in 50 years (2,500-year recurrence interval) ground motion would be experienced as very strong perceived shaking and moderate damage. Based on HAZUS-MH simulations of Westbrook, Add# buildings are predicted to experience damage, ranging from slight to complete, from the 2,500-year (2% in 50 years) recurrence interval earthquake. The estimated economic losses are about $Add# million for the 2,500-year event.
2. Given its coastal setting, there is some risk of a tsunami reaching Westbrook. However, the risk of a significant tsunami is generally believed to be very low. There are two primary tsunami sources that could affect the Southern New England coast: 1) a tsunami generated by an earthquake along the Puerto Rican trench (located in the Caribbean); and 2) a slope failure of the continental shelf off of New England (likely to an earthquake). A landslide of the Cumbre Viejo in the Azores is also a potential New England tsunami source. If these occurred, and a tsunami reached Long Island Sound area, it would have to propagate as a tidal bore within Long Island Sound to reach Westbrook, further reducing Westbrook's risk.

Table 2 cont.: Westbrook Natural Hazard Overview

Climate Change and Westbrook

Westbrook Climate Today	Westbrook Climate 2050
Temperature: The average temperature is about 60°F. • The average low temperature in Winter (December, January and February) ranges from 22°F to 32°F, with the coldest temperature occurring during January. • The average high temperature in Summer (July and August) ranges from 80°F to 81°F, with the coldest temperature occurring during January. • Days above 90°F (based on state-wide data): 7 days • Heat Index above 105°F(based on state-wide data): 5 to 8 (lower in Westbrook - about 1 event every 3 years)	Temperature: The average temperature could be between 2°F and 8°F higher than today. • Average Summer temperature (based on state-wide data): could be between 2°F and 8°F higher than today. • Days above 90°F (based on state-wide data): 20 to 40 days • Heat Index above 105°F(based on state-wide data): 14 (lower in Westbrook, but still expected to increase relative to today to at least 1 event per year) • Spring will arrive sooner, summers will grow hotter, and the weather will becoming more extreme with swings between above-average winter temperatures to extreme cold with large snowfall events.
Intense Precipitation: • The 25-year recurrence interval, 24-hour rainfall at Westbrook: 6.35 inches	Intense Precipitation: Within the Northeast U.S., from 1996 to 2014, the amount on intense rainfall (heaviest 1% of all daily events) was about 50% higher than the period of 1901 to 1995. The frequency and intensity of intense rainfall is expected to increase.
Sea Levels and Coastal Flooding: • 10% AEP Flood Stillwater Elevation: 5.6 feet NAVD88 • 2% AEP Flood Stillwater Elevation: 7.7 feet NAVD88 • 1% AEP Flood Stillwater Elevation: 9.2 feet NAVD88 • 0.2% AEP Flood Stillwater Elevation: 14.9 feet NAVD88	Sea Levels and Coastal Flooding: There is very high confidence that sea levels near Westbrook will increase by about 1 foot by the year 2050 (relative to the year 2000). A reasonable mid-range planning bound is 1.7 feet (relative to the year 2000). Assuming 1.7 feet increase: • 10% AEP Flood Stillwater Elevation: 7.3 feet NAVD88 • 2% AEP Flood Stillwater Elevation: 9.4 feet NAVD88 • 1% AEP Flood Stillwater Elevation: 10.9 feet NAVD88 • 0.2% AEP Flood Stillwater Elevation: 16.6 feet NAVD88

Table 3: Climate Change Westbrook

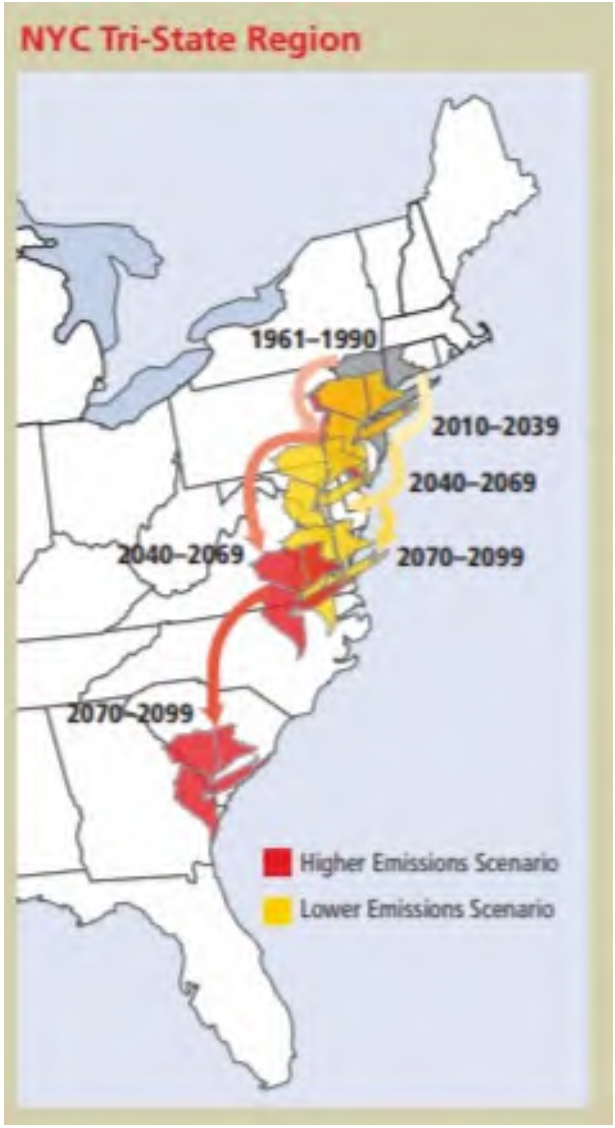


Figure 2: Latitudinal Changes in Regional Climate (source Union of Concerned Scientists)

Section 5: Natural Hazard Mitigation Strategies

SECTION 5 - NATURAL HAZARD MITIGATION STRATEGY

The Westbrook Local Planning Team (LPT) prepared an updated mitigation strategy to reduce the potential losses identified in the risk assessment (see **Section 4** and **Attachment 3**) based on the Town's existing mitigation capabilities and ability to improve these capabilities in the future. This updated strategy serves as a roadmap for the next 5 years that builds upon the natural hazard mitigation related work carried out over the last five years based on the 2014 HMP Update. This strategy includes the following four elements as per 44 Code of Federal Regulations (CFR) part 201.6:

1. Hazard Risk Mitigation Goals
2. Hazard Mitigation Implementation and Progress
3. Existing Hazard Mitigation Capabilities
4. Hazard Risk Mitigation Measures/Actions

In the 2014 HMP Update existing capabilities and actions included in elements 3 and 4 above were combined into a single comprehensive table (Figure 29). To better differentiate between these complimentary elements, this Plan Update present elements 3 and 4 as separate tables relative to the type of natural and climate related hazard. It is important to note that a majority of the new measures and actions outlined in this HMP Update focus on the highest ranked hazards due to the potential impacts these hazards may have on the Town.

1. HAZARD RISK MITIGATION GOALS

The Westbrook Local Planning Team (LPT) met on September 13, 2019 to review proposed hazard mitigation goals. In consideration of the State of Connecticut's 2019 Plan Update and feedback provided by the LPT and Planning Commission, the LPT endorsed the following five goals for this Plan Update.

Mitigation Goals

1. Promote reduction or elimination of injury to or loss of life and property, loss of natural environments, the associated economic impacts from natural hazards
2. Promote implementation of sound floodplain management and other natural hazard mitigation principles on a local and regional level
3. Implement effective hazard mitigation projects on a local and regional level.
4. Increase research and planning activities for the mitigation of natural hazards on a local and regional level.
5. Increase and promote response preparedness

2. HAZARD MITIGATION IMPLEMENTATION AND PROGRESS

The Westbrook LPT met on September 13, 2019 to document the progress made by the Town over the last 5 years based on the actions outlined in the 2014 HMP Update. Based on the input provided by members of the LPT, the team identified the following progress based on the Figure 29 outlined in the 2014 HMP Update (see http://www.rivercog.org/NHMP/NHMP_FINAL_AdoptedWB082814.pdf). It is important to note that many of the following items continue to be ongoing activities which are included as existing capabilities presented in **Table 4** and as measures/actions in **Table 5.**

Natural Hazard Mitigation Plan Implementation, Maintenance & Review

ANNUAL REVIEW OF MITIGATION EFFORTS & PLAN IMPLEMENTATION: The Town's lead agencies reported on implementation of the Plan each year and integrated updates into its annual reports.

5-YEAR REVIEW & UPDATE NATURAL HAZARD MITIGATION PLAN: The Town started the update process in December of 2018.

CAPITAL IMPROVEMENT PROGRAM: Participated in annual updates to the 5-year capital improvement programs at the State, Regional and municipal levels that resulted in funding hazard mitigation actions;

BENEFIT-COST ANALYSIS & GRANTS: Evaluated opportunities for public funding of mitigation projects where public benefits exceed costs, but did not apply for public grant opportunities.

Planning & Regulatory Standards

LAND USE REGULATIONS: Maintained, and strengthened (as needed), subdivision and zoning regulations to make safer new roads, lots and structures to natural hazards (NHs) such as flooding, wind-related hazards, etc.

FLOODPLAIN MANAGEMENT & ENFROCEMENT: Continued to ensure that all new construction or substantial improvements meet or exceed NFIP requirements. Enforced flood proof construction standards.

ROAD STANDARDS: Updated existing road standards to reflect current best management practices for low impact development and amended subdivision regulations accordingly.

BUIDLING STANDARDS: Implemented State Building/Fire Code and local Flood Code for construction that minimizes loss of life and property damage due to Natural Hazards including mandatory wind code compliance (as outlined below).

MANDATORY WIND CODE COMPLIANCE: Ensured all building permit applicants construct their projects to meet 110 mile per hour wind load standard per the State Building Code.

HAZARD MITIGATION IIMPLEMENTATION AND PROGRESS (cont.)

STORMWATER MANAGEMENT: Required land use permitting within new and redeveloping areas that require stormwater retention as appropriate to avoid downstream impacts.

STORMWATER MANAGEMENT: Maintained stormwater infrastructure (annually).

COASTAL AREA MANAGEMENT: Evaluated all land use proposals within the Coastal Boundary for consistency with the relevant policies and standards of the CT Coastal Management Act in accordance with CGS 22a-90 through 22a-112.

UNDERGROUND UTILITIES: Require underground utilities for new development; require retrofitting during redevelopment of existing sites to bury utilities where appropriate to mitigate NHs.

PUBLIC UTILITIES: Limit extension of public utilities that would encourage new development in areas vulnerable to natural hazards.

ZONES CHANGES: Discourage zone changes that allow greater intensity or density of use in areas vulnerable to natural hazards.

Information Systems, Data Management & Analysis

GEOGRAPHIC INFORMATION SYSTEM: Updated the information for risk assessment in this Plan Update to better identify and assess areas, structures and populations potentially affected by natural disasters. Updates made based on updates made annually over the last 5 years to the Town's GIS Data.

RISK ASSESSMENT: Updated the information for risk assessment based on additional natural and climate related hazards as a part of this Plan Update.

ASSET MANAGEMENT: Completed an inventory of storm water catch basins and outfalls in the MS4 area as a part of the asset management program to facilitate maintenance of stormwater systems, develop estimates for upgrades and assess repair costs in the event of damage from NHs.

ELECTRONIC RECORDS PRESERVATION: Converted paper records maintained by the Land Use Dept. to an electronic format, consistent with any State recommendations, to ensure their survival. Established protocols for practices going-forward including back-up of existing electronic records in another location.

PERMIT TRACKING SYSTEM: Upgraded existing system to enable collection of data regarding development activities in Flood Hazard Areas.

STRUCTURAL REPORTS: Required structural engineering reports for expansion or alteration of buildings within the V zone from 2014 to 2019.

SPECIAL ASSISTANCE REGISTRY: Continue to maintain registry of individuals that may have unique vulnerabilities or be less able to respond and recover during a disaster utilizing the best available technology. Create Maps for use by emergency responders.

Natural Systems Protection Improvements

RIPARIAN BUFFERS: Promoted the implementation of riparian buffers for existing and new waterfront development utilizing the Coastal Riparian Landscaping Guide for Long Island Sound http://clear.uconn.edu/crlg.

AQUIFER RECHARGE: Continued to protect areas of high groundwater recharge potential as identified in the Recharge Mapping Study conducted by Wesleyan through open space acquisition and minimization of impervious surfaces.

Physical & Infrastructure Improvements

STORMWATER INFRASTRUCUTURE: The Town cleaned the catch basins on an annual basis.

EMERGENCY GENERATORS: Assess the adequacy of emergency generators in all critical facilities including private telecommunication towers. Make upgrades as necessary.

ROAD EVALUATION: Evaluated the 1) Old Mail Trail, Grove Beach Rd. S, Riverview, Menunketesuck, Elm Ave. and 2) Winthrop Bridge over Falls River to develop plans for improvement or elevation for emergency access and evacuation in flood conditions.

WINTHROP RD. BRDIGE REPLACEMENT: Completed the replacement of the Winthrop Rd. Bridge in 2017.

HAZARD MITIGATION IIMPLEMENTATION AND PROGRESS (cont.)

GROVE BEACH RD. S DRAINAGE SWALE IMPROVEMENT: completed Survey work & preliminary discussions with CTDEEP for planned improvement.

Public Information and Outreach

OEM WEBPAGE/FACEBOOK: Continued to maintain and update the OEM website and Facebook page with Natural Hazard Preparedness & Recovery Information.

INCIDENT NOTIFICATION SYSTEM: & HOTLINE: The Town participates in Connecticut's CT Alert ENS (Emergency Notification System), which is contracted through Everbridge.

COUNCIL OF BEACHES: The Town engaged the Council of Beaches to participate in developing and implementing hazard mitigation recommendations.

REPETITIVE LOSS PROPERTIES: The Town encouraged repetitive loss property owners to obtain assistance from DEEP and FEMA to acquire hazard mitigation funds to elevate structures where appropriate.

ON-LINE MAPPING: The Town continued to publicize the availability of GIS hazard mapping on the town website.

VULNERABLE POPULATION OUTREACH: The Town continued to reach out through Visiting Nurses Association and Social Services to provide individual instruction on emergency preparedness to vulnerable populations.

WATER CONSERVATION: The Town coordinated with the Connecticut Water Company (CWC) on public education and public service announcements during droughts.

Actions to Reduce Risk and Minimize Impacts During NH Events

NATURAL HAZARD MITIGATION TRAINING: The Town continued to rain and educate emergency responders about mitigating NHs.

FIREFIGHTER TRAINING AND EDUCATION: The Westbrook Fire Department completed annual training and education of firefighters for brush and forest fires, with consideration for large areas of phragmites.

GROUP HOMES DISASTER PLANS: Westbrook continued to work with Group Homes and other facilities housing populations with unique vulnerabilities to enhance Disaster Plans.

PUBLIC TRANSIT FUNDING: Westbrook continued to support regional transportation district (RTD) to facilitate movement of people without means of transportation prior to NH events.

SEPTIC SYSTEMS**:** Westbrook continued to design and install septic systems within flood zones in a manner that avoids impairment or contamination during flooding.

3. EXISITING HAZARD MITIGATION CAPABILITIES

Westbrook has an organization structure in-place to plan for and respond to natural disasters (see Key Contacts in **Attachment 8**). **Table 4** presented on the following pages summarizes an updated overview of the existing natural hazard mitigation capabilities already in place in Westbrook. In addition to the mitigation capabilities outlined in the 2014 Plan Update, **Table 4** includes additional capabilities developed by the Town since the last update. Because of the number of existing public and private entities involved in natural hazard mitigation, the LPT used this list as a catalyst for preparing a more comprehensive inventory of future mitigation capabilities over the next five years.

EXISTING MITIGATION CAPABILITIES	STATUS	SCHEDULE	COSTS	PRIORITY	RESPONSIBLE AGENCIES	POSSIBLE FUNDING SOURCE
GENERAL MULTIPLE HAZARDS						
Design/Building Standards (i.e. Enforcement of State Building and Fire Codes): Continue to implement State Building/Fire Code and local Flood Code for construction that minimizes loss of life and property damage due to Natural and Climate-related hazards. The 2018 Connecticut State Building Code contains many detailed regulations regarding wind loads, earthquake resistant design, flood resistant design, flood-proofing and snow loads.	Reviewed annually, changes made as necessary	Daily;	Low	High	Westbrook Board of Selectmen and Finance (BOS/BOF), Planning Commission (PC), Zoning Commission (ZC), Land Use Department (LUD), Department of Public Works (DPW), Department of Public Health (DPH), Town Engineer (TE), Building Official (BO)	Westbrook Operating Budgets (OBs) and Other Programs (OPs)
Local Emergency Operations Plan: Every community in Connecticut is required to have a Local Emergency Operations Plan (LEOP) as per Connecticut General Statutes Section 28-7 (a). These plans address mitigation, preparedness, response and recovery from a variety of natural and man-made emergencies. These plans contain important information regarding flooding, dam failures and winter storms. In addition, these plans include details on the Town's mutual aid agreements with other communities as well as the Regional Emergency Support Plan (RESP) and State Response Framework (SRF). Therefore, the LEOP is a mitigation measure that is relevant to many of the hazards discussed in this plan. The LEOP is available online through secure access for town personnel.	Reviewed annually, changes made as necessary	Daily	Low	High	Westbrook Emergency Management (EM)	Westbrook OB and OPs FEMA Emergency Management Grant Program (EMPG) Connecticut Department of Emergency Management & Homeland Security (DEMHS)
Land Use Regulations: Subdivision and Zoning Regulations: Site Plan Review. Town permitting agencies and public officials should assist businesses, through the site plan review process, to plan for, adapt to and mitigate against future SLR and climate change impacts.	Reviewed annually, changes made as necessary	Daily	Low	High	BOS/BOF, PC , ZC, LUD, DPW, TE	Westbrook OBs and OPs
OEM Website/Facebook: Maintain Town website with updated with NH preparedness and recovery information and assistance	Reviewed and updated before and after major hazard events.	As needed	Low	High	OEM	Westbrook OB and Capital Improvement Programs (CIPs)

Table 4: Existing Hazard Mitigation Capabilities

EXISTING MITIGATION CAPABILITIES	STATUS	SCHEDULE	COSTS	PRIORITY	RESPONSIBLE AGENCIES	POSSIBLE FUNDING SOURCE
GENERAL MULTIPLE HAZARDS (cont.)						
Centralized Public Safety Dispatch/CT Alert Emergency Notification System (ENS): The Town utilizes joint communications and dispatch for public safety. The Town participates in Connecticut's CT Alert ENS (Emergency Notification System), which is contracted through Everbridge.	Active	Daily	Low	High	RTSD, FD and OEM	OB FEMA EMPG DEMHS
Emergency Generators: The Town has invested in backup emergency generators that are in place at Town Hall, EOC, 2 Fire Stations, 3 schools and the Department of Public Works. These generators give the town the ability to sustain operations during the event of an emergency.	On-site at public safety facilities	As needed during power outages; tested monthly	Low	High	FD, OEM, Town Hall Facilities, Schools, Library and DPW	OB FEMA EMPG DEMHS
Public Transit Funding: Support regional transportation district (RTD) to facilitate movement of people without means of transportation prior to NH events.	Town currently contributed to 9TT System funding	Ongoing	Low to Medium	High	BOS/BOF, OEM	CIP Regional Transportation Program (RTP) Statewide Transportation Improvement Project (STIP)
Portable Water Pumps: Rivers and ponds in town are available to be tapped into if necessary for fire -fighting support.		As needed	Low	Medium	FD	Westbrook OB FEMA EMPG DEMHS
FEMA Resources: A tanker task force is available through State Fire mobilization. FEMA has 8-12 tankers that can be deployed anywhere in the US within 72 hours.		As needed	Low	High	EM, FD	DEMHS FEMA
Group Homes Permitting: Future permitting of these facilities shall include the requirement for the preparation of a disaster plan tailored to the needs of the specific clientele, or location of these facilities shall be discouraged in areas of known natural hazards.	Reviewed annually, changes made as necessary	Daily;	Low	Medium	ZC	OB
Geographic Information System: Maintain a comprehensive GIS Database of Town assets to assist in assessing the natural and climate related hazard risks in the Town.	Ongoing	Data reviewed annually and updated as needed	Low	Medium to High	Assessor's Office	OB
Electronic and Paper Records Preservation: Maintain electronic database and multiple back-up servers for preserving electronic files. Convert remaining paper records into electronic format consistent with state recommendations	Ongoing		Low	Medium	BOS and all Town Departments	OB

Table 4: Existing Hazard Mitigation Capabilities

EXISTING MITIGATION CAPABILITIES	STATUS	SCHEDULE	COSTS	PRIORITY	RESPONSIBLE AGENCIES	POSSIBLE FUNDING SOURCE
FLOOD RELATED HAZARDS						
Participation in the National Flood Insurance Program (NFIP): Westbrook participates in the NFIP. The NFIP aims to reduce the impact of flooding on private and public structures. It does so by providing affordable insurance to property owners, renters and businesses and by encouraging communities to adopt and enforce floodplain management regulations. These efforts help mitigate the effects of flooding on new and improved structures. Overall, the NFIP reduces the socio-economic impact of disasters by promoting the purchase and retention of general risk insurance, but also of flood insurance, specifically. The NFIP provides grant funding to reduce &/or eliminate flood hazards impacts.	NFIP Participating community.	Daily	Low	High	PC and BOS	OB
Emergency Action Plan (s) (EAP): Emergency Action Plans (EAPs) are required for High Hazard Class "C" and Significant Hazard Class "B" dams. The three dams in Westbrook that must meet this requirement includes 1) Chapman Pond Dam, 2) Wrights Pond Dam, and 3) Messerschmidt Pond Dam. In essence an EAP establishes the guidelines and procedures for addressing emergency conditions identified at the dam in time to take mitigative action such as notifying the appropriate emergency management officials of potential, impending, or active failing of the dam.	EAP Updates in process.	Inspections required every 5 years	Low to Medium	High	Connecticut Department of Energy and Environmental Protection (CT DEEP)	CT DEEP
Design Standards (Flood Regulatory Enforcement): Enforce, through existing zoning, building and flood permitting processes, construction standards to minimize flood risks. Continue to require structural engineering reports for expansion or alteration of buildings within the V zone.	Flood standards are enforced through existing standards	Daily	Low	High	BOS/BOF, ZC, TE, BO	OB
Structural Reports: Continue to require structural engineering reports for expansion or alteration of buildings within the VE Zone.	Currently Required	Performed on a project by project basis	Low	Medium	BOS/BOF, ZC, TE, BO,	OB, OPs

Table 4: Existing Hazard Mitigation Capabilities

EXISTING MITIGATION CAPABILITIES	STATUS	SCHEDULE	COSTS	PRIORITY	RESPONSIBLE AGENCIES	POSSIBLE FUNDING SOURCE
FLOOD RELATED HAZARDS (cont.)						
Stormwater Management: Provide for annual maintenance of stormwater infrastructure, including catch basins, detention basins and outfalls. Continue 1) to implement the actions prescribed by the Town's Stormwater Management Plan (July 2017) including routine inspections and cleaning of catch basins; and 2) land use permitting that encourages storm water retention within new and redeveloping areas (rain gardens, curbless roads, etc.).	Ongoing	Catch Basins cleaned annually	Low	High	BOS/BOF, DPW	CIP
Water Quality Monitoring: Continue to meet the requirements of the NPDES and the Connecticut Public Health Code. Monitor water quality from stormwater runoff at public beaches in the town following flooding or heavy rain events.	Ongoing	Conducted following flooding events	Low	High	BOS/BOF, DPW	CIP
Street Sweeping and Leaf Removal: The Westbrook Department of Public Works conducts street sweeping annually that typically begins in April and takes four (4) to five (5) weeks.	Ongoing	Begins in April taking 4-5 weeks	Low	High	BOS/BOF, DPW	CIP
SEVERE WEATHER HAZARDS: Severe Winter Weather, Lightening and Severe Wind						
Roadway Treatments: The Town uses a combination of salt and sand to treat the roads when needed for winter storms.	Ongoing	As neeed-for winter storms	Medium	High	BOS/BOF, DPW	OB, CIP
Tree Trimming: The Westbrook Tree Warden and local electric company, Eversource (formerly the Connecticut Power & Light Company), conducts regular tree trimming. The town responds to downed tree limbs caused by winds, lightning strike reports and other weather-related incidents.	Ongoing	Performed on an annual basis, as needed	Low to Medium	High	BOS/BOF, DPW Eversource	OB, CIP Eversource
Mandatory Wind Code Compliance: Ensure all building permit applicants construct their projects to meet 110 mile per hour wind load standard per state building code.	Reviewed annually, changes made as necessary	Daily	Low	High	BOS/BOF, PC , ZC, LUD, DPW, TE	OB, OPs

Table 4: Existing Hazard Mitigation Capabilities

EXISTING MITIGATION CAPABILITIES	STATUS	SCHEDULE	COSTS	PRIORITY	RESPONSIBLE AGENCIES	POSSIBLE FUNDING SOURCE
CLIMATE-RELATED HAZARDS: Fire Related Hazards						
Permits Required for Outdoor Burning: The Town of Westbrook requires a certificate of open burning for outdoor burning of brush. The property-owner must come into the Fire Station and fill out a form to receive a certificate from the Open Burning Official. The burning of leaves is not allowed in Connecticut.	Reviewed annually, changes made as necessary	Open burning from 10am to 5pm on sunny/ partly sunny days	Low	High	Open Burning Official, Fire Marshal, RTSD	OB and Ops DEEP
Fire Hydrant Regulations: Westbrook regulates that fire hydrants be installed at all new developments at the expense of the developer. Hydrants are spaced / located as directed by the Westbrook Fire Department.	Reviewed annually, changes made as necessary	Performed daily on a project by project basis	Low	High	BOS/BOF, PC	OB and OPs
Subdivision Review: Westbrook Fire and Building Departments are involved in reviewing subdivision plans from conceptual design through occupancy to ensure that there is adequate access for fire trucks and an adequate water supply.	Reviewed annually, changes made as necessary	Daily	Low	High	BOS/BOF, PC , ZC, LUD, DPW, TE	OB OPs

Table 4: Existing Hazard Mitigation Capabilities

HAZARD RISK MITIGATION MEASURES

Development Approach

The LPT used a two-phased approach to developing hazard risk mitigation measures for this Plan Update. First, the LPT and planning consultant identified **ADD # (ADD #**) mitigation actions from Table 29 of the 2014 HMP Update for inclusion for mitigation actions as yet to be implemented. The LPT and planning consultant then organized these mitigation actions by the type of natural hazard as presented in **Table 1** of **Section 4** and consolidated 17 road evaluation mitigation actions from the 2014 HMP Update into a single mitigation action for this HMP Update. Second, the LPT and planning consultant focused the development of the new mitigation actions on the highest ranked hazards due to the potential impacts these hazards may have on the Town in the future. In preparing the new mitigation actions, the LPT and planning consultant integrated similar and complementary mitigation actions outlined in the 2014 HMP Update with new actions. The purpose of this approach was to reduce redundancies and enhance previously developed actions based on revised vulnerability assessment outlined in this Plan Update.

Prioritization

Upon identification of the mitigation actions for inclusion, the LPT and planning consultant prioritized mitigation measures based on a benefit/cost review process predicated on local knowledge of the hazard areas, cost information, timeline estimate for implementation and an assessment of benefits and costs.

The LPT evaluated various approaches for prioritizing local mitigation actions including those outlined in FEMA's March 2013 *Local Mitigation Planning* Handbook, other local plans and FEMA's STAPLEE method. The LPT developed an approach based on FEMA's March 2013 *Local Mitigation Planning Handbook (*that includes elements derived from the City of Portland Oregon's 2016 Mitigation Action Plan).

This approach utilizes a qualitative benefit/cost analysis (although less detailed than used for FEMA's Hazard Mitigation Assistance Grants Programs). The approach qualitatively rates benefit and costs in terms of: high, medium and low, as follows:

Benefits

- **High:** Action will support compliance with a legal mandate or, once completed, will have an immediate impact on the reduction of risk exposure to life and property.
- **Medium:** Once completed, action will have a long-term impact on the reduction of risk exposure to life and property, has a substantial life safety component, or project will provide an immediate reduction in the risk exposure to property.
- **Low:** Long-term benefits of the action are difficult to quantify in the short term.

Costs

- **High:** Would require an increase in revenue via an alternative source (i.e., municipal bonds, grants, fee increases) to implement. Existing funding levels are not adequate to cover the costs of the proposed project.
- **Medium:** Could budget for under existing capital budget but would require a reapportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years.
- **Low:** Possible to fund under existing budget. Project is or can be part of an existing ongoing program or would not require substantial effort to initiate or appropriate funds.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly. To support the benefit/cost review, the LPT also estimated the length of time and project costs for each mitigation action as follows:

Estimated Timeline

For actions where funding is already available the action or strategy is identified as "ongoing." Since most of the actions were identified as a part of preparing this initial plan, most do not currently have funding. Therefore, length of time for implementation of each mitigation action are based on the amount of time it would take upon receiving funding. The estimated timeframes included:

- 1-2 years,
- 3-5 years,
- 5+ years, and
- ongoing.

Estimated Cost

To support the benefit/cost review the LPT used the following estimated cost categories:

Low: Less than $50,000

Medium: Between $50,000 - $100,000

High: Over $100,000

Note: The estimated costs vary from the "Costs" included in the benefit/cost analysis in that the costs provide preliminary cost estimates in dollars of each action to assist the Town for future planning and budgeting purposes.

MITIGATION ACTION PRIORITIZATION

Based on an evaluation of the results of the benefit/cost review, the LPT prioritized each mitigation action and strategy using the following qualitative rating system of high, medium and low.

High Priority: An action that has benefits that exceed cost, has funding secured or is an ongoing project. High priority actions can be completed in the short-term or mid-term (1 to 5 years) or are projects that are long-term projects that can be initiated in the short-term and will have large positive impacts once completed.

Medium Priority: An action that has benefits that exceed costs, and for which funding has not yet been secured, but is eligible for funding. Actions can be completed in the short- or mid-term, once funding is secured, or are projects that are long-term projects that can be initiated in the short-term and will have large positive impacts once completed.

Low Priority: An action that will mitigate the risk of a hazard that has benefits that do not exceed the costs or are difficult to quantify, for which funding has not been secured, that is not eligible for grant funding, and for which the time line for completion is long-term or uncertain. Low priority actions may be eligible for grant funding from other programs that have not yet been identified. Financing is unknown, and they can be completed over the long term.

The LPT prioritized the mitigation action plan based on the results of the benefit/cost review of the proposed actions as presented in **Table 5** on the next five pages. In addition to the benefit/cost review results based on the elements outlined above, **Table 5** provides details for each action relative to the agencies responsible for leading and coordinating the implementation of each action and potential funding sources.

CODES FOR TABLE 5 (following pages):

Responsible Agencies

BO = Building Official	CRMT = Coastal Res. Mgmt. Team
BOF = Board of Finance	CIRCA = CT Inst. of Res. And Climate Adaptation
BOS = Board of Selectmen	CWC = CT Water Company
ConnDOT = CT Dept. of Transport.	DEEP = CT Dept. Energy & Env. Prot.
CC = Conservation Commission	DEMHS = CT Dept. Emer. Mgmt. & Homeland Security

CODES FOR TABLE 5 (cont.):

Potential Funding Sources

CIP = Capital Improvement Program

CDBG-DR = Community Development Block Grant (Disaster Recovery)

EMGP = Emergency Management Performance Grant

FMA = Flood Mitigation Assistance

HMGP = Hazard Mitigation Grant Program

MRGP = CIRCA Municipal Resilience Grant Program

OBs = Operating Budgets

OPs = Other Programs

Pre-Disaster Mitigation (PDM) Grant Program

RTP = Regional Transportation Program

Silver Jackets (FEMA/USACE)

STIP = Statewide Transportation Improvement Project

Responsible Agencies

DPW = Dept. of Public Works	NOAA—Nat'l Ocean. & Atmos. Admin.
EDC = Economic Dev. Commission	OEM = Office of Emergency
FEMA = Fed. Emergency Mgmt. Agency	PC = Planning Commission
FD = Fire Department	RSTD= Resident State Trooper's
FM = Fire Marshall	PRC = Parks and Recreation
HC = Harbor Commission	TE = Town Engineer
HDC = Historic District Commission	TW = Tree Warden
HUD = Dept. of Housing & Urban Dev.	USACE = US Army Corp. of Eng.
LUD = Land Use Department	WPCC: H2O Pol. Control Com.

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
MULTIPLE HAZARDS							
Action 1. **Implement Local Hazard Mitigation Plan**. The Planning Commission will monitor and evaluate progress in addressing action items in this Plan and include those accomplishments in its annual report to the Town.	High	Low	2019 to 2024	Low	High	Westbrook (WB) Planning Commission (PC) and Land Use Department (LUD)	Westbrook (WB) Operating Budgets (OB), Other Programs (OP)
Action 2. **Use Capital Improvement Program (CIP) to set aside funds for infrastructure improvements** to reduce loss of life and property during natural hazard (NH) events.	High	Low	2019 to 2024	Low	High	WB Board of Selectmen and Finance (BOS/BOF)	WB Operating Budgets (OB), Other Programs (OP) Federal Emergency Management Agency (FEMA)
Action 3. **Prepare a Grant Application and Administration Plan (GAAP).** Prepare detailed application plan for grant opportunities, including FEMA Hazard Mitigation Grant, USACE, NOAA, HUD, CIRCA, DOT, DECD and EPA programs a benefit-cost analysis for each opportunity. As a part of the plan development, identify and Prioritize Physical Improvement Projects.	High	Low	2019 to 2024	Medium	High	WB PC and BOS	FEMA HMGP, PDM and FMA HUD CDBG-Disaster Recovery Funds NOAA
Action 4. 5**-Year Review & Update of Natural Hazard Mitigation Plan**. The Planning Commission will reconvene its multi-agency Committee every 5 years to update the Plan.	High	Low	2023 to 2024	Low	High	Resident State Trooper's Department (RTSD), BOS and LUD	FEMA Pre-Disaster Mitigation (PDM) Grant Connecticut Department of Emergency Management and Public Safety (DEMHS)
Action 5. **Maintain and upgrade as necessary all facility mechanicals, such as generators,** in municipal and other **critical facilities**.	High	Low	2019 to 2024	Low to High	High	WB all departments, BOS /BOF	FEMA HMGP and PDM DEMHS
Action 6. Purchase and install a **generator** for back-up power for the **Public Works Transfer Station**.	Medium	Medium	2019 to 2021	Medium to High	Medium	WB BOS/BOF, RTSD, Fire Department (FD), Department of Public Works (DPW), Office of Emergency Management (OEM)	WB OP, CIP DEMHS FEMA

Table 6: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
MULTIPLE HAZARDS Cont.							
Action 7. **Update town-wide evacuation plan** (Including vulnerable populations and that includes a plan for evacuation public housing, assisted-living facilities, schools). See State Evacuation Plan.	Medium	Low	2019—2022	Low	Medium	OEM	DEMHS FEMA Westbrook OB, CIP
Action 8. **Telecommunication Tower Generators** (Private). Evaluate whether generators are needed for back-up power at telecommunications facilities.	Medium	Low	2019—2022	Low	Medium	Private Telecommunications Facilities	DEMHS FEMA Westbrook CIP
Action 9. **Review and Update Current Mutual Aide agreements**.	Medium	Low	2019—2022	Low	Medium	BOS, OEM, RTSD, FD	DEMHS FEMA Westbrook OBs
Action 10: **Update inventory of town assets in the Town's comprehensive GIS database** including asset categories outlined in this 2019 NHMP Update.	High	Low	ongoing	Low	High	BOS/BOF and all Town Departments	Westbrook Operating CIPs FEMA PDM or HMGP
Action 11: **Conduct a Comprehensive Zoning Map Audit** to identify/consider what changes may be advisable to guide development away from areas that are at risk to impacts from natural and climate-related hazards	High	Low to Medium	2019—2022	Low	Medium	LUD, W&B, P&Z, DPW, PC	Westbrook OBs/CIPs CIRCA
Action 12: Encourage privately owned gas stations to install and maintain **emergency back-up generators**		Low	2019—2022	Low	Medium	BOS, OEM	FEMA HMGP, PDM Westbrook CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
MULTIPLE HAZARDS Cont.							
Action 13. Street Tree Management Plan. Develop and Implement a tree hazard management program to encourage appropriate planting and maintenance practices to minimize future storm damage to buildings, utilities and streets with consideration of the need to reduce heat island effects from extreme heat and preserving community character.	High	Low to Medium	Ongoing	Low to Medium	High	BOS/BOF, DPW, Tree Warden (TW)	WESTBROOK OP
Action 14: Conduct a **municipal buildings capabilities assessment**. The purpose of the assessment will be to identify buildings for future investment for renovation or new construction to ensure the candidate buildings are in compliance with standards for use as a shelter.	High	Medium to High	2019—2023	High	Medium	BOS/BOF	WESTBROOK CIP
Action 15: **Incident Notification System:** Enlist public participation through public workshops to develop methods for emergency notifications of hazard events. **Tenant Notification:** Develop a mechanism for tenants to register for disaster notifications.	High	Low to Medium	Bi-Annually	Low to Medium	Medium	OEM	FEMA WESTRBOOK OB
Action 16: **Recovery and Reconstruction Plan**: Prepare a post-disaster recovery and reconstruction plan to re-establish infrastructure and public services, etc. damaged or destroyed by any NH event, including establishment of a "rainy day" fund in case Federal assistance is insufficient or delayed.	High	Low to Medium	2019—2022	Low to Medium	High	BOS/BOF, OEM, Building Official (BO) and Fire Marshal	FEMA HMGP, FMA, PDM CIRCA Resilience Grants
Action 17: Conduct **Landlord Incentives Study** to identify what incentives would motivate property owners to make investments to reduce future damages to their properties resulting from NH events.	High	Medium	2019 to 2022	Low to Medium	Medium	BOS/BOF LUD	WESTBROOK CIP FEMA HMGP, PDM, FMA

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
MULTIPLE HAZARDS Cont.							
Action 18: **Cooperative Agreements for Shelters.** Maintain agreements for shelters that can provide specialized services, throughout the region. Shelters with the capacity to provide for companion pets and medical equipment needs for individuals with disabilities are two examples of such specializations.	High	Low	Ongoing	Low	High	CT DEMHS Red Cross	FEMA EMGP CT DEMHS Red Cross
Action 19: **Refuges of Last Resort.** Identify refuges of last resort for those unable to reach designated shelter.	High	Low	Ongoing	Low	Medium	CT DEMHS Red Cross	FEMA EMGP CT DEMHS Red Cross
Action 20: Conduct a **Local Social Resources Assessment.** Identify local resources to assist with those populations (i.e. elderly, disabled, non-English speakers, who may frequent, reside, or work) in Westbrook. Seek grants to provide funding for developing more detailed data to assist in the social – demographic analysis of how Westbrook will be affected by natural hazards.	High	Medium	2019—2023	Low to Medium	Medium	PC, ZC, LUD	HUD FEMA Westbrook OP,CIP
Action 21: **Temporary Housing Assessment**. Evaluate the need for post disaster housing for residents displayed by flood or another natural disaster.	M	Medium	2019—2023	Low to Medium	Medium	WESTBROOK PC, ZC, LUD	HUD FEMA WESTBROOK OP,CIP
Action 22: Boats: **Identify areas where boats can be stored during flooding and hurricane events**.	M	Low	2019—2022	Low	Medium	PC, ZC, Harbor Management Commission (HMC)	WESTBROOK OP
Action 23: **Post Disaster School Arrangements.** Establish reciprocal arrangements with other school districts for getting students back into classes during extended recovery periods.	High	Low	2020—2023	Low	Medium	BOS, OEM, Board of Education and CT DEMHS	WESTBROOK OP CT DEMHS

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
MULTIPLE HAZARDS Cont.							
Action 24: **Immobile Evacuees Planning**: Review annually the program to evacuate persons without means of transportation, including registration and house numbering.	High	Low	2019—2021	Low	Medium	BOS/BOF, OEM	WESTBROOK OP
Action 25: Conduct **Natural Hazard Mitigation Training** on an annual basis.	High	Low to Medium	2019—2024	Low to Medium	High	BOS/BOF, OEM	WESTBROOK OP, CIP
Action 26**: Voluntary Actions.** Promote and highlight voluntary mitigation actions taken by individual property owners and Beach Associations to protect their properties.	High	Low	Annually	Low	High	BOS/BOF, LUD, Building Official, Economic Development Commission (EDC); OEM	OB, CIP
Action 27: **Evacuation Zones.** Explore the merits of establishing formal evacuation zones in the next update of the Emergency Operations Plan.	High	Low	2020—2023	Low	Medium	BOS/BOF, OEM	WESTBROOK OP FEMA EMPG
Action 28: **Caches.** Consider creating stores of emergency supplies in areas of town that will be cut off during major Flooding and other natural hazard events. **Drinking Water Cache.** Install drinking water tanks with a supply of bleach for private well water purification that can be used during natural hazard events.	High	Low	2020—2022	Low	Medium	BOS/BOF, OEM	WESTBROOK OP
Action 29: **Regional Hazard Mitigation Grant Program Manager.** Provide grant administration services for member communities participating in Hazard Mitigation Grant Programs.	High	Medium	2020—2023	Low to Medium	Medium	BOS/BOF, PC, ZC, LUD	HUD FEMA Westbrook OP,CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Departments	Potential Funding Sources
FLOOD HAZARDS							
Action 30. **Develop an Emergency Operations Plan** regarding potential **coastal flooding**	Medium	High	2-3 years	Medium	Medium	OEM, DPW, RTSD and Fire Department	Westbrook OBs and CIP DEMHS FEMA EMPG
Action 31. **Evaluate publicly owned and managed outfalls and outlets** along the shoreline of Westbrook to identify infrastructure that would benefit from the installation of backflow prevention (e.g. tide gates, check valve)	Medium	Low	1 year	Low	Medium	BOS/BOF, DPW	Westbrook OB, OP and CIP
Action 32. Continue to **participate in National Flood Insurance Program (NFIP)** (or other) training offered by the State and/or FEMA that addresses flood hazard planning and management.	High	Low	Ongoing	Low	High	BOS/BOF; LUD	FEMA DEMHS DEEP Westbrook
Action 33. Incorporate the procedures for **tracking high water marks** following a flood into emergency response plans.	Medium	Low	Ongoing	Low	Medium	DPW; PD; FD; LUD FEN	FEMA Silver Jackets (USACE) Westbrook
Action 34. Participate in **reviews of regulatory floodplain maps updates and revisions**.	High	Medium to High	Ongoing	Low	High	BOS/BOF; LUD;	FEMA Westbrook OB
Action 35: Obtain **updated aerial imagery** and planimetric data in order to allow for assessment of such factors as extent of damage from NHs, compliance with building standards, identification of shoreline hardening and shoreline erosion and accretion.	High	High	2019—2020	Low	High	BOS/BOF; LUD;	FEMA Westbrook OB

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
FLOOD HAZARDS (cont.)							
Action 36. **Land Acquisition** (Near-term): Identify and prioritize areas for the purchase wetlands and other flood prone open space to enhance natural resources while improving coastal resiliency and flood retention.	High	Medium/ High	Ongoing	High	Medium	BOS/BOF, LUD, PC	FEMA HMGP, PDM and FMA WESTBROOK CIP
Action 37: Evaluate the possibility of participating in FEMA's **Community Rating System (CRS)** program that would result in reducing the cost of NFIP premiums while improving coastal flood resiliency.	MED	Medium	2019—2022	Low	Low	BOS/BOF, LUD, PC	FEMA FMA WESTBROOK CIP
Action 38. Evaluate **"green infrastructure"** program to link, manage, and expand existing parks, preserves, greenways, etc.	MED	Medium	3-5 years	Low to Medium	Low	Conservation Commission (CC), DPW	EPA, CT DEEP WESTBROOK and FEN OPs, CIPs
Action 39: Encourage **Repetitive Loss Property** Owners to **pursue flood mitigation funding** for actions such as elevation or acquisition of structures where appropriate on a voluntary basis	High	Medium to High	Ongoing	Low	High	BOS/BOF, ZC, BO, TE	FEMA HMA grants OBS OP, OB, CIP
Action 40: **West Beach Dune Restoration.** Evaluate potential alternatives for the restoration of dunes along West Beach to develop a range of solutions that will renew the coastal beach and dune system, provide storm damage protection for local residents, increase flood control for adjacent properties, and restore an important Town resource.	High	Medium	2019—2024	High	High	BOS/BOF, CC, LAC, DPW, DEEP	WESTBROOK CIP DEEP
Action 41: **Patchogue & Menunketesuck River Mitigation Plan.** Develop and implement mitigation plans for previously identified nutrient and sediment nonpoint source pollution sites to reduce vulnerability to coastal storms, sea level rise, flooding, and erosion.	High	Medium	2019—2024	High	High	BOS/BOF, CC, LUD, DPW, DEEP	WESTBROOK CIP DEEP
Action 42: LAND USE. Focus on **promoting new development in non-vulnerable areas of Town**.	High	Low	2019-2024	Low	High	BOS, PC, CRMT	FEMA WESTBROOK OP, CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
FLOOD HAZARDS (Cont.)							
Action 43: **Shore Protection Systems.** Conduct a study of existing shore protection systems along the entire Westbrook coast to analyze overall impacts and develop recommendations for mitigation including identification of opportunities for compensation for the hardening of one part of the shoreline by removing the equivalent extent of flood and erosion control structures from another part of the shoreline.	High	Medium	2019—2024	Medium High	High	BOS/BOF, CC, LAC, DPW, DEEP	WESTBROOK CIP DEEP
Action 44: **Grove Beach Flood Mitigation/ Wetland Study.** Conduct a comprehensive hydraulics/hydrology study to identify the cause of flooding and to recommend mitigation measures that focus on reducing flooding within the area. The study will focus on improving watershed connectivity by increasing culvert sizes and improving wetland holding capacity and natural function. The study will evaluate the need for wetland restoration including: fragmentation caused by human activity, the effects of surrounding impervious surfaces, and the presence of non-native invasive species.	High	Medium	2019—2024	Medium to High	High	BOS/BOF, CC, LAC, DPW, DEEP	WESTBROOK CIP DEEP
Action 45: **Floodplain Management Studies.** Update Floodplain Management studies for Patchogue River, Town Center and Cold Springs Brook Watersheds.	High	Medium	2019—2024	Medium to High	High	BOS/BOF, CC, LAC, DPW, DEEP	WESTBROOK CIP DEEP
Action 46: **Certified Floodplain Manager.** Have one or more staff members obtain CFM certification.	High	Low	2020-2022	Low	Medium	BOS/BOF, LUD, DPW	CT DEEP, WESTBROOK OP, CIP
Action 47: **Road Evaluation**: Evaluate roads at least annually to develop plans for improvement or elevation for emergency access and evacuation.	High	Medium	2019—2023	Low to Medium	High	BOS/BOF, DPW, TE ConnDOT	FHWA ConnDOT Statewide Transportation Improvement Project (STIP) Regional Transportation Program (RTP) WESTBROOK CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
FLOOD RELATED HAZARDS (Cont.)							
Action 48: Conduct a **roadway emergency access and evacuation planning study** to develop conceptual plans and prioritization for pursuing engineering, design and construction funding of roadways identified in the 2014 HMP Update. Roadways should include: 1) Willard Ave. Bypass; 2) Boston Post Road (Route 1); 3) Coral Sands—Dolphin, Striper, Tarpon; 4) West Beach—Seaside Ave.; 5) Middle Beach Salt Island Rd., Pepperidge, Stokes, Gerard; 6) Little Stannard Beach Rd.; 7) Stannard Beach—Second Avenue; 8) Old Kelsey Point Rd.; 9) Chapman Beach Rd./Walden Dr.; 10) Hammock Rd.; 11) Doc's Hill Rd.; 12) Old Clinton Rd. (Rte. 145); 13) McVeagh & Toby Hill Rd.; 14) Meeting House Ln.; 15) Pond Meadow Rd.; 16) E. Pond Meadow Rd.; 17) Stevenstown Rd. (Route 145)	High	Medium	2019—2022	Medium	High	BOS/BOF, DPW, TE ConnDOT	FHWA ConnDOT STIP RTP WESTBROOK and
Action 49: Establish the BOS as the **Flood and Erosion Control Board (FECB)** for the Town of Westbrook per Section 25-85 Establishment of flood or erosion control system. The FECB may be the BOS in municipalities with a population not exceeding 50,000. FECB projects will require political support, funding and engineering. The BOS could create ad-hoc committees or use the Town Engineer to investigate these projects as they arise on a case by case basis similar to how the Town has made repairs to sea walls and other public improvement projects.	High	Low	2019—2021	Low to Medium	High	BOS/BOF, PC, LUD	WESTBROOK OP, CIP
Action 50: **Repetitive Loss Area Analysis (RLAA).** Many repetitive loss (RL) structures have been demolished and rebuilt or elevated to higher standards than minimum FEMA requirements. Based on this extensive and successful effort by the Town and residents, it is recommended to perform a formal RLAA to identify the impact to Town's NFIP insurance rate due to repetitive loss. The results from the RLLA will help further support Town and property owner resilience and mitigation activities, including acquiring, relocating and/or flood mitigation of RL properties.	Medium	Low	2019—2021	Low to Medium	High	BOS/BOF, LUD, DPW	CT DEEP, WESTBROOK OP, CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
FLOOD RELATED HAZARDS (Cont.)							
Action 51: **Sea Level Rise.** Seek grants funds to collaborate with an academic institution to research and study the social, economic, environmental and policy-related impacts from SLR.	High	Low	2029-2024	Low to Medium	High	All Town Departments	FEMA FMA, PDM, HMGP DEMHS Westbrook OP, CIP
Action 52: Prepare a **Coastal Community Resilience and Climate Adaptation Study**. Include development of a roadway improvement plan to identify specific projects, project costs and funding mechanisms. It is recommended that the plan include a strategy of improving only the portions of key roads that are subject to chronic and high probability floods in the near-term. Include this as a part of the Resilience and Climate Adaptation Study. Hold formal meetings with ConnDOT regarding improvement and resilience of State roads and bridges located within the Town limits. Also, include a **Marsh Migration Analysis** to Identify areas where tidal marshes are likely to advance upslope as sea levels continue to rise and develop conservation strategy.	High	Medium	2019—2022	Medium	High	PC, LUD Economic Development (ED)	NOAA CIRCA Westbrook OP
Action 53: NATIONAL FLOOD INSURANCE PROGRAM (NFIP). Until FEMA changes their mapping guidelines to address sea level rise, provide residents with **Town-specific flood hazard maps** reflecting sea level rise projections for 2050 and 2100, in line with the State of Connecticut.	High	Medium	2019—2021	Low to Medium	High	BOS/BOF, LUD	FEMA FMA, PDM, HMGP DEMHS Westbrook OP, CIP
Action 54: **Open Space Plan.** Consider adding sea level rise to the Town's considerations for preserving as open space those areas that flood waters are projected to inundate.	High	Medium	2020-2022	Low to Medium	Medium	BOS/BOF, LUD	DEEP Westbrook OP, CIP
Action 55: **Salt Island Overlook Habitat Restoration -** Develop & Implement Forest Tree Planting Plan for Salt Island Overlook to restore a coastal forest habitat and increase coastal storm resiliency.	High	Medium	2019—2024	Medium to High	High	BOS/BOF, CC, LAC, DPW, DEEP	WESTBROOK CIP DEEP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
FLOOD RELATED HAZARDS (Cont.)							
Action 57: STORMWATER. **Analyze the existing stormwater infrastructure under precipitation only and combined coastal flood-precipitation** events. This data is necessary to comprehensively characterize the Town's flood risk and to identify the need for additional catch basins/pump stations/additional tide gates/green infrastructure.	High	Medium	2019 — 2022	Medium	High	BOS/BOF, PC, LUD	EPA CT DEEP WESTBROOK OP, CIP
Action 58: SHORELINE PROTECTION. Develop a Town-wide and regional beach nourishment plan.	High	Medium	2019 — 2022	Low to Medium	High	BOS/BOF, HMC, PC, LUD, DPW, Council of Beaches, Beach Associations	FEMA DEEP WESTBROOK OP, CIP
Action 59: SHORELINE PROTECTION. **Employ Living Shoreline solutions** for select areas including low wave energy environments such as tidal marsh borders and river mouths.	High	Medium	2019 — 2024	Medium to High	Medium	BOS/BOF, HMC, PC, LUD, DPW, Council of Beaches, Beach Associations	FEMA, NOAA DEEP WESTBROOK OP, CIP
Action 60: SHORELINE PROTECTION. **Program to maintain Existing Groins.**	H	Medium	2019 – 2022		High	BOS/BOF, DPW, Council of Beaches, Beach Associations	FEMA HMGP, PDM and FMA WESTBROOK OP, CIP
Action 61: PUBLIC SAFETY: Flood Protection. **Provide flood protection for at-risk Essential and Lifeline Facilities**.	High	High	2019 — 2024	High	High	BOS/BOF, PC, LUD, DPW	FEMA HMGP, PDM and FMA WESTBROOK OP, CIP
Action 62: Coordinate with USACE relative to proposed, future dredge projects and re-use of dredge materials for Town beach nourishment, salt marsh maintenance and restoration projects.	High	Low	2019— 2024	Low	High	BOS/BOF, PC, DPW	USACE WESTBROOK OP, CIP
Action 63: PROTECTION OF PRIVATE PROPERTY. **Assist homeowners in protecting homes**, on an individual property basis, using methods available under the existing flood regulations and ordinances (such as elevating houses). Also, **provide guidance to homeowners on floor elevations considering sea level rise**.	High	Medium	2019 — 2024	Medium	High	BOS/BOF, PC, BO, Council of Beaches, Beach Associations	FEMA HMGP, PDM and FMA HUD CDBG-DR NOAA WESTBROOK OP, CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
FLOOD RELATED HAZARDS (Cont.)							
Action 64: **Every 10-years, adopt future coastal flood risk overlay maps** and sea level rise projections.	High	Medium	2019—2028	Low to Medium	High	BOS/BOF, PC, CRMT	FEMA, NOAA, USACE WESTBROOK OP, CIP
Action 65: **Develop a permit, maintenance and operations plan for stormwater structures** including tide gates and culverts for pre- and post-flood recovery operations, to promote post-flood drainage. Maintenance activities are covered under the Town's MS4 General Stormwater Permit.	High	Low to Medium	2019—2023	Low to Medium	Medium	BOS/BOF, DPW, TE	EPA CT DEEP WESTBROOK OP, CIP
Action 66: SHORELINE PROTECTION. **Evaluate the technical feasibility of constructing dunes and berms.**	High	Medium	2019—2023	Medium	High	BOS/BOF, DPW, TE	
Action 67: **HISTORIC PROPERTIES**. The Town should provide flood mitigation guidance to property owners that is consistent with Historic District Regulations.	High	Medium	2019—2022	Low to Medium	High	LUD, Historic District Commission (HDC)	HUD CT Department of Economic & Community Development (DECD) WESTBROOK OP, CIP
Action 68: Request the USACE to perform a **feasibility study under Section 103 Hurricane and Storm Damage Protection,** to support future USACE grants.	MED	Low	2019–2023	Low	Medium	BOS/BOF, LUD, PC, Beach Associations	USACE CT DEEP WESTBROOK OP, CIP
Action 69: Evaluate **Coastal Flood and Climate Change Effects on Municipal Bond Rating**.	High	Low	2019—2023	Low	Medium	BOS/BOF	WESTBROOK OP, CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
SECONDARY HAZARDS: DAM FAILURE							
Action 70. **Dam** Owners responsible for review and update of **Emergency Action Plans** (EAP) and **Maintenance and Operations Plans** for the 3 High Hazard Dams per state requirements to ensure the plans are up to date & have protocols in place to maintain safe operations of the Dams.	High	Low	2019—2024	Low	High	DAM OWNERS CT DEEP Dam Safety Section	CT DEEP DAM OWNERS
Action 71. **Private Dam Evaluation**: Evaluate remaining privately-owned dams; work with DPW and State DEEP for repairs as needed.	High	Medium	Annually	Low	High	DAM OWNERS CT DEEP Dam Safety Section	CT DEEP
Action 72. **Per the EM emergency operations plan** assess downstream risks due to catastrophic failure.	High	Medium	2019—2022	Low to Medium	High	BOS/BOF, OEM, DPW, DEEP	CT DEEP WESTBROOK OP, CIP
CLIMATE RELATED HAZARDS: Drought							
Action 73. Conduct a **town-wide study of ground and surface water capacity** as it relates to planning for droughts.	High	Medium	2019—2023	Low to Medium	High	BOS/BOF, FD, Fire Marshall (FM), CT Water Company (CWC)	CWC WESTBROOK OP, CIP
Action 74. Coordinate with the CWC on public education and public service announcements in anticipation of and during times of drought.	High	Low	2019—2021	Low	High	BOS/BOF, FD, Fire Marshall (FM), CCWC	CWC WESTBROOK OP, CIP
CLIMATE RELATED HAZARDS: Wildfire							
Action 75. Wildfire Education: Conduct public education and outreach to the public on potential wildfire hazards caused by camp fires & open air burning.	High	Low to Medium	Annually	Low	Medium	BOS/BOF, FD, Fire Marshall (FM)	FEMA EMPG, HMGP, PDM WESTBROOK OP, CIP
Action 76. Firefighting Infrastructure Analysis: Evaluate existing firefighting infrastructure to identify needs for improvement to cover gaps in availability.	High	Low	HMP Update	Low	High	BOS/BOF, FD, Fire Marshall (FM), PC	FEMA EMPG, HMGP, PDM WESTBROOK OP, CIP

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

MITIGATION ACTIONS	Benefits	Costs	Timeline	Estimated Project Costs	Priority	Responsible Agencies	Potential Funding Sources
CLIMATE RELATED HAZARDS: Heat							
Action 77. Protect Vulnerable Populations by: 1) Organize outreach to vulnerable populations, including establishing & promoting accessible heating or cooling centers in the community; and 2) Educate citizens on the dangers of extreme heat & cold, and the steps they can take to protect themselves when extreme temperatures occur.	High	Medium	2019—2022	Medium	Medium	BOS/BOF, PRTSD, FD, OEM	FEMA, CT DEEP DEMHS WESTBROOK Ops,
SEVERE WINTER WEATHER							
Action 78. Maintain adequate supply of sand other road treatment materials.	High	Low	Annually	Low	High	DPW	WESTBROOK OP, OB

Table 5 cont.: Natural Hazard Mitigation Action Matrix & Prioritization

Section 6: Regional and Inter-community Relationships

SECTION 6 - REGIONAL AND INTERCOMMUNITY CONSIDERATIONS

Some hazard mitigation issues are strictly local. The problem originates primarily within the municipality and can be solved at the municipal level. Other issues are inter-community issues that involve cooperation between two or more municipalities. There is a third level of mitigation which is regional; involving a state, regional or federal agency or an issue that involves three or more municipalities.

The Westbrook Zoning Commission is the primary Town agency responsible for regulating development in town and the Planning Commission has regulatory jurisdiction over the subdivision of land. Feedback to the Westbrook Zoning and Planning Commissions was ensured through the participation of the Westbrook Planning Commission Chair and Planning, Zoning and Development Coordinator on the Local Planning Team (LPT). In addition the public meetings were held during official Westbrook Planning Commission meetings that included the participation of the Planning Commission members. As a part of developing this Plan Update, the Town coordinated with the Connecticut Department of Energy and Environmental Protection (DEEP) to update pertinent repetitive loss property and NFIP claims related details for the Town (see **Attachment 4**. The LPT also included the participation of other key local, regional and state entities. Neighboring communities and other regional and state entities were provided an opportunity to participate and provide input at the two public meetings held in June and September of 2019. The Town will continue to collaborate with local, regional and state agencies as a part of the implementation of actions outlined in this plan. Below is a more detailed overview of the regional and intercommunity considerations for this plan.

REGIONAL PARTNERS

In many communities, mitigating natural hazards, particularly flooding, is more than a local issue. The drainage systems and shoreline protection structures that serve these communities are a complex system of storm drains, outfalls, roadway drainage structures, on-site septic systems, revetments, sea walls, groins and other facilities owned and operated by a wide array of agencies including but not limited to the Town of Westbrook, Council of Beaches, Beach Associations, Connecticut DEEP, Connecticut Department of Transportation (DOT), and the U.S. Army Corps of Engineers. The planning, construction, operations and maintenance of these structures are integral to the flood hazard mitigation efforts of communities. These agencies must be considered as regional partners in hazard mitigation. These agencies also operate under the same constraints as communities do including budgetary and staffing constraints and numerous competing priorities. **Section 5** of the Plan Update includes several mitigation actions where several of these agencies will participate in moving hazard mitigation efforts forward in collaboration with the Town. Implementation of these actions will require that all parties work together to develop solutions.

REGIONAL FACILITIES WITHIN WESTBROOK

Major facilities owned, operated and maintained by federal, state, regional, local or private entities in Westbrook include: I-95 (Connecticut Turnpike), and State Routes 1 (Boston Post Road), 145 (Old Post, Old Clinton, Horse Hill, and Stevenstown Roads), 153 (Essex Road), 166 (Spencer Plain Road) (CTDOT), Route 625 (Grove Beach North), Middlesex Health—Shoreline Medical Center, Connecticut State Police Troop F; Tidelawn Manor Assisted Living Facility; the Westbrook Senior Center; and Westbrook Shoreline East Train Station located in Westbrook.

INTERCOMMUNITY CONSIDERATIONS

Westbrook, as well as its surrounding communities are close to build-out south of Interstate 95, but some parcels may undergo significant re-development in the future. To avoid impacts from any residential and commercial development, communication between Westbrook and the surrounding communities, including input in the review processes, is vital.

Section 7: Plan Adoption and Implementation

SECTION 7- PLAN ADOPTION AND IMPLEMENTATION

Adopting, implementing, monitoring, evaluating, and updating the Town's Local Natural Hazard Mitigation Plan Update are necessary steps to sustaining a viable plan that will assist the community in becoming more resilient to natural hazards long into the future. An overview of how the Town will carry out each of these tasks is outlined as follows.

PLAN ADOPTION

The Draft Plan was provided to the Town on May 10, 2019 for review and distribution to the public, and local, regional and state stakeholders. The Town posted the Draft Plan on the Town websites in November 2019 for public review and input. A public meeting was held on September 16, 2019 at Westbrook Town Hall to: 1) present the Draft Plan and 2) solicit input and feedback on the Draft Plan from the public. Based on feedback provided at the public meeting and received from the public online, the Draft Plan was revised in November 2019. The Town then submitted the Draft Plan Update to the Connecticut Department of Emergency Management Agency and Homeland Security (DEMHS) and the Federal Emergency Management Agency (FEMA) for review. Upon receiving conditional approval of the plan by FEMA, the plan was presented and approved by the Westbrook Board of Selectmen on **ADD MONTH XX, 2019.**

PLAN IMPLEMENTATION

The implementation of the Plan commences upon its formal adoption by the Board of Selectmen and official approval by DEMHS and FEMA. Section 5 details the mitigation strategy that prioritizes the various actions identified to reduce the impacts from future natural hazards. A local hazard mitigation working group (including the LPT) will be responsible for overseeing the implementation of the plan.

In addition, the Local Planning Team (LPT), that includes Town officials as presented in Section 2, will identify existing planning documents and regulations where relevant policies and actions outlined in this Plan Update may be incorporated to improve the potential for the implementation of mitigation actions across related programs and agencies. Relevant programs, policies, and/or regulations may include updates to existing polices and regulations such as the following:

- Updates to the Local Building Code based on changes that occur to the Connecticut State Building Code
- Plan of Conservation and Development Update (ongoing)
- Westbrook Zoning Regulations, May 30, 2019, including Section 10.11 Floodplain Compliance
- Westbrook Zoning Regulations, March 1, 2019, including Section 37 Saybrook Point District
- Westbrook Zoning Regulations, March 1, 2019, including Section 32 Shopping Center Business B-2 District
- Westbrook Zoning Regulations, March 1, 2019, including Section 59 Coastal Area Management (CAM) Zone

PLAN MONITORING AND EVALUATION

On an annual basis, the LPT led by the Westbrook First Selectman will coordinate a meeting to review the Plan progress over the last year. This Plan review will include an evaluation of hazard mitigation activities such as ongoing projects, changes in developing new mitigation actions resulting from a natural disaster event, changes in local, State and federal regulations that may impact the implementation of future projects, and modification of existing actions. As a part of this process, the working group will evaluate and assess the effectiveness of the action items outlined in the plan have been in achieving the plan goals and objectives. The results of this evaluation will be posted to The Town websites to gather public input on the progress of the Plan as well as to provide the public with the opportunity to provide additional mitigation activities for the working group's consideration.

A review and evaluation of the Town's Plan will be conducted on a 5-year basis in compliance with the 2000 Disaster Mitigation Act and Part 201.6 of 44 Code of Federal Regulations (CFR). In the event of a major disaster event impacting the Town of Westbrook, the Town may update the plan at that time with actions to address unexpected impacts resulting from the damages to the community, if needed.

FEDERAL AND STATE FUNDING SOURCES

Several of the proposed hazard mitigation projects and actions may be eligible activities for funding under the three FEMA Hazard Mitigation Assistance (HMA) Grant Programs. The FEMA HMA Grant Programs include two non-disaster mitigation grant programs that include the Pre-Disaster Mitigation and Flood Mitigation Assistance grant programs, and one disaster mitigation grant program that is the Hazard Mitigation Grant Program (HMGP). State and federal funding source details are presented in **Attachment 5.**

Attachment 1: Community Profile

Community Profile Overview

This section of the Plan presents details about the Town assets which categorically include:

- People
- Support, High Occupancy and Vulnerable Population facilities;
- Essential Facilities including emergency response, police, fire, hospitals, etc.;
- Lifeline Systems including water, wastewater, electrical power, etc.;
- High Potential Loss Facilities, including high hazard dams; and
- Transportation Infrastructure.

Demographic Overview

Per the 2010 United States Census and 2013-2017 American Community Survey:

Age and Sex:

Population:	6,956
Population change since 2000:	+/- 10.6%
Percent female/male:	49.9%/50.1%
Age:	
persons <5 years:	2.7%
persons <18 years:	12.8%
persons ≥ 65 years:	21.4%

Race:

White alone:	94.7%
Black or African Amer. alone:	1.1%
Amer. Indian or Alaska Native alone:	0%
Asian alone:	0.2%
Two or more races:	1.5%
Hispanic or Latino:	4.6%

Health:

With disability, under 65 years:	10.2%
Persons w/o health insurance, under 65 years:	8.8%

Education:

High school graduate or higher, greater 25 years:	91%
Bachelor's degree or higher, greater 25 years:	42.6%

Economy:

In civilian labor force, total, greater 16 years:	66.9%
In civilian labor force, female, greater 16 years:	64.7%

Income and Poverty:

Median household income (2017$):	$95,583
Per capita income (2017$):	$58,608
Persons in poverty:	7.8%

Family and Living Arrangements:

Households :	2,873
Persons per Household:	2.37
Language spoken at home other than English, greater than 5 years:	9.8%
Median house cost:	$378,900
Percent owner-occupied:	77.1%

Population Density: 439.6/sq. mile

The Town combined have a total area of 21 square miles that includes 16 square miles of land and 5 square miles of water. Westbrook has the typical physical characteristics of a Long Island Sound coastal town, with uplands bordered by low-lying areas, tidal wetlands, salt marshes, tidal flats, and beaches. Westbrook has over 5 linear miles of shoreline abutting Long Island Sound and the Menunketesuck and Patchogue Rivers. The areas to the south of Interstate 95 (I-95) are low-lying, consisting mostly of tidal marsh and coastal plain. The area to the north of I-95 consists of rolling hills of bedrock, thin glacial till and , with a network of valley streams and inland wetlands.

Demographics

Based on the 2010 U.S. Census, the population per square mile is 439.6, which is lower than the average for Connecticut as a whole (738.1), and slightly lower than Middlesex County (448.6). (**Figure 1-1**)

The number of residents increased from 6,292 based on the 2000 US Census to 6,956 based on the 2013-2017 American Community Survey (ACS). Westbrook includes a largely white population, representing about 95% of all residents. Hispanics or Latinos make up the largest single minority group at 4.6% of all residents.

Based on the 2010 U.S. Census, the population includes 12.8% of residents under the age of 18, 4.3% between the ages of 20 to 24, 21.4% between the ages of 25 to 44, 32.5% between the ages of 45 to 64, and 20.2% who are 65 years or older.

There are 2,873 households, with an average household size of 2.37.

The median household income in Westbrook was $95,583, which is above both the median averages of $73,781 for the State and $81,673 for Middlesex County. Poverty is at 7.8% which is lower than the State rate of 10.1% and slightly higher than the Middlesex County rate of 6.8%.

Housing costs are $378,900 for the median value, owner-occupied housing unit compared to the State at $270,100 and Middlesex County at $283,700. Seventy-seven (77) % of the housing units are owner-occupied compared to the state at sixty-six (66)%.

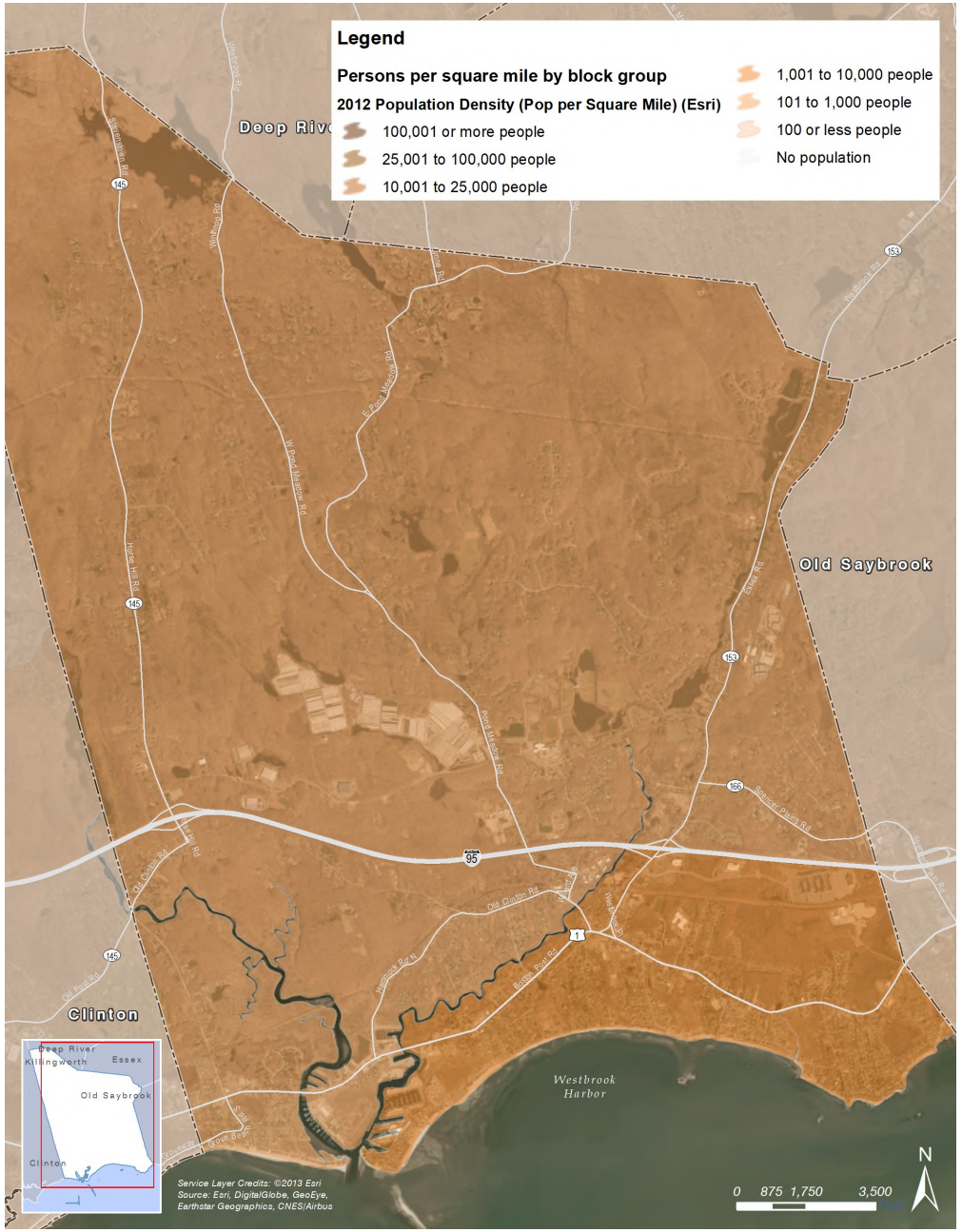


Figure 1-1: Population Density

Social Vulnerability

The term Social Vulnerability describes how resilient a community is to external stresses, such as natural hazards, on human health. The Social Vulnerability Index (SVI) employs U.S. Census Bureau variables to identify neighborhoods that may need additional support in preparing for hazards or recovering from disasters, and is a useful tool for emergency response planners and public health officials. U.S. Census Bureau data to determine the social vulnerability of every census tract (census tracts are subdivisions of counties for which the Census Bureau collects statistical data). The SVI ranks each tract on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes: 1) Socioeconomic; 2) Household Composition/Disability; 3) Each tract receives a separate ranking for each of the four themes, as well as an overall ranking.

The SOVI for the Town is categorized as Medium for the entire Town based on the results of two US Census tracts, and as shown in **Figure 1-2**.

A detailed risk profile, by census tract within the Town was performed using the ATSDR SVI Dashboard https://svi.cdc.gov/map.aspx. The results are presented in **Table 1-1**.

This analysis identified no Social Vulnerability Index flags for Westbrook's only census tract number 680100.

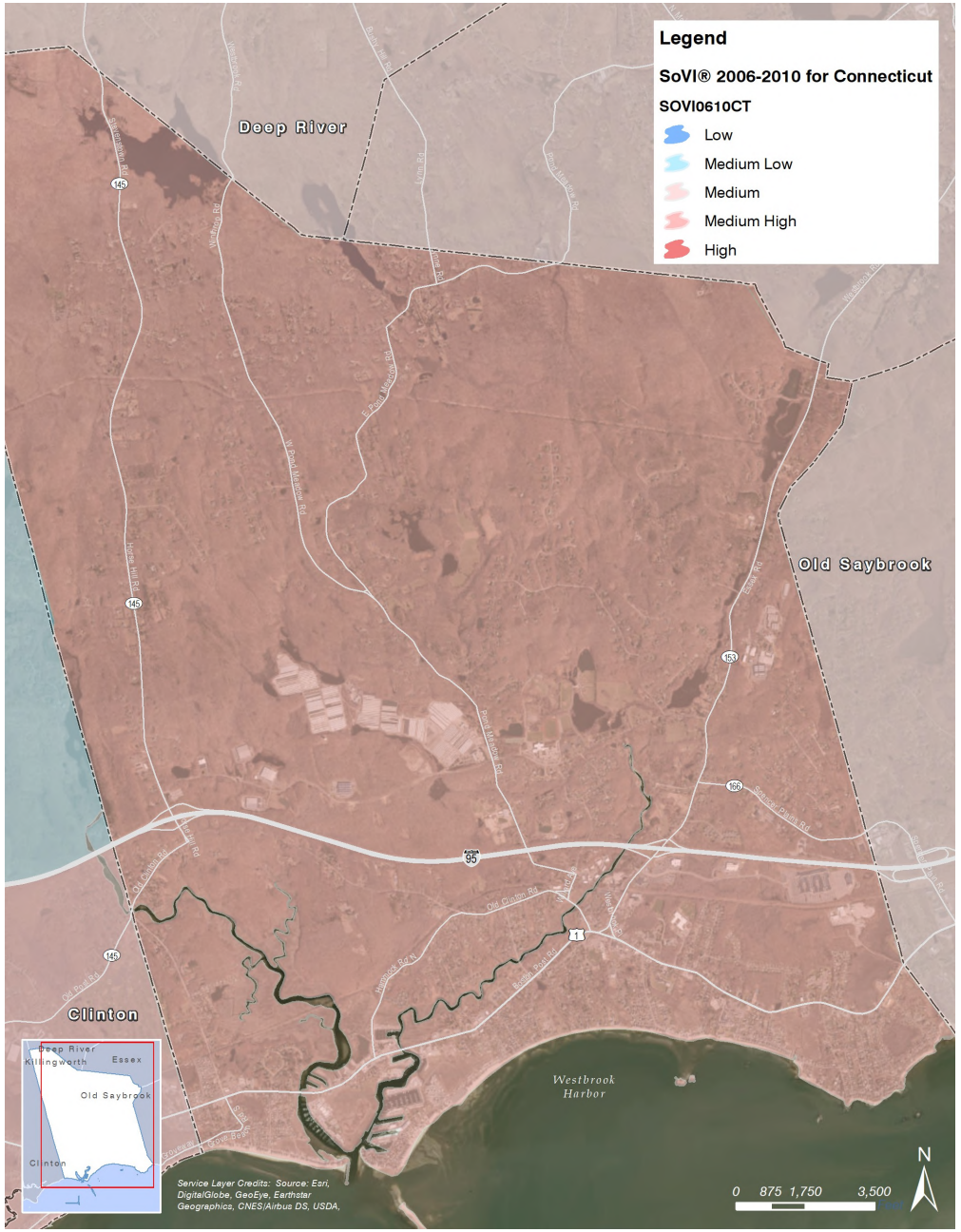
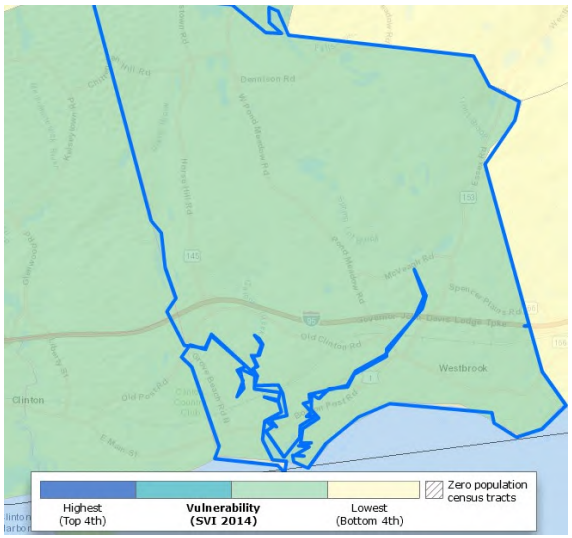


Figure 1-2: Social Vulnerability Index

US Census Tract 680100



Additional data: 897 individuals within census tract 680100 are predicted to be uninsured. (13.1% of tract population)

Table 1-1: Westbrook Social Vulnerability Profile Analysis
https://svi.cdc.gov/map.aspx

Socioeconomic Theme

Measure	Number	Number MOE	Percentage	Percentage MOE	Percentile Rank (among all US tracts)	SVI Flags
Persons below poverty estimate, 2010-2014 ACS	410	205	6.0%	3.0%	20th	No
Civilian (age 16+) unemployed estimate, 2010-2014 ACS	381	148	10.0%	3.8%	61st	No
Per capita income estimate, 2010-2014 ACS*	$44,966	$7,866			10th	No
Persons (age 25+) with no high school diploma estimate MOE, 2010-2014 ACS	416	152	7.9%	2.9%	34th	No
SOCIOECONOMIC DOMAIN SUMMARY					27th	0

* Per capita income is the average income per person in each tract. Unlike the other variables for which a high percentage indicates potentially higher social vulnerability, a higher per capita income is associated with lower social vulnerability.

Household Composition/Disability Theme

Measure	Number	Number MOE	Percentage	Percentage MOE	Percentile Rank (among all US tracts)	SVI Flags
Persons aged 65 and older estimate, 2010-2014 ACS	1,328	163	19.2%	2.3%	81st	No
Persons aged 17 and younger estimate, 2010-2014 ACS	1,086	159	15.7%	159.0%	12th	No
Civilian noninstitutionalized population with a disability estimate, 2010-20	733	165	10.7%	2.4%	39th	No
Single parent household with children under 18 estimate, 2010-2014 ACS	98	70	3.6%	2.6%	14th	No
HOUSEHOLD COMPOSITION/DISABILITY DOMAIN SUMMARY						

Minority Status/Language Theme

Measure	Number	Number MOE	Percentage	Percentage MOE	Percentile Rank (among all US tracts)	SVI Flags
Minority (all persons except white, non-Hispanic) estimate, 2010-2014 ACS	548	291	7.9%	4.2%	18th	No
Persons (age 5+) who speak English "less than well" estimate, 2010-2014 ACS	129	115	1.9%	1.7%	57th	No
MINORITY STATUS/LANGUAGE DOMAIN SUMMARY					36th	0

Housing/Transportation Theme

Measure	Number	Number MOE	Percentage	Percentage MOE	Percentile Rank (among all US tracts)	SVI Flags
Housing in structures with 10 or more units estimate, 2010-2014 ACS	51	60	1.4%	1.7%	35th	No
Mobile homes estimate, 2010-2014 ACS	274	78	7.7%	2.1%	74th	No
At household level, more people than rooms estimate, 2010-2014 ACS	5	20	0.2%	0.8%	20th	No
Households with no vehicle available estimate, 2010-2014 ACS	70	75	2.6%	2.7%	24th	No
Persons in institutionalized group quarters estimate, 2010-2014 ACS	127	67	1.8%	1.0%	77th	No
HOUSING/TRANSPORTATION DOMAIN SUMMARY					47th	0

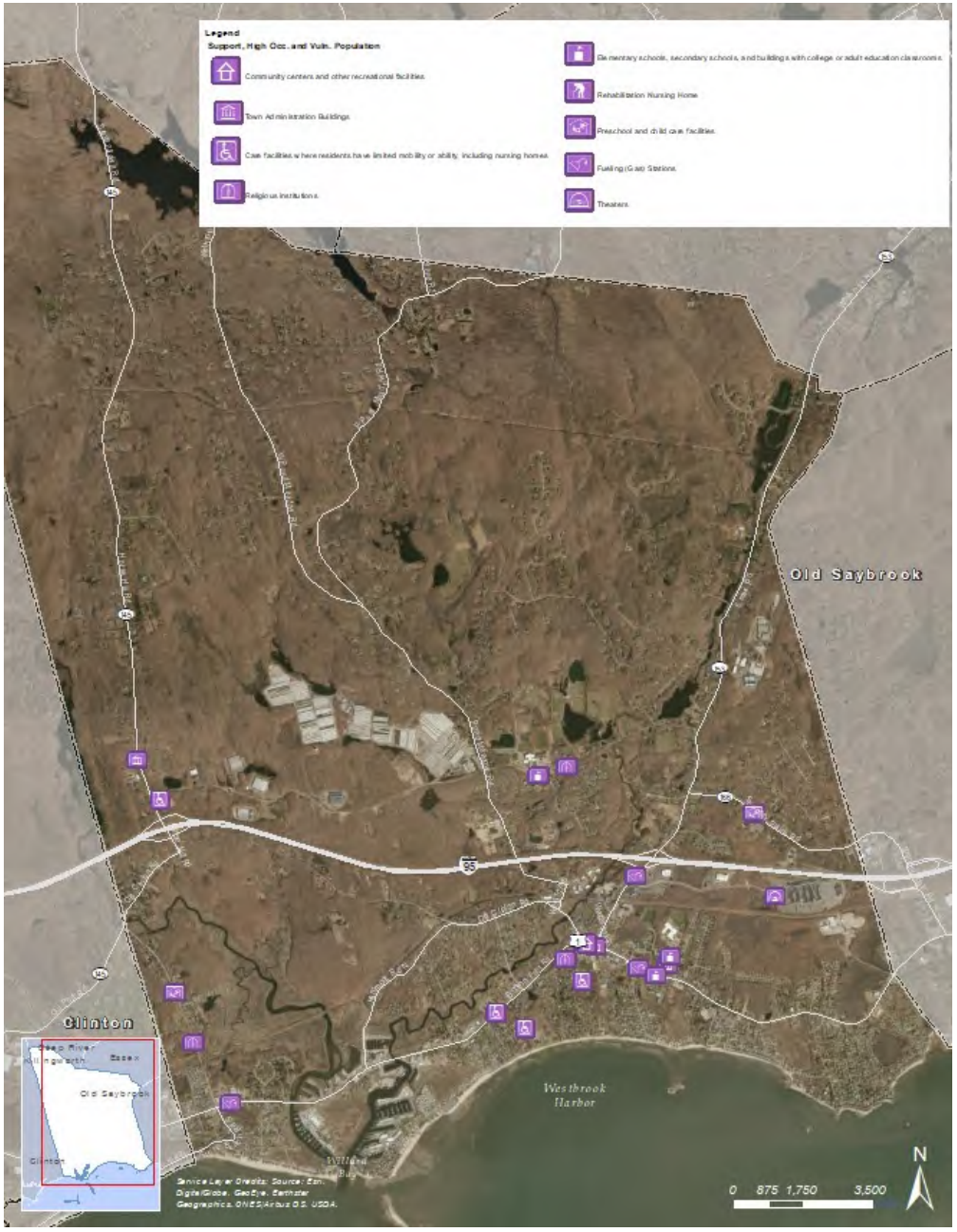


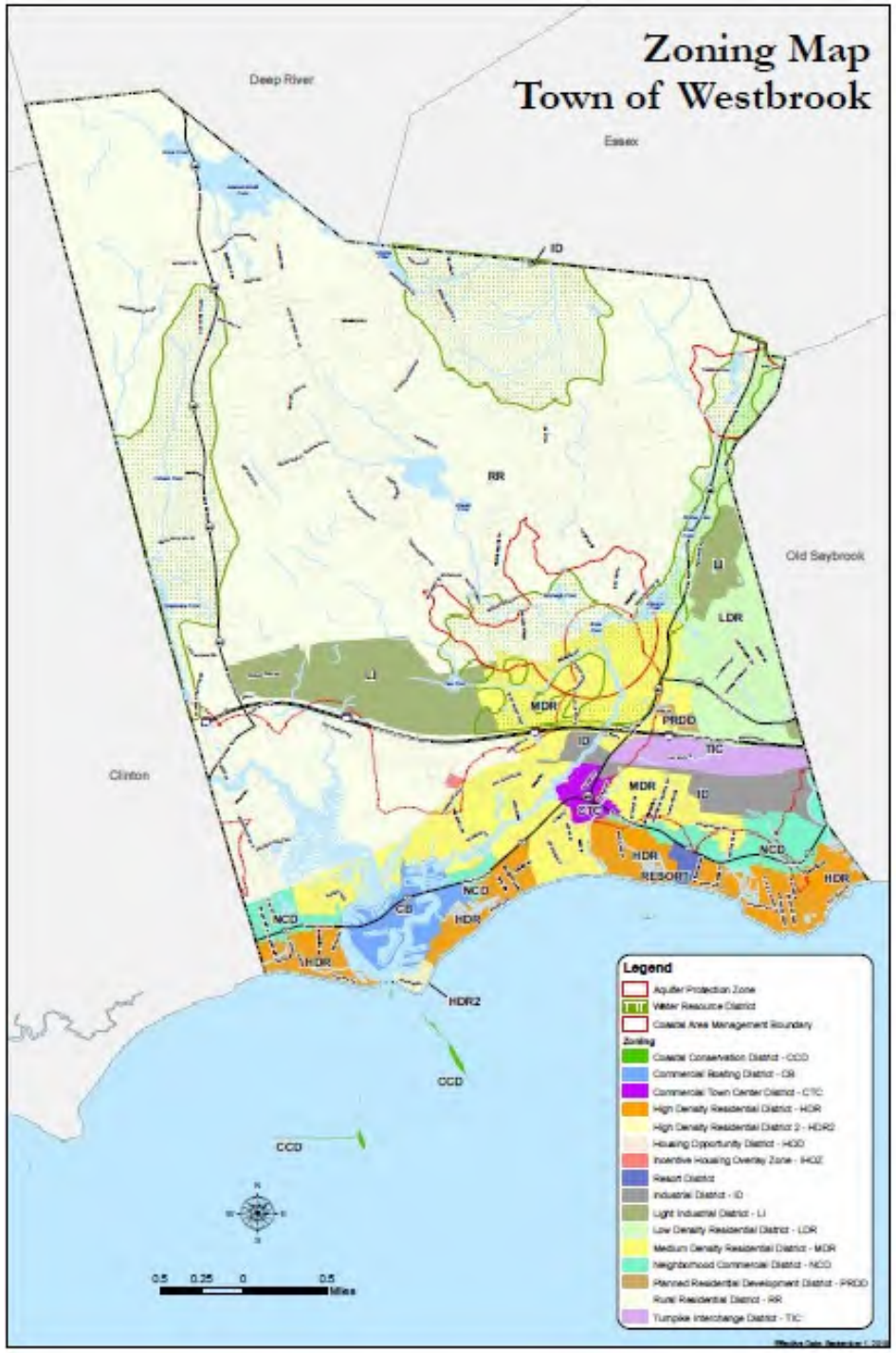
Figure 1-3: Support, High Occupancy and Vulnerable Population Facilities

Support, High Occupancy and Vulnerable Population Facilities

Support, High Occupancy, and Vulnerable Population Facilities in Westbrook are shown on **Figure 1-3**. These include:

- Long-term Care Facilities,
- Schools,
- Pre-schools and Children's care facilities,
- Town Administration Buildings
- Grocery & Supply Stores
- Theaters
- Religious Institutions
- Museums and Galleries,
- Community Centers & Other Recreational Facilities
- Athletic Fields
- Hotels and Inns

Image of Westbrook Town Hall at 866 Boston Post Road



Land Use (Existing)

Westbrook contains about 10,352 acres (16 square miles) of land area. About two-thirds of this area is devoted to residential, commercial or industrial and open space land-uses. The remaining third of the land area is vacant or potentially available for future development.

Land area, broken down by general land use category is shown in **Table 1-2** and presented in **Figure 1-4**. Land use trends show that residential development continues to make up the second largest area of developed land in the Town at 27% of the total area. It is important to note that most of the land south of Interstate 95 is close to built out which includes much of the Town's commercial and industrial land uses. Of the remaining developed land, about 6% is commercial and 5% transportation (i.e. roadway right of ways). Overall, the distribution of land use remained similar with one change of note that was a decrease of 6% of the total land area dedicated to commercial and industrial uses. This change in development pattern did not result in a decrease in the Town's vulnerability to natural and climate-related hazards.

Land Use	Acres Total	Acres (%)
Residential:	2,741	26.5%
Commercial/Industrial	690	6.7%
Other (i.e., transportation, utility)	758	7.3%
Open Space/Agriculture	2,497	24.1%
Vacant Land:	3,409	32.9%
Community Facilities/Institutional	257	2.5%
TOTAL	10,352	100%

Table 1-2 Land Use by Parcel Type

Open Space and Undeveloped Land: Approximately 14% of land in Westbrook is dedicated to open space owned by several entities including the federal government, state government, Town, and land trusts. During the preparation of the 2011 Plan of Conservation and Development (2011 POCD) the Westbrook residents identified preservation of open-space as a high-priority.

Figure 1-4: Existing General Land Use

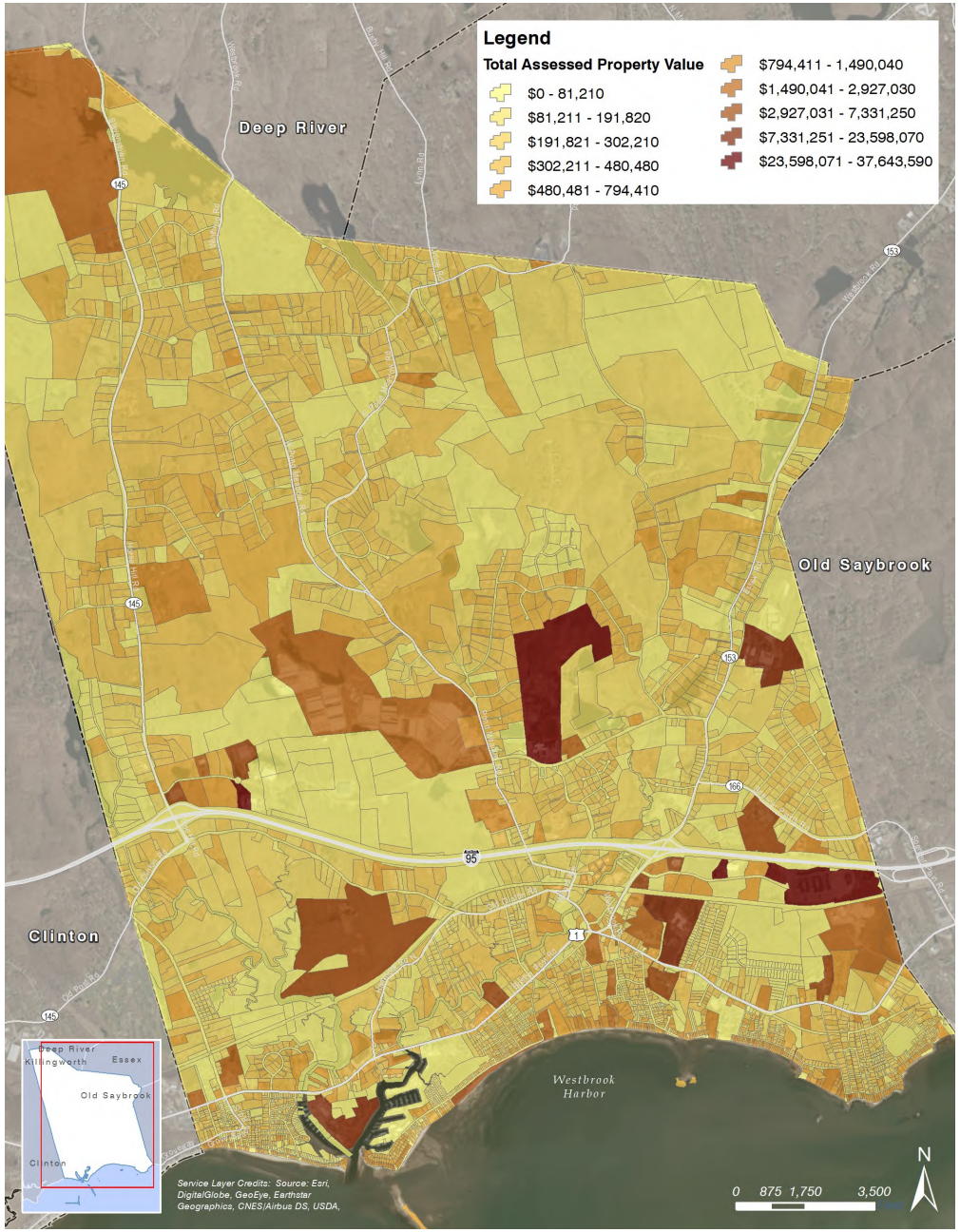


Figure 1-5: Assessed Property Values

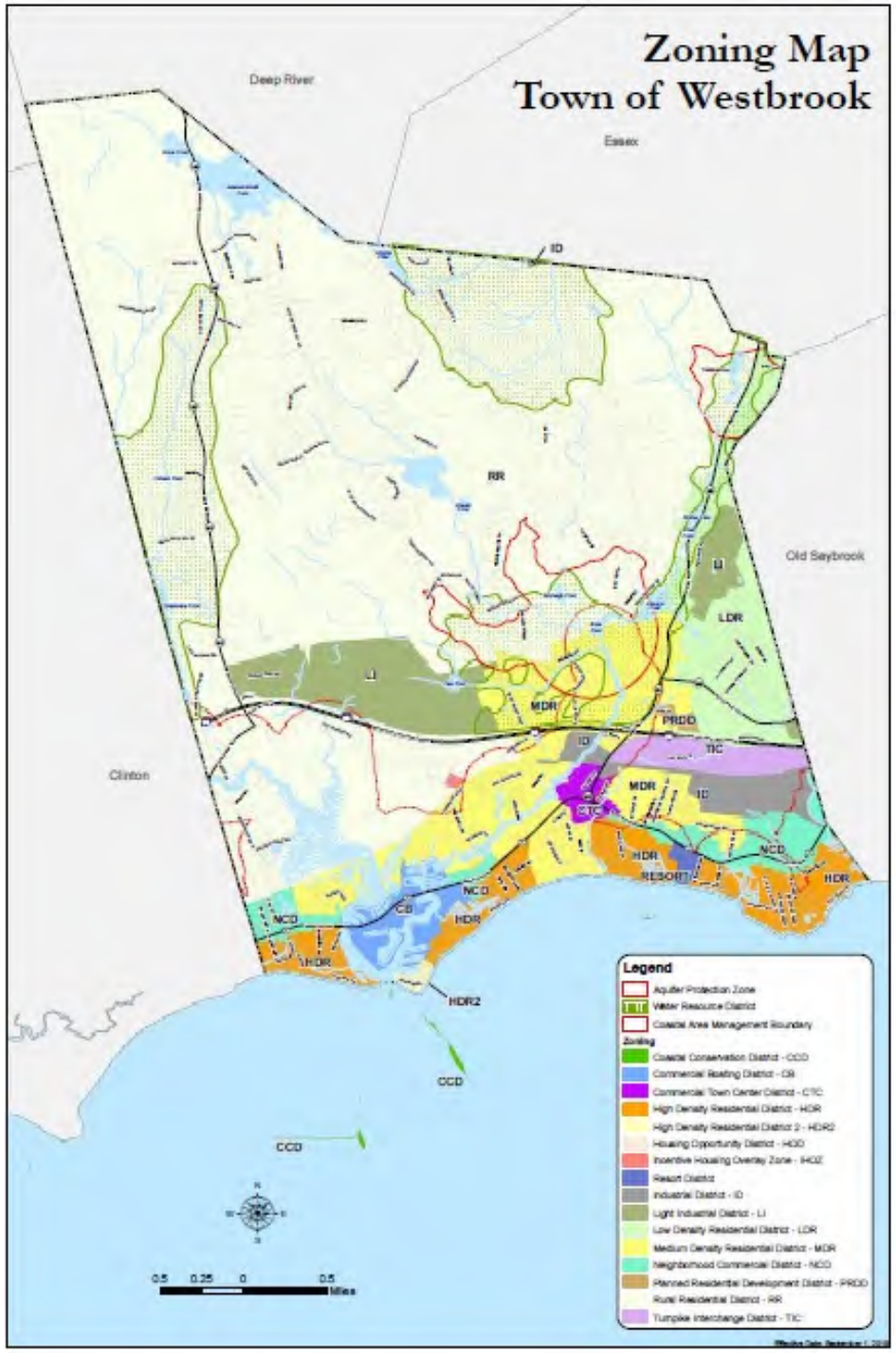
Current Asset Value

Figure 1-5 shows the total assessed values for the Town based on the 2018 Grand List of Taxable Property (Grand List) for Westbrook.

According to the Town Assessor's office, Westbrook has 3,583 residential dwellings (which accounts for over 91.6% of structures) and 330 Commercial/ Industrial/Administrative buildings.

The total assessed real estate regular net property value (excluding contents) based on the 2018 Grand List was $1,023 million dollars compared to $1,051 million dollars based on the 2014 Grand List. This indicates that the total real estate assessed regular net property valuation decreased by 28 million dollars from the 2014 Plan Update.

The 2018 Grand List also indicated that there are 7, 954 motor vehicles valued at $60.9 million dollars which is an increase of 353 vehicles and about $6 million in value.



Zoning

As of September 1, 2019, the Town of Westbrook has sixteen (16) zoning districts as shown on **Figure 1-6**. Zoning Districts include:

- Coastal Conservation District (CCD)
- Commercial Boating District (CB)
- Commercial Town Center District (CTC)
- High Density Residential District (HDR)
- High Density Residential District 2 (HDR2)
- Housing Opportunity District (HOD)
- Incentive Housing Overlay Zone (IHOZ)
- Resort District
- Industrial District (ID)
- Light Industrial District (LI)
- Low Density Residential District (LDR)
- Medium Density Residential District (MDR)
- Neighborhood Commercial District (NCD)
- Planned Residential Development District (PRDD)
- Rural Residential District (RRD)
- Turnpike Interchange District (TIC)

Most of the land area north of I-95 include lower density residential zoning districts combined with light industrial and turnpike interchange closer to I-95. Most of the land area south of I-95 is near built-out and includes higher density residential combined with commercial boating, neighborhood commercial and commercial Town Center as well as industrial districts.

Figure 1-6: Zoning Map

Land Use (Future)

The 2011 Plan of Conservation and Development (POCD) includes future growth principles that are consistent with the State's including:

Goals/Principles

1. Redevelop and revitalize regional centers and areas of mixed land uses with existing or planned physical infrastructure.
2. Expand housing opportunities and design choices to accommodate a variety of household types and needs.
3. Concentrate development around transportation nodes and along major transportation corridors to support the viability of transportation options and land reuse.
4. Conserve and restore the natural environment, cultural and historical resources, and traditional rural lands.
5. Protect environmental assets critical to public health and safety.
6. Integrate planning across all levels of government to address issues on a local, regional, and statewide basis.

Future Development Areas:

Westbrook Town Center: This Plan places a particular emphasis on redevelopment in Westbrook Town Center and the redevelopment of areas along major transportation routes to reinforce community structure. These strategies utilize existing physical infrastructure, and promotes the maintenance of infrastructure to support the desired development pattern.

Future Housing: The Plan expresses a need for and provides strategies for diversifying housing choices to meet current and anticipated demographic and affordability needs. It also looks at ways to capitalize on the existing housing stock and to encourage appropriate new housing development in areas that reinforce the traditional development pattern.

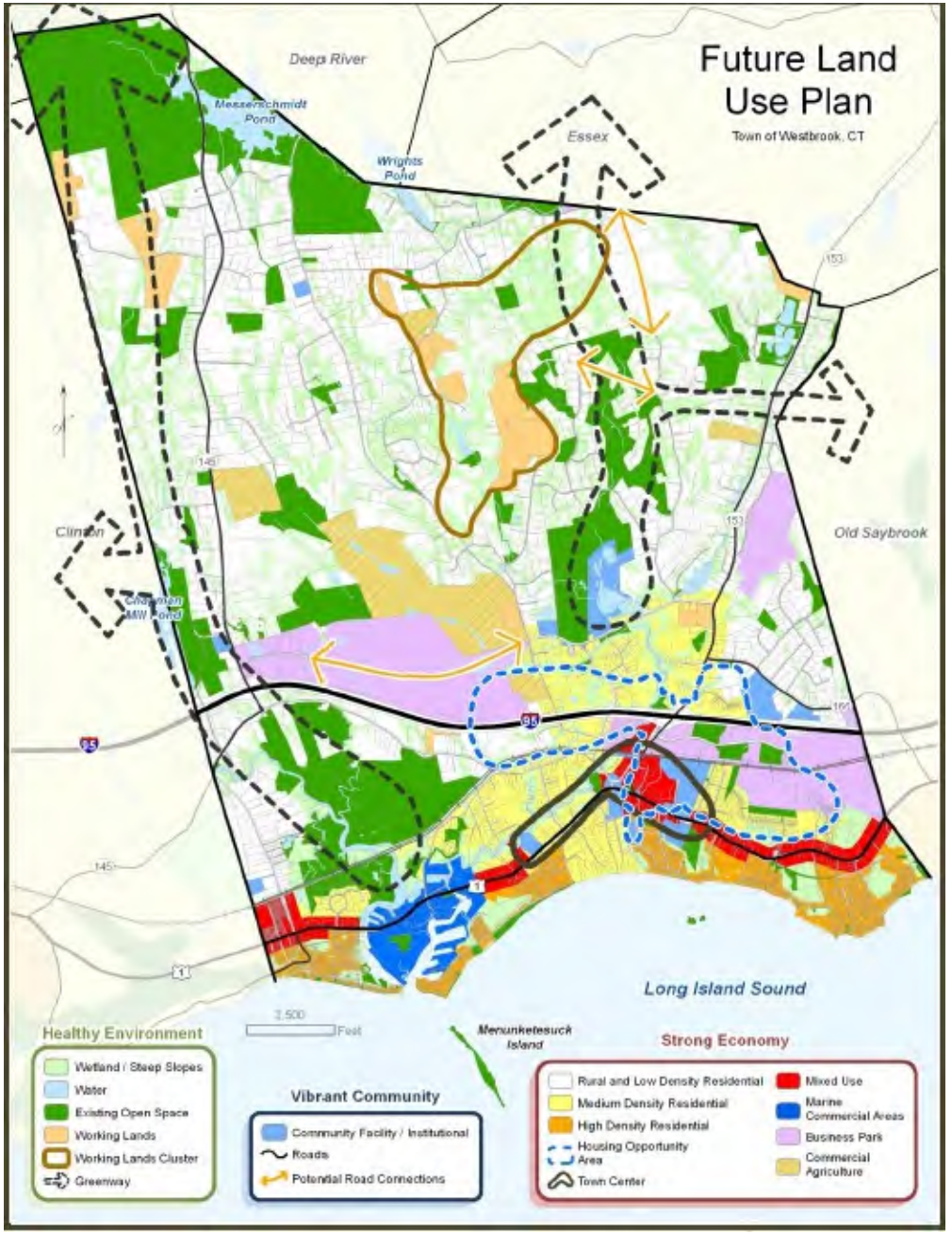


Figure 1-7: Westbrook Future Land Use Map

Transportation Infrastructure

The Town are served by major highways (Interstate 95 (I-95), major arterials such as U.S. Route 1, CT Route 145, Route 153 and Route 166, and a network of smaller roads that provide access throughout the Town and serve as collectors for the major arterials and highways. The Town is also served by several bus routes of the 9 Town Transit District, as well as a train station which offers a stop on both Amtrak's Northeast Regional service and the Shore Line East Railroad. The Town's piers, dock and marinas, while not formally part of the Town's transportation system, are available to provide water access and egress.

An overview of the roadways, and bridges by jurisdiction, is presented below and is followed by a detailed list of each road and bridge included for analysis for this evaluation. **Figure 1-8** on the following page shows the locations of the major transportation infrastructure.

Roads

The State roads make up approximately 17 miles of total roadway within Westbrook. The five (5) key State roads include:

- Route 1 (Boston Post Road)
- Route 145 (Horse Hill Road)
- Route 153 (Essex Road, Westbrook Road, Plains Road)
- Route 166 (Spencer Plain Road)
- Route 625 (Grove Beach North)

Municipal roads make up approximately 46 miles of total roadway within Westbrook. "Key" roads (including both municipal and State roads) are the main arteries serving Westbrook and also provide Town ingress and egress (to State highways). These roads are also essential for providing emergency response services and for evacuation. In addition the following 75 +/- municipal and State roads are highlighted because these roadways are located in the FEMA Special Flood Hazard Area and/or 500-year flood zone:

- Antonie Rd
- Apogee Ln
- Avenue A, B, C
- Beach Ct and Way
- Bellstone Ave
- Beverly Road
- Blue Gill Ln
- Boston Post Road (Route 1)
- Broadway S and N
- Brookside Ave E and W
- Canton Rd
- Captains Dr
- Cedar Ln
- Chapman Avenue
- Chapman Beach Rd
- Cherry Street
- Dennison Rd.
- Dolphin Ave
- East and West Pond Meadow Roads
- Eckford Ave
- Elm Ave
- Fern St
- Fisk Lane
- Fox Lane
- Gerrard Ave
- Goodrich Ave
- Grove Beach Rd S and N
- Grove Ter
- Hogan Rd
- Indian Trail

- Leeway Dr
- Lilac Ln and Rd
- Linden Ave S and N
- Lynne Rd
- McVeagh Rd
- Meadow Point Rd
- Mels Rd
- Menunketesuck Rd
- Minnow Ln
- Mohawk Rd
- Mohican Rd, Mohican Rd E
- Nolin Rd
- Oak Dr.
- Old Clinton Road (route 145)
- Old Kelsey Point Rd
- Old Mail Trail
- Old Pent Road
- Old Salt Works Rd
- Park Row
- Pepperidge Ave
- Pequot Rd
- Pilots Point Dr
- Pioneer Rd
- Pointina Rd
- Pond Meadow Road
- Portside Dr
- Post Ave
- Riverview Rd
- Sachem Road
- Sagamore Ter Drive
- Sagamore Ter E, S and W
- Salt Island Rd
- Seaside Ave
- Seascape Dr
- 2nd Ave
- Shore Ln
- South Ln
- South Main St
- Stannard Ct and Dr
- Stokes Ave
- Striper Ave
- Sunrise Rd
- Tarpon Ave
- Toby Hill Rd
- Trolley Ave
- Trout Lake Dr
- Uncas Rd, Uncas Rd E
- Underway Drive
- Wesley Ave
- Westbrook Rd
- Young Rd.

Transportation Infrastructure (cont.)

Bridges

There are 13 bridges in Westbrook, including bridges where I-95 (Connecticut Turnpike) overpasses Town and State roads, Amtrak rail bridges overpassing Town and State roads, and where I-95, State and Town roadways overpass rivers. **Figure 1-8** presents the transportation infrastructure.

Two (2) I-95 (Connecticut Turnpike) bridges located within the Town limits:

- I-95 Bridge over the Menunketesuck River
- I-95 Bridge over the Patchogue River

Two (2) Amtrak Rail bridges:

- Amtrak Rail Bridge over the Menunketesuck River
- Amtrak Bridge over the Patchogue River

Five (5) State bridges, including:

- Route 1 over the Menunketesuck River
- Route 1 over the Patchogue River
- Route 145 (Horse Hill Road) over I-95
- Route 153 (Essex Road) over I-95
- Route 145 (Old Clinton Road) Bridge over the Menunketesuck River
- Causeway South Bridge over South Cove (Route 154)

Four (4) Town bridges:

- Chapman Mill Pond Road over I-95
- Grove Beach Road Bridge over Amtrak
- Wesley Avenue over the Patchogue River
- Grove Beach North over Amtrak

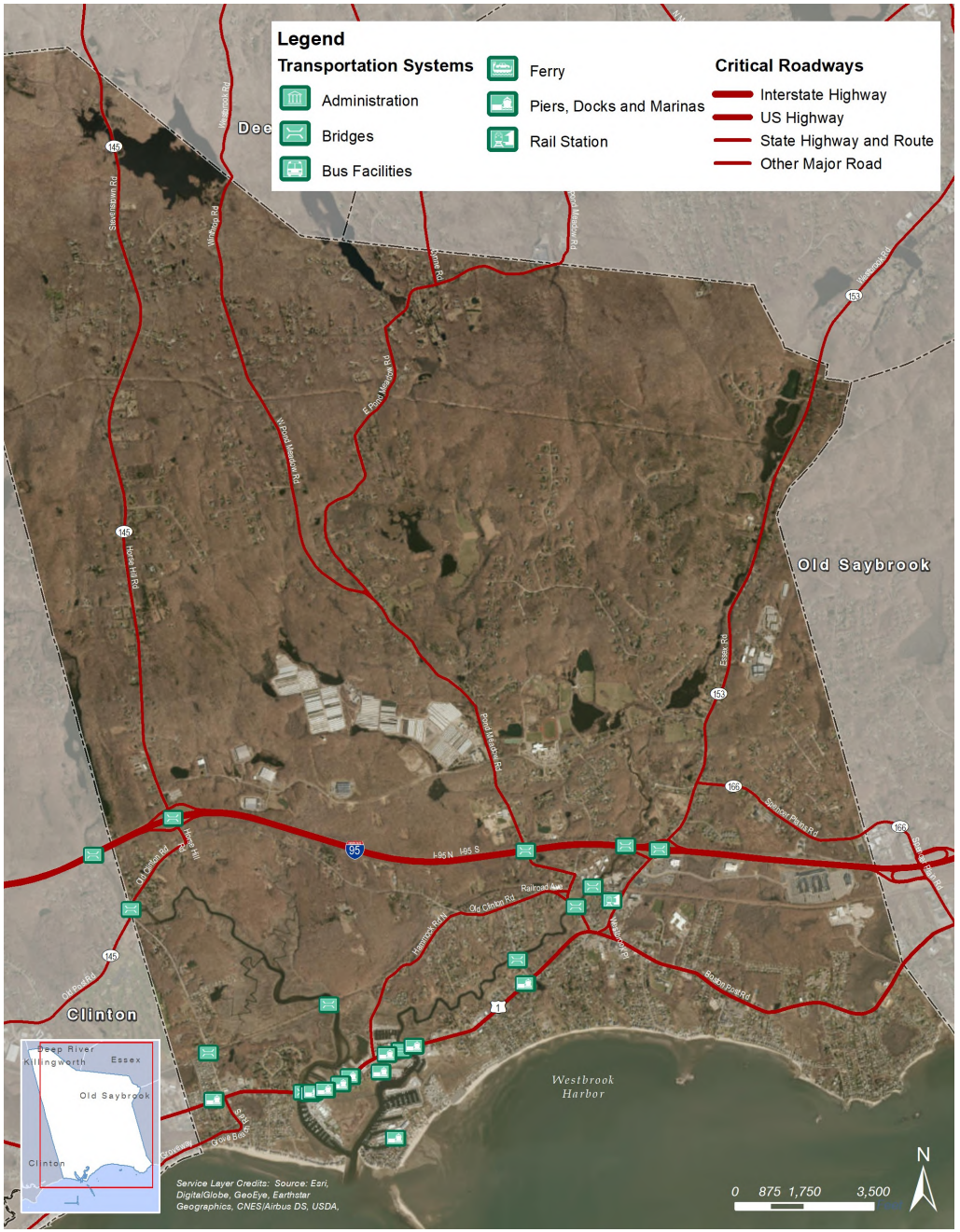


Figure 1-8: Transportation Infrastructure

Attachment 1: Community Profile

Essential Facilities and Lifeline Systems

Essential Facilities and Lifeline Systems in Westbrook are presented in **Figure 1-9**. Essential facilities include facilities that provide critical services including public safety (e.g. police, fire, emergency shelters), health care, and town and regional services necessary for response during and after natural disasters. More information about these services are described below. Lifeline Systems include power generation and transmission, communication systems, potable water supply and sanitary wastewater treatment.

Public Safety and Health Care

Public safety within the Town of Westbrook is the responsibility of the Resident State Troopers Office for police services, Fire Department, Office of Emergency Management, and Department of Public Works. The State of Connecticut Troop F is located at 315 Spencer Plains Road in Westbrook and the Fire Department Headquarters is located at 18 South Main Street in Westbrook. The Town's Office of Emergency Management is located at 866 Boston Post Road. Westbrook is also home to State of Connecticut Troop F located at 315 Spencer Plains.

The Resident State Troopers Office consists of two (2) Resident Troopers who are supported by a full-time administrative assistant. The Resident State Troopers Office is engaged in several mutual aid agreements with other municipalities and entities. Some of these agreements allow the Resident State Troopers Office to rapidly supplement the their patrol force in the case of a large- scale emergency.

The Fire Department includes 4 officers. The full-time fire officers include the Fire Chief, Deputy Fire Chief, 1 Assistant Fire Chief, 1 Burning Official. The officers are supported by a full-time administrative assistant. The Department is tasked with providing fire protection (fire prevention and fire extinguishing), emergency medical response, search and rescue, fire education and a host of other services.

The Office of Emergency Management, located at 866 Boston Post Road. Donald Izzo serves as the Emergency Management Director and is responsible for developing, organizing, directing and coordinating the Town's Emergency Management Program with the goal of saving lives and protecting property by maintaining emergency operational capabilities that mitigate, prepare for, respond to, and recover from any emergency or disaster.

The Town's designate emergency shelter is located the Daisy Ingraham Elementary School at 105 Goodspeed Drive and the back-up shelter is located at Westbrook High School at 156 McVeagh Road.

The two (2) healthcare facilities include:

- Middlesex Health-Shoreline Medical Center at 250 Flat Rock Road; and
- Lakebrook Medical Center at 5 Pequot Road.

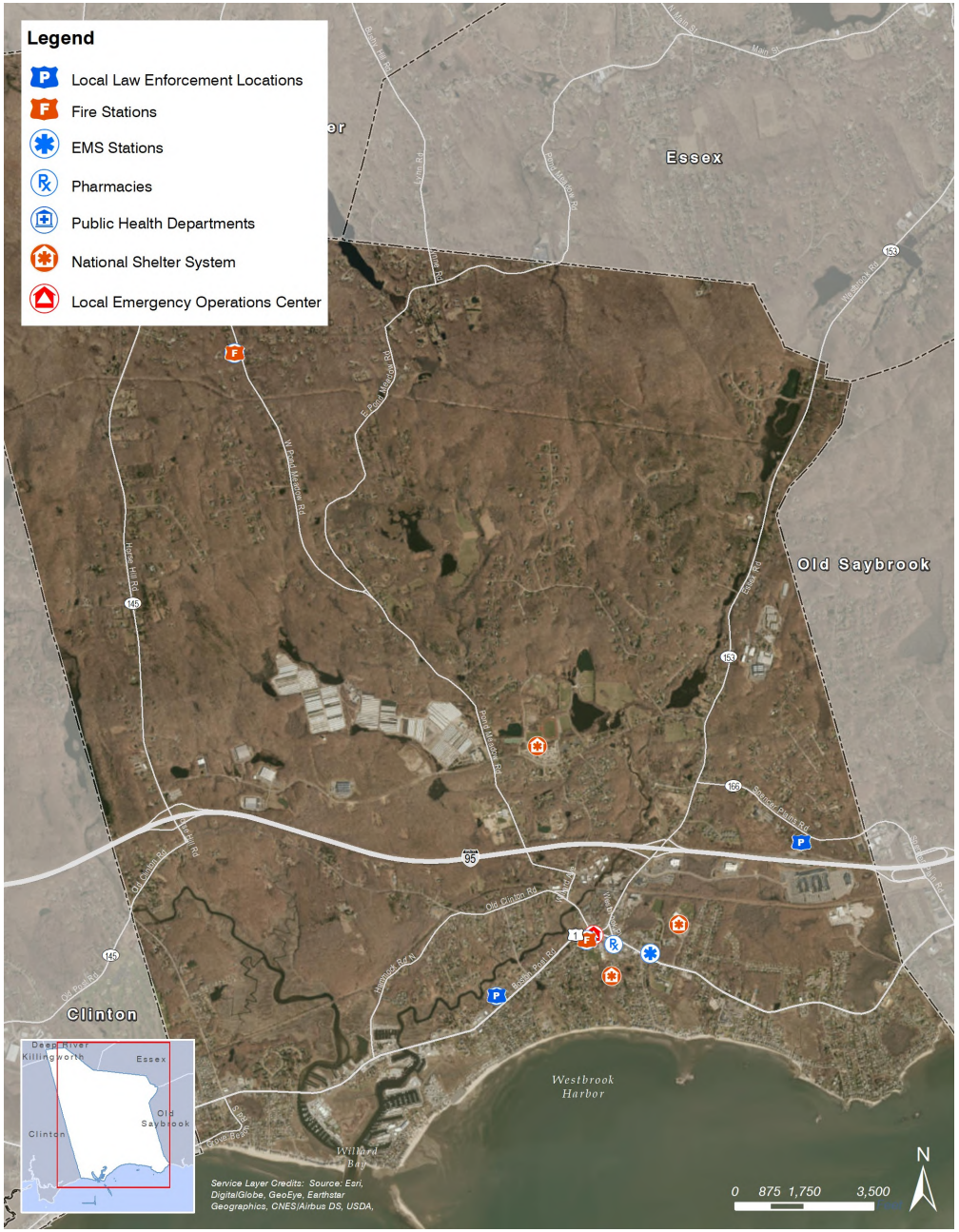


Figure 1-9: Essential Facilities

The two Middlesex healthcare facilities include walk-in care for non-emergency medical service, laboratory services and X-rays (at the Urgent Care Facility).

Utilities

Electrical service for The Town is provided by Eversource (formerly the Connecticut Power & Light Company) and distributed via overhead transmission lines and two electrical substations located in neighboring Old Saybrook at: 1) Bokum Road; and 2) Elm Street. No public power generation occurs within the limits of Westbrook and power generation facilities are located outside of the Town limits. Eversource has an on-going program of system resilience and hardening to minimize outages, in particular focused on tree maintenance (>90% of outages are due to falling limbs on power lines) and electrical system hardening.

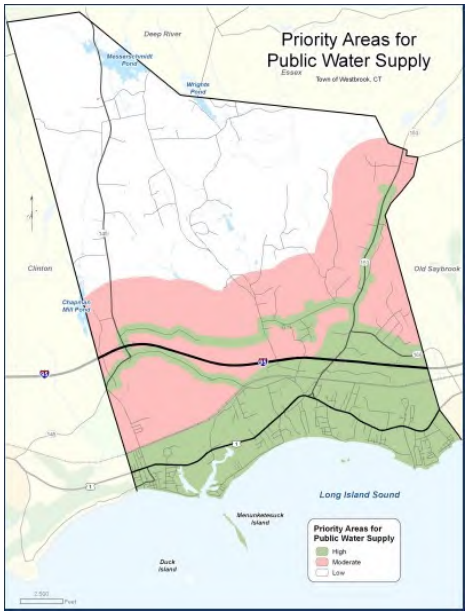
Gas service is provided by Southern Connecticut Gas. Xfinity and Frontier provide cable and telecommunications services, respectively. **Figure 1-10** shows the lifeline systems located in Westbrook.

Water Supply

The following description is based on the description of Westbrook's water supply from the 2011 POCD.

The Connecticut Water Company (the "CWC") supplies drinking water in Westbrook by a 1.6 million gallon water storage tank built in 2010 in Westbrook north of I-95 off Route 145. However, Much of Westbrook is not served by a public water supply.

Most houses and buildings rely on private, on-site wells. In these areas, it is critical to have adequate and accessible water sources for fighting fires. Well use in areas near the shoreline are of concern because of the density of development and septic systems. This area is labeled as a "High Priority" area for Public Water Supply on the Priority Areas for Public Water Supply. The Town currently requires new development located within 1,500 feet of a water line to connect to the public water line. The Town should continue this approach and consider expanding this requirement to developments located within 3,000 feet of a public water line. These areas are shown as "Moderate Priority" on the Priority Areas for Public Water Supply map (facing).



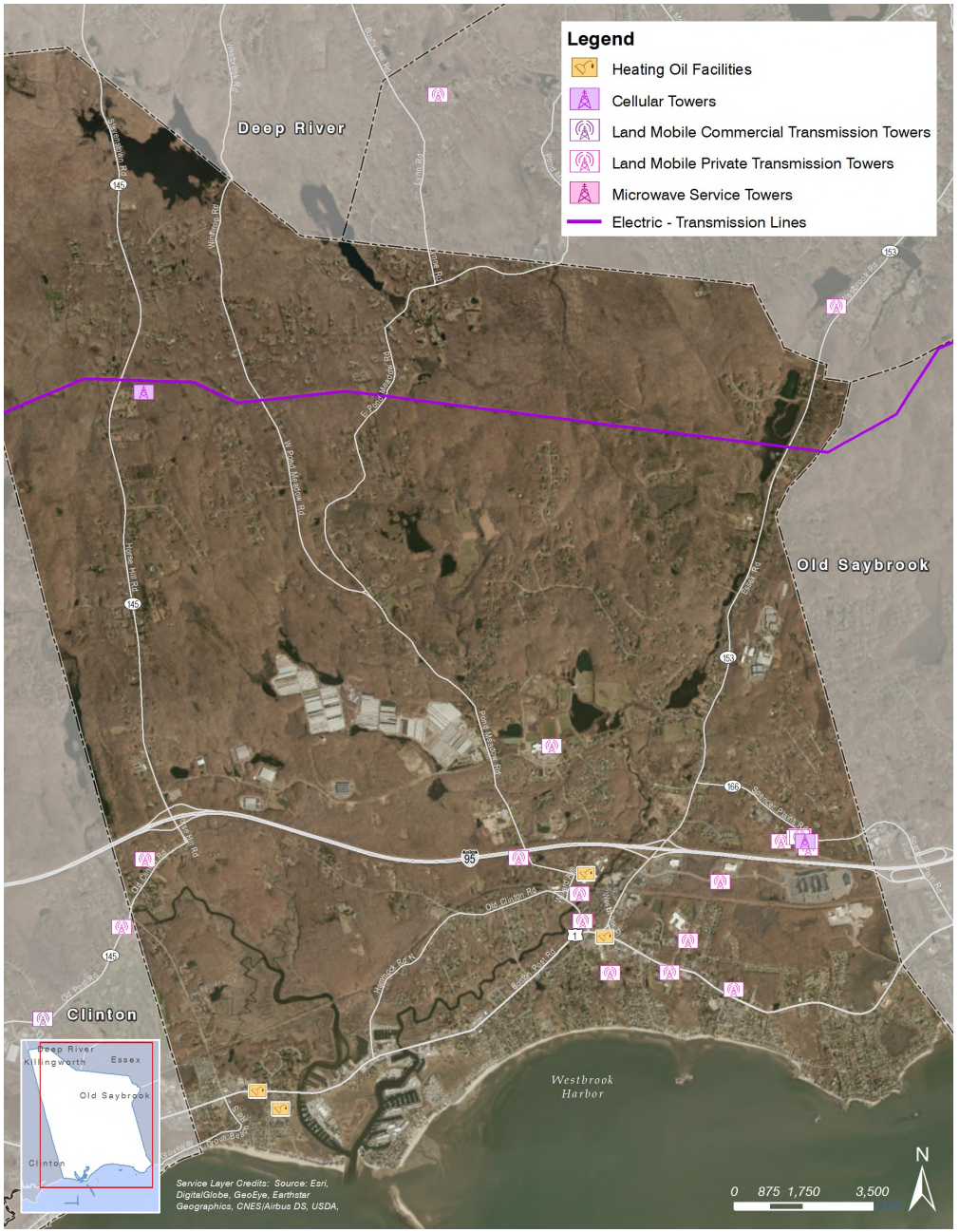


Figure 1-10: Lifeline Facilities in Westbrook

High Potential Loss Facilities: Dams

High potential loss are those facilities, such as dams, whose failure can result in catastrophic loss of human life. The Connecticut Department of Energy and Environmental Protection (DEEP) requires the registration of all dams over six feet in height. As of 2019, there were three such dams in Westbrook as shown on **Figure 1-12**. Two (2) of the three (3) dams in Westbrook are Class C High Hazard potential dams that are required to prepare Emergency Action Plans (EAPs) under Section 22a-6b of the Connecticut General Statutes and Section 22a-6b-1 of the Regulations of Connecticut State Agencies. Both the Messerschmidt and Wrights Pond Dam are Class C High Hazard Dams. The following describes the flood conditions in the vicinity of the 2 Westbrook Class C dams.

Messerschmidt Dam: The Messerschmidt Dam, Class C, DEEP dam # 15401, is a publicly owned dam by DEEP located near the Westbrook Road next to the northern border with the Town of Deep River. The Reservoir behind the dam is approximately 73 acres in size. According to the state Department of Energy and Environmental Protection, the pond is an artificial impoundment of the Falls River, fed by several small streams with a maximum depth of 16 feet near a dam at the eastern end. The dam and pond impoundment are located at a high ground elevation of 164 feet NAVD and outside the limits of current or future coastal flooding. The spillway discharges to a drainage swale that appears to be hydraulically connected to the Deep River via a roadway drainage culverts. The area upgradient and immediately downgradient from the dam which is classified as a FEMA A zone.

Image of the Messerschmidt Dam

Wrights Pond Dam: Wrights Pond Dam Class C, DEEP dam # 15402, is a is a publicly owned dam by DEEP located close to Wrights Pond Road in the northern part of Westbrook near the border with the Town of Essex. The Reservoir and Dam are located at a high ground elevation, approximately 125 feet NAVD88 and outside the limits of current and future coastal flooding.

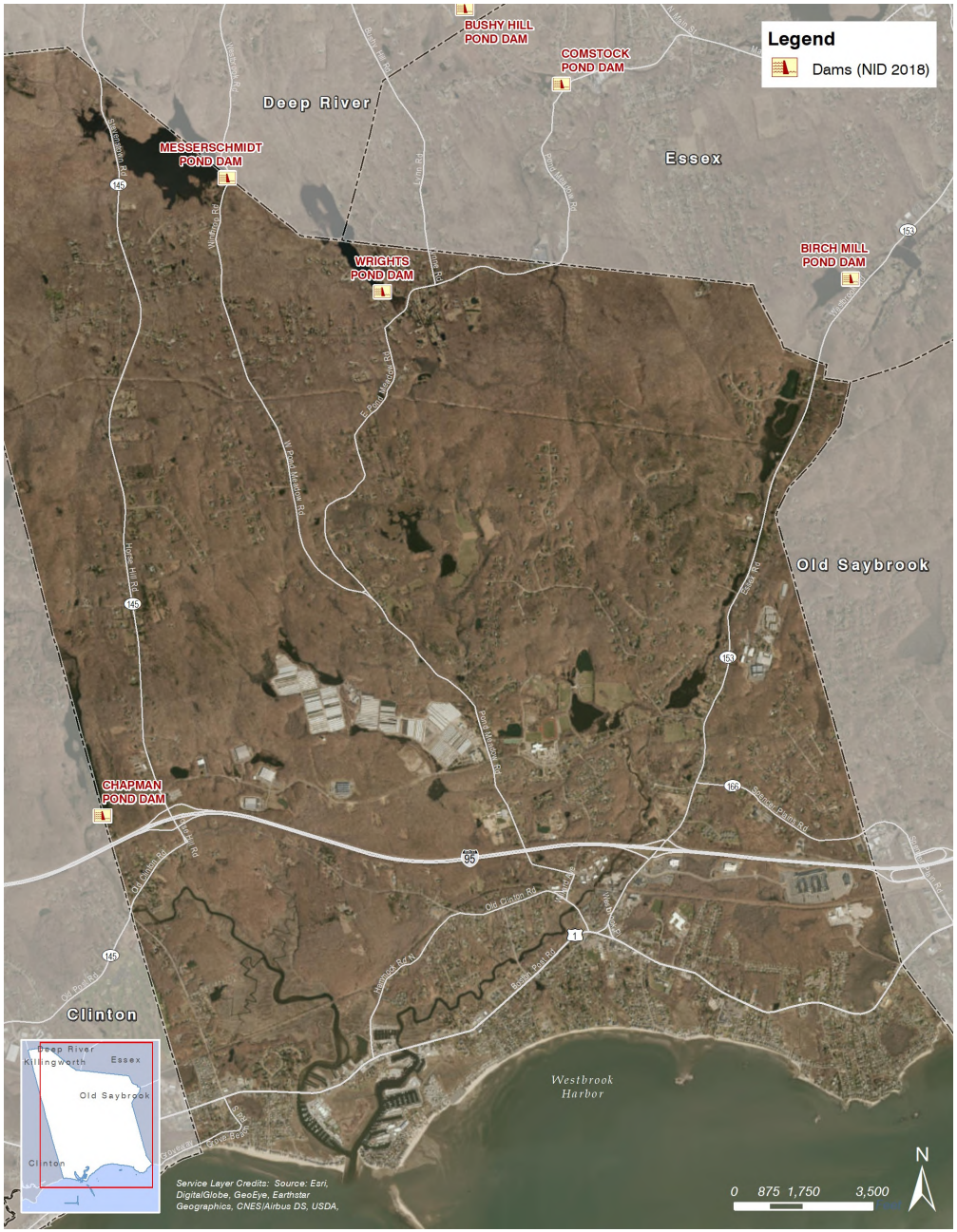


Figure 1-11: Location of Dams in Westbrook

Stormwater Management

Stormwater within Westbrook is primarily managed through a network of catch basins, manholes, underground piping, culverts and outfalls. Surface stormwater runoff also drains to the marshes and embayments. While much stormwater run-off is to adjacent marshes, green infrastructure is not presently utilized to provide on-site infiltration of stormwater.

The stormwater management infrastructure is owned and operated by the Town. The Town is in the process of mapping the town-wide stormwater management infrastructure. Currently, the Town has collected information on approximately forty percent (%) of the town-wide system. While the data collected to-date is not complete, the data collected to-date includes:

- 479 storm water catch basins
- 18 stormwater manholes
- 40 sewer manholes

The most recently available mapping of the Town's catch basins and manholes is presented in **Figure 1-12.** Piped stormwater is discharged via gravity flow to drainage outfalls to the Menunketesuck River, Patchogue River, Long Island Sound and local waterways. The Town also does not have any stormwater pump stations. Based on the available information, existing outfalls do not have tide gates or backflow preventers.

Wastewater Pollution Control

All Westbrook properties are served by on-site sewage disposal systems. The WPCC has adopted a Sewer Avoidance Plan to manage and regulate on-site sewage disposal systems, and an ordinance was passed in 2006 to implement that plan through the oversight of the Westbrook Health Department. The Westbrook Water Pollution Control Commission (WPCC) was established on June 21, 1981, and is governed by Connecticut General Statutes Chapter 103, Section 7-245.

The Water Pollution Control Commission is in the process of working on a Wastewater Management Plan for the Town of Westbrook. The town is under a pollution abatement order (WC-5233) from the Connecticut Department of Energy and Environmental Protection (DEEP). Several areas of town were identified in past engineering reports as needing a solution. The majority of the areas are south of Route 1 and tend to be in the FEMA flood zone. The scope of the Wastewater Management Plan will entail upgrades to subsurface sewage disposal systems where on-site treatment is feasible and small community systems in areas where off-site treatment is necessary. The WPCC will soon be working on the process of selecting an engineering firm to assist them with updating the Wastewater Engineering Plan.

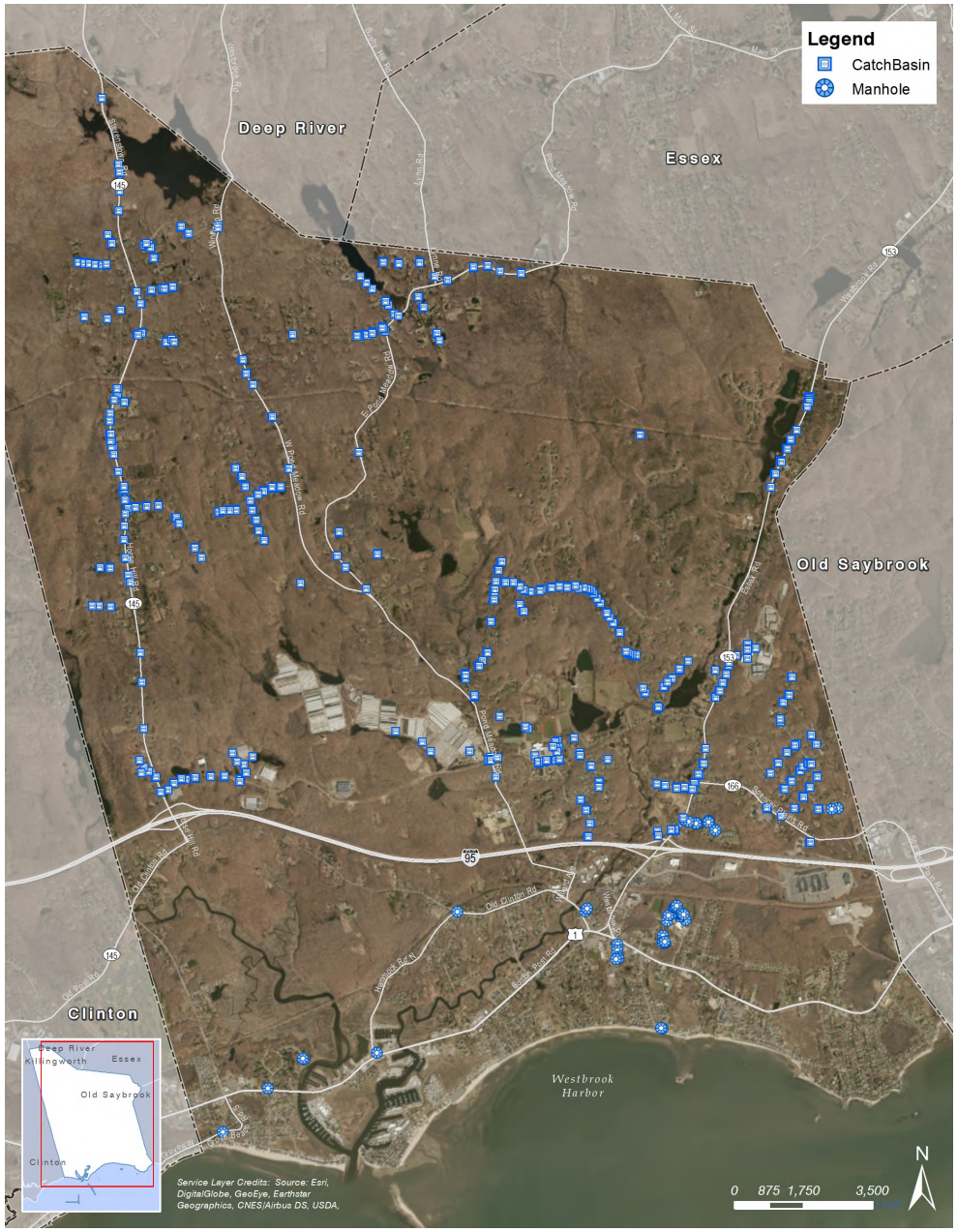


Figure 1-12: Stormwater Management System

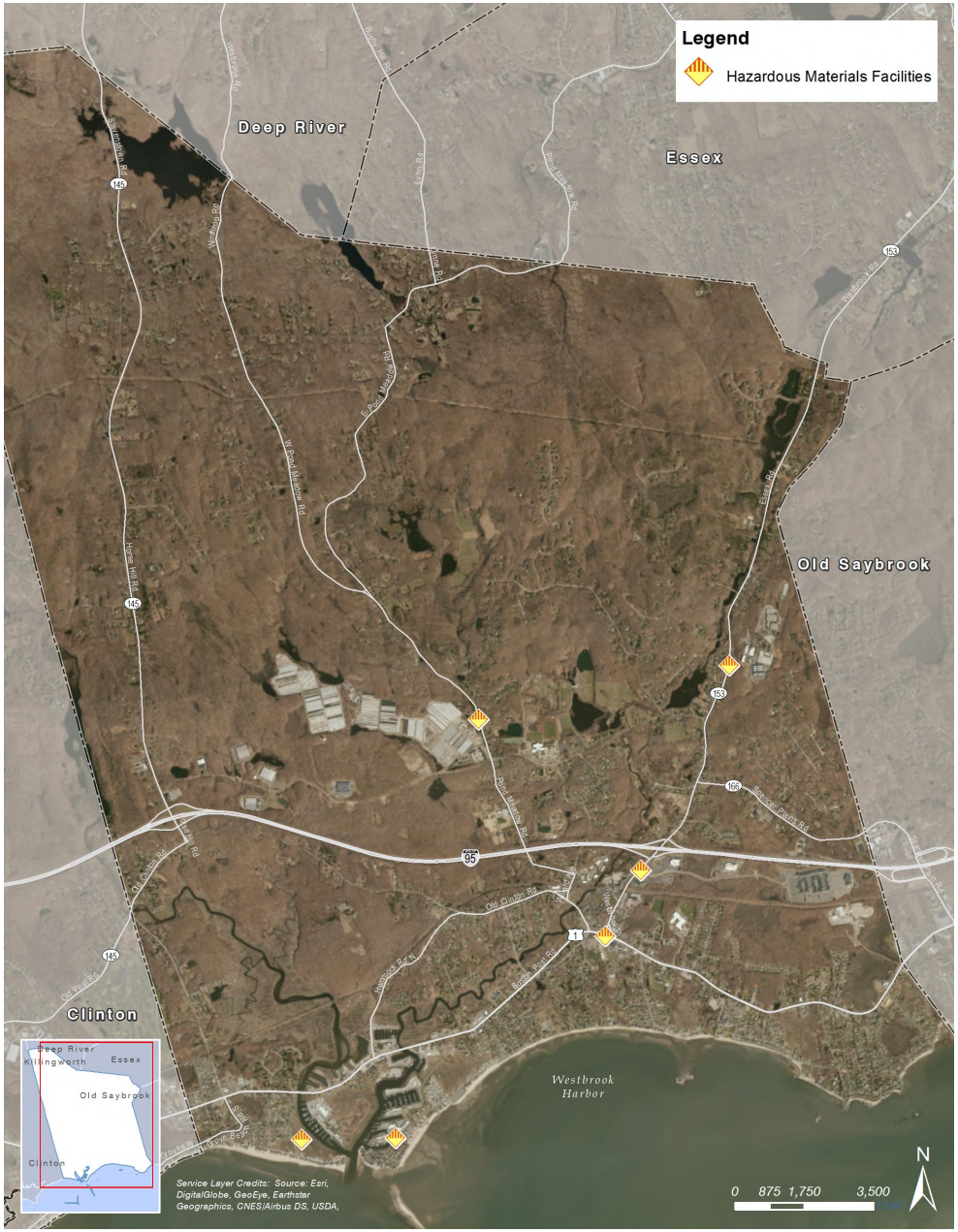


Figure 1-13: Hazardous Materials Facilities and Landfills

Hazardous Materials Facilities and Landfills

Facilities regulated by DEEP and the EPA located in Westbrook are shown in **Figure 1-13.** There are 6 HazMat Category IV Facilities identified by the Environmental Protection Agency (EPA) within Westbrook. Animal shelters are included because these facilities are often repositories for hazardous waste.

Of the 6 waste facilities, 2 are located within FEMA special flood hazard zones. These include:

- 62 Pilots Point, Westbrook, CT 06498
- 82 Pequot Road, Westbrook, CT 06498

Natural Resources—Marshes and Critical Habitats

Tidal Marshes and Wetlands: Much of the Westbrook land area south of Interstate 95 consists of intertidal salt marshes and tidal wetlands. The largest intertidal marsh systems are the Stewart B. McKinney National Wildlife Refuge and Salt Meadow National Wildlife Refuge (abutting the Menunketesuck River north and south of Route 1).

Menunketesuck River: In the vicinity of Westbrook, the Menunketesuck River is a tidal estuary and has extensive fresh and brackish tidal wetlands. The Salt Meadow unit within the Menunketesuck River watershed has diverse and critical habitat and is recognized as containing "Important Bird Areas" by the National Audubon Society. As a tidal estuary, with direct connection to Long Island Sound, the Menunketesuck River shorelines experience water level fluctuations from both tides and coastal storm surges.

Brooks, Creeks and Rivers: The Westbrook wetlands and marshes are fed and drained by brooks, creeks and rivers, which discharge into the Long Island Sound. These include Menunketesuck and Patchogue Rivers. These waterways extend upland of the tidal marshes and wetlands, including both rivers, which are hydraulically connected. Coastal flooding propagates inland up these rivers and connect to lakes and ponds (Chapmans Pond and Johnson Pond).

Marshes: The tidal salt marshes, located at the margin between land and water, are dynamic ecosystems that provide ecological and economic value. The marshes provide habitat for wildlife and fisheries and add to the quality of life and aesthetics of Town residents. The marshes provide some level of resilience to coastal flooding, primarily through wave attenuation and erosion control. The marshes also provide water quality benefits through surface runoff storage and infiltration and pollutant absorption. **Figure 1-14** presents the locations of existing tidal and inland wetlands, beaches, estuarine embayments, intertidal flats, shorelands and places of coastal access for Westbrook.

Marshes are also some of the most susceptible ecosystems to climate change, in particular accelerated rates of sea level rise. Long-term changes to air and water temperature and precipitation may affect species composition and type of habitat. However, the most significant climate change impact to the marshes will be sea level rise. A climate change effect is the advancement of the marsh in response to sea level rise. Another key issue is the potential for chronic or episodic erosion of beaches that separate the marshes from Long Island Sound, which will increase due to the effects of climate change. Beach erosion is discussed in the next section.

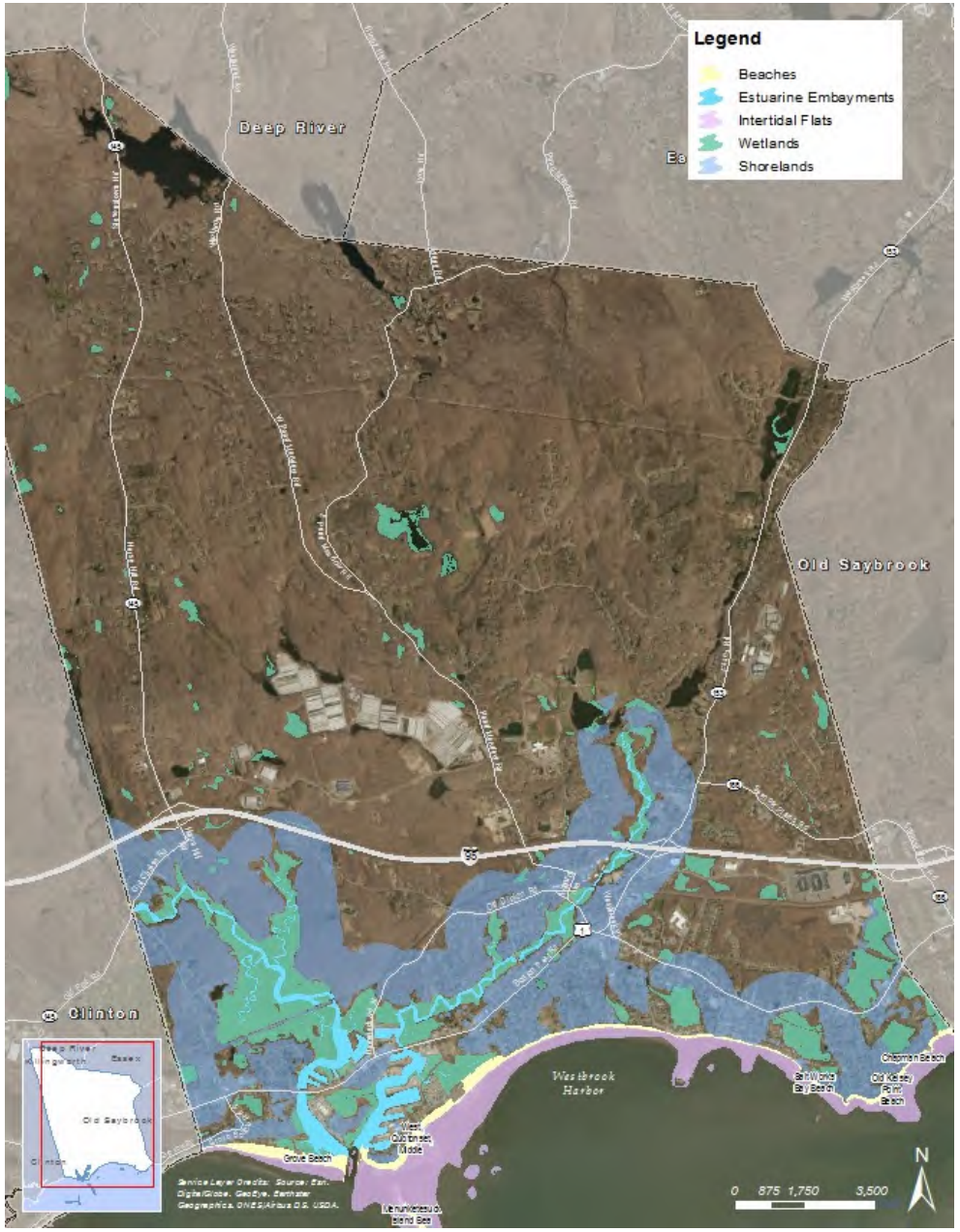


Figure 1-14 Tidal and Inland Wetlands and Critical Habitats

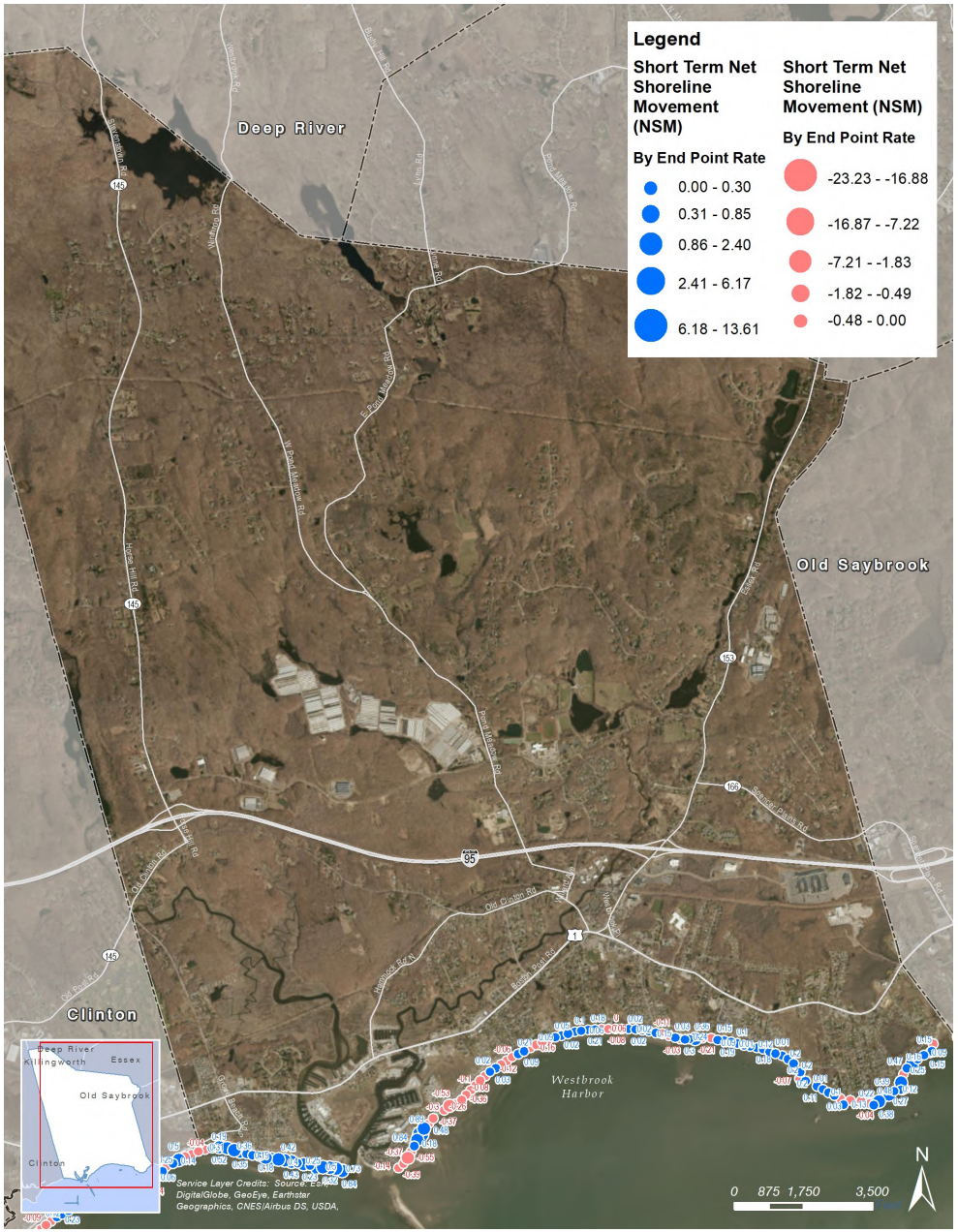


Figure 1-15: Observed net shoreline change (meters/yr.) from 1983 to 2006

Natural Resources—Beaches

Westbrook's southern shoreline includes 17 beaches. Typical of the Connecticut coast, Westbrook's beaches consist of barrier spits and pocket beaches. Beach shoreline protection in the form of groins and jetties have been constructed along many of the beaches in Westbrook. About 4 miles of the Westbrook shoreline is potentially erodible, of which about 1 to 1.5 miles have been significantly affected by erosion. Areas from west to east that have been historically affected by shoreline erosion include: Grove Beach, West Beach (AKA Town Beach), Quonteset Beach, Middle Beach, Little Stannard Beach, Old Kelsey Point, Cedar Crest Beach and Chapman Beach. The "Analysis of Shoreline Change in Connecticut", completed by University of Connecticut (CLEAR), Sea Grant and the Connecticut Department of Energy and Environmental Protection (DEEP), analyzed how the Connecticut shoreline has changed between the late 1800s and 2006 through loss (erosion) and gain (accretion) over time. Shoreline statistics include:

Shoreline "rate of change statistics" reflect a cumulative summary of the processes that altered the shoreline for the time period analyzed. **Figure 1-15** present the shoreline change statistics for the short term. The values calculated for Westbrook include:

Westbrook – Long Island Sound Beaches

Short-Term (1983 to 2006):

Net Shoreline Movement:

Minimum: -12.12 meters

Maximum: 19.51 meters

Average: 2.4 meters

End Point Rate (average): 0.10 meters/year

Long-Term (1880 to 2006):

Net Shoreline Movement:

Minimum: -39.7 meters

Maximum: 80.9 meters

Average: 2.5 meters

End Point Rate (average): 0.02 meter/year

The long term effects of sea level rise on the beaches will be increased erosion and migration of barrier beaches and spits landward. Over the past century, the sea level in Long Island Sound has risen approximately 10 inches. Landward beach migration can progress as long as there are glacial deposits available to replenish the sediment supply and infrastructure does not impede the natural movement of the beach. At Westbrook, sediment supply is limited, and the large number of coastal structures impedes natural sediment transport.

Cultural and Historic Sites

There is one historic districts and 26 historic properties located within Westbrook. The sole Historic District is the Westbrook Town Center Historic District.

Westport Town Center Historic District:

The Westbrook Town Center Historic District includes the historic town center of Westbrook which extends along the Boston Post Road and centers at the intersection with Essex Road. The Town Center has been a critical center of activity since the early 1700s even before the Town was incorporated in 1840. For over three centuries the Town Center Historic District has included residential, commercial, civic activities, and places of religious worship. The district was formally listed on the National Register of Historic Place (NRHP) in 2017.

As noted in the Town's NRHP nomination form, the district extends along Boston Post Road from Westbrook Town Hall in the west to the Oxford Academy campus in the east. A major lobe extends linearly along Old Clinton Road, which is primarily residential in character, while properties are also include on South Main Street (an old alignment of the post road). The district includes 195 historically significant buildings spread over 178 acres, most of which are residential. These buildings exhibit a broad diversity of styles, having been built between roughly the mid-18th and mid-20th centuries. Prominent buildings include the former library (1904) shown in **Figure 1-17**, located in the triangular green at Route 1 and Essex Road, the former town hall (1932 Colonial Revival, originally a school), presented in **Figure 1-18** and another former town hall, originally a private residence built in 1854 and adapted for the town's use in 1940.

The 26 historic properties located within Westbrook include:

- 4 National Register Federal Historic Properties; and
- 24 State Register Historic Properties (Note 2 of the 4 Register Federal Historic Properties are also on the State Register.

Figure 1-17: Image of the former Town library built in 1904.

Figure 1-18: Image of the former Town Hall now serving as a Town office.

Attachment 2: Natural Hazards

NATURAL HAZARDS OVERVIEW

Natural hazards are **natural events** that threaten lives, property, and other assets. Within Connecticut, natural hazards typically include:

- Severe Weather Hazards such as Hurricanes and Tropical Storms, Nor'easters, Lighting, Intense Rainfall, Hail, Heavy Snowfall and Ice Storms.
- Climate-Related Hazards such as extreme heat and cold, drought and wildfire.
- Geologic Hazards such as earthquakes, landslides and tsunamis.

Severe weather hazards, including hurricanes, tropical storms and nor'easters can result in coastal flooding (storm surge and waves). These flood events will become worse in the future due to climate-related changes to sea level rise and, perhaps, storm intensity. Coastal flooding can result in the secondary hazard of shoreline change. Severe weather hazards can also result in high winds, lightning, hail, intense rainfall and tornadoes.

Coastal Connecticut is also vulnerable to tsunamis, a geologic hazard; however, the likelihood of a significant tsunami impacting coastal Connecticut is considered very low.

Localized intense rainfall can result in urban flooding where existing stormwater management capacity is exceeded. It can also result in flash flooding of streams and rivers and exceedance of water reservoir dam capacity.

Hazard Probability

Natural hazards can often be predicted, including predicting their likelihood of occurrence. The probability of a specific natural hazard occurring is typically defined in terms of its annual exceedance probability (AEP). This refers to the probability that a hazard condition will be met or exceeded in any given year. In lieu of the AEP, the term recurrence interval (in years) is often used.

Climate Change

Climate change, a result of increased greenhouse gas emissions and secondary effects, will significantly impact certain natural hazards. There is high scientific consensus that coastal flooding in Connecticut will become worse due to sea level rise. Storm intensity may also increase, resulting in increased flood elevations. There is high scientific consensus that climate change will result in increased rainfall intensity within Connecticut as well as the frequency of extreme rainfall events. There is also scientific consensus that climate change will result in in extended periods of extreme heat (heat waves) and cold.

WESTBROOK NATURAL HAZARDS

GZA performed an analysis of multiple natural hazards and identified those hazards that are relevant to the Town. These are presented in **Table 2-1**. These hazards are characterized in detail in the following pages.

Severe Weather Hazards:
Severe Wind:
Hurricanes/Tropical Storms
Thunderstorms
Tornadoes
Lightning
Intense Rainfall
Hail
Flood:
Storm Surge
Sea Level Rise
Urban Drainage Flooding
Shoreline Change
Severe Winter Weather:
Snowfall
Ice Storms
Climate-Related Hazards:
Extreme Temperature:
Extreme Heat
Extreme Cold
Drought
Wildfire
Geologic Hazards:
Earthquake

Table 2-1: Natural Hazards applicable to Westbrook

Severe Weather Hazards: Severe Wind

SEVERE WIND

Severe wind (including high to extreme wind) will typically occur in the Town as a result of: 1) tropical storms and hurricanes; 2) extratropical nor'easters; 3) severe thunderstorms; and 4) tornadoes. Severe thunderstorms and tornadoes are convective weather events. Extreme "straight line" convective wind events include microbursts, macrobursts and derechos. Derechos are widespread, long-lived, and violent convectively-induced "straight-line" windstorms associated with a fast moving band of severe thunderstorms,. "Thunderstorm winds", arising from convection are winds with speeds greater than 58 mph or winds of any speed producing, damage, injury or fatality.

Severe wind poses a threat to life, building structures, and essential facilities (e.g., electrical utilities) due to the effects of wind loads, flying debris, and/or downed trees and power lines. Severe wind will typically cause the greatest damage to lightly-constructed structures, in particular manufactured homes. Downed tree limbs can also cause property and vehicle damage, impact roadways, and in rare instances, cause loss of life. These storms may be accompanied by lightning, which can spark fires. During hurricanes and tropical storms, high winds can also occur coincident with intense rainfall and during nor'easters, high winds can occur coincident with snow (blizzards), rain and a snow/rain mix.

Wind speeds are categorized by the National Weather Service based on potential for structure damage and public health risk, with a distinction between sustained (1-minute duration) wind speeds and gust (3 second duration) wind speeds:

- Wind Advisory: 1) sustained winds of 31 to 39 mph for an hour or more; and/or 2) wind gusts of 46 to 57 mph for any duration.
- High Wind Watch/Warning: 1) sustained winds of 40 mph for one hour or more; or 2) wind gusts of 58 mph or higher for any duration.
- Hurricane Warning: sustained winds of 74 mph or higher or frequent (for more than 2 hours) gusts of 74 mph or greater associated with a tropical cyclone.
- Extreme Wind: 1) surface winds of 115 mph or greater associated with a derecho or sustained hurricane winds.
- Severe Thunderstorm Watch/Warning: winds of 58 mph or higher and/or hail 1-inch in diameter or larger.

The Connecticut State Building Code (using ASCE 7-10) utilize wind gusts as the basis for structure design. The regulatory 3 second gust speeds applicable to Westbrook (**Table 2-2**). GZA performed an extreme value statistical analysis of historical wind data (sustained 1 minute, 10-meter wind speeds) at the nearby New London/Groton Airport. The results are presented in **Figure 2-1**.

Mean Recurrence Interval (yrs)	3-second Gust (mph)
10	79
25	89
50	98
100	107
300	122
700	132
1,700	143

Table 2-2: ASCE 7-10 Wind speed Mean Recurrence Intervals (3-second peak gust in mph)

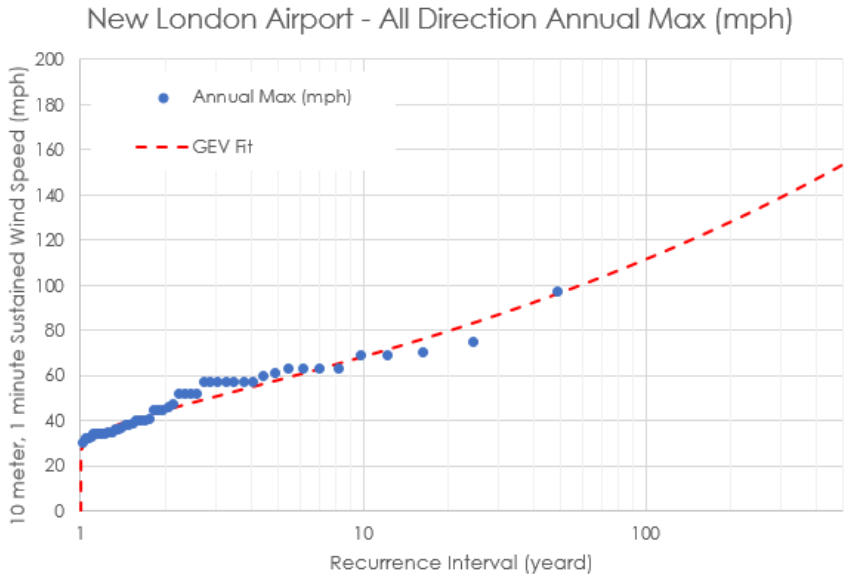


Figure 2-1: Mean 1-minute sustained wind speed based on GZA Extreme Value Analysis of New London/Groton Wind Data

SEVERE WIND cont.

Westbrook Design Wind Speeds for Buildings and Other Structures

The Connecticut State Building Code wind speed design requirements (in terms of 3-second gust) are:

- Risk Category I: 122 mph - 300 year recurrence interval;
- Risk Category II: 132 mph - 700 year recurrence interval; and
- Risk Categories III-IV: 143 mph - 1,700 year recurrence interval.

Risk categories are based on occupancy and use and are described in **Table 2-3**.

Historical Occurrence at Westbrook and Vicinity

During 1996 to 2018, Middlesex County experienced 17 days of High Wind events with estimated gusts of about 58 to 80 mph resulting in about $560,000 in property damage and no deaths. During 1950 and 2018, Middlesex County and surrounding areas had 60 days with Thunderstorm (convective) winds resulting in no deaths and $211,250 damage.

(Source: NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/)

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following severe wind probabilities at and near Westbrook:

- High Winds: near 100% AEP or 1 year recurrence interval
- Hurricane wind speeds or greater: +/- 1.2% AEP or 80-year recurrence interval (about 1/80 in any given year). Note that the Hurricane of 1938 was not included in the airport data set, which would increase the chance of experiencing sustained Hurricane wind speeds or greater to about 2.5% AEP or 40-year recurrence interval
- Extreme Wind: less than 0.2% AEP or 500-year recurrence interval

TABLE 1604.5
RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

RISK CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities.
II	Buildings and other structures except those listed in Risk Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing elementary school, secondary school or day care facilities with an occupant load greater than 250. • Buildings and other structures containing adult education facilities, such as colleges and universities, with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident care recipients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000 [a]. • Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Risk Category IV. • Buildings and other structures not included in Risk Category IV containing quantities of toxic or explosive materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(1) or 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and Are sufficient to pose a threat to the public if released [b].
IV	Buildings and other structures designated as essential facilities, including but not limited to: • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures. • Buildings and other structures containing quantities of highly toxic materials that: Exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the *International Fire Code*; and Are sufficient to pose a threat to the public if released [b]. • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water storage facilities and pump structures required to maintain water pressure for fire suppression.

Table 2-3: Building Code Risk Categories of Buildings and Other Structures
See Connecticut State Building Code for additional detail.

Climate Change Effects and Severe Wind Occurrence

The attribution of high wind events to climate change is uncertain. There is moderate scientific consensus, that the intensity and frequency of intense hurricanes could increase within southern New England due primarily to the increase in sea water temperature along the East Coast. There is lower confidence, and less understanding, in the attribution of increased extratropical nor'easters and thunderstorms frequency and intensity to climate change.

HURRICANES

Hurricanes, tropical storms and tropical depressions are tropical cyclones (rotating low pressure weather systems that have organized thunderstorms but no pressure fronts - a boundary separating two air masses of different densities). Tropical cyclones with maximum sustained surface winds of less than 39 miles per hour (mph) are called tropical depressions. Those with maximum sustained winds between 39 mph and 73 mph are tropical storms. Hurricanes are tropical cyclones with sustained wind speeds of 74 mph or higher.

East Coast hurricanes originate in the Atlantic basin, which includes the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. A six-year rotating list of names, updated and maintained by the World Meteorological Organization, is used to identify these storms. "Hurricane Season" begins on June 1 and ends on November 30, although hurricanes can, and have, occurred outside of this time frame (NOAA National Ocean Service).

The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating, or category, based on a hurricane's maximum sustained winds. The higher the category, the greater the hurricane's potential for property damage (NOAA National Ocean Service). A major hurricane (Categories 3, 4 and 5) has sustained wind speeds of 111 mph or higher on the Saffir-Simpson Hurricane Wind Scale.

Historic hurricane and tropical storm tracks which have passed within 100 nautical miles of Westbrook are presented in **Figure 2-2**. (source https://coast.noaa.gov/hurricanes/) Historic hurricane tracks which have passed within 100 nautical miles of Westbrook are presented in **Figure 2-3**. A distance of 100 nautical miles is a reasonable representation of hurricanes that have the potential to cause flooding within Long Island Sound.

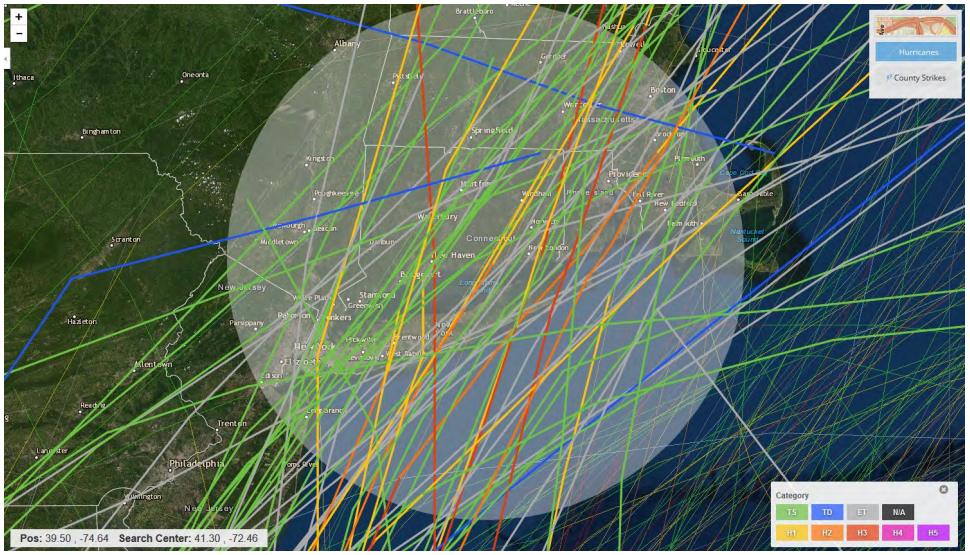


Figure 2-2: Hurricanes and Tropical Storms within 100 miles of Westbrook (66 events)

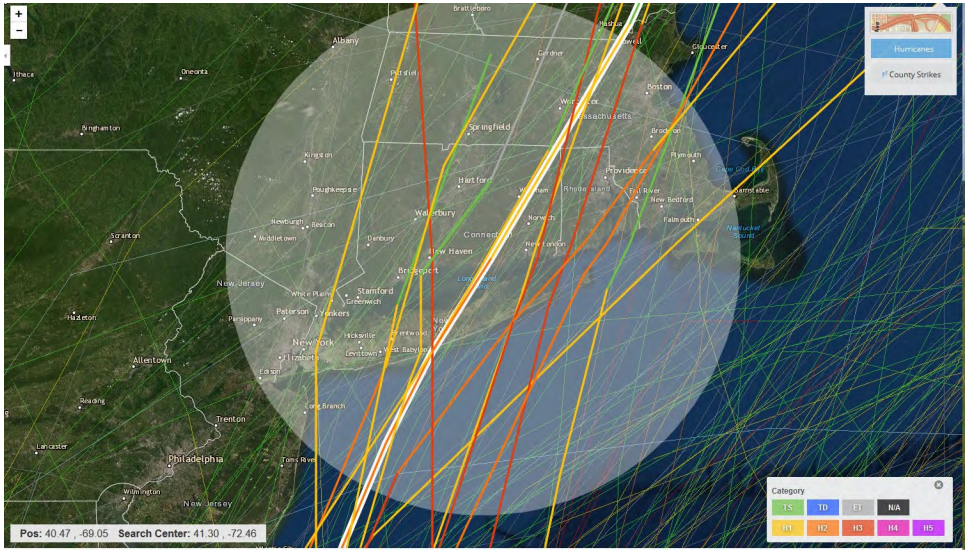


Figure 2-3: Hurricanes within 100 miles of Westbrook (14 events)

HURRICANES

Fifteen hurricanes have tracked within 100 nautical miles during NOAA's period of record, including the following significant hurricane. The Hurricane of 1938 was a major hurricane (≥ Category 3) at landfall west of Westbrook.

Table 2-5 summarizes the top ten water levels at the NOAA New London and Bridgeport tide stations relative to MHHW. The highest observed water levels resulted from hurricanes, with the highest documented flood water level observed during the Hurricane of 1938. The top observed water levels at New London have resulted from six hurricanes, one tropical storm and three Nor'easters.

Name	Date	Category	Landfall (relative to Westbrook)
Gloria 1985	9/16 to 10/02/1985	H1 (Category 1)	West
Unnamed 1858	9/14 to 9/17/1858	H1 (Category 1)	East
Unnamed 1894	10/01 to 10/12/1894	H1 (Category 1)	At Westbrook
Unnamed 1934	9/05 to 9/10/1934	H1 (Category 1)	West
Donna 1960	8/29 to 9/14/1960	H2 (Category 2)	At Westbrook
Unnamed 1944	9/09 to 9/16/1944	H2 (Category 2)	East
Bob 1991	9/16 to 9/29/1991	H2 (Category 2)	East
Carol 1954	8/25 to 9/01/1954	H3 (Category 3)	East
Unnamed 1869	9/07 to 9/09/1869	H3 (Category 3)	East
Hurricane of '38	9/09 to 9/23/1938	H3 (Category 3)	West
Unnamed 1879	8/13 to 8/20/1879	H1 (Category 1)	East
Unnamed 1916	7/10 to 7/22/1916	H1 (Category 1)	East
Belle 1976	8/06 to 08/10/1976	H3 (Category 3)	West
Unnamed 1893	8/15 to 8/26/1893	H3 (Category 3)	West

Table 2-4: Hurricane tracks within 100 miles of Westbrook

Station	1	2	3	4	5
8461490 New London[1]	9/21/1938 7.53 feet	8/31/1954 6.53 feet	10/30/2012 4.89	11/25/1950 4.53 feet	9/14/1944 4.03 feet
	6	7	8	9	10
	9/12/1960 3.83 feet	11/7/1953 3.73 feet	10/31/1991 3.42 feet	8/28/2011 3.39 feet	11/12/1968 3.33 feet
	1	2	3	4	5
8467150 Bridgeport[2]	10/30/2012 5.72	8/28/2011 4.72	12/11/1992 4.72	10/31/1991 4.06	10/25/1980 3.67
	6	7	8	9	10
	3/29/1984 3.29	9/27/1985 3.27	10/19/1996 3.21	11/12/1968 3.20	4/16/2007 3.19

Table 2-5: NOAA Station Top Ten Water Levels (in feet above MHHW)

Hurricane recurrence intervals reflect the frequency at which hurricanes can be expected to occur within a given distance of a given location. The total number of hurricane strikes within Middlesex County during 1900 and 2010 is 5 (**Figure 2-4**). The total number of major hurricanes strikes within Middlesex County is 3. **Figures 2-5 and 2-6** shows hurricane recurrence intervals (aka return periods) for hurricanes passing within 50 miles of various locations. In the vicinity of Westbrook, the hurricane passing recurrence interval is about 17 to 18 years. In simpler terms, this means that a hurricane is likely to strike or pass near Westbrook, on average, about 6 to 8 times per 100 years. In the vicinity of Westbrook, the recurrence interval for major hurricanes striking or passing near (Cat 3 and above) is about 52 to 70 years. **Figure 2-7** shows the zones of origin and tracks for different months during the hurricane season. These figures depict average conditions. Hurricanes can originate in different locations and travel much different paths from the average. Regardless, they provide a good sense of the general pattern of hurricane tracks near Long Island Sound. The likelihood of a hurricane striking near Westbrook is much greater during the months of August through October.

Historical Occurrence at Westbrook and Vicinity

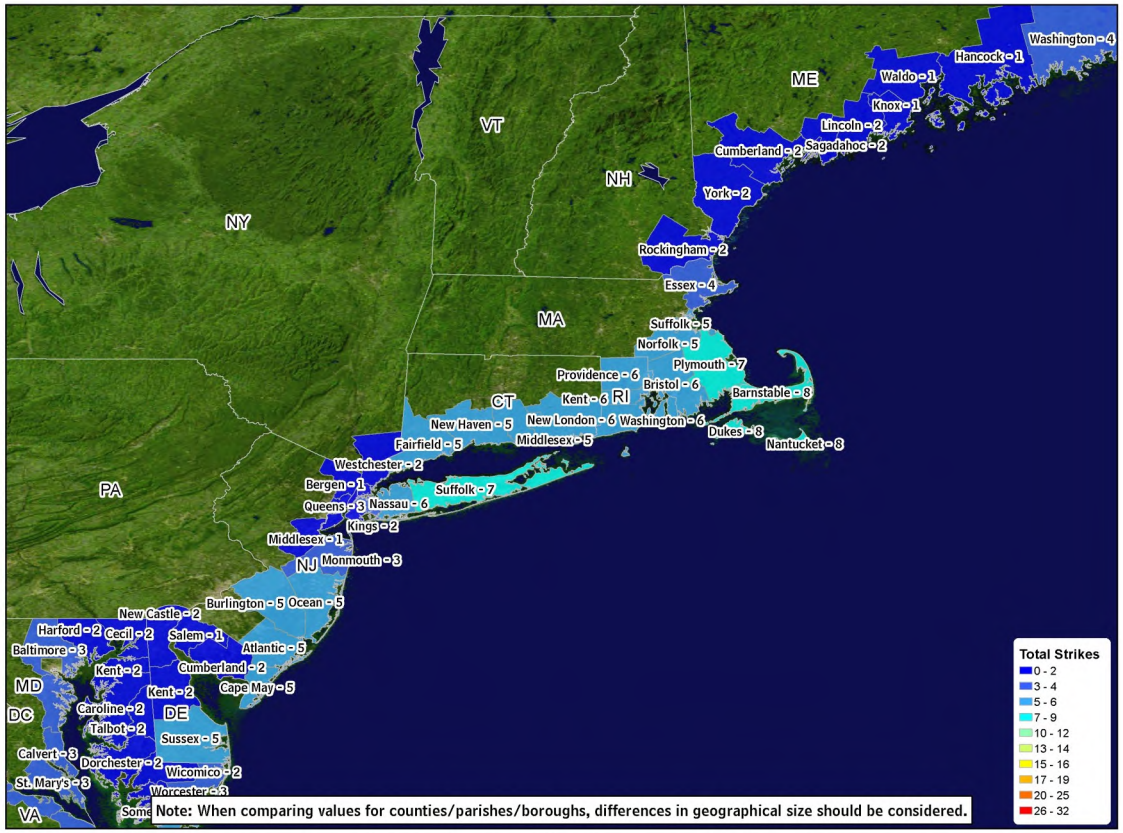
In the vicinity of Westbrook, the hurricane recurrence interval of the hurricane passing or striking in the vicinity of Westbrook is about 17 to 18 years. In the vicinity of Westbrook, the recurrence interval for major hurricanes (Cat 2 and above) is about 52 to 70 years.

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following conservative hurricane strike probability at and near Westbrook:

- All Hurricanes: 7% AEP or 15-year recurrence interval
- Major (≥ Cat 3) Hurricanes: 2% AEP or 50-year recurrence period

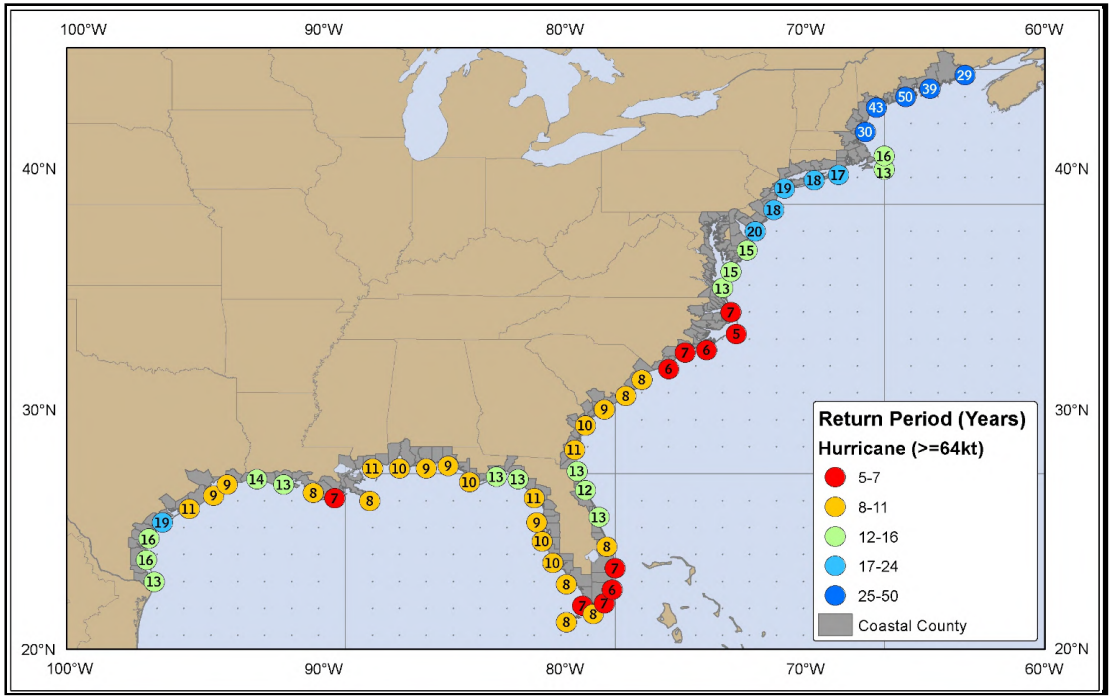
Hurricanes striking the vicinity of Westbrook will pass over Long Island, somewhat reducing their intensity.

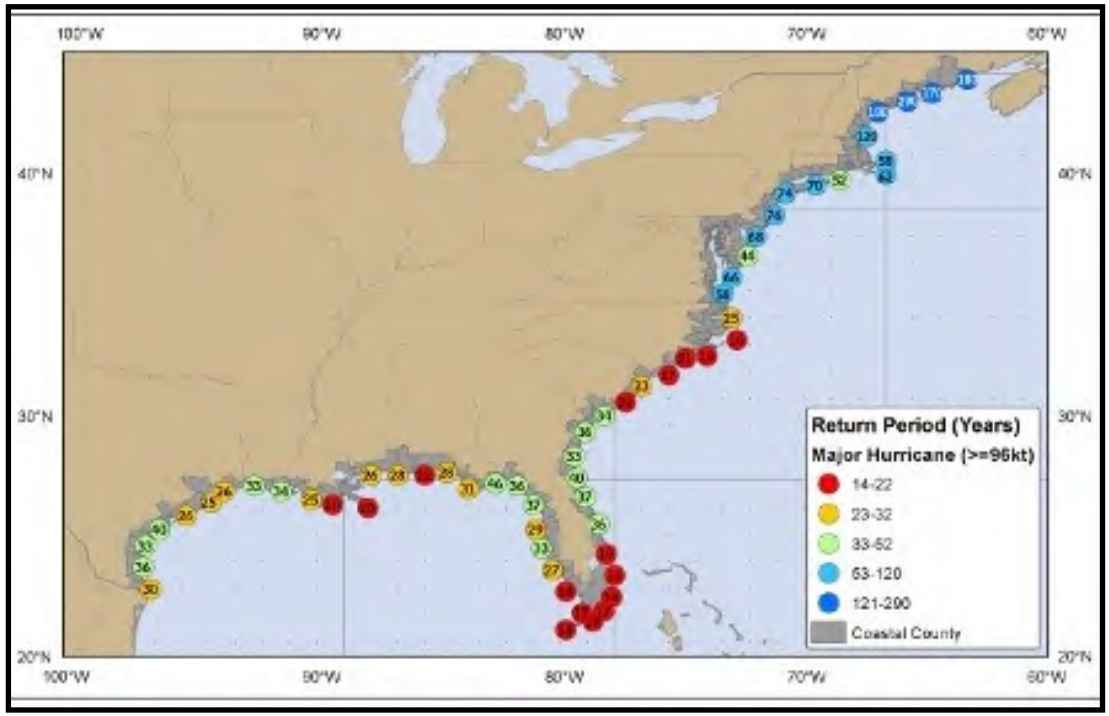


Total number of hurricane strikes by counties/parishes/boroughs, 1900-2010

Data from NWS NHC 46: Hurricane Experience Levels of Coastal County Populations from Texas to Maine. Jerry D. Jarrell, Paul J. Hebert, and Max Mayfield. August, 1992, with updates.

Figure 2-4: Hurricane Strikes (source - https://www.nhc.noaa.gov/climo/)





Figures 2-5 and 2-6: Hurricane Recurrence Interval (all hurricanes - top and major hurricanes - bottom)
(Source: (Source: https://www.nhc.noaa.gov/climo/#bac)

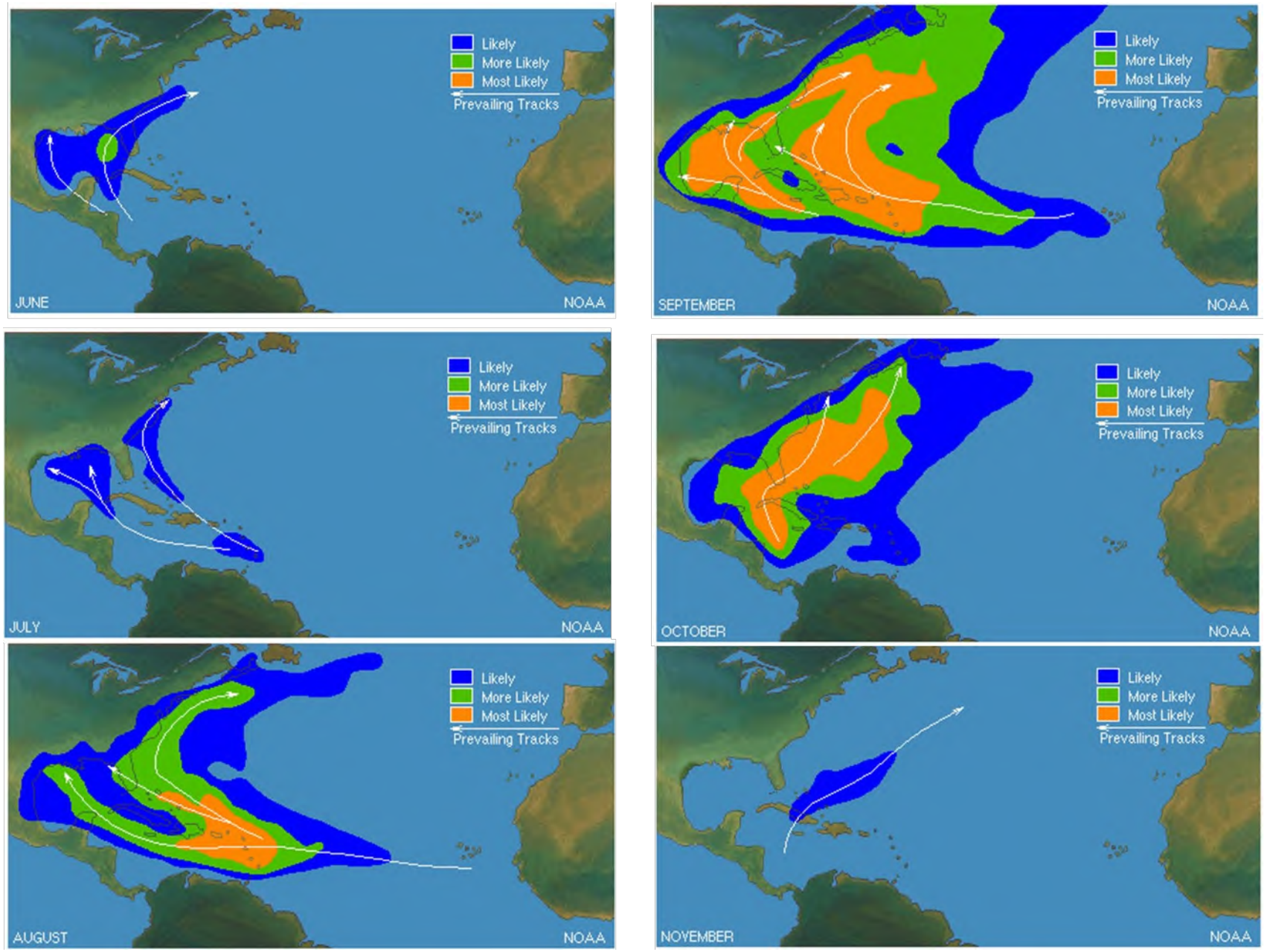


Figure 2-7: Hurricane Origin and Track Probability by Month

THUNDERSTORMS

A thunderstorm is characterized by lightning and thunder and usually produces gusty winds, heavy rain, and sometimes hail. Cumulonimbus clouds produce lightning, which locally heats the air to 50,000 degrees Celsius, which in turn produces an audible shock wave, known as thunder. Tornadoes can also be generated during these events. Three basic ingredients are required for a thunderstorm to form: moisture, rising unstable air (air that keeps rising when given a nudge), and a lifting mechanism. Every thunderstorm has an updraft (rising air) and a downdraft (sinking air). Sometimes strong downdrafts known as downbursts can cause tremendous wind damage, similar to that of a tornado. A small (< 2.5-mile path) downburst is known as a "microburst" and a larger downburst is called a "macroburst."

The peak season for severe thunderstorms in the Northeast U.S. is June through August, although thunderstorms also occur in the Spring and Fall, and thunder can occur during winter snow storms. Hazards from thunderstorms include high to extreme winds, lightning, torrential downpours, and hail. Thunderstorms can spawn tornadoes and cause flash floods, downed trees and power lines, power outages, and mudslides. Roads may become impassable due to flooding, downed trees, or a landslide. Power lines may be downed due to high winds, and services such as water or phone may not be able to operate without power. Lightning can cause severe damage and injury. Fatalities are uncommon, but can occur.

Figure 2-8 shows the average number of thunderstorm days throughout the U.S. Connecticut, including Middlesex County, experiences between 20 and 30 thunderstorm days each year.

An average thunderstorm is 15 miles across and lasts 30 minutes; severe thunderstorms can be much larger and longer. According to the National Weather Service:

- a severe thunderstorm is a thunderstorm that produces a tornado, winds of at least 58 mph (50 knots or ~93 km/h), and/or hail at least 1" in diameter; and
- An approaching severe thunderstorm is a thunderstorm with winds equal to or greater than 40 mph (35 knots or ~64 km/h) and/or hail of at least ½"

Observed structural wind damage may imply the occurrence of a severe thunderstorm. Hail of 1" or greater can damage property such as plants, roofs and vehicles. http://www.weather.gov/bgm/severedefinitions

Derechos: Based on climatology, Connecticut is located in a zone where derechos are predicted to occur about 1 every four years (typically during April to August).

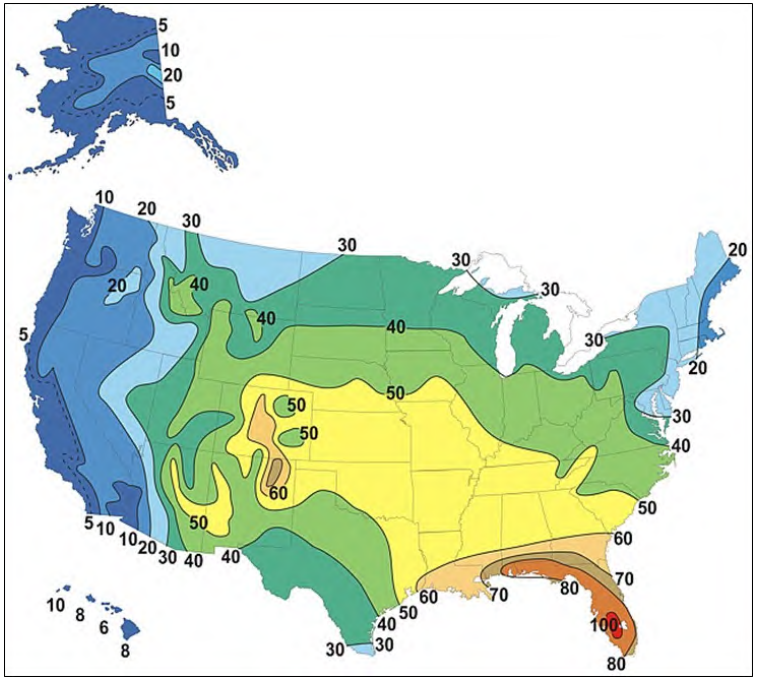


Figure 2-8: Average Annual Number of Thunderstorms in U.S.
(Source: http://www.srh.noaa.gov/jetstream/tstorms/tstorms_intro.html)

Historical Occurrence at Westbrook and Vicinity

Based on NOAA's Storm Events Database, 91 thunderstorm wind events have occurred in Middlesex County from 01/1969 to 10/2019, resulting in about $214.25k in property damage (about $2,354 per event) and 0 deaths. For this database, thunderstorm wind events were included that produce wind gusts of at least 58 mph and/or hail one inch in diameter (about the size of a quarter) or larger or of any speed producing a fatality, injury or damage. 26 of these events resulted in damage and no event resulted in death or injury. Of these, 3 thunderstorm events impacted the Westbrook. The most severe thunderstorm, resulting in $2K in wind damages, occurred on June 30, 2019. Other severe thunderstorms were reported in Westbrook on July 23, 2008 and June 9, 2011 (Ref. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/).

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following thunderstorm wind probability at and near Westbrook (within Middlesex County):

- Thunderstorm Winds within Middlesex County: +/- 56% AEP or minimum of 1-year to 2-year recurrence interval (29 years with 1 or more events over 52 years)
- Based on proportional land area, the estimated AEP at Westbrook is about 1 to 2% (+/- 50 year recurrence interval)

TORNADOES

A tornado is a violently rotating column of air that has contact with the ground and is often visible as a funnel cloud. The destruction caused by tornadoes ranges from light to catastrophic depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damage to structures of light construction, including residential dwellings and particularly manufactured homes. Tornadoes are more likely to occur during the months of March through May and tend to form in the late afternoon and early evening.

Since 2007, tornadoes have been categorized according to the Enhanced Fujita scale:

Scale	Wind speed estimate		Potential damage
	mph	km/h	
EF0	65–85	105–137	Minor damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.
EF1	86–110	138–177	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111–135	178–217	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136–165	218–266	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations are badly damaged.
EF4	166–200	267–322	Devastating damage. Well-constructed and whole frame houses completely leveled; cars and other large objects thrown and small missiles generated.
EF5	>200	>322	Incredible damage. Strong-framed, well-built houses leveled off foundations are swept away; steel-reinforced concrete structures are critically damaged; tall buildings collapse or have severe structural deformations; some cars, trucks, and train cars can be thrown approximately 1 mile (1.6 km).

Table 2-5: Enhance Fujita Scale for Tornadoes

Attachment 2: Natural Hazards

Prior to 2007, tornadoes were categorized according to the Fujita Tornado Intensity Scale:

Scale	Wind Speed Estimate (mph)	Potential Damage
Category F0:	Gale tornado (40-72 mph)	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
Category F1	Moderate tornado (73-112 mph)	Moderate damage. The lower limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads.
Category F2	Significant tornado (113-157 mph)	Considerable damage. roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
Category F3	Severe tornado (158-206 mph)	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
Category F4	Devastating tornado (207-260 mph)	Devastating damage. Well-constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.
Category F5	Incredible tornado (261-318 mph)	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile sized missiles fly through the air in excess of 100 yards; trees debarked; incredible phenomena will occur.

Table 2-6: Original Fujita Tornado Intensity Scale

Tornadoes can occur anywhere in Connecticut, although relatively infrequently. Between 1950 and 2018, there were 97 tornado events within Connecticut (including 8 in Middlesex County), resulting in 4 fatalities, 709 injuries. The longest tornado path was 44 miles and the widest path was 1400 yards. The data for this period for the State is presented below (source: http://www.tornadohistoryproject.com/tornado/Connecticut/table)

Magnitude	Number of Events	No. of Injuries	No. of Deaths	Property Damage
F0/EF0	19	7	0	$500 to $20,500
F1/EF1	51	9	0	$676,000 to $6,762,502
F2/EF2	21	88	0	$10,687,000 to $106,870,000
F3/EF3	4	62	1	$5,105,000 to $51,050,000
F4/E4	2	540	3	$100M to $1B

Magnitude	Avg. No of Events/year	Avg. No. of Injuries/Event	Avg. No. of Deaths/Event	Avg. Property Damage/ Event
All	1.4	7.3	0.04	
F0/EF0	0.3	0.4	0	$26 to $107
F1/EF1	0.8	0.2	0	$13,255 to $132,598
F2/EF2	0.3	4.2	0	$508,905 to $5,089,048
F3/EF3	0.06	15.5	0.25	$1,276,250 to $12,762,500
F4/E4	0.03	270	1.5	$50M to $500

Table 2-7 Connecticut Tornado Data for the period of 1950 to 2018

Tornado risk is calculated from the destruction path that has occurred within 30 miles of the location. Details for Middlesex County are presented in **Table 2-8.** **Figure 2-9** shows the locations and tracks of Middlesex County tornadoes. These tornadoes ranged in severity from F0 to F3. These tornadoes occurred between the months of June and August. There have been 8 tornadoes in the last 68 years near (within Middlesex County) Westbrook.

Date	County, State	Fujita	Fatalities	Injuries	Damage ($)
8/1/1983	Middlesex, Connecticut	0	0	0	<$50
6/30/1998	Middlesex, Connecticut	0	0	0	-
7/19/1963	Middlesex, Connecticut	1	0	0	$2,500
7/21/1972	Middlesex, Connecticut	1	0	0	$2,500
6/27/1974	Middlesex, Connecticut	1	0	0	$50 to $500
6/30/1998	Middlesex, Connecticut	1	0	0	-
7/12/1950	Middlesex, Connecticut	2	0	0	$2,500
8/21/1951	Middlesex, Connecticut	3	0	8	$250,000

Table 2-8: Middlesex County, Connecticut Tornado Data for the period of 1950 to 09/2019

Historical Occurrence at Westbrook Vicinity

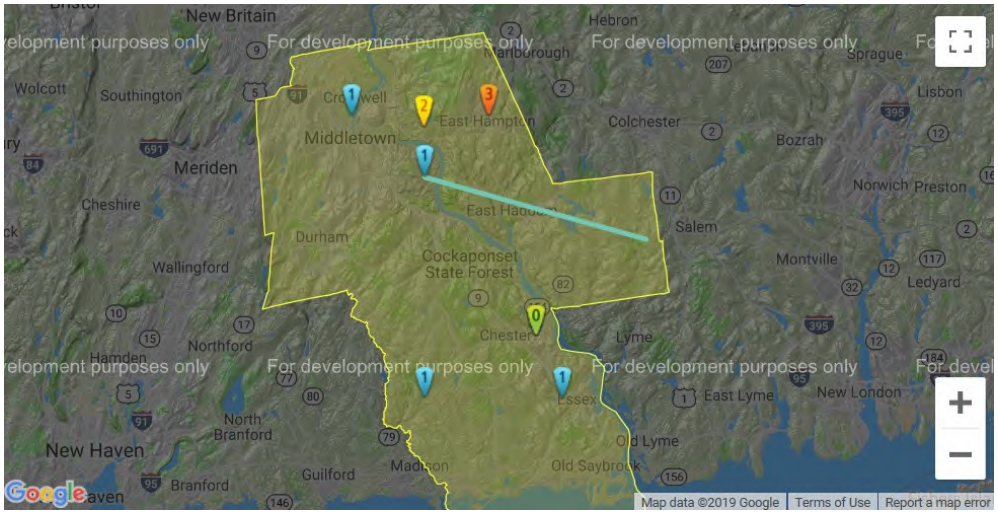
Of the 8 tornadoes in Middlesex County, the F3 tornado during August, 1951 resulted in the largest degree of damages at $250K. The 7 other tornadoes combined accounted for less than $7,530 in total damages where most of the tornadoes ranged in severity from F0 to F2. Ref. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following tornado probability at and near Westbrook (within Middlesex County):

- Tornadoes within Middlesex County: 12% AEP or 8-year recurrence interval (8 years with 1 or more events over 68 years)
- Major tornado within Middlesex County: 1.5% AEP or 70-year recurrence interval
- Based on the proportional land area, the Westbrook tornado AEP is about 0.2% and the Westbrook major tornado AEP is expected to be very low.

Figure 2-9: Location of Middlesex County Tornadoes
http://www.tornadohistoryproject.com/tornado/Connecticut /Middles/



THUNDERSTORMS - TORNADOES

During May 15, 2018 a squall line brought widespread high winds and wind damage to the Northeast. This happened one day after another squall line swept from Ohio to Virginia.

Beginning as a small broken line of thunderstorms around midday in northwest Pennsylvania, the line eventually congealed and raked across Pennsylvania, southern New York, Connecticut, Massachusetts, Rhode Island, northern Delaware and Maryland through the evening, producing well over 200 reports of high winds or wind damage.

Roughly 600,0000 people were without power at the time of peak outage in Pennsylvania, Connecticut, Virginia, New jersey and New York following the squall line.

Beginning as a small broken line of thunderstorms around midday in northwest Pennsylvania, the line eventually congealed and raked across Pennsylvania, southern New York, Connecticut, Massachusetts, Rhode Island, northern Delaware and Maryland through the evening, producing well over 200 reports of high winds or wind damage.

National Weather Service post-storm damage surveys and video confirmed 9 tornadoes touched down in Connecticut, New York, and Pennsylvania.

Two people died in Connecticut.

(Source The Weather Channel https://weather.com/storms/severe/news/2018-05-16-derechos-back-to-back-east-coast-may2018)

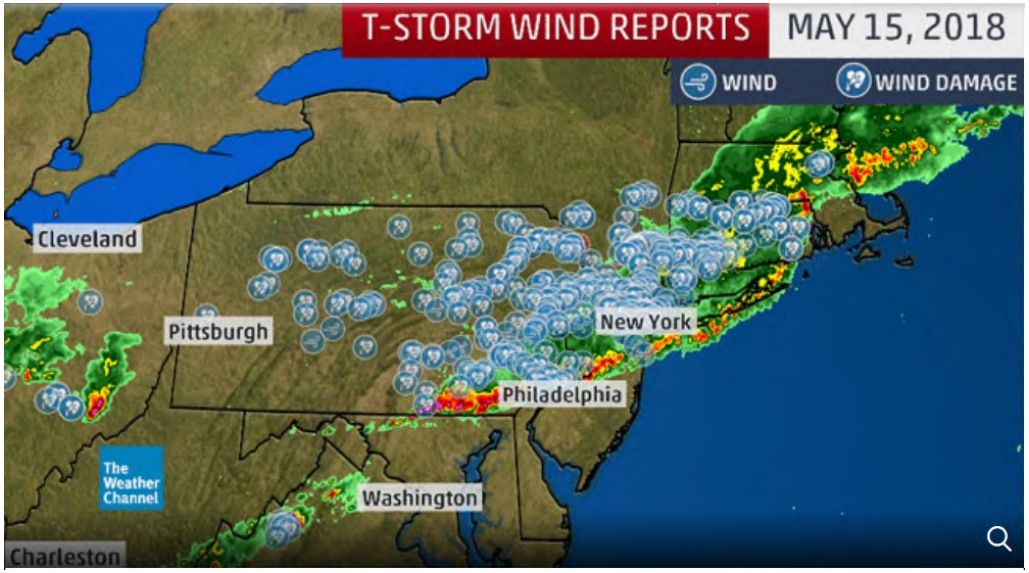


Figure 2-10: Radar and thunderstorm wind/wind damage reports (blue dots) from the derecho on May 15, 2018 from noon through 9 p.m. EDT.

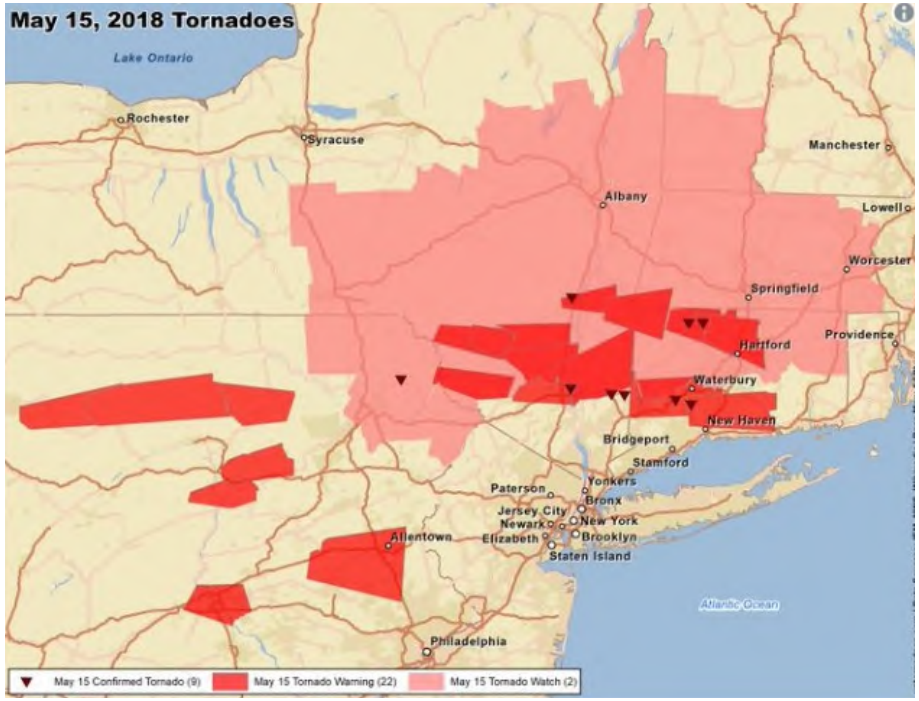


Figure 2-11: Confirmed Tornadoes, EFO0 to EF2 in strength. Four in Connecticut, four in New York and one in Pennsylvania.

Severe Weather Hazards: Lightning

LIGHTNING

Lightning strikes primarily occur during the summer months. There were 20 lightning deaths in the U.S. in 2018, none of which occurred in Connecticut (https://www.weather.gov/safety/lightning-fatalities18).

Lightning is the second most common storm-related killer in the United States. It causes several billion dollars in property damage each year and kills several dozen people. It is a frequent cause of wildfires and costs airlines billions of dollars per year in extra operating expenses.

Lightning is a giant spark of electricity in the atmosphere between clouds, the air, or the ground. In the early stages of development, air acts as an insulator between the positive and negative charges in the cloud and between the cloud and the ground. When the opposite charges builds up enough, this insulating capacity of the air breaks down and there is a rapid discharge of electricity that we know as lightning. The flash of lightning temporarily equalizes the charged regions in the atmosphere until the opposite charges build up again. Lightning can occur between opposite charges within the thunderstorm cloud (intra-cloud lightning) or between opposite charges in the cloud and on the ground (cloud-to-ground lightning).

Connecticut, including Middlesex County, has a moderate risk associated with Lightning strikes relative to other states. **Figures 2-12** and **2-13** show the number of fatalities and relative fatality rates by state. During the period of 2009 and 2018 (10 years), there has been 1 lightning fatality in Connecticut (average of 0.1 per year).

Historical Occurrence at Westbrook and Vicinity

Since 1997, Lightning was reported 16 times resulting in about $188k in property damage, 3 injuries and 1 death. The reporting sources included newspapers, broadcast media and law enforcement entities covering Middlesex County. Two of these reported lightening occurrences impacted Westbrook directly on August 11, 2008 and July 19, 2010 resulting in a total of $57,500 in property damage.

NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following Lightning probability at and near Westbrook (within Middlesex County):

- Lightning Events resulting in fatality, injury and/or damage within Middlesex County: 38% AEP or 3-year recurrence interval (8 years with 1 or more events over 21 years)

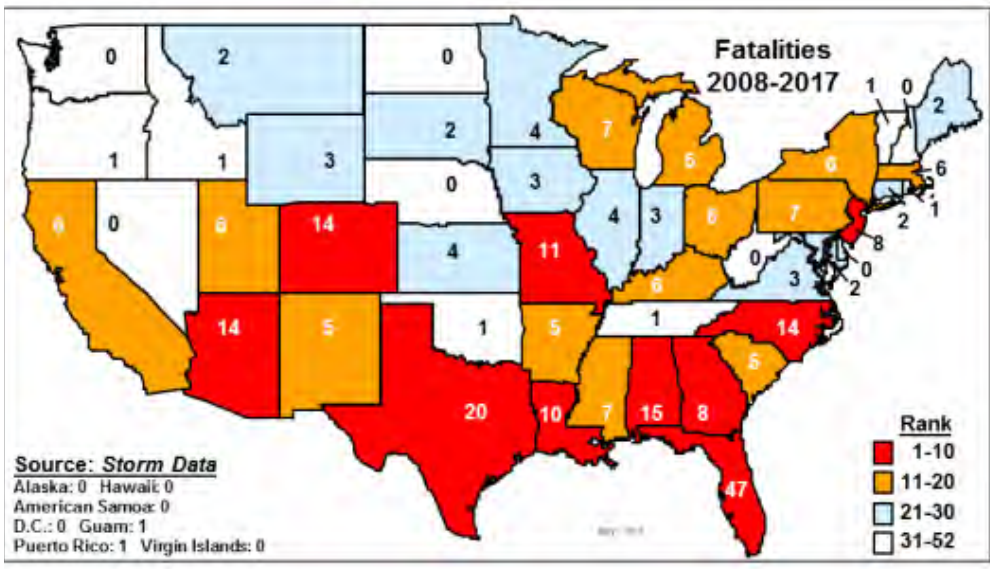


Figure 2-12: Lightning Fatalities by State, 2008-2017; (Source: Vaisala)

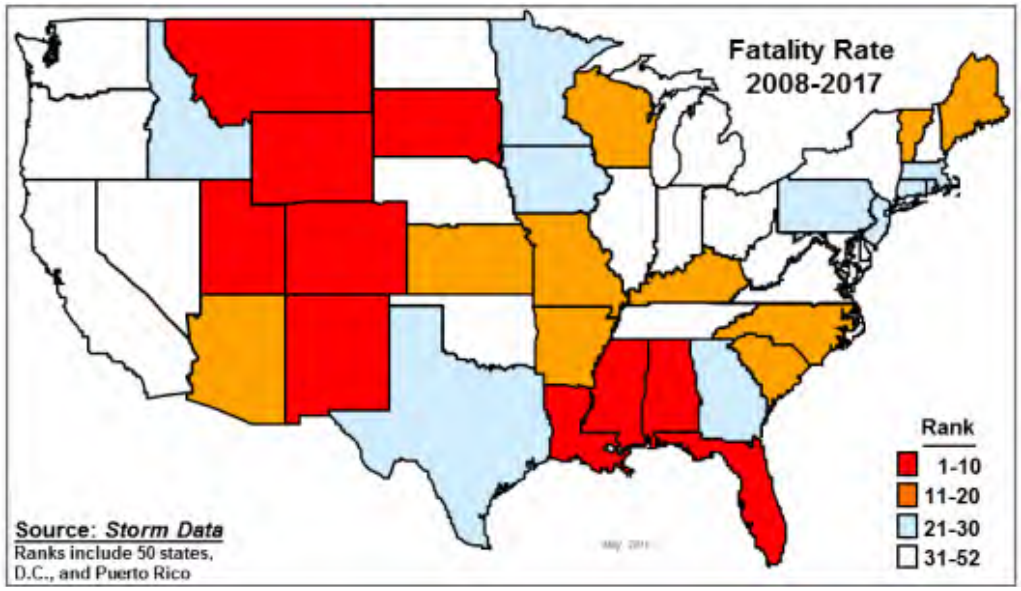


Figure 2-13: Lightning Fatalities Weighted by Population, 2008-2017; (Source: Vaisala)

Severe Weather Hazards: Intense Rainfall

INTENSE RAINFALL

Intense, heavy rainfall can result in localized flooding including flash flood events. Several factors contribute to intense precipitation flooding including rainfall intensity and duration. Other factors include the presence of streams and rivers, soil type, ground cover, drainage and the capacity of stormwater infrastructure. **Table 2-9** presents precipitation projections for the vicinity of Westbrook by the NOAA's National Weather Service (NOAA Atlas 14).

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.342** (0.260-0.447)	**0.411** (0.313-0.537)	**0.524** (0.398-0.687)	**0.618** (0.466-0.814)	**0.748** (0.548-1.02)	**0.845** (0.609-1.17)	**0.947** (0.665-1.35)	**1.06** (0.711-1.53)	**1.23** (0.793-1.81)	**1.36** (0.861-2.04)
10-min	**0.485** (0.369-0.633)	**0.583** (0.443-0.761)	**0.743** (0.563-0.973)	**0.876** (0.661-1.15)	**1.06** (0.777-1.44)	**1.20** (0.863-1.65)	**1.34** (0.943-1.91)	**1.50** (1.00-2.16)	**1.74** (1.12-2.57)	**1.93** (1.22-2.89)
15-min	**0.570** (0.434-0.744)	**0.686** (0.521-0.896)	**0.875** (0.664-1.15)	**1.03** (0.777-1.36)	**1.25** (0.914-1.69)	**1.41** (1.01-1.95)	**1.58** (1.11-2.24)	**1.77** (1.18-2.55)	**2.04** (1.32-3.02)	**2.27** (1.44-3.40)
30-min	**0.793** (0.604-1.04)	**0.954** (0.725-1.25)	**1.22** (0.923-1.59)	**1.43** (1.08-1.89)	**1.73** (1.27-2.36)	**1.96** (1.41-2.71)	**2.20** (1.54-3.12)	**2.46** (1.65-3.54)	**2.85** (1.84-4.20)	**3.16** (2.00-4.74)
60-min	**1.02** (0.774-1.33)	**1.22** (0.929-1.60)	**1.56** (1.18-2.04)	**1.84** (1.39-2.42)	**2.22** (1.63-3.02)	**2.51** (1.81-3.47)	**2.81** (1.98-4.00)	**3.16** (2.11-4.54)	**3.65** (2.36-5.39)	**4.05** (2.56-6.07)
2-hr	**1.33** (1.01-1.72)	**1.60** (1.22-2.07)	**2.04** (1.55-2.65)	**2.41** (1.83-3.14)	**2.91** (2.15-3.94)	**3.29** (2.39-4.53)	**3.69** (2.62-5.24)	**4.16** (2.79-5.95)	**4.86** (3.15-7.13)	**5.44** (3.46-8.11)
3-hr	**1.54** (1.18-1.98)	**1.85** (1.42-2.39)	**2.37** (1.81-3.07)	**2.79** (2.12-3.63)	**3.38** (2.50-4.56)	**3.82** (2.78-5.24)	**4.29** (3.05-6.07)	**4.84** (3.26-6.90)	**5.67** (3.68-8.29)	**6.38** (4.06-9.45)
6-hr	**1.96** (1.51-2.51)	**2.35** (1.81-3.02)	**3.01** (2.31-3.87)	**3.55** (2.71-4.58)	**4.29** (3.20-5.75)	**4.84** (3.55-6.60)	**5.44** (3.89-7.66)	**6.15** (4.15-8.69)	**7.21** (4.70-10.5)	**8.12** (5.18-11.9)
12-hr	**2.43** (1.88-3.10)	**2.92** (2.27-3.73)	**3.73** (2.88-4.77)	**4.40** (3.38-5.65)	**5.33** (3.98-7.09)	**6.01** (4.42-8.14)	**6.75** (4.85-9.42)	**7.62** (5.16-10.7)	**8.93** (5.84-12.9)	**10.0** (6.42-14.7)
24-hr	**2.85** (2.22-3.61)	**3.46** (2.69-4.38)	**4.45** (3.45-5.65)	**5.27** (4.07-6.71)	**6.40** (4.81-8.46)	**7.24** (5.35-9.74)	**8.15** (5.89-11.3)	**9.23** (6.28-12.9)	**10.9** (7.14-15.6)	**12.3** (7.89-17.8)
2-day	**3.18** (2.49-3.99)	**3.91** (3.06-4.91)	**5.10** (3.98-6.42)	**6.08** (4.72-7.70)	**7.44** (5.63-9.79)	**8.44** (6.28-11.3)	**9.53** (6.95-13.2)	**10.9** (7.43-15.1)	**13.0** (8.55-18.5)	**14.8** (9.55-21.3)
3-day	**3.45** (2.71-4.31)	**4.23** (3.33-5.30)	**5.52** (4.32-6.93)	**6.59** (5.13-8.30)	**8.06** (6.12-10.6)	**9.14** (6.82-12.2)	**10.3** (7.55-14.3)	**11.8** (8.06-16.3)	**14.1** (9.29-19.9)	**16.1** (10.4-23.1)
4-day	**3.70** (2.92-4.62)	**4.52** (3.56-5.65)	**5.87** (4.61-7.35)	**6.98** (5.45-8.78)	**8.52** (6.48-11.1)	**9.65** (7.22-12.8)	**10.9** (7.97-15.0)	**12.4** (8.50-17.1)	**14.8** (9.77-20.9)	**16.9** (10.9-24.1)
7-day	**4.42** (3.50-5.48)	**5.30** (4.19-6.59)	**6.75** (5.32-8.40)	**7.94** (6.23-9.93)	**9.59** (7.32-12.4)	**10.8** (8.10-14.3)	**12.1** (8.88-16.5)	**13.7** (9.44-18.7)	**16.2** (10.7-22.6)	**18.3** (11.8-25.9)
10-day	**5.12** (4.06-6.33)	**6.04** (4.79-7.47)	**7.54** (5.96-9.35)	**8.79** (6.91-10.9)	**10.5** (8.02-13.5)	**11.8** (8.83-15.4)	**13.2** (9.61-17.8)	**14.8** (10.2-20.1)	**17.2** (11.4-24.0)	**19.2** (12.5-27.2)
20-day	**7.25** (5.79-8.90)	**8.24** (6.58-10.1)	**9.87** (7.85-12.2)	**11.2** (8.87-13.9)	**13.1** (10.0-16.6)	**14.5** (10.9-18.7)	**15.9** (11.6-21.1)	**17.6** (12.2-23.6)	**19.8** (13.2-27.4)	**21.7** (14.1-30.4)
30-day	**9.04** (7.24-11.1)	**10.1** (8.07-12.3)	**11.8** (9.40-14.5)	**13.2** (10.5-16.3)	**15.2** (11.6-19.1)	**16.6** (12.5-21.3)	**18.2** (13.2-23.8)	**19.7** (13.7-26.4)	**21.9** (14.6-30.0)	**23.5** (15.3-32.8)
45-day	**11.3** (9.07-13.7)	**12.4** (9.93-15.1)	**14.2** (11.3-17.3)	**15.6** (12.4-19.2)	**17.7** (13.6-22.2)	**19.3** (14.5-24.5)	**20.8** (15.1-27.0)	**22.4** (15.6-29.8)	**24.3** (16.3-33.2)	**25.7** (16.8-35.7)
60-day	**13.2** (10.6-16.0)	**14.3** (11.5-17.4)	**16.1** (12.9-19.7)	**17.7** (14.1-21.6)	**19.8** (15.2-24.7)	**21.5** (16.1-27.1)	**23.1** (16.7-29.7)	**24.5** (17.1-32.5)	**26.3** (17.6-35.8)	**27.5** (18.0-38.0)

Table 2-9: Predicted Rainfall Intensity by Duration and Recurrence Interval for Westbrook
(See table details at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html)

While there is no specific, single set of criteria that defines "intense rainfall", the rainfall intensities associated with a 25-year recurrence interval are a reasonable benchmark (a 1 in 4 chance of being met or exceeded in any given year). This figure indicates short duration intensities (30 minutes and 1-hour) on the order of 1.7 and 2.2 inches per hour respectively and longer duration intensities (24 hours) on the order of an average 0.27 inch per hour (one day total rainfall amounts of about 6.4 inches).

Historical Occurrence at Westbrook and Vicinity

During the period between 1996 and 2005, Middlesex County experienced 22 days with Heavy Rain events, an average of about 2.4 event days per year, with no documented property damages, injuries or death. Ref. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following intense rainfall probability at and near Westbrook (within Middlesex County):

- Intense Rainfall within Middlesex County: 4% AEP or approximately a 25-year recurrence interval

Severe Weather Hazards: Hail

HAIL

Hailstorms are a potentially damaging outgrowth of severe thunderstorms. Hailstorms frequently accompany thunderstorms, so their locations and spatial extents overlap. Large hail (greater than 1 inch in diameter) can be destructive. Hail can cause substantial damage to vehicles, roofs, landscaping, and other areas of the built environment. U.S. agriculture is typically the resource most affected by hail storms, which cause severe crop damage even during minor events. A recent risk, due to the widespread use of solar panels, is hail-related damage to solar panels.

Hail storms are not common in Connecticut, including Middlesex County. Connecticut hail data indicates that since 1960 there have been 24 days with reports of hail greater than .75 inches in size (an average of 0.4 events per year), with 0 injuries, 0 deaths, and $100k+ property damage. (source: NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/).

Hail reported on June 20, 1995 included baseball size hailstones lasting for up to 20 minutes in Deep River just north of Westrbook. This resulted in hundreds of thousands of dollars in damages. The report noted that hailstones broke hundreds of windows in buildings and automobiles, tore holes in roofs, dented siding and automobiles, and ruined gardens.

The Hail Risk Score (**Table 2-10**) provides a short-to-medium term view of future hail risk based on the last 10 years of ultra-high resolution radar data. The score is based on a scale of 1 to 10, with the lowest score of 1 representing Very Low hail risk (damaging hail unlikely in the next 5-10 years) and the highest score of 10 representing Extreme hail risk (damaging hail very likely every year).

The Hail Risk Score for the Westbrook area is 1 (reference: stormersite.com) .

Hail Risk Score	Hail Risk	Hail Risk Guidance
1	Very low	Damaging Hail unlikely in next 5-10 years
2	Very Low to Low	Damaging Hail likely every 5 years
3	Low	Damaging Hail likely every 2-4 years
4	Low to Moderate	Damaging Hail likely every 2-3 years
5	Moderate	Damaging Hail likely every other year
6	Moderate	Damaging Hail very likely every other year
7	Moderate to High	Damaging Hail likely every 1-2 years
8	High	Damaging Hail very likely every 1-2 years
9	Very High	Damaging Hail likely every year
10	Extreme	Damaging Hail very likely every year

Table 2-10: Hail Risk Score Classifications

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following hail probability at and near Westbrook (within Middlesex County):

- 31% AEP or approximately a 3 year recurrence interval (17 years with 1 or more events over 55 years)

Severe Weather Hazards: Flood

FLOOD

A flood is the partial or complete inundation of normally dry land. The various types of flooding include riverine flooding, coastal flooding, and shallow flooding. Common impacts of flooding include damage to personal property, buildings and infrastructure; bridge and road closures; service disruptions; and injuries or even fatalities.

The Town is vulnerable to:

- **Coastal storm surge.** Due to its low-lying coastal setting on Long Island Sound, the nearshore portions of Westbrook are vulnerable to coastal flooding including flood inundation and waves. The tidal marshlands located just inland along the Menunketesuck and Patchogue Rivers are also vulnerable to coastal flooding including flood inundation.
- **Rainfall events.** Inland (urban) flooding associated with large rainfall events, in particular within areas with impervious surfaces, poor drainage and inadequate stormwater management.
- **Nuisance flooding (aka coastal shallow water flooding)**. Coastal, frequent shallow water flooding due to astronomical high tides.
- **River Flooding**. The Town is vulnerable to some riverine flooding from the Men River and other smaller tributaries.

Coastal Flooding

Coastal floods in Connecticut are due to tropical cyclones (hurricanes and tropical storms) and extratropical nor'easters. The top ten highest water levels recorded at the NOAA tide stations (as of 1938 to August, 2019) located in the vicinity of Westbrook (the NOAA tide station at New London) are presented in **Table 2-11**.

More than ten major coastal flood events have occurred in Connecticut over the last 50 years. Several resulted in minimal-to-moderate damage to Middlesex County. Extreme flooding resulting from coastal storm surges at Westbrook result from two types of storms: Extra-tropical storms (Nor'easters) and tropical cyclones (Tropical Storms and Hurricanes).

The most intense hurricane of record in the vicinity of Westbrook is the Hurricane of 1938. According to NOAA, this hurricane was a Category 3 intensity at landfall along the Connecticut coast. The approximate peak water levels at New London during the Hurricane of 1938 were Elevation 8.5 to 9 feet NAVD88. There were also several high intensity hurricanes during the 1800s and early 1900s that made landfall along Long Island, although details about their intensity are limited.

Hurricane Gloria in September 1985 arrived at low tide and resulted in storm surges of about 4 feet, which did not result in extensive damage to the coastline. Hurricane Bob in August 1991 made landfall over Block Island, RI and did not result in extensive damage to the coastline in Middlesex County. An unnamed coastal storm in October 1991 (aka the Perfect Storm) joined up with the remains of Hurricane Grace and resulted in the 7th highest floods near Westbrook. In August 2011, Hurricane Irene, weakened to a tropical storm, caused extensive damage throughout Middlesex County.

Hurricane Sandy, although its landfall was over 200 nautical miles south of Westbrook, was one of the most significant flood events in Connecticut. Sandy's storm surge when combined with tides, caused peak water levels to reach approximately Elevation 6.5 feet NAVD88 at Westbrook.

Table 2-11: Top Ten Coastal Floods near Westbrook
Note: Water levels are referenced to feet above MHHW with no adjustment for sea level rise.

Station	1	2	3	4	5
8461490 New London	Hurricane of 38 9/20/1938 8.74 feet	Hurricane Carol 8/30/1954 7.74 feet	Hurricane Sandy 10/30/2012 6.10	Great Appalachian Storm 11/24/1950 5.74 feet	Great Atlantic Hurricane 9/13/1944 5.24 feet
	6	7	8	9	10
	Hurricane Donna 9/11/1960 5.04 feet	Perfect Storm 11/6/1953 4.94 feet	Nor'easter 10/31/1991 4.63 feet	Hurricane Irene 08/29/2011 4.60 feet	Nor'easter 11/11/1968 4.54 feet

Coastal Flood Probability

Flood hazard mitigation planning requires characterizing flooding in terms of risk, specifically associating different flood levels with a probability of occurrence. Flood probabilities are typically described in terms of the annual chance of occurrence. For example, the 1% annual chance flood elevation has, in any given year, a 1/100 chance of being met or exceeded. This flood is also known as the 100-year return period flood. There are several publicly-available, industry-accepted sources of flood probability data for the vicinity of Westbrook. These include:

1. FEMA Flood Insurance Study and Rate Maps: FEMA has characterized the current flood hazard within Westbrook for the purposes of the National Flood Insurance Program (NFIP). FEMA uses the 1% annual chance (100-year return period) flood event to characterize flood risk, presented on Flood Insurance Rate Maps (FIRMs). FEMA also presents the 0.2% annual chance flood inundation limits in these maps. **Figure 2-15** presents the effective (i.e., currently applicable) FEMA Flood Insurance Rate Map (FIRM) flood limits and elevations, used to calculate flood insurance rates for Westbrook.
2. Statistical analysis of the NOAA New London tide station water level data: Statistical analysis of the NOAA New London tide station water level data provides an indication of the recurrence interval of flooding based on an approximately 80-year period of record. The gage at New London has too brief a period of record for extrapolating extreme water levels without significant uncertainty.
3. The USACE North Atlantic Coast Comprehensive Study (NACCS): The USACE performed extensive regional coastal flood hazard analyses after Hurricane Sandy (the North Atlantic Coast Comprehensive Study). These analyses utilized interpretation of meteorological parameters, numerical computer modeling of storm surge and waves, and statistical analysis (e.g., Joint Probability Method-Optimum Sampling, Empirical Simulation Technique) to characterize regional flood hazards.

There is no exact prediction of flood probability; rather, there are a range of probabilities (and corresponding flood elevations) that reflect different prediction methods, error and uncertainty. The NOAA New London, CT tide gage data has significant uncertainty for predicting floods beyond 20 to 50-year recurrence interval floods due to the limited period of record and likely under-predicts the flood hazard. The FEMA stillwater flood projections for Westbrook, which were also developed using tide gage data, have similar uncertainty (stillwater elevation is the flood elevation that occurs in the absence of wave effects). The USACE NACCS utilized the "state-of-the-practice" methodology; however, there is significant statistical uncertainty and some model error.

Overall, the USACE NACCS currently presents the most robust analysis of coastal flood hazards in the vicinity of Westbrook.

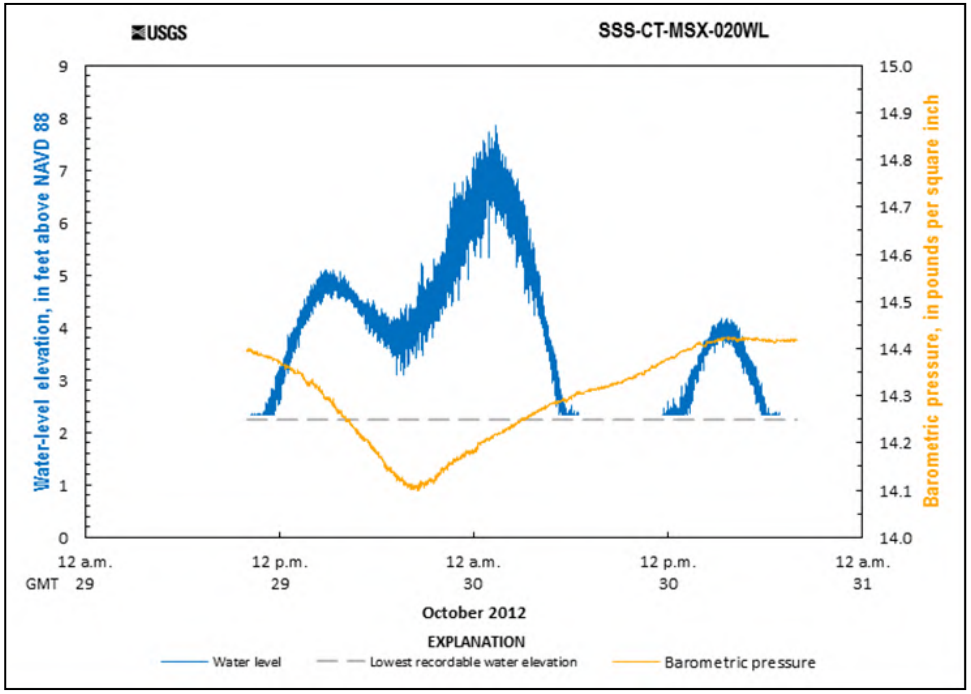


Figure 2-14: New London USGS Tide Gage water levels during Hurricane Sandy

The tide gage data from the New London USGS gage indicated a peak water level during Irene of about Elevation 6.5 feet NAVD88 (about or slightly higher than the bridge deck elevation). In comparison, the same tide gage (shown above in **Figure 2-14**) measured a peak water level of about Elevation 8 feet NAVD88 during Sandy. The gage data likely includes some wave effects and the actual stillwater flood elevation during Sandy was lower.

Coastal flooding at Westbrook occurs due to storm surge and waves within Long Island Sound. Coastal storm surges will also propagate up waterways that are hydraulically connected with Long Island Sound and the Menunketesuck and Patchogue Rivers. Flood frequency is characterized in terms annual exceedance probability (also recurrence interval). An assessment of the coastal flood frequency (i.e. probability) applicable to the Town was performed based on the following data sources.

- The current FEMA FIRMs and Flood Insurance Studies (FIS). The current FEMA FIS is the Middlesex County, Connecticut (All Jurisdictions) study, revision date February 6, 2013, Flood Insurance Study Number 09007CV001B.
- Statistical analysis of the NOAA New London tide station water level data.
- The results of the Army Corps of Engineers (USACE) North Atlantic Coast Comprehensive Study (NAACS). The study provides nearshore storm surge and wave hazard data at several locations along the Westbrook shoreline.

FEMA Flood Hazard Determination

Through FEMA's flood hazard mapping program, Risk Mapping, Assessment and Planning (MAP), FEMA identifies flood hazards, assesses flood risks and partners with states and communities to provide accurate flood hazard and risk data to guide them to mitigation actions. Flood hazard mapping is an important part of the National Flood Insurance Program (NFIP), as it is the basis of the NFIP regulations and flood insurance requirements. FEMA maintains and updates data through Flood Insurance Rate Maps (FIRMs) and risk assessments. FEMA coastal transects provide detailed flood data around Westbrook and are summarized in **Table 2-12**. Flood elevations are presented in **Table 2-12** for: 1) the stillwater elevation, which is the water level in the absence of waves; 2) the Total Water Level which includes the stillwater elevation and the effects of wave setup; and 3) the Base Flood Elevation (BFE). The BFE is the flood having a one percent chance of being equaled or exceeded in any given year. This is the regulatory standard also referred to as the "100-year flood" and includes the Total Water Level plus wave plus wave runup. **Figure 2-15** on the following page shows the FEMA special flood hazard area in Westbrook as well as coastal transects 9 through 18.

FEMA FIS Coastal Transect No.	Stillwater Elevation (SWEL) (in feet)				Total Water Level (in feet)	FEMA Flood Zone	Base Flood Elevation (in feet)
	10%	2%	1%	0.2%	1%		
18	5.5	7.7	9.2	15	10.5	VE AE	13 10-13
17	5.6	7.7	9.2	14.9	12.4	VE AE	18 12-14
16	5.6	7.8	9.2	14.9	11.7	VE AE	14 12-14
15	5.6	7.8	9.2	14.8	11.7	VE AE	14-17 12-14
14	5.6	7.8	9.2	14.7	11.6	VE AE	13-17 11-14
13	5.6	7.8	9.2	14.7	10.7	VE AE	13-17 11-14
12	5.6	7.8	9.2	14.7	11.5	VE AE	13-17 11-14
11	5.7	7.8	9.2	14.6	11.6	VE AE	12-17 10-14
10	5.7	7.8	9.2	14.6	10.2	VE AE	12-17 10-14
9	5.7	7.8	9.2	14.5	10.8	VE AE	13-16 11-13

Table 2-12: FEMA Coastal Transect Data around Westbrook
Note: Water levels are referenced to feet, NAVD88

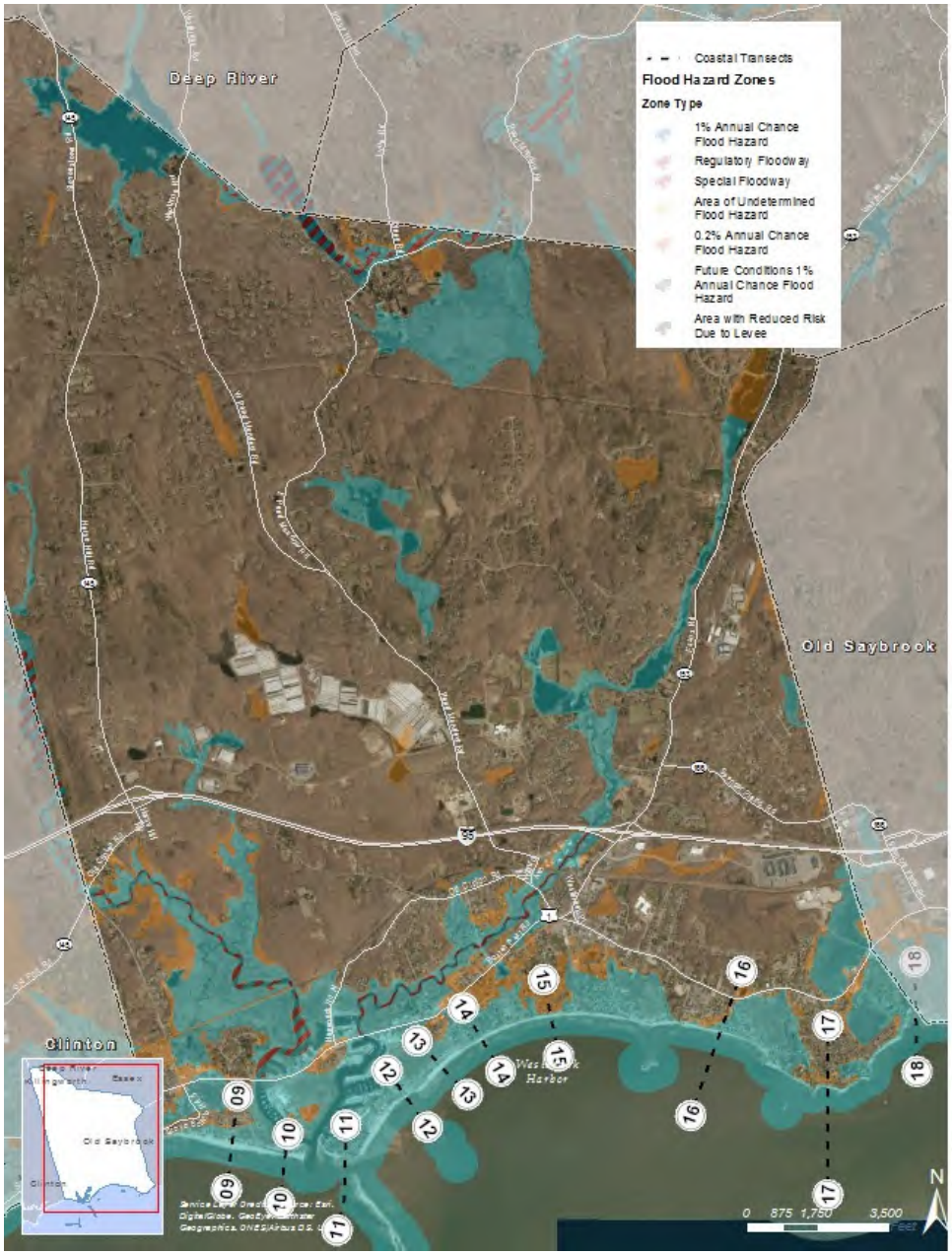


Figure 2-15: FEMA Flood Insurance Rate Map Flood Hazard Zones and Base Flood Elevations

NOAA Tide Station Water Level Analysis

NOAA statistically analyzed annual water level data at the NOAA Bridgeport and New London tide gages using the Generalized Extreme Value (GEV) probability distribution. The results are shown in **Figure 2-16** (in meters relative above MHHW). The 95% confidence intervals are also shown.

GZA independently performed similar statistical analyses with comparable results. The mean 1% annual exceedance stillwater elevation is estimated using this analysis and corrected for Westbrook is at about Elevation 7.5 feet NAVD88.

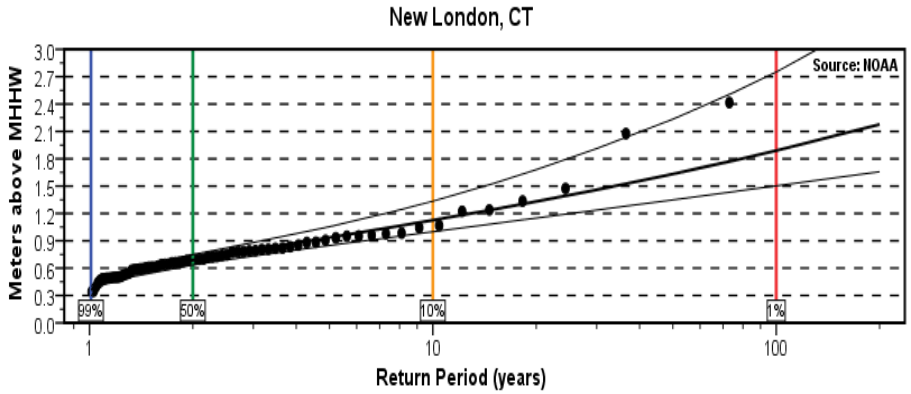


Figure 2-16: NOAA Annual Exceedance Probability Curve for the New London Station

USACE North Atlantic Coast Comprehensive Study

The results of the USACE NACCS are available at specific model "save point" locations. **Figure 2-17** shows the locations of "save points" along the Westbrook shoreline which correspond to the mean still water elevations for each "save point" presented in **Table 2-13** on the following page. USACE-predicted Total Water Level data, including the stillwater elevation plus wave setup, and wave heights are available at these locations.

Due to the updated methodology used by the USACE, the flood hazard data developed by the USACE NACCS are expected to be indicative of what future editions of the FEMA FIS and FIRMs will be for Westbrook.

Figure 2-17: USACE North Atlantic Coast Comprehensive Study Results Save Points

North Atlantic Coast Comprehensive Study

Table 2-13 presents flood stillwater levels and wave heights at representative save points, as predicted by the USACE NACCS study. Figure 2-13 shows the locations of the NACCS save points. The save point locations correspond to the FEMA transect locations in **Table 2-12**. The values presented below represent mean values. The range of uncertainty (95% confidence intervals) associated with the stillwater levels at the 1% and 0.2% floods is about 4 feet. The NACCS predicted values differ somewhat from FEMA due to the difference in methodologies used. Consistent with FEMA, the NACCS-predicted 1% wave heights indicate high velocity (VE) zones along Westbrook's shorelines.

Historical Occurrence at Westbrook and Vicinity

For the period of 1996 to 2018, there have been 12 coastal flood events in Middlesex County, including 1 day with property damage (resulting in $320k of damage), no injuries and no deaths. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following coastal flood probability at and near Westbrook (within Middlesex County):

- See Tables 2-12 and 2-13.

NACCS Save Point	Mean Stillwater Elevation (SWEL)							Mean 1% Wave Height, ft.
	100%	50%	20%	10%	2%	1%	0.2%	
8240	2.6	3.7	5	5.9	7.9	8.9	11.6	7.7
8239	2.6	3.7	5	5.9	7.9	8.9	11.6	8.7
8238	2.6	3.7	5	5.9	7.9	8.8	11.7	8.4
8237	2.6	3.7	5	5.9	7.9	8.8	11.7	9.0
8236	2.6	3.7	5	5.8	7.8	8.8	11.5	9.1
8235	2.6	3.7	5	5.9	7.9	8.8	11.7	8.5
8234	2.6	3.7	5	5.9	8.0	9.0	11.8	8.3

Table 2-13: NACCS Save Point Data around Westbrook
Note: Water levels are referenced to meters, NAVD88

Sea Level Rise

Sea Level Rise (SLR) is the rise of global ocean waters. Relative SLR change (RLSC) is the drainage of sea level relative to the adjacent land mass and is unique to a given geographic location. RSLC is caused by several factors, including: 1) ground settlement due to post-glacial isostatic adjustment; 2) warming of ocean waters, resulting in volume expansion; 3) increase in ocean volumes due to melting Arctic and land ice; 4) ocean density gradients due to the infusion of lower density fresh water; and 5) changes to global ocean circulation patterns (e.g., the Gulf Stream and Labrador Current).

As shown in **Figure 2-18**, the observed RSLC at the NOAA New London station, over the last approximately 80 years, indicates a mean sea level rise trend of 2.56 millimeters (mm) per year (with a 95% confidence interval of +/- 0.21 mm per year) (2.65 mm/yr = 0.10 inch/year).

Compared to Global Sea Level Rise. Over the last century, sea levels along the New England coast have risen faster than the global mean rate (which is about 1.7 to 1.8 mm per year). In fact, the observed sea level rise along the Northeast coast (from Mid-Atlantic region to Boston) is experiencing some of the largest rates of sea level rise in the world. This has been due, in part, to post-glacial land subsidence (glacial isostatic adjustment). Consistent with global sea level rise, other factors include increases in the ocean volume (due to glacial ice melt) and thermal expansion (due to increasing sea temperatures). Recent studies (Geophysical Research Letters, 2013), however, attribute the recent significant increase in the rate of sea level rise along the New England coast to ocean dynamics, specifically the effects and movement of the Gulf Stream and its interaction with cold, less dense water flowing down from Greenland.

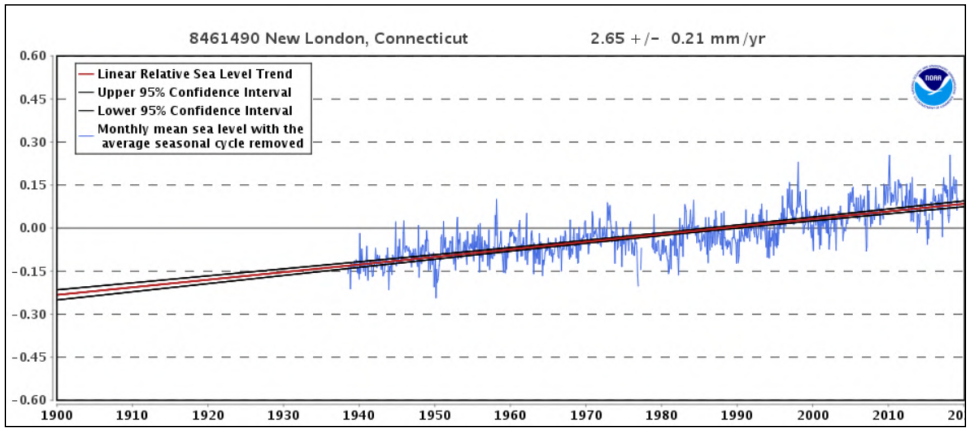


Figure 2-18: Observed Sea Level Rise at New London, Connecticut

Sea Level Rise Uncertainty

While the sea level of Long Island Sound is clearly rising, predicting the future rate of sea level rise is complex, highly uncertain, and dependent on many unknown factors (such as future emissions of greenhouse gases, rate and amount of ice melt, etc.).

NOAA and the USACE have developed ranges of RSLC for use on federal projects in the United States. The 2013 USACE projections range from Low to Intermediate to High. The USACE Low projections are generally consistent with the observed historical rates of RSLC. Observed RSLC over recent years indicate a trend of increased rates. As indicated in **Figure 2-19,** recent projections adopted by NOAA indicate the potential for even higher RSLC. The predicted sea level rise at New London between the years 2017 and 2116 (based on projections at NOAA tide station 8467150 at New London, CT and USACE 2013/NOAA2017 projections) are summarized in **Table 2-15** and **Figure 2-19** (facing) (in feet relative to the NAVD88 elevation datum). These projections were developed using the USACE Sea Level Change Curve Calculator (version 2017.42) and are based on USACE 2013/NOAA 2017 projections.

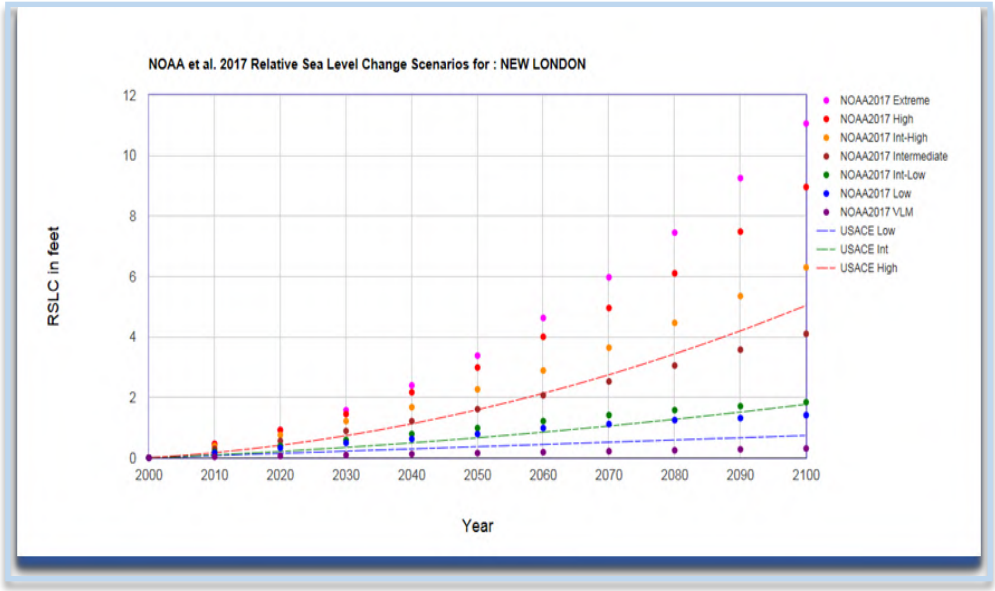


Figure 2-19: Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for USACE2013/NOAA 2012 projections)

Year	NOAA (LOW)	USACE (LOW)	NOAA (INT-LOW)	USACE (INT)	NOAA (INT-HIGH)	USACE (HIGH)	NOAA (HIGH)
2017	-	-	-	-	-	-	-
2040	0.17	0.17	0.32	0.32	0.65	0.79	1.03
2050	0.13	0.13	0.43	0.43	1.09	1.38	1.85
2070	0.39	0.39	0.88	0.88	1.95	2.42	3.18
2100	0.61	0.61	1.59	1.59	3.77	4.71	6.25

Table 2-15: Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for USACE 2013/NOAA 2017 projections; relative to the year 2017)

NOAA 2017 projections (mean values) are presented in **Figure 2-19** and **Table 2-16**. The USACE 2013 projections are shown for comparison. NOAA 2017 utilizes six descriptive categories: VLM (representing vertical land movement); Low; Intermediate-Low; Intermediate; Intermediate-High; High; and Extreme.

Year	NOAA (VLM)	NOAA (LOW)	NOAA (INT-LOW)	NOAA (INT)	NOAA (INT-HIGH)	NOAA (HIGH)	NOAA (Extreme)
2017	-	-	-	-	-	-	-
2040	0.06	0.29	0.46	0.88	1.34	1.84	2.07
2050	0.09	0.46	0.65	1.28	1.93	2.66	3.05
2070	0.16	0.79	1.08	2.20	3.31	4.62	5.64
2100	0.25	1.08	1.51	3.77	5.97	8.63	10.73

Table 2-16: Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for NOAA et. al. 2017 projections; relative to the year 2017)

Table 2-16 presents the NOAA 2017 mean projections, interpolated from the year 2017. (These interpolations assume a RSLC of about 0.33 feet between the years 2000 and 2017.) **Table 2-17** presents estimated exceedance probabilities associated with the six NOAA 2017 projections (shown in Figure 2-5) for several possible future climate climate scenarios (Representative Concentration Pathways RCP 2.6, RCP 4.5, RCP 8.5) adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5).

In general, the median "Intermediate-Low" is considered appropriate as an "analysis and planning lower bound" and either the median "Intermediate" or median "Intermediate-High" is appropriate as an "analysis and planning upper bound".

GMSL Rise Scenario	RCP 2.6	RCP 4.5	RCP 8.5
Low (0.3 m)	94%	98%	100%
Intermediate-Low (0.5 m)	49%	73%	96%
Intermediate (1.0 m)	2%	3%	17%
Intermediate-High (1.5 m)	0.4%	0.5%	1.3%
High (2.0 m)	0.1%	0.1%	0.3%
Extreme (2.5 m)	0.05%	0.05%	0.1%

Table 2-17: Probability of Exceeding Global Mean Sea Levels in 2100 for Several Representative Concentration Pathways (RCP) Scenarios (reproduced from "Global and Regional Sea Level Rise Scenarios for

The variance between the NOAA, 2017 projections increases significantly by mid-century. The NOAA 2017 Intermediate-Low projection has a high (possible to certain) likelihood of occurrence (49% to 96% by 2100). The NOAA 2017 Intermediate projection has low to moderate (possible to certain) likelihood of occurrence (2% to 17% by 2100). The NOAA 2017 Extreme GMSL scenario is a worst case scenario. For the New London area, the Extreme RSLC scenario for the year 2100 is about 11 feet. Note that the probabilities presented here are approximate; however, they are appropriate for use in understanding the risk of different sea level rise scenarios and planning.

The exceedance probabilities associated with the USACE projections can be approximated using Table 2-15 as a guide along with the following: USACE 2100 RSLC High (lies between the NOAA 2017 Intermediate-High and Intermediate); USACE 2100 RSLC Intermediate (close to NOAA 2017 Intermediate-Low); USACE 2100 RSLC Low (between NOAA 2017 Low and VLM). At mid-century (2050) the USACE 2050 High RSLR is consistent with NOAA 2017 Intermediate; the 2050 USACE Intermediate is consistent with the NOAA 2017 Low. As an approximate guide, the 2100 USACE High RSLC projection has a very low to moderate chance of occurrence (exceedance probabilities of 0.4% to 17%) and the USACE Intermediate RLSC projection has a possible to certain chance of occurrence (exceedance probability of 49% to 100%).

The State of Connecticut, in PA 13-179, "An Act Concerning the Permitting of Certain Coastal Structures by the Department of Energy and Environmental Protection" references NOAA CPO-1 report (an earlier NOAA report, dated December, 2012) and requires that State and Municipal Plans of Conservation and Development, Civil Preparedness Plans and Municipal Hazard Mitigation Plans must "consider" the sea level change scenarios from the NOAA CPO-1 report. PA 13-179 also charged the University of Connecticut, Department of Marine Science to update the NOAA CPO-1 projections every 10 years based on local conditions and the state of the science.

Based on verbal communication with the University of Connecticut, we understand that forthcoming updates to the NOAA COP-1 projections will result in recommendations as follows: 1) for mid-range planning, assume that sea level will be 1.7 feet higher than the national tidal datum in Long Island Sound by the year 2050 (relative to the year 2000); 2) planners should be aware that the rate of sea level is expected to continue to increase, with a 3.25 feet rise in sea level by 2100; and 3) greenhouse gas emissions will be monitored and new assessments will be developed at decadal intervals. However, a 1 May 2018 White Paper sponsored by CIRCA and written by the UConn School of Law entitled *Statutory Adoption of Updated Sea-Level Rise* Scenarios, dated 1 May 2018, noted that PA 13-179 does not specify a means to which the UConn updates to the NOAA Report are promulgated. In spite of this challenging legal dilemma ***these recommended values are close to the NOAA 2017 Intermediate projections*** (see **Table 2-16**). They are also reasonably represented by the 2013 USACE High projections. See **Tables 2-15** and **2-16** for projections relative to the year 2017.

The report "Global and Regional Sea Level Rise Scenarios for the United States"; NOAA Technical Report NOS CO-OPS 083; January, 2017 (NOAA, 2017) presents general guidance about selection of projections for planning purposes. One planning approach is to: 1) use a scientifically plausible, but currently low expected likelihood of occurrence as a planning upper bound; and 2) define a mid-range scenario as a baseline for planning, such as adaptation plans covering the next three decades (2050). These projections would bound a planning "envelope".

In consideration of the information presented above, as well as State guidance, it is recommended that the USACE High RSLC Scenario be considered as an appropriate projection for adaptation planning. It is also recommended that the USACE Intermediate RSLC Scenario be considered as having a very high (possible to near certain) likelihood of occurrence. However, projections representing greater rates of relative sea level rise should be considered on a case-by-case basis for design of costly or critical infrastructure.

Rising Tides

A reasonable estimate of the effects of RSLC on tides can be developed by linear superposition of the predicted RSLC to the current epoch tidal datums. **Table 2-17** presents the current and predicted changes to the tidal datums for Old Westbrook due to RSLC for the years 2040, 2070 and 2100, in feet NAVD88.

Figure 2-21 shows the predicted tidal inundation due to between 1 foot and 6 feet sea level rise, relative to MHHW. Assuming the 2013 USACE High RSLC scenario, RSLC amounts corresponding to future years are:

1 foot (MHHW = 2.5 feet NAVD88):	Years 2040 to 2045
2 feet (MHHW = 3.5 feet NAVD88):	Year 2060
3 feet (MHHW = 4.5 feet NAVD88):	Years 2075 to 2080
4 feet (MHHW = 5.5 feet NAVD88):	Year 2090
5 feet (MHHW = 6.5 feet NAVD88):	Year 2100

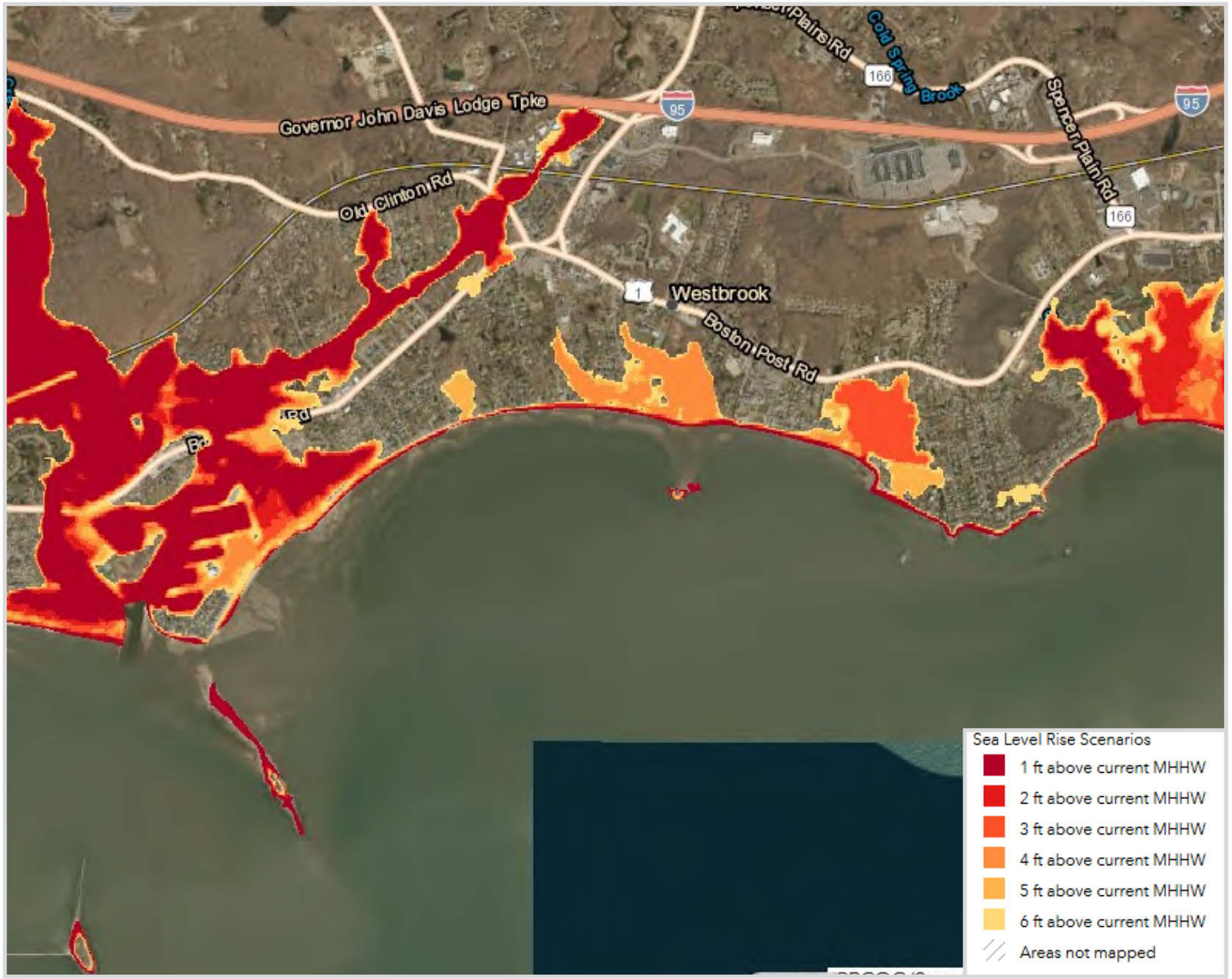


Figure 2-21: Limits of Flood Inundation due to Relative Sea Level Rise in relation to Mean Higher High Water (MHHW)

Except for areas along the beaches and near tidal wetlands, the effects of tidal flooding on the Town are currently minimal. The Mean Higher High Water (MHHW) assuming the 2013 USACE High RSLC projection for the years 2080 to 2100 is very close to the water levels experienced during Hurricane Sandy peak flood. These conditions would result in flooding throughout the Town similar to that experienced during Sandy, but on a daily basis.

These results were used to conduct the vulnerability assessment outlined in **Attachment 3** of this Plan Update.

	Current	2040		2070		2100	
		USACE High SLR	USACE Int SLR	USACE High SLR	USACE Int SLR	USACE High SLR	USACE Int SLR
MSL	-0.28	0.51	0.04	2.14	0.60	4.43	1.31
MHW	1.14	2.12	1.54	4.14	2.23	6.98	3.11
MHHW	1.5	2.48	1.90	4.50	2.59	7.34	3.47
MLW	-2.06	-1.08	-1.66	0.96	-0.96	3.83	-0.07
MLLW	-2.3	-1.31	-1.90	0.73	-1.20	3.59	-0.31

Table 2-18: Projected Westbrook Tidal Datums Based on 2013 USACE High RSLC Projections

Intense Rainfall and Urban Flooding

Intense, heavy rainfall can result in localized flooding including flash flood events. Risks due to intense rainfall is predominantly associated with flash flooding and are typically related to the capacity of the existing stormwater infrastructure to manage stormwater run-off. High velocity stormwater flow can also occur during these events. Damages can include localized flooding, damage to property and vehicles and potentially safety risk to the public.

While there is no specific, single set of criteria that defines "intense rainfall", the rainfall intensities associated with a 25-year recurrence interval are a reasonable benchmark (a 1 in 4 chance of being met or exceeded in any given year). This figure indicates short duration intensities (30 minutes and 1-hour) on the order of 1.7 and 2.2 inches per hour respectively and longer duration intensities (24 hours) on the order of an average 0.27 inch per hour (one day total rainfall amounts of about 6.4 inches).

Historical Occurrence at Westbrook and Vicinity

- During the period between 1996 and 2005, Middlesex County experienced 22 days with Heavy Rain events, an average of about 2 to 3 event days per year, with no documented property damages, injuries or death. Ref. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/
- During the period between 1996 and 2018, Middlesex County experienced 17 days with Flash Flood events, an average of about 0 to 1 event day per year, with $250k in documented property damages, 0 injuries, and 0 deaths. Ref. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following urban flooding probability at and near Westbrook (within Middlesex County):

- Urban Flooding due to Intense Rainfall within Middlesex County: 4% AEP or approximately a 25-year recurrence

Effects of Climate Change

The attribution of rainfall intensity and frequency has high confidence. Average annual precipitation in the Northeast increased 10 percent from 1895 to 2011, and precipitation from extremely heavy storms has increased 70 percent since 1958. During the this century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. Average precipitation is likely to increase during winter and spring, but not change significantly during summer and fall.

Figure 2-15: Add Date Total Rainfall and area photographs during storm

Shoreline Change

Shoreline Change

Shoreline change along the Town's Long Island Sound shorelines is due to both: 1) long -term erosion (with localized areas of beach accretion); and 2) episodic erosion due to coastal storms (with combined flood and waves). Due to the increased storm and wave activity during the Fall and Winter, beach profiles may change seasonally from an eroded "winter" beach to a fuller "summer" beach; however, this seasonal effect is less prominent along Long Island Sound compared to beaches that are directly exposed to the Atlantic Ocean.

A 2014 cooperative effort between the Connecticut Department of Energy & Environmental Protection (DEEP), the Connecticut Sea Grant (CT Sea Grant) and the University of Connecticut Center for Land Use Education and Research (UCONN-CLEAR) conducted a time series analysis of the Connecticut shoreline from different time periods between 1880 and 2006 to establish Connecticut shoreline trends. Westbrook was included in this analysis

Historical Occurrence at Westbrook and Vicinity

Connecticut Shoreline Change analysis indicates that Westbrook gained 2.47 meters of coastal shoreline between 1880 and 2006.

SHORELINE CHANGE STATISTICS

Shoreline "rate of change statistics" reflect a cumulative summary of the processes that altered the shoreline for the time period analyzed. **Figures 2-22 and 2--23** present the shoreline change statistics for the long-term and short term, respectively. The values calculated for Westbrook include:

Westbrook – Long Island Sound Beaches

Short-Term (1983 to 2006):

- Net Shoreline Movement:
  - Minimum: -12.12 meters
  - Maximum: 19.51 meters
  - Average: 2.4 meters
- End Point Rate (average): 0.10 meters/year

Long-Term (1880 to 2006):

- Net Shoreline Movement:
  - Minimum: -39.7 meters
  - Maximum: 80.9 meters
  - Average: 2.5 meters
- End Point Rate (average): 0.02 meter/year

Estimated Probability of Occurrence at and near Westbrook

Data is not currently available to develop quantitative estimates of shoreline change.

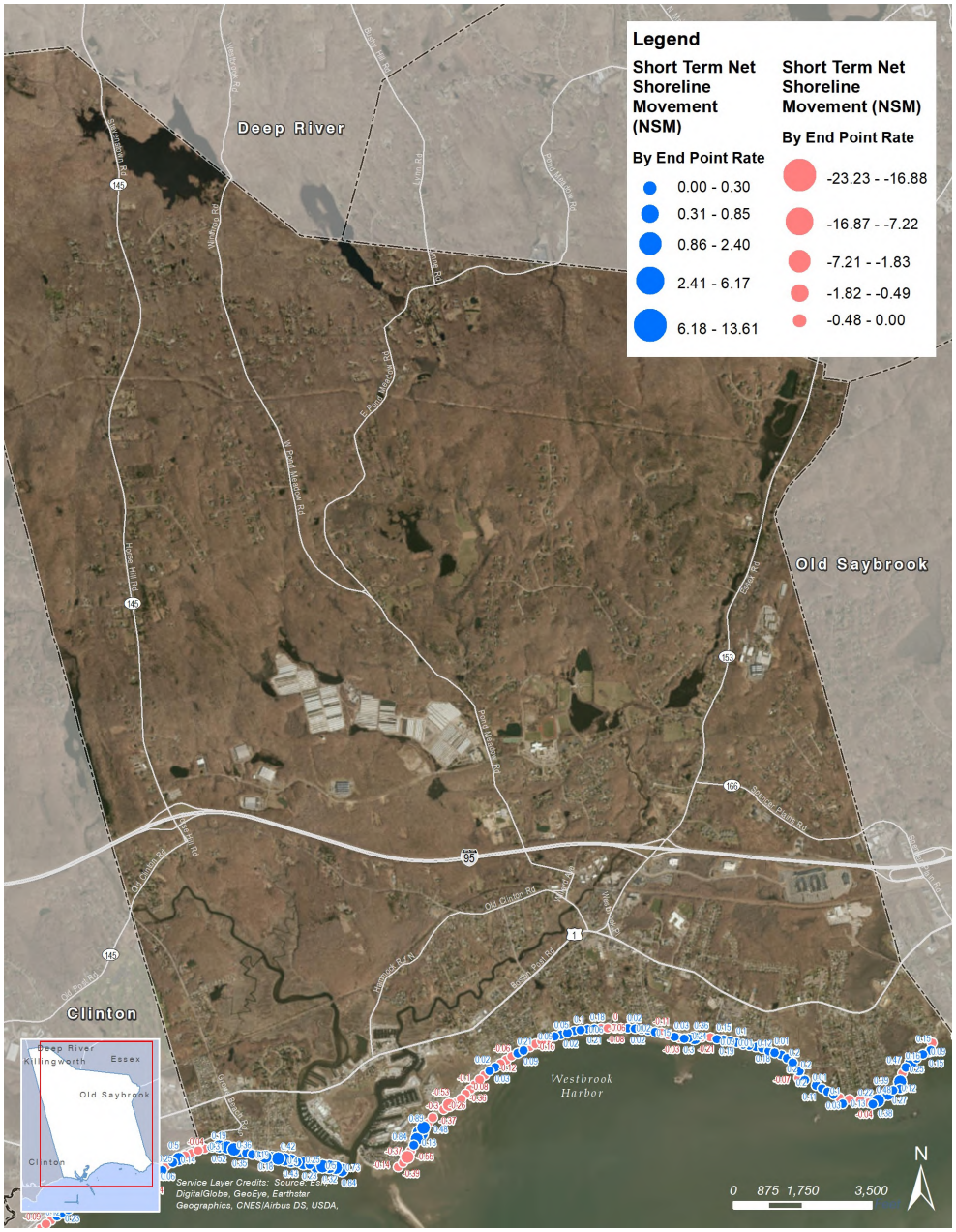


Figure 2-22: Short Term Shoreline Change

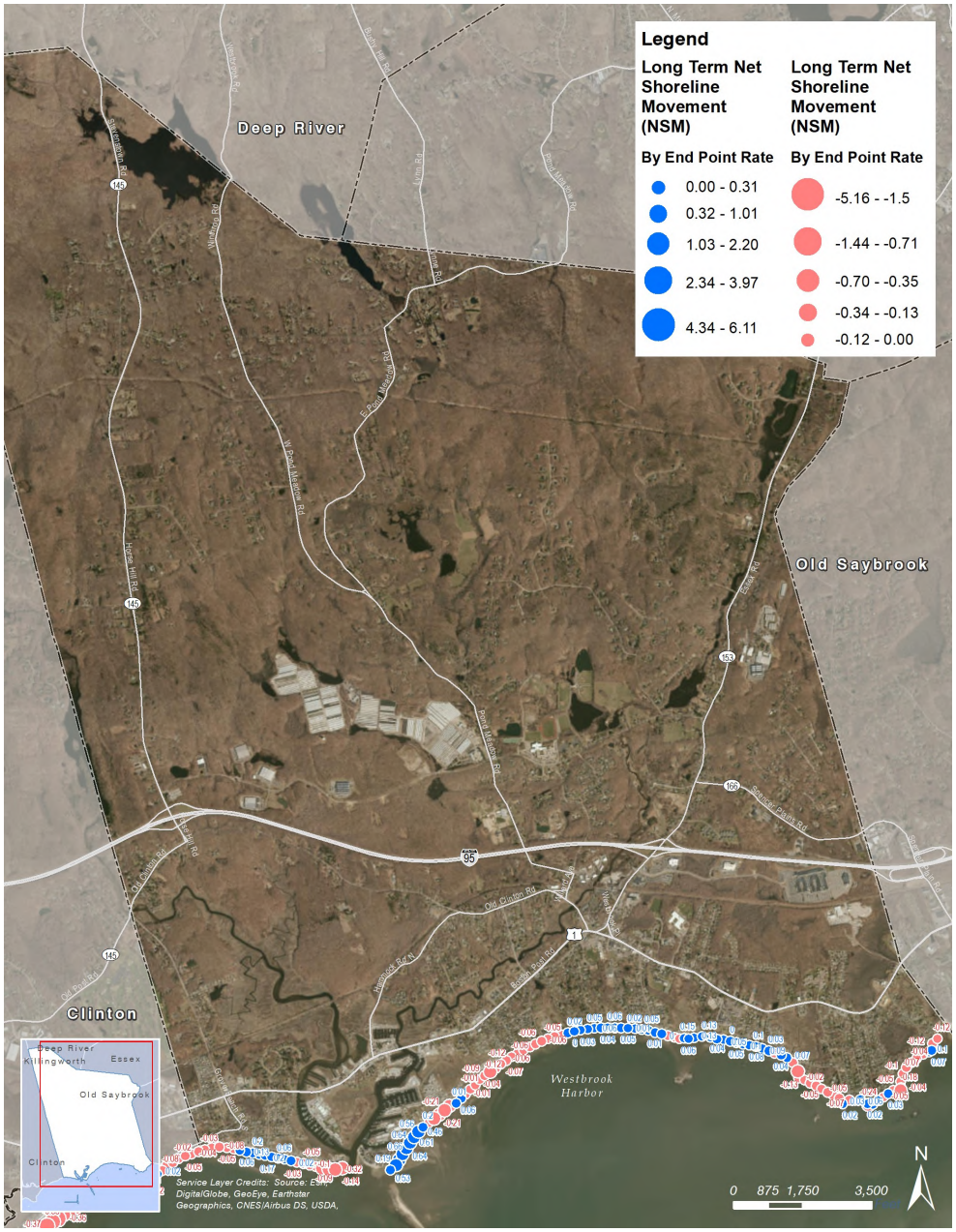


Figure 2-23: Long Term Shoreline Change

Severe Weather Hazards: Winter Weather

SEVERE WINTER WEATHER: SNOWFALL

Severe winter weather includes large snow events, blizzards and ice storms. As defined by the National Weather Service, a blizzard is a snowstorm with sustained winds or frequent gusts of 35 miles an hour or greater and considerable falling and/or blowing snow (i.e., reducing visibility frequently to less than a quarter of a mile) for a period of 3 hours or longer. NOAA's National Centers for Environmental Information produces the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two thirds of the U.S. The RSI ranks snowstorm impacts on a scale from 1 to 5, as shown in **Table 2-19**. RSI is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population density and societal impacts. Currently, the index uses population data based on the 2000 Census. A similar storm index is the Northeast Snowfall Impact Scale (NESIS), also shown below. Reference NOAA; https://www.ncdc.noaa.gov/snow-and-ice/rsi/

Severe winter weather in Connecticut is almost always associated with nor'easters. Table **2-20** presents Groton/New London, CT (which is the nearest National Weather Service local forecast office to Westbrook) average snowfall distribution by month. **Table 2-21** summarizes the major nor'easters that occurred between the 1880's and now in the Northeast U.S. and includes RIS and NESI values (if available). Ref. https://gis.ncdc.noaa.gov/maps/ncei/rsi

Figure 2-24 indicates the average annual snowfall amounts for the Northeast U.S. The average snowfall per year near Westbrook is 25 to 50 inches, with generally lower snowfall rates in coastal Connecticut versus inland Connecticut. For the period between 1981 to 2010, the average annual snowfall rates at nearby Groton/New London, Connecticut was 23.2 inches with average number snowfall days of 10.2 days per year.

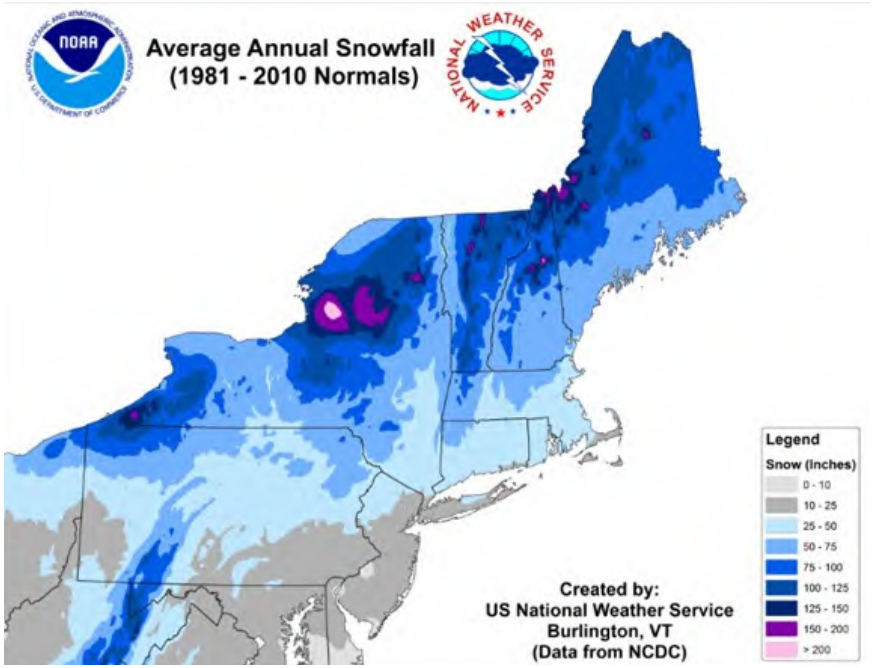


Figure 2-24: Average Annual Snowfall (http://www.weather.gov/btv/winter)

Category	RSI Value	Description
1	1-3	Notable
2	3-6	Significant
3	6-10	Major
4	10-18	Crippling
5	18+	Extreme

Category	NESIS Value	Description
1	1-2.5	Notable
2	2.5-4	Significant
3	4-6	Major
4	6-10	Crippling
5	10+	Extreme

Table 2-19: Regional Snowfall Index (RSI) and Northeast Snowfall Impact Scale

Month	Average Snowfall in inches
January	6
February	8
March	3
April	1
November	1
December	5
Year	23.2

Table 2-20: Average snowfall per month in inches (Groton/New London)

Table 2-21: Major Historical Nor'easters in the New England Region (Bold indicates est. snowfall near Westbrook > 6" to12")

Event	Northeast Category/RSI Value	Date	Description
Great Blizzard of 1888	NA	March 11-14, 1888	One of the worst blizzards in U.S. history. Dropped 40–50 inches (100–130 cm) of snow, killed 400 people, mostly in New York.
Great Appalachian Storm of November 1950	4/14.5	November 24-30, 1950	A very severe storm that dumped more than 30 inches (76 cm) of snow in many major metropolitan areas along the eastern United States, record breaking temperatures, and hurricane-force winds. The storm killed 353 people.
The Blizzard of'58	**3/7.9**	February 16-17, 1958	This coastal storm brought heavy snow and strong winds to the Northeast and resulted in 19.4 inches of snow in Boston.
	0/0	March 3-5, 1960	This wind-driven snowstorm brought whirling snow from Virginia to New York, before blowing into New England. Left 19.8 inches of
Ash Wednesday Storm of 1962	1/1.8	March 5-9, 1962	Caused severe tidal flooding and blizzard conditions from the Mid-Atlantic to New England, killed 40 people.
February Blizzard	**5/34.0**	February 24-27, 1969	This storm lasted several days and left 26.3 inches of snow in Boston.
Eastern Canadian Blizzard of March 1971	4/10.8	March 3-5, 1971	Dropped over 32 inches (81 cm) of snow over areas of eastern Canada, killed at least 30 people.
Groundhog Day Gale of 1976	NA	February 1-5, 1976	Caused blizzard conditions for much of New England and eastern Canada, dropping a maximum of 56 inches (140 cm) of snow.
January Blizzard	**2/5.4**	January 20-21, 1978	The January blizzard occurred just a couple of weeks before the infamous Blizzard of '78 and left 21.4 inches of snow in Boston.
Northeastern United States blizzard of 1978	**5/18.4**	February 5-7, 1978	A catastrophic storm, which dropped over 27 inches (69 cm) of snow in areas of New England, killed a total of 100 people, mainly people trapped in their cars on metropolitan Boston's inner beltway
1991 Perfect Storm (the "Perfect Storm," combined Nor'easter/ hurricane)	0/0	October 28-November 2, 1991	Very unusual storm which evolved into a hurricane, tidal surge caused severe damage to coastal areas, especially Massachusetts, killed 13 people.
December 1992 nor'easter	2/4.7	December 10-12, 1992	A powerful storm which caused severe coastal flooding throughout much of the northeastern United States.
1993 Storm of the Century	5/22.1	March 12-15, 1993	A superstorm which affected the entire eastern U.S., parts of eastern Canada and Cuba. It caused 6.65 billion (2008 USD) in damage, and killed 310 people.
Christmas 1994 nor'easter	NA	December 22-26, 1994	An intense storm which affected the east coast of the U.S., and exhibited traits of a tropical cyclone.
North American Blizzard of 1996	**5/21.8**	January 6-10, 1996	Severe snowstorm which brought up to 4 feet (120 cm) of snow to areas of the mid-Atlantic and northeastern U.S.
April Fools Storm	2/4.7	March 31-April 1, 1997	This April Fools storm dropped more than 2 feet of snow in Boston.

Table 2-21: Major Historical Nor'easters in the New England Region cont. (Bold indicates est. snowfall near Westbrook > 6" to12")

Event	Northeast RSI/ NESIS Category	Date	Description
North American Blizzard of 2003	**4/14.7**	February 14-22, 2003	Dropped over 2 feet (61 cm) of snow in several major cities, including Boston, and New York City, affected large areas of the Northeastern and Mid-Atlantic U.S., and killed a total of 27 people.
North American Blizzard of 2005	**NA**	January 20-23, 2005	Brought blizzard conditions to southern New England and dropped over 40 inches (100 cm) of snow in areas of Massachusetts.
North American Blizzard of 2006	**2/5.0**	February 11-13, 2006	A powerful storm that developed a hurricane-like eye when off the coast of New Jersey. It brought over 30 inches (76 cm) of snow in some areas and killed 3 people.
April 2007 nor'easter	0/1.0	April 13-17, 2007	An unusually late storm that dumped heavy snow in parts of Northern New England and Canada and heavy rains elsewhere. The storm caused a total of 18 fatalities.
November 2009 nor'easter	0/0	November 11-17, 2009	Formed from the remnants of Hurricane Ida, produced moderate storm surge, strong winds and very heavy rainfall throughout the mid-Atlantic region. It caused US$300 million (2009) in damage, and killed six people.
December 2009 North American blizzard	**1/2.8**	December 16-20, 2009	A major blizzard which affected large metropolitan areas, including New York City, Philadelphia, Providence, and Boston. In some of these areas, the storm brought up to 2 feet (61 cm) of snow.
March 2010 nor'easter	0/0.3	March 12-16, 2010	A slow-moving nor'easter that devastated the Northeastern United States. Winds of up to 70 miles per hour (110 km/h) snapped trees and power lines, resulting in over 1 million homes and businesses left without electricity. The storm produced over 10 inches (25 cm) of rain in New England, causing widespread flooding of urban and low-lying areas. The storm also caused extensive coastal flooding and beach erosion.
December 2010 North American blizzard	**2/3.4**	December 5, 2010-January 15, 2011	A severe and long-lasting blizzard which dropped up to 36 inches (91 cm) of snow throughout much of the eastern United States.
January 8–13, 2011 North American blizzard and January 25–27, 2011 North American blizzard	**2/3.4**	January 8-13 and January 25-27, 2011	In January 2011, two nor'easters struck the East Coast of the United States just two weeks apart and severely crippled New England and the Mid-Atlantic. During the first of the two storms, a record of 40 inches (100 cm) was recorded in Savoy, Massachusetts. Two people were killed.

Table 2-21: Major Historical Nor'easters in the New England Region cont. (Bold indicates est. snowfall near Westbrook > 6" to12")

Event	Northeast RSI/ NESIS Category	Date	Description
2011 Halloween nor'easter	1/2.6	October 28-November 1, 2011	A rare, historic nor'easter, which produced record breaking snowfall for October in many areas of the Northeastern U.S., especially New England. The storm produced a maximum of 32 inches (81 cm) of snow in Peru, Massachusetts, and killed 39 people. After the storm, the rest of the winter for New England remained very quiet, with much less than average snowfall and no other significant storms to strike the region for the rest of the season.
November 2012 nor'easter	0/0.3	November 7-10, 2012	A moderately strong nor'easter that struck the same regions that were impacted by Hurricane Sandy a week earlier. The storm exacerbated the problems left behind by Sandy, knocking down trees that were weakened by Sandy. It also left several residents in the Northeast without power again after their power was restored following Hurricane Sandy. Highest snowfall total from the storm was 13 inches (33 cm), recorded in Clintonville, Connecticut.
Late December 2012 North American storm complex	3/9.2	December 17-31, 2012	A major nor'easter that was known for its tornado outbreak across the Gulf Coast states on Christmas day as well as giving areas such as northeastern Texas a white Christmas. The low underwent secondary cyclogenesis near the coast of North Carolina and dumped a swath of heavy snow across northern New England and New York, caused blizzard conditions across the Ohio Valley, as well as an ice storm in the mountains of the Virginia and West Virginia.
Early February 2013 North American blizzard	**3/NA**	February 7-18, 2013	An extremely powerful and historic nor'easter that dumped heavy snow and unleashed hurricane-force wind gusts across New England. Many areas received well over 2 feet (61 cm) of snow, especially Connecticut, Rhode Island, and eastern Massachusetts. The highest amount recorded was 40 inches (100 cm) in Hamden, Connecticut, and Gorham, Maine, received a record 35.5 inches (90 cm). Over 700,000 people were left without power and travel in the region came to a complete standstill. The storm killed 18 people. Left 24.9 inches of snow in Boston and 22.8 inches in Providence.

Table 2-21: Major Historical Nor'easters in the New England Region cont. (Bold indicates est. snowfall near Westbrook > 6" to12")

Event	Northeast RSI/ NESIS Category	Date	Description
March 2013 nor'easter	1/1.6	March 1-21, 2013	A large and powerful nor'easter that ended up stalling along the eastern seaboard due to a blocking ridge of high pressure in Newfoundland and pivoted back heavy snow and strong winds into the Northeast United States for a period of 2 to 3 days. Many officials and residents were caught off guard as local weather stations predicted only a few inches (several centimeters) of snow with a change to mostly rain. Contrary to local forecasts, many areas received over one foot (30 cm) of snow, with the highest amount being 29 inches (74 cm) in Milton, Massachusetts. Several schools across the region, particularly in the Boston, Massachusetts, metropolitan area, remained in session during the height of the storm, not knowing the severity of the situation. Rough surf and rip currents were felt all the way southwards towards Florida's east coast.
January 2015 North American Blizzard	**3/6.2**	January 23-31, 2015	Unlike recent historical winter storms, there was no indication that a storm of this magnitude was coming until about 3 days in advance. The Blizzard began as an Alberta Clipper in the Midwestern States, which was forecast to transfer its energy to a new, secondary Low Pressure off the coast of the Mid Atlantic and move northeastward and pass to the south and east of New England. Several reports of over 30 inches (76 cm) across the State of Massachusetts, breaking many records. A maximum of 36 inches (91 cm) was recorded in at least four towns across Worcester County in Massachusetts and the city of Worcester itself received 34.5 inches (88 cm), marking the city's largest storm snowfall accumulation on record. The city of Boston recorded 24.6 inches (62 cm), making it the largest storm snowfall accumulation during the month of January and the city's sixth largest storm snowfall accumulation on record. On the coast of Massachusetts, Hurricane Force gusts up to around 80 mph (130 km/h) along with sustained winds between 50 and 55 mph (80 and 89 km/h) at times, were reported. The storm also caused severe coastal flooding and storm surge. The storm bottomed out to a central pressure of 970 mb (970 hPa). By January 28, the storm began to pull away from the area.
October 2015 North American storm complex	0/0	September 29-October 2, 2015	In early October, a low pressure system formed in the Atlantic, Tapping into moisture from Hurricane Joaquin, the storm dumped a huge amount of rain, mostly in South Carolina.

Table 2-21: Major Historical Nor'easters in the New England Area cont.

Event	Northeast RSI/ NESIS Category	Date	Description
January 2016 United States blizzard (also known as Winter Storm Jonas, Snowzilla, or The Blizzard of 2016 by media outlets)	4	January 19-29, 2016	This system dumped 2 to 3 feet (61 to 91 cm) of snow in the East Coast of the United States. States of Emergencies were declared in 12 States in advance of the storm as well as by the Mayor of Washington D.C. The blizzard also caused significant storm surge in New Jersey and Delaware that was equal to or worse than Hurricane Sandy. Sustained damaging winds over 50 mph (80 km/h) were recorded in many coastal communities, with a maximum gust to 85 mph (137 km/h) on Assateague Island, Virginia. A total of 55 people died due to the storm.
February 2017 United States blizzard (also known as Winter Storm Niko and The Blizzard of 2017 by media outlets)	**4.17.8**	February 6-11, 2017	Forming as an Alberta clipper in the northern United States on February 6, the system initially produced light snowfall from the Midwest to the Ohio Valley as it tracked southeastwards. It eventually reached the East Coast of the United States on February 9 and began to rapidly grow into a powerful nor'easter, dumping 1 to 2 feet (30 to 61 cm) across the Northeast Megapolis. The storm also produced prolific thunder and lightning across Southern New England. Prior to the blizzard, unprecedented and record-breaking warmth had enveloped the region, with record highs of above 60 °F (16 °C) recorded in several areas, including Central Park in New York City. Some were caught off guard by the warmth and had little time to
October 2017 nor'easter	0/0	October 28-31, 2017	An extratropical storm absorbed the remnants of Tropical Storm Philippe. The combined systems became an extremely powerful nor'easter that wreaked havoc across the Northeastern United States and Eastern Canada. The storm produced sustained tropical storm force winds along with hurricane force wind gusts. The highest wind gust recorded was 93 mph (150 km/h) in Popponesset, Massachusetts. The storm caused over 1,400,000 power outages. Damage across New England, especially in Connecticut, Massachusetts, and Rhode Island, was extreme. This was due to the combination of the high winds, heavy rainfall, saturated ground, and most trees still being fully leaved. Some residents in Connecticut were without power for nearly a week following the storm. Heavy rain in Quebec and Eastern Ontario, with up to 98 mm (3.9 in) in the Canadian capital region of Ottawa, greatly interfered with transportation.

Table 2-21: Major Historical Nor'easters in the New England Region cont. (Bold indicates est. snowfall near Westbrook > 6" to12")

Event	Northeast RSI/ NESIS Category	Date	Description
January 2018 North American blizzard	**4/17.8**	January 2-6, 2018	A powerful blizzard that caused severe disruption along the East Coast of the United States and Canada. It dumped snow and ice in places that rarely receive wintry precipitation, even in the winter, such as Florida and Georgia, and produced snowfall accumulations of over 2 feet (61 cm) in the Mid-Atlantic states, New England, and Atlantic Canada. The storm originated on January 3 as an area of low pressure off the coast of the Southeast. Moving swiftly to the northeast, the storm explosively deepened while moving parallel to the Eastern Seaboard, causing significant snowfall accumulations. The storm received various unofficial names, such as Winter Storm Grayson, Blizzard of 2018 and Storm Brody. The storm was also dubbed a "historic bomb cyclone".
March 1-3, 2018 nor'easter (also known as Winter Storm Riley or False Tropical Storm Riley by media outlets)	2/4.4	March 1-5, 2018	A very powerful nor'easter that caused major impacts in the Northeastern, Mid-Atlantic and Southeastern United States. It originated as the northernmost low of a stationary front over the Midwest on March 1, which moved eastward into the Northeast later that night. A new low pressure system rapidly formed off the coast on March 2 as it slowly meandered near the coastline. It peaked later that day and began to gradually move out to sea by March 3. Producing over 2 feet (24 in) of snow in some areas, it was one of the most significant March snowstorms in many areas, particularly in Upstate New York. In other areas, it challenged storm surge records set by other significant storms, such as Hurricane Sandy. It also produced widespread damaging winds, with gusts well over Hurricane force strength in some areas across Eastern New England as well as on the back side in the Mid-Atlantic via a sting jet. Over 2.2 million customers were left without power.
March 6-8, 2018 nor'easter (also known as Winter Storm Quinn by media outlets)	1/2.2	March 2-9, 2018	A powerful nor'easter that affected the Northeast United States. It came just days after another nor'easter devastated much of the Northeast. Frequent cloud to ground Thundersnow as well as snowfall rates of up to 3 inches (7.6 cm) an hour were reported in areas around the Tri-State Area, signaling the rapid intensification of the storm. Late in the afternoon, an eye-like feature was spotted near the center of the storm. It dumped over 2 feet of snow in many areas across the Northeast, including many areas in New England where the predominant precipitation type was rain for the previous storm. Over 1 million power outages were reported at the height of the storm due to the weight of the heavy, wet snow on trees and power lines. Many people who lost power in the previous storm found themselves in the dark again.

Table 2-21: Major Historical Nor'easters in the New England Region cont. (Bold indicates est. snowfall near Westbrook > 6" to12")

Event	Northeast RSI/ NESIS Category	Date	Description
March 12-14, 2018 nor'easter (also known as Winter Storm Skylar by media outlets)	1/2.2	March 11-14, 2018	A powerful nor'easter that affected portions of the Northeast United States. The storm underwent rapid intensification with a central millibaric pressure dropping down from 1001 mb to 974 mb in just 24 hours. This was the third major storm to strike the area within a period of 11 days. The storm dumped over up 2 feet of snow and brought Hurricane force wind gusts to portions of Eastern New England. Hundreds of public school districts including, Boston, Hartford, and Providence were closed on Tuesday, March 13.
March 20–22, 2018 nor'easter (also known as Winter Storm Toby and Four'easter by media outlets)	1/1.6	March 20-22, 2018	A powerful nor'easter that became the fourth major nor'easter to affect the Northeast United States in a period of less than three weeks. It caused a severe weather outbreak over the Southern United States on March 19th before moving off of the North Carolina coast on March 20th and spreading freezing rain and snow into the Mid-Atlantic States after shortly dissipating later that night. A new low pressure center then formed off of Chesapeake Bay on March 21st and then became the primary nor'easter. Dry air prevented most of the precipitation from reaching the ground in areas in New England such as Boston, Hartford, and Providence, all of which received little to no accumulation, in contrast with what local forecasts had originally predicted. In Islip, New York at the height of the storm, snowfall rates of up to 5 inches per hour were reported. 8 inches was reported at Central Park and over 12 inches was reported in many locations on Long Island as well in and around New York City and in parts of New Jersey.

Historical Occurrence at Westbrook and Vicinity

Between 1996 and 2018, there were a total of 70 reports of Heavy Snow including 42 days in Middlesex County, 0 days with property damage and no injuries or fatalities. Heavy Snow in the NOAA database is defined as snow accumulation meeting or exceeding locally/regionally 12 and/or 24 hour warning criteria: typically 4, 6 or 8 inches or more within 12 hours or 6, 8 or 10 inches or more in 24 hours.

From December 2010 through February 2011, southern New England, including Middlesex County, saw a series of winter storms that led to record snowfall for the season. Hartford experienced a record 57 inches of snow. Heavy snow, combined with rain led to numerous flooding problems across the county, roof collapses, and downed trees and utility lines. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

The results indicate the following Snowfall probability at and near Westbrook (based on Groton/New London, Connecticut (which is the nearest National Weather Service local forecast office to Westbrook):

- 8– 10 snow days per year
- Average annual snowfall of 23 inches
- 86% AEP or 1 year recurrence interval Heavy Snowfall (19 years with 1 or more events over 22 years)
- Reasonably conservative monthly snowfall upper bound: 40 inches (maximum monthly upper bound of 60 inches)

Effects of Climate Change

The attribution of Heavy Snowfall events to climate change and understanding is moderate. High sea surface temperatures, increased atmospheric moisture and polar vortex conditions may result in an increased frequency of Heavy Snowfall.

SEVERE WINTER WEATHER: ICE STORMS

Ice storms are an occasional component of severe winter weather. Rain that falls and freezes on contact with cold surfaces is called freezing rain, while sleet is precipitation that freezes in the air before hitting the ground in the form of ice pellets. Heavy accumulations of ice can bring down trees or tree branches that may damage utility wires, causing power and communications outages, which may take days to repair. Ice can increase the weight of branches by 30 times. A 1/2-inch accumulation on power lines can add 500 lbs. of weight. Even slight accumulations of ice result in slippery conditions for motorists and pedestrians.

The National Weather Service issues:

- an Ice Storm Warning for a quarter-inch or more of ice accumulation
- a Freezing Rain Advisory for ice accumulation of less than one quarter-inch

Ice storms are relatively rare events in Connecticut, including Westbrook.

Historical Occurrence at Westbrook and Vicinity

There was one ice storm recorded in the NOAA Storm Events Database for Middlesex County between 1950 and 2019. Between 1990 and 2018, there was a 1 day with ice storm events in Connecticut (an average of 0.04 event per year), resulting in 0 injury and $0 property damage.

Estimated Probability of Occurrence at and near Westbrook

The results indicate that the probability of Ice Storms at and near Westbrook is low. Quantitative probabilities are not available.

Effects of Climate Change

The attribution of Ice Storm events to climate change and understanding is low to moderate. High sea surface temperatures, increased atmospheric moisture and polar vortex conditions may result in an increased frequency of Ice Storms.

Extreme Winters

While the average annual snowfall at Westbrook is on the order of 23 inches, there are often years with much greater snowfall amounts. Extreme Connecticut storms events include:

- Blizzard of 1978 (+/- 40 inches)
- Snowstorm of February 2003 (+/- 15 to 30 inches)
- Ice Storm of November 2002
- Winter Storm of December 1996
- Blizzard of March 1993 (+/-15 to 24 inches)
- Great Blizzard of 1888 (+/- 50 inches)
- Great Snow of 1717 (+/- 50 to 60 inches with 16-foot drifts)
- Winter Storm Nemo of 2013 (+/- 40 inches; 4 to 5 inches per hour)
- Winter Storm Juno of 2015 (+/- 27 to 33 inches)

New Haven, CT, after the Blizzard of 1888 | Worst Snowstorms in New England History
Yankee archives/New Haven Colony Historical Society

Figure 2-25: Blizzard of 1888, New Haven, Connecticut

Example Winter Storm

Winter storms that impact Westbrook are almost always nor'easters and these can range from wintry mix of rain and snow to heavy snowfall blizzards. These storms typically also create storm surge and high winds. Winter Storm Nemo is representative of Connecticut winter nor'easters. Snow and rainfall began at 9 a.m. on February 8 across New England; by late that day, totals reached 8 in (200 mm) near Milton, Vermont. Later that evening, snow was falling at 2 to 3 inches (5 to 8 cm) per hour in coastal Massachusetts, and at an extreme rate of over 6 inches per hour in parts of Connecticut. Thunder and lightning along with small hail were reported within the heavy band of snow in Connecticut. When the snow stopped, the highest amount recorded was 40 inches (100 cm) in Hamden, Connecticut. Total snowfall near Westbrook was about 30 to 33 inches. (source: Wikipedia.org)

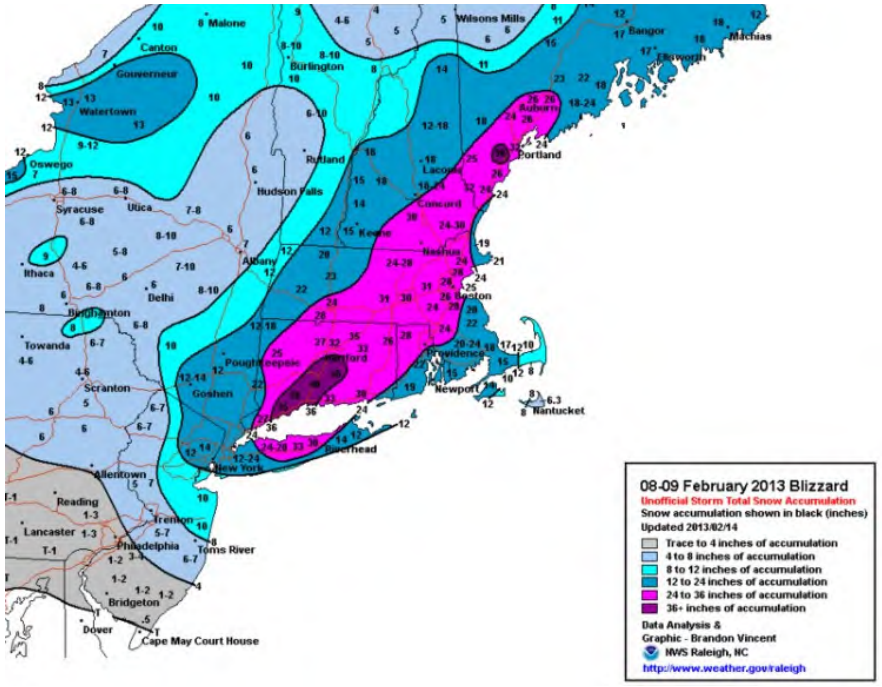
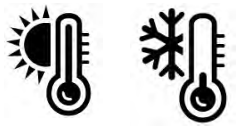


Figure 2-26: Observed Snowfall Winter Storm Nemo, February 2013

Extreme Temperatures



EXTREME TEMPERATURE: HEAT

The National Weather Service in Taunton issues:

- Excessive Heat Warnings when the daytime heat indices reach 105° F or greater for 2 or more hours
- A Heat Advisory is issued when the daytime heat indices reach 100-104°F for 2 or more hours
- A Heat Wave is defined as 3 or more days of temperatures of 90° F or above.

Heat Index

The Heat Index, also known as the Apparent Temperature, is a subjective measure of what it feels like to the human body when relative humidity is factored into the actual air temperature. Relative humidity is a measure of the amount of water in the air compared with the amount of water that air can hold at the current temperature. The body cools itself through the evaporation of perspiration or sweat. However, when the relative humidity is high, the increased moisture content in the air decreases the evaporation of perspiration or sweat. For example, a hot and very humid air mass with a temperature of 94 degrees and a relative humidity of 45 percent yields an apparent temperature of 100 degrees. Holding the temperature constant and increasing the relative humidity to 60 percent yields an apparent temperature of 110° F.

The National Weather Service will initiate alert procedures when the Heat Index is expected to exceed 104° F (depending on local climate). Under these conditions, sunstroke and heat exhaustion are likely, and physical activity or being outside for long periods is risky, potentially leading to heat stroke.

These dangerous heat days pose the greatest threat to kids and the elderly, and to people who don't have easy access to air conditioning. The Heat Index values were derived for shady, light wind conditions, and exposure to full sunshine can increase heat index values by up to 15°F. (http://www.nws.noaa.gov/om/heat/heat_index.shtml).

From 1979-2014, excessive heat exposure caused in excess of 8,000 deaths in the United States (EPA, May 2014). During this period, more people in this country died from extreme heat than from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

The average high temperatures in Groton/New London, Connecticut (which is the nearest National Weather Service local forecast office to Westbrook) during July and August are 81 and 80 degrees F , respectively. The record hot temperature for Connecticut was 106°F on July 15, 1995 (in Danbury). Temperatures along the Connecticut coast, however, are generally moderated by the close proximity to the Atlantic Ocean, with warmer winters and longer frost-free seasons than inland areas.

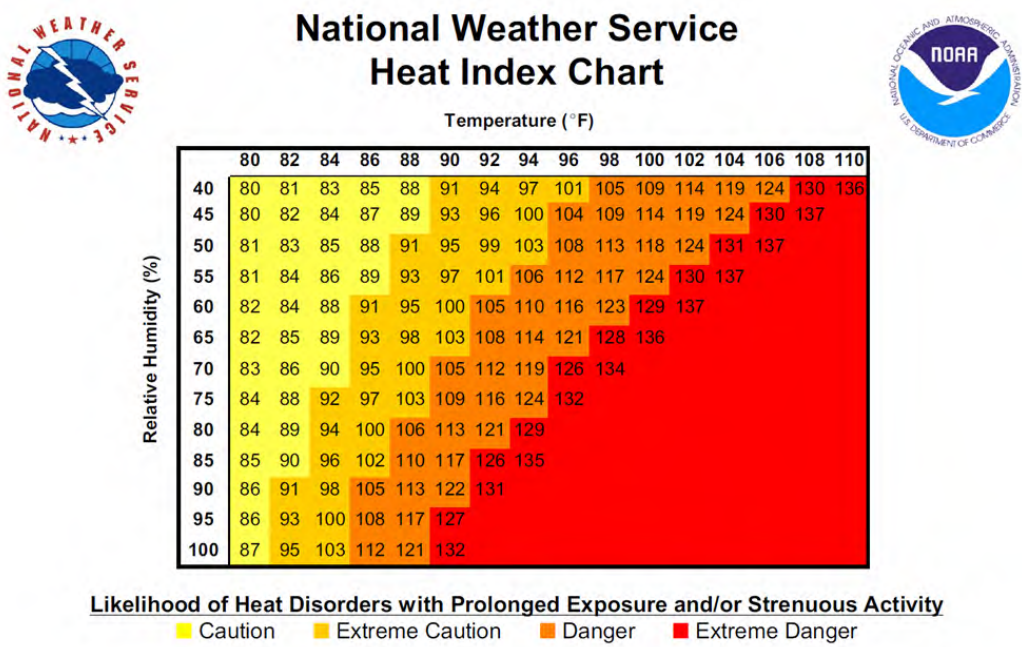


Figure 2-27: Heat Index Chart

Historical Occurrence at Westbrook and Vicinity

Between 2010 and 2018, there were a total of 4 events with Excessive Heat, including 2 days with Excessive Heat events in Middlesex County and no fatalities or injuries. These included July 22, 2011 and July 1, 2018. Ref. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

The results indicate that the probability of Excessive Heat near Westbrook (Middlesex County) is:

- 30% AEP or 1 event every 3 years.

Additional Heat Effects

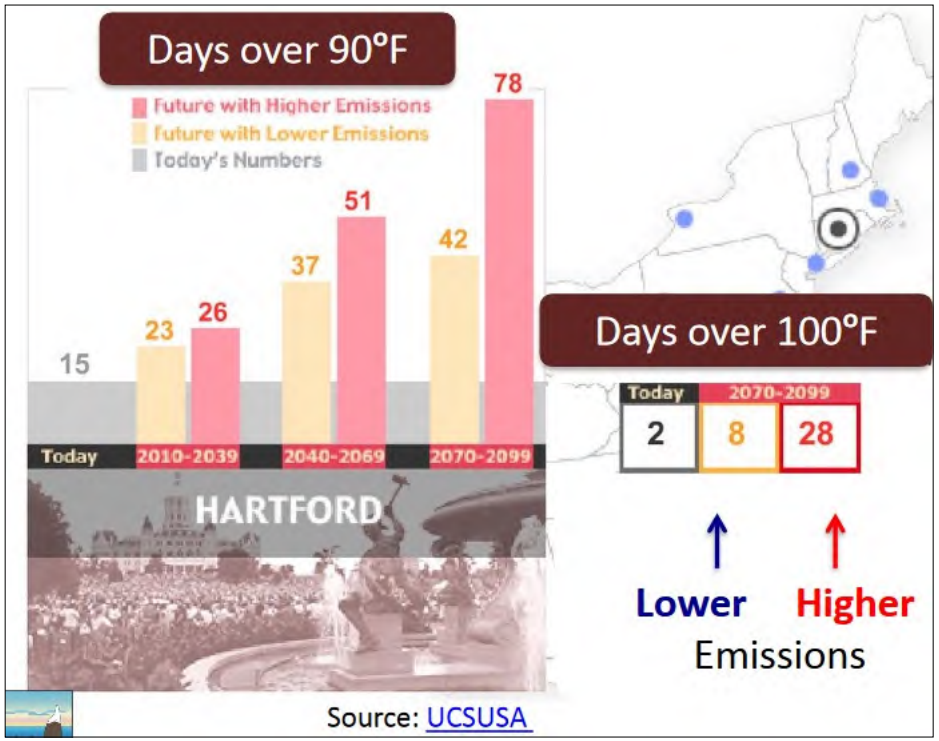
In addition to the Heat Index, air quality is a significant issue related to extreme temperature. Summers in the U.S. bring more than just searing, dangerously hot days. When the air is stagnant and there is little air circulation, hot weather can trigger high levels of air pollution that can have health consequences. High temperatures on sunny days make ground-level ozone (a major component of smog) form much more readily. An EPA study looking at more than 20 years of measurements across most of the rural areas in the eastern U.S. found that harmful ozone concentrations increased nearly linearly as temperatures increased and named the effect the "climate penalty on ozone."

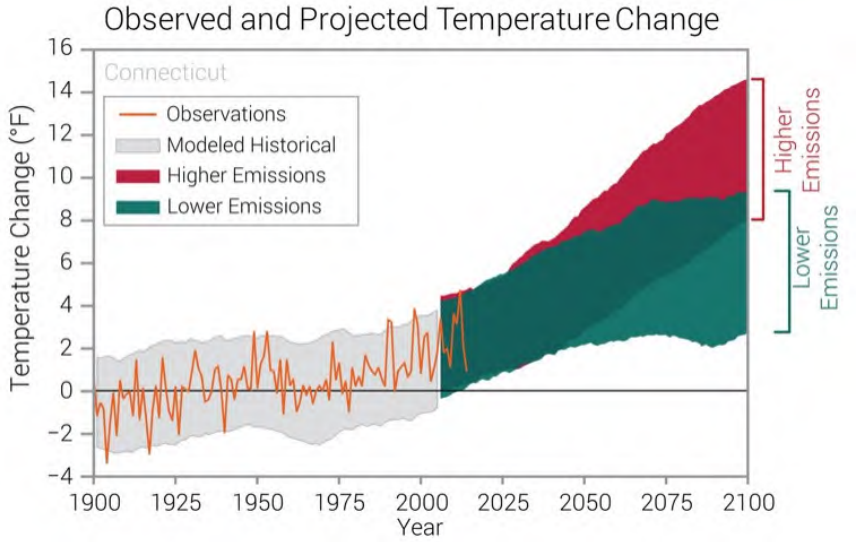
Effects of Climate Change

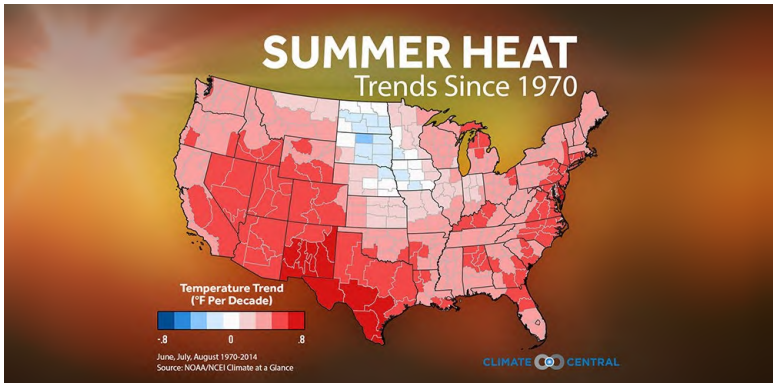
The confidence of attribution of Excessive Heat to climate change, and understanding, is high. Temperatures in Connecticut have increased about 3 degrees F since the beginning of the 20th Century as shown in **Figure 2-28**. The Hartford Metro area currently experiences 15 days a year over 90° F as shown in **Figure 2-29** below. Southeast Connecticut coastal communities are expected to fall below the predicted values for Hartford.

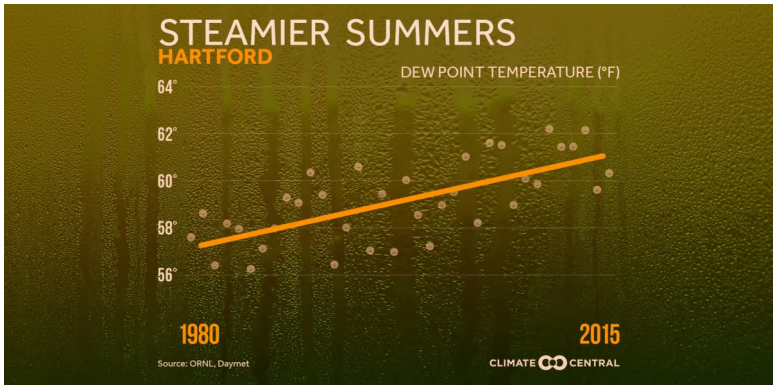
The trend of warming, characterized as average annual temperature, has been about 0.7°F per decade in Connecticut since 1970 as shown in **Figure 2-30** (below middle right). Heat waves are projected to become more intense. **Figure 2-32** on the following page shows the predicted range of days above 100° F for Hartford and Boston. Southeast Connecticut coastal communities are expected to fall below the predicted values for both cities

As summers get hotter from the increase in greenhouse gases, they are also getting stickier. More evaporation occurs in a warming atmosphere, and on a world where water covers nearly three-quarters of the surface, it means an increase in water vapor in the air. During the period of 980 to 2015, the dew point temperature increased from about 59 ° F to 62 ° F.









Figures 2-28 through 2-31: Change in Temperature since 1900 (Image Source: NOAA) (top); Days with Heat Index above 90 and 100 degrees (bottom left) Rising temperatures since 1970 (middle right); Dew Point Increase since 1980 (bottom right)

http://statesatrisk.org/connecticut/all

Effects of Climate Change

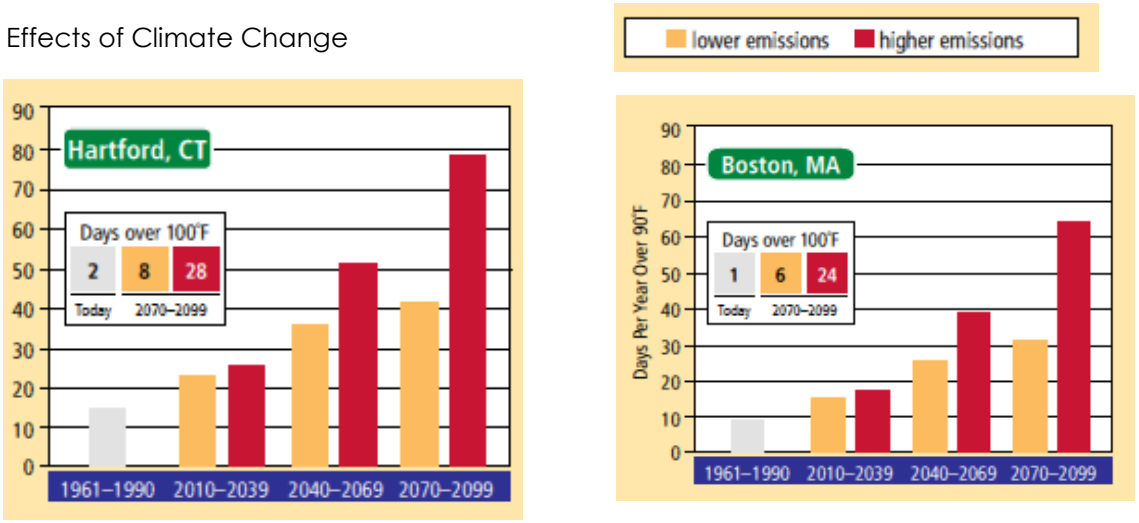


Figure 2-32: Predicted Days above 100° F (source Union of Concerned Scientists)

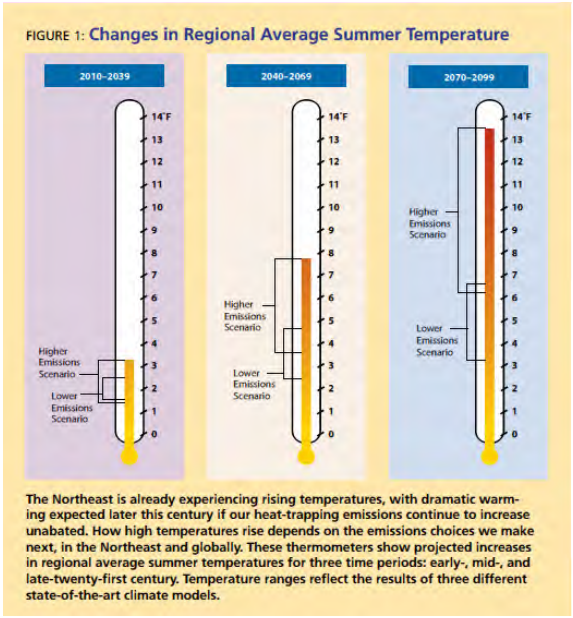


Figure 2-33: Predicted Rise in Average Northeast U.S. Temperatures (source Union of Concerned Scientists)

In addition to the effect of climate change on extreme heat events, the overall increase in global and local temperature averages will significantly change climate patterns within the Northeast U.S., including Westbrook. Spring will arrive sooner, summers are growing hotter, and the weather is becoming more extreme with swings between above-average winter temperatures to extreme cold with large snowfall events. Per the Union of Concerned Scientists summary reports, if global greenhouse gas emissions continue, the Northeast can expect dramatic temperature increases and other climate changes within the next several decades. Recent observations indicate that these effects are already underway, including within southeastern Connecticut. Average summer temperatures may increase between 6° F and 14° F by 2100 (see **Figure 2-33**). The overall effect will be a shift in the Connecticut climate equivalent to that historically experienced in lower latitudes, ranging between the Chesapeake Bay area to South Carolina. (see **Figure 2-34**)

With its coastal setting, Westbrook benefit from cooling summer sea breezes, which are the result of warming of the land area during the day (relative to the cooler water temperatures). Even these may change due to changes in both water and land temperatures.

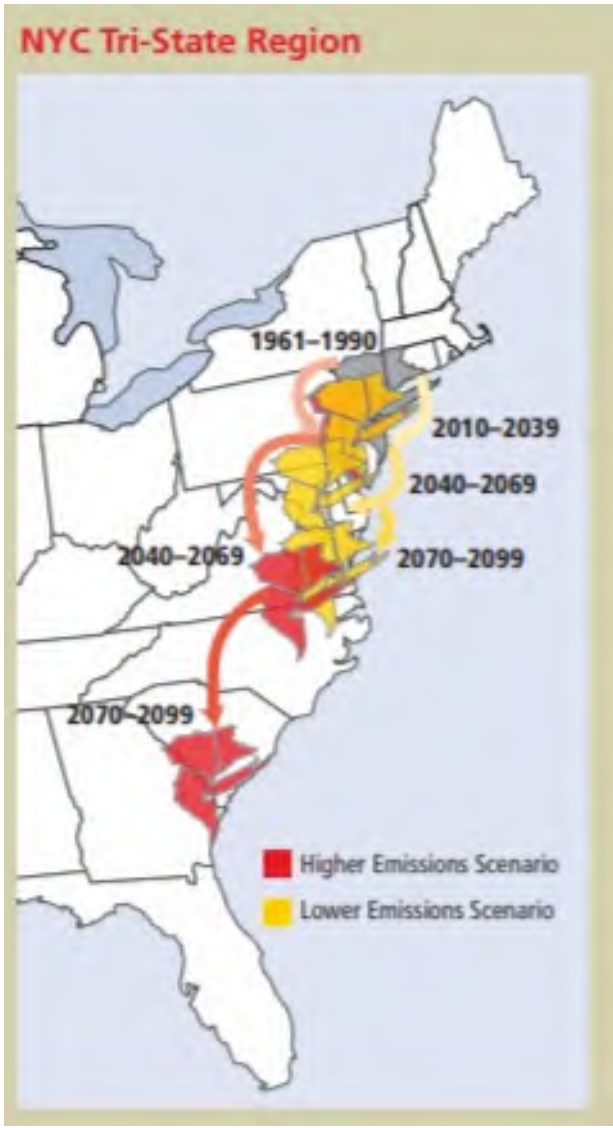


Figure 2-34: Latitudinal Changes in Regional Climate (source Union of Concerned Scientists)

EXTREME TEMPERATURE: COLD

Extreme cold events are generally defined as a prolonged period of excessively cold weather. Extreme cold conditions are often, but not always, part of winter storms. Winter in Massachusetts almost always includes periods of extreme cold weather. Exposure to cold can cause frostbite or hypothermia and has the potential to become life-threatening. Although anyone can suffer from cold-related health issues, some people are at greater risk than others, such as:

- Older adults
- Young children
- Those who are sick; and
- Those without adequate shelter

Heating sources can be impacted by power failures due to winter storms. Infants and the elderly are more at risk of serious or life-threatening health problems from extreme cold. Secondary hazards may include risk of fires or carbon monoxide poisoning from space heaters, generators, inadequately cleaned or vented fireplaces, or use of candles.

The following extreme cold warnings and advisories are issued by the National Weather Service (NWS):

- Freezing Warning – When minimum shelter temperature drops to 32° F or lower during the growing season.
- Frost Advisory – Issued under clear, light wind conditions with forecast minimum shelter temperature at 33-36° F during the growing season.
- Wind Chill Warning – Wind chill index is -25° F or lower for at least three hours using only sustained wind.
- Wind Chill Advisory - Wind chill index is between -15° F and -24° F for at least three hours using only sustained wind.

The National Weather Service Wind Chill Chart indicates the amount of time in which frostbite may occur on exposed skin based on temperature and wind speed. The National Weather Service maintains a Wind Chill Calculator, which calculated wind chill based on temperature and wind speed, as A period of extremely low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined warning criteria (typical value around -35° F or colder). Ref. http://www.wpc.ncep.noaa.gov/html/windchill.shtml.

The lowest temperature recorded in Connecticut was -32° F on February 16, 1943 in Falls Village and January 22, 1961 in Coventry, according to NOAA (https://www.ncdc.noaa.gov/extremes/scec/records).

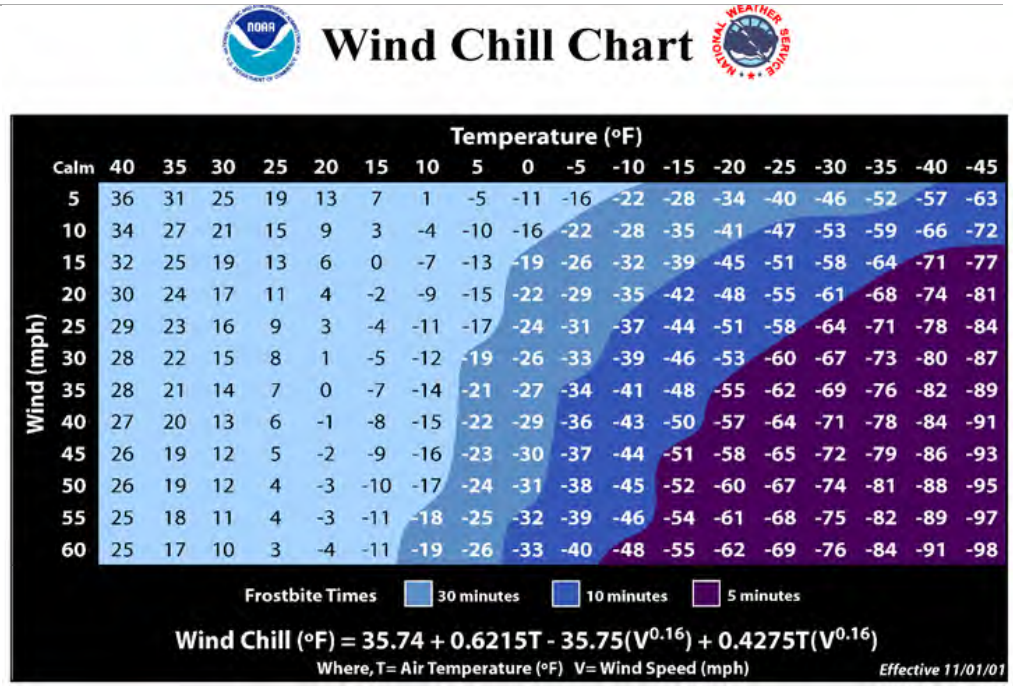


Figure 2-35: Wind Chill Chart

Nationally, there have been 887 recorded cold fatalities since 1988, with a 10 year average of 30 fatalities/year. http://www.nws.noaa.gov/om/hazstats/resources/weather_fatalities.pdf

Historical Occurrence at Westbrook and Vicinity

Middlesex County has experienced 2 day (January 17, 2000 and January 21, 2000) with an Extreme Cold/Wind Chill event resulting in no fatalities or injuries. Ref. NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/

Estimated Probability of Occurrence at and near Westbrook

- The average low temperature during January (the average coldest month) at Westbrook is 23°F.
- Quantitative probability data for Extreme Cold events is not available.

Effects of Climate Change

The confidence of attribution of Extreme Cold to climate change, and understanding, is moderate. It appears that warming trends have weakened polar vortex winds resulted in meandering of these winds. This condition allows cold Arctic air to dip further south, resulting in a variable New England winter with temperatures varying from above-average warm to periods of extreme cold.

Drought

DROUGHT

Droughts occur when there has not been enough rainfall and water levels get low, in particular when precipitation and other water resources fall below expectations but the demand for water remains. They can happen anywhere in the United States, and droughts increase the risk of other hazards like wildfires, flash floods, and possible landslides or debris flows. Drought is a slow-onset hazard that can last for months or years. Droughts are generally classified into different types including:

- meteorological drought - lack of precipitation
- agricultural drought - lack of soil moisture
- hydrologic drought - reduced streamflow or groundwater levels.

As a hazard, it has the potential to impact many aspects of life, including two of our most important needs: drinking water and food. Because of the long duration of droughts, the impacts last for years and can ripple through a community over time.

Drought is an important issue in Connecticut and the Town due to effects on agricultural and water resources. The Town's drinking water sources (the supply reservoir in Killingworth Dighton and Kelseytown distribution reservoir in Clinton) can be effected by drought.

The Connecticut Drought Preparedness and Response Plan ("Drought Plan") provides state and local decisionmakers and public water suppliers with a set of formal operating procedures and administrative guidance for proactive drought planning and response. The Drought Plan is designated as a "support plan" within the State Response Framework, Connecticut's umbrella emergency management operations document.

Connecticut maintains a Drought Management Plan and five levels of drought are used to characterize drought severity and response: Normal; Advisory; Watch; Warning; and Emergency. A determination of drought level in Connecticut as per the 2019 State Hazard Mitigation Plan Update (2019 SHMP Update) is based on seven indices presented in the States 2003 Drought Plan: precipitation, groundwater levels, streamflow, reservoir levels, Palmer Drought Severity Index (PDSI), Crop Moisture Index, Vegetation Drought Response Index (only available during growing season), and fire danger.

According to NOAA, Connecticut is made up of three climate divisions: Northwest (01), Central (02) and Coastal (03). Based on Westbrook's location the Town is in the Coastal Climate Division. The Draft Drought Plan that will serve as an update to the 2003 plan identifies five (5) stages of increasingly dry conditions that are designed to more closely align with the U.S. Drought Monitor terminology: Heightened Awareness, Below Normal Conditions, Moderate Drought, Severe Drought and Extreme Drought.

In consideration of just the Palmer Drought Severity Index (PDSI) severe droughts have occurred periodically in Connecticut, most recently during 1929-1931, 1957, 1964-1966, 2002, 2007-2008, 2012, 2013, and 2015-2017. Connecticut experienced its drought of record during the 1960s with rainfall deficits reaching their highest levels in the spring of 1965. This drought severely limited water resources throughout the state.

Historical Occurrence at Westbrook and Vicinity

As per the 2019 SHMP Update a total of three distinct drought events have been recorded in NOAA's NCEI storm database from 1996 to 2017 for Middlesex County resulting in no fatalities, injuries or loss. The total recorded United States Department of Agriculture (USDA) Annualized Insured Crop Losses was $1,069 with no other recorded economic damages. The events occurred during April, May, and June 2002.

Figure 2-36 on the following page presents the Connecticut Drought Periods from 2000 based on the U.S. Drought Monitor that was established in 2000. Since 2000, the longest duration of drought (D1-D4) as presented on **Figure 2-36** in Connecticut lasted 46 weeks beginning on June 21, 2016 and ending on May 2, 2017. The most intense period of drought occurred the week of November 15, 2016 where D3 affected 44.5% of Connecticut land.

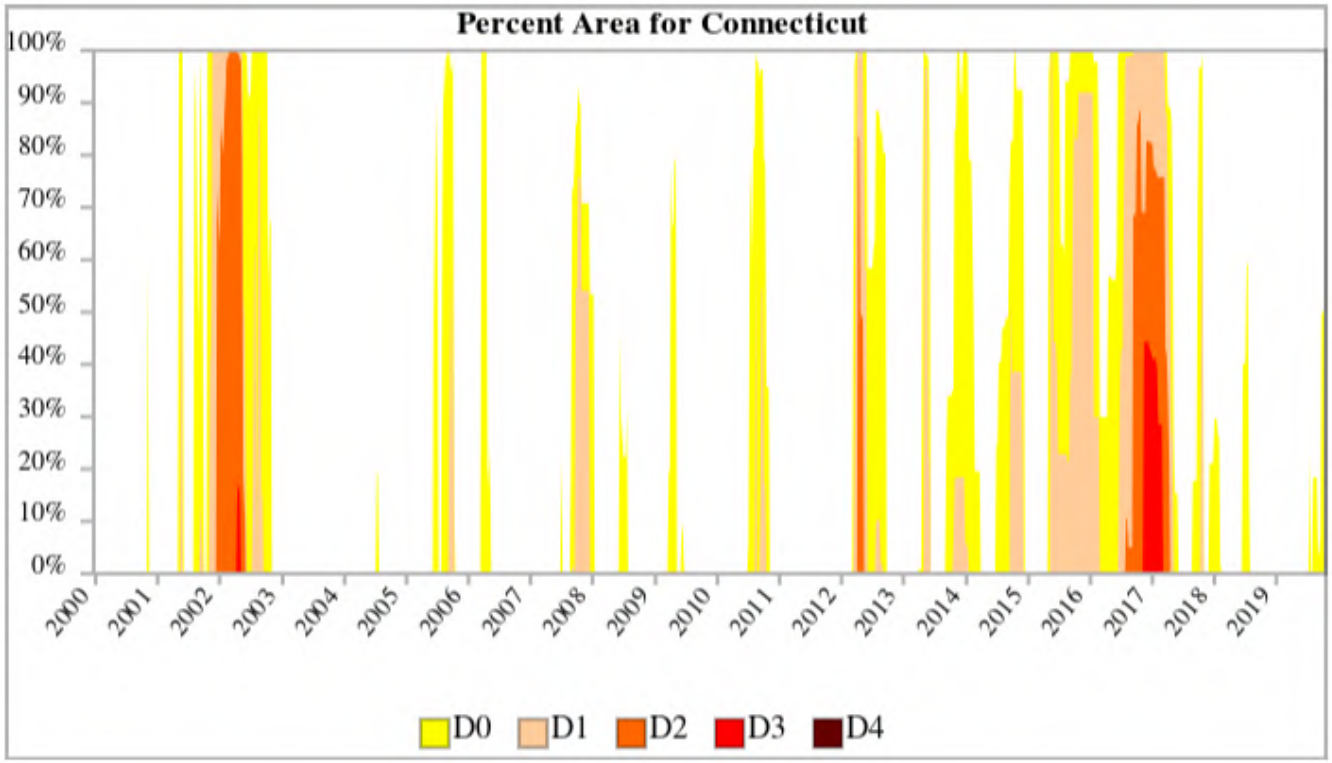
Estimated Probability of Occurrence at and near Westbrook

Based on recent drought history (2000 to 2018), Connecticut has had a Drought Advisory during 11 of the 19 years; a Drought Watch during 5 of the 19 years; and a Drought Warning during 1 of the 19 years. Based on this limited data:

- Drought Warnings are expected in Connecticut: 5% AEP or 20-year recurrence interval

Effects of Climate Change

The confidence of attribution of Drought to climate change is moderate. Increased air temperatures and evapotranspiration can increase drought potential. In the Northeast U.S, the relationship between increased rainfall intensity and drought is uncertain.



D0 - Abnormally Dry •Short-term dryness slowing planting, growth of crops •Some lingering water deficits •Pastures or crops not fully recovered	**50.0%** of State	**50.0%** D0-D4
D1 - Moderate Drought •Some damage to crops, pastures •Some water shortages developing •Voluntary water-use restrictions requested	**0.0%** of State	**0.0%** D1-D4
D2 - Severe Drought •Crop or pasture loss likely •Water shortages common •Water restrictions imposed	**0.0%** of State	**0.0%** D2-D4
D3 - Extreme Drought •Major crop/pasture losses •Widespread water shortages or restrictions	**0.0%** of State	**0.0%** D3-D4
D4 - Exceptional Drought •Exceptional and widespread crop/pasture losses •Shortages of water creating water emergencies		**0.0%** of State

Figure 2-36: Connecticut Drought Periods from 2000 (https://www.drought.gov/drought/states/connecticut)

Wildfire

WILDFIRE

A wildfire is a non-structure/vehicle fire that occurs in undeveloped, wildland vegetated areas, including grass, brush/shrub, and forested areas. Wildfires occur when natural vegetation is ignited naturally, such as by lightning, or by human activity. Sometimes, wildfires are set intentionally for management of vegetation or to limit accidental fire risk. Wildfires may be unnoticed at first. Unnoticed fires often can spread to the urban-wildland interface and threaten developed areas.

About 41.5% of Westbrook consists of non-contiguous forest, which presents an area for wildfire to occur. The Local Planning Team identified no significant brush fire hazard areas. An average of 500 acres of Connecticut woodland are burned by forest fires each year (CT DEEP).

There have been no reports of significant property damage or deaths related to brush fires or wildfire. Apparatus listed on the Westbrook Fire Department's website indicates that the Town has all-terrain vehicles capable of fighting remote brush fires located off existing roadways.

Historical Occurrence at Westbrook and Vicinity

The most recent wildfire in Connecticut occurred on 07/05/2002 in Litchfield County, according to the NOAA Storm Events Database. The fire was started by smoke from the Nemoscau region of northern Quebec. The smoke moved from the region on July 7, 2002. The NOAA Storm Events database lists zero (0) wildfires as having occurred in Middlesex County from 1950 to 2017.

Estimated Probability of Occurrence at and near Westbrook

The historical data indicates that the probability of wildfire within Westbrook is low. Quantitative probabilities of occurrence are not available. The number of brush fires each year is variable and usually increases during years of dry spring and summer (Ostroskey, 2014).

Effects of Climate Change

The confidence of attribution of Wildfire to climate change is low. Increased air temperatures and evapotranspiration can increase Wildfire potential.

Earthquake

EARTHQUAKE

Earthquakes occur as the result tectonic activity. An earthquake is sudden ground motion or trembling caused by an abrupt release of accumulated strain acting on the tectonic plates that comprise the Earth's crust along faults. Although earthquakes have caused much less economic loss annually in the United States than other hazards such as floods, they have the potential for causing great and sudden loss. Within 1 to 2 minutes, an earthquake can devastate part of an area through ground-shaking, surface fault ruptures, and ground failures. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. The focal depth of an earthquake is the depth from the surface to the region where the earthquake's energy originates (the focus). The epicenter of an earthquake is the point on the Earth's surface directly above the focus. The effects of earthquakes are: 1) ground shaking; 2) ground displacement; and 3) loss of soil strength (liquefaction). Ground shaking is represented by the Peak Ground Acceleration (PGA) and spectral acceleration (SA) response. The PGA reflects the ground acceleration at the top of bedrock. Thick deposits of soil over bedrock will modify (typically increase) the acceleration, resulting in ground surface accelerations that are greater than the PGA. Liquefaction is a function of soil type and density. Earthquake intensity is characterized by: 1) the Richter Scale; and 2) the Modified Mercalli Scale. Seismic hazards include damage to structures and infrastructure, landslides and tsunamis.

The National Seismic Hazard Maps (NSHM) (and the hazard model from which they are derived) are used by engineers who construct buildings need to know how strongly a particular site might be shaken by earthquakes. The NSHMs compile known earthquake sources, their distance from the site in question, and other seismological and geological information to project potential maximum expected ground motions at a site over a particular period of time (50 years).

Soil deposits above bedrock are classified based on shear wave velocity according to Site Class. Site Class Definitions are presented in **Table 2-22. Figures 2-39** present the surficial geology. The geologic data indicates that the majority of Westbrook consists of shallow glacial till or bedrock.

Figure 2-38 presents the 2% probability of exceedance in 50 years PGA. The 2% in 50 years PGA in the vicinity of Westbrook is 0.14g, where g is the acceleration of gravity (32.2 ft/sec^2).

Building response is evaluated using the mapped seismic coefficients Ss and S_1. Ss is the mapped 5% damped spectral response acceleration at short periods. S_1 is the 5% damped spectral response acceleration at a period of 1 second. S_{DS} and S_{D1} are the design 5% damped spectral accelerations at short and 1 second periods respectively. S_{MS} and S_{M1} are the MCE 5% damped spectral accelerations at short and 1 second periods respectively, where MCE is the Maximum Considered Earthquake.

Richter Scale	Earthquake Effects
2.5 or less	Not felt or felt mildly near the epicenter, but can be recorded by seismographs
2.5 to 5.4	Often felt, but only causes minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can totally destroy communities near the epicenter

Table 2-22: Richter Scale

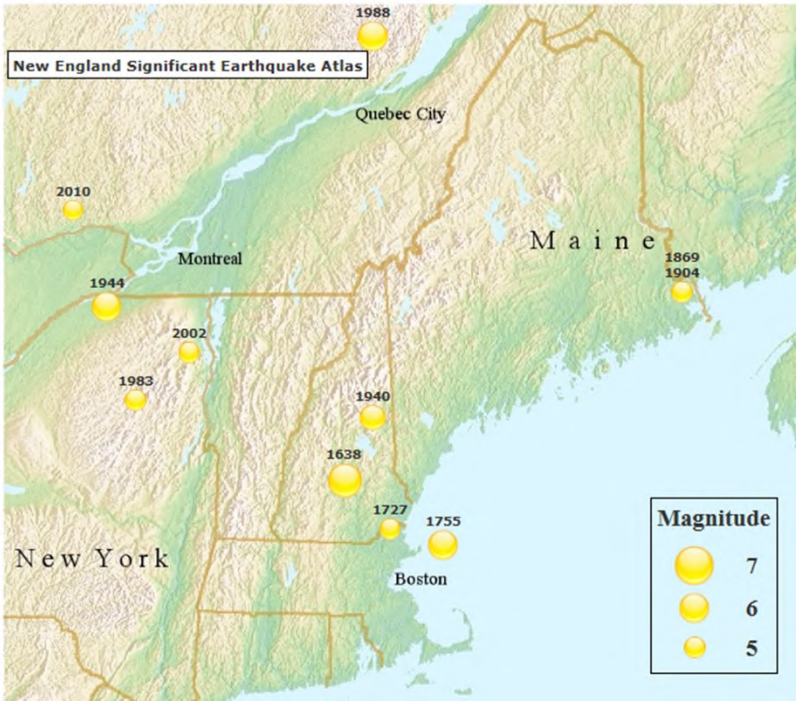


Figure 2-37: Significant Earthquakes in New England http://aki.bc.edu/quakes_historical.htm

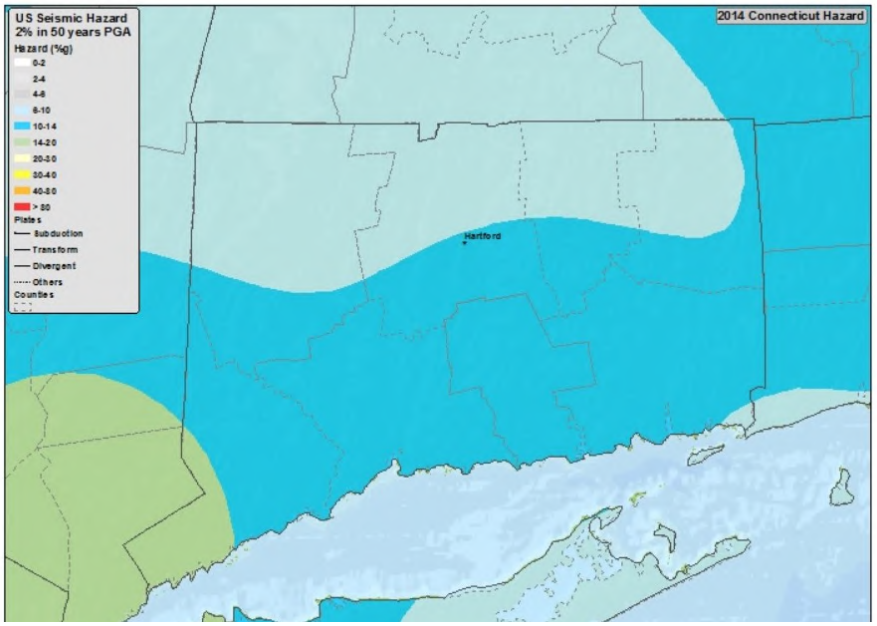


Figure 2-38: 2% probability of exceedance in 50 years Map of Peak Ground Acceleration

2010 ASCE-7 Standard – Table 20.3-1
SITE CLASS DEFINITIONS

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index PI > 20, • Moisture content w ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response	See Section 20.3.1		

Table 2-18: Site Class Definitions

Westbrook, CT, USA
Latitude, Longitude: 41.2959741, -72.46415630000001

Print

Date	10/14/2019, 4:28:26 PM
Design Code Reference Document	ASCE7-10
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	0.167	MCE_R ground motion. (for 0.2 second period)
S_1	0.059	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.267	Site-modified spectral acceleration value
S_{M1}	0.142	Site-modified spectral acceleration value
S_{DS}	0.178	Numeric seismic design value at 0.2 second SA
S_{D1}	0.095	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	B	Seismic design category
F_a	1.6	Site amplification factor at 0.2 second
F_v	2.4	Site amplification factor at 1.0 second
PGA	0.084	MCE_G peak ground acceleration
F_{PGA}	1.6	Site amplification factor at PGA
PGA_M	0.134	Site modified peak ground acceleration
T_L	6	Long-period transition period in seconds
SsRT	0.167	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	0.186	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.059	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.066	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.5	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.898	Mapped value of the risk coefficient at short periods
C_{R1}	0.898	Mapped value of the risk coefficient at a period of 1 s

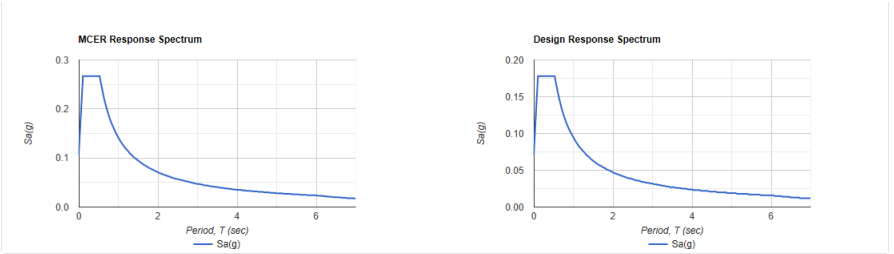


Table 2-17: Seismic Hazard Report for Westbrook (https://seismicmaps.org/)

Figure 2-39: Surficial Geology of Westbrook
http://cteco.uconn.edu/maps/town/QuatGeol/Quaternary_Geology_Westbrook.pdf

Historical Occurrence at Westbrook and Vicinity

According to the USGS Earthquake Catalog data search, there have been 8 earthquakes of magnitude 2.5 or greater which have occurred in Connecticut or off the coast since 1974. The largest was a magnitude 3.8 which occurred in Long Island Sound off the coast of New Haven in 1981. (https://earthquake.usgs.gov/earthquakes/search/ As show in **Figure 2-37**, there have historically been significant (Richter magnitudes between 5 and 7) earthquakes in the vicinity of Connecticut.

Estimated Probability of Occurrence at and near Westbrook

Based on the National Seismic Hazard Maps included in the Massachusetts State Building Code (assuming Stiff Soil Site Class D and Risk Category II conditions):

- 2% in 50 years PGA (2,475 years recurrence interval; Maximum Considered Earthquake) in the vicinity of Westbrook is 0.14g
- 10% in 50 years PGA (500 years recurrence interval) in the vicinity of Westbrook is 0.03g
- Per the Connecticut State Building Code, the values of Ss and S_1 at Westbrook are 0.167g and 0.059g, respectively.
- the values of S_{DS} and S_{D1} at Westbrook are 0.178g and 0.095g
- the values of S_{MS} and S_{M1} at Westbrook are 0.267g and 0.142g,
- Localized areas of soft soil will have different seismic parameters
- Different Risk categories will have different seismic parameters
- See Connecticut State Building Code for application of the Seismic Coefficients
- The occurrence of historic earthquakes, PGA, Site Class and applicable seismic coefficients indicate that the seismic risk at Westbrook is low. Amplified ground motion may occur within localized areas within Westbrook classified as Site Classes D and E. These areas my also be susceptible to liquefaction.

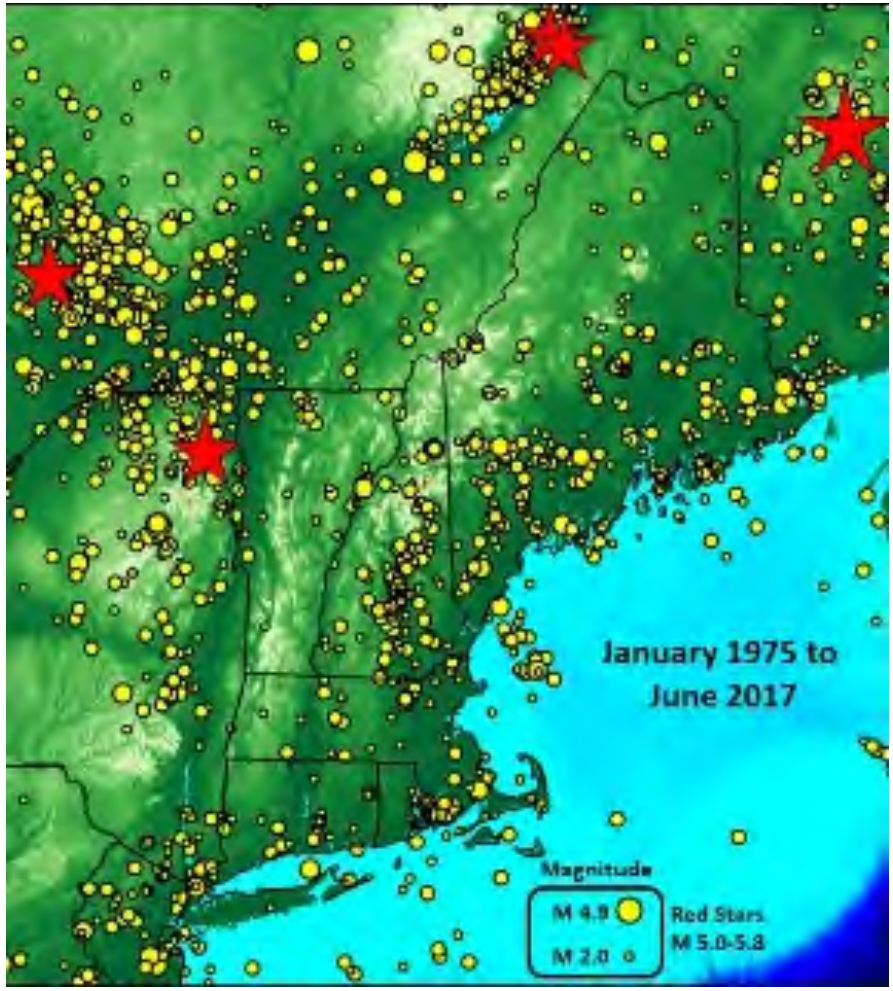


Figure 2-40: Area Earthquakes during January 1975 and June 2017
Source: Weston Observatory website

Attachment 3: Natural Hazard Risk

Attachment 3: Natural Hazard Risk

Overview

A Natural Hazard Risk Assessment was conducted by GZA to evaluate the potential consequences of natural hazards to the people, economy, and built and natural environments of the Town of Westbrook. The risk assessment was performed based on guidance provided by the FEMA Local Mitigation Planning Handbook, and included the Local Planning Team (LPT).

The Natural Hazard Risk Assessment evaluates the effects of the relevant natural hazards (described in Attachment 2) on the community assets (identified in Attachment 2). The methodology assesses risk in terms of: 1) the likelihood (i.e., frequency) of the natural hazard occurring; 2) the predicted effects (damages, losses, etc.); and 3) the consequences (e.g., costs) associated with those effects.

A vulnerability analysis was performed based on historical data and by on spatially comparing the hazard data to the community assets. In particular, the vulnerability of the Town to flooding was assessed by identifying which assets are located within the FEMA flood zones (Special Flood Hazard Areas).

The FEMA Multi-Hazard MH-HAZUS program was used to evaluate losses due to seismic, flood and hurricane hazards. The hazards were ranked using a scoring system. The scoring system is based on the likelihood/frequency, severity/magnitude, and potential impact area.

Historical Hazard Events

Previous federal Presidential Disaster Declarations in Connecticut and in Middlesex County were reviewed. FEMA Repetitive Loss Property data within the Town was also evaluated.

Presidential Disaster Declarations:

Under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C. §§ 5121-5207 (the Stafford Act), a Governor of a State affected by an emergency or a disaster can submit a request for a declaration by the President of the United States that a major disaster exists. The President can declare a major disaster for any natural event, including any hurricane, tornado, storm, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought, or, regardless of cause, fire, flood, or explosion, that the President determines has caused damage of such severity that it is beyond the combined capabilities of state and local governments to respond.

A major disaster declaration provides a wide range of federal assistance programs for individuals and public infrastructure, including funds for both emergency and permanent work (FEMA, "The Disaster Declaration Process", https://www.fema.gov/disaster-declaration-process).

Table 3-1 presents disaster declarations which have been made since 1991 in Connecticut (current through August 2019). These disaster declarations included Middlesex County. Based on the occurrence rate, the expected frequency of disaster declarations is about 1 every 2 years.

Based on past declarations, the most common natural disasters were Severe Weather Hazards, including flooding, winter storms, snowstorms; and hurricanes and tropical storms.

Disaster	Year	Incident Period
Severe Storms and Flooding (DR-4410)	2018	September 25—26
Severe Storms, Tornado, and Straight-line Winds (DR-4385)	2018	May 15
Severe winter storm and snow storm (DR-4213)	2015	January 26—29
Severe winter storm and snow storm (DR-4087)*	2013	February 8—11
Hurricane Sandy (DR-4087)*	2012	October 27—November 8
Severe Storm (DR-4046)*	2011	October 29-30
Tropical Storm Irene/Hurricane (EM-4023)*	2011	August 27—September 1
Snowstorm (DR-1958)	2011	January 11—12
Severe Storms & Flooding (DR-1904)*	2010	March 12—May 17
Severe Storms & Flooding (DR-1700)*	2007	April 15—27
Severe Storms & Flooding (DR-1619)	2005	October 14-15
Tropical Storm (DR-1302)	1999	September 16—21
Blizzard (DR-1092)	1996	January 7—13
Coastal Flooding, Winter Flood (DR-972)	1992	December 10—13
Hurricane (DR-916)	1991	August 19

*Emergency Declaration for Middlesex County

Table 3-1: Disaster Declarations in Connecticut 1991 to 2018

Ranking Hazards

The natural hazards were ranked based on impacts to the Town based on likelihood/frequency, severity/magnitude, and potential impact area. Each hazard category was provided a score based on the criteria as shown in **Table 3-2**. For each hazard, the product of the points from each category was determined and the hazards ranked from highest value to lowest. The hazard rankings are presented in **Table 3-3.** The details of each natural hazard are presented in **Attachment 2**, including the expected probability of occurrence (i.e. Likelihood/Frequency). A Hazard Vulnerability Assessment was performed to evaluate the expected consequences (i.e., the Severity/Magnitude and Impact Area) of the top ranked hazards. The results of the vulnerability assessment are presented in this Attachment, in order of the hazard rank.

Likelihood/Frequency		
Point Value	Category	Characteristics and Frequency
1	Very Low	Events that occur or are exceeded less often than once in 100 years (less than 1% probability)
2	Low	Events that occur or are exceeded from once in 50 years to once in 100 years (1% to 2% probability)
3	Medium	Events that occur or are exceeded from once in 5 years to once in 50 years (2% to 20% probability)
4	High	Events that occur or are exceeded more frequently than once in 5 years (greater than 20% probability)
Severity/Magnitude		
Point Value	Category	Characteristics
1	Minor	Limited and scattered property damage; no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e., 1 or 2 communities); essential services (utilities, hospitals, schools, etc.) not interrupted; no injuries or fatalities.
2	Serious	Scattered major property damage (more than 50% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services are briefly interrupted; some injuries and/or fatalities.
3	Extensive	Consistent major property damage; major damage to public infrastructure (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and fatalities.
4	Catastrophic	Property and public infrastructure destroyed; essential or lifeline services stopped, thousands of injuries and fatalities.
Impact Area Assessment		
Point Value	Category	Characteristics
1	Small	In localized, unpopulated or lightly areas of Town, without structures or critical facilities
2	Medium	Impacting only portions of the Town
3	Large	Town-wide and/or essential and lifeline facilities

Table 3-2: Natural Hazard Ranking Classification

Severe Weather Hazards:	Rank
Severe Wind:	
Hurricanes/Tropical Storms	3
Thunderstorms	6
Tornadoes	5
Lightning	8
Intense Rainfall	7
Hail	7
Flood:	
Storm Surge	1
Sea Level Rise	2
Urban Drainage Flooding	5
Severe Winter Weather	
Snowfall	4
Ice Storms	6
Climate-Related Hazards:	
Extreme Temperature:	
Hot	8
Cold	8
Drought	7
Wildfire	9
Geologic Hazards:	
Earthquake	7
Landslides	0
Tsunami	0
Secondary Hazard:	
Dam Failure	4

Table 3-3 : Natural Hazard Ranking Results for Westbrook

Table 3-3 presents the results of the hazard ranking for the Town. The top ranked hazards include: 1) coastal storm surge; 2) sea-level-rise; 3) hurricanes (severe wind and related effects); 4) severe winter weather (large snowfall event); and 4) a dam failure (breach) of the Chapman Pond, Messerschmidt Pond and Wrights Pond Dams.

The extent of coastal storm surge impacts a large area of shoreline and low-lying areas of Town south of Interstate 95, it is the top-ranked hazard due to: 1) flood inundation impacts to the Town's Essential Facilities; 2) impacts to transportation infrastructure, including Routes 1 and 145, and bridges with lower deck elevations; 3) impacts to the lifeline systems on-site wastewater management systems and heating oil facilities; 4) impacts to Beach Communities and marinas; and 5) marshes and beaches.

Sea level rise is the 2nd ranked hazard due to the increasing extent and depth of flooding, as well as the worsening effects of waves resulting principally to rising sea levels. This will in turn result in greater impacts to even larger extents of shoreline and increasing the vulnerability of major transportation, essential facilities, lifeline systems, residential and commercial properties as well as increasing the size of regularly flooded marshes while further eroding the beaches.

Severe wind and related damages during hurricanes is ranked third due to its relatively high frequency, its coincidence with coastal flooding and its potential for wide-spread damage. In particular, a hurricane strike at or near Westbrook with a 1% probability of occurrence would be catastrophic (similar to ones in 1938 & 1954).

Failure of the high-hazard Chapman Pond, Messerschmidt Pond and Wrights Pond Dams due to a dam breach is a high ranked hazard due to the potential extent of flood inundation and potential loss of life.

Severe winter weather (including greater than 10-inches snowfall) most frequently occur during Nor'easters, coincident with high winds, cold temperatures and blizzard conditions. They present risks due to transportation impacts (limited use of roadways), cold temperatures (including wind chill) and the potential for structure damage (roof failures). Its relative high probability of occurrence makes severe winter weather as a high ranked hazard.

Certain hazards currently rank low, but are expected to become more impactful in the future due to climate change. In particular, these include:

- Urban flooding due to intense local precipitation. The intensity and frequency of rainfall events is expected to increase (significantly) in the future that will affect the capacity of the Town's stormwater infrastructure provide adequate drainage.
- Extreme temperatures. The frequency and intensity of heat waves is expected to increase in the future. Overall warming will also increase the duration and intensity of tick-borne diseases such as Lyme's Disease.
- Drought. Droughts are expected to increase in the future with potential impacts to the Town's water supply.

For comparison of Westbrook's hazard ranking with the Connecticut in general, **Table 3-4** and **Figure 3-1** summarizes the hazard risks for Connecticut's 2019 Plan Update. The Town's hazard ranking is generally consistent with the State.

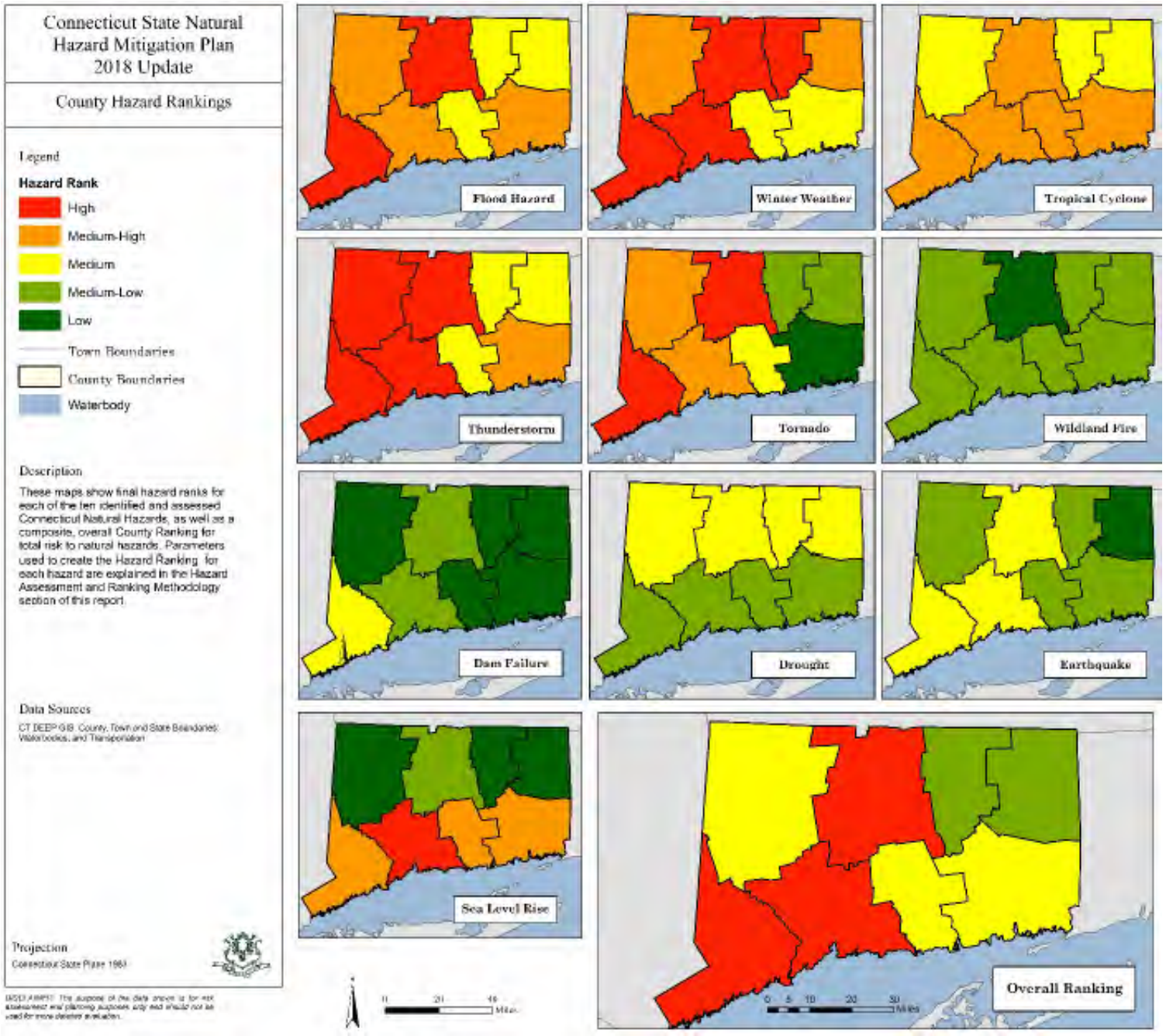


Figure 3-1: Connecticut State Hazard Assessment - County Hazard Rankings

County	Dam Failure Hazard Ranking	Drought Hazard Ranking	Earthquake Hazard Ranking	Flood Hazard Ranking	Sea Level Rise Hazard Ranking	Thunderstorm Hazard Ranking	Tornado Hazard Ranking	Tropical Cyclone Hazard Ranking	Wildland Fire Hazard Ranking	Winter Weather Hazard Ranking
Fairfield	Medium	Medium-Low	Medium	High	Medium-High	High	High	Medium-High	Medium-Low	High
Hartford	Medium-Low	Medium	Medium	High	Medium-Low	High	High	Medium-High	Low	High
Litchfield	Low	Medium	Medium-Low	Medium-High	Low	High	Medium-High	Medium	Medium-Low	Medium-High
Middlesex	Low	Medium-Low	Medium-Low	Medium	Medium-High	Medium	Medium	Medium-High	Medium-Low	Medium
New Haven	Medium-Low	Medium-Low	Medium	Medium-High	High	High	Medium-High	Medium-High	Medium-Low	High
New London	Low	Medium-Low	Medium-Low	Medium-High	Medium-High	Medium-High	Low	Medium-High	Medium-Low	Medium
Tolland	Low	Medium	Medium-Low	Medium	Low	Medium	Medium-Low	Medium	Medium-Low	High
Windham	Low	Medium	Low	Medium	Low	Medium	Medium-Low	Medium	Medium-Low	Medium-High

Table 3-4: Connecticut State Hazard Assessment - County Hazard Rankings

Note: Hazards indicated in red and orange represent the greatest risk based on frequency, severity and range of impact.

Table 3-5 Definitions

Frequency:

Very Low: Events that occur less frequently than once in 1,000 years (less than 0.1% per year).

Low: Events that occur from once in 100 years to once in 1,000 years (0.1% to 1% per year)

Medium: Events that occur from once in 10 years to once in 100 years (1% to 10% per year).

High: Events that occur more frequently than once in 10 years (greater than 10% per year).

Severity:

Minor: Limited and scattered property damage; no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e., 1 or 2 communities); essential services (utilities, hospitals, schools, etc.) not interrupted; no injuries or fatalities.

Serious: Scattered major property damage (more than 50% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services are briefly interrupted; some injuries and/or fatalities.

Extensive: Consistent major property damage; major damage to public infrastructure (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and fatalities.

Catastrophic: Property and public infrastructure destroyed; essential services stopped, thousands of injuries and fatalities.

Hazard Vulnerability Assessment

As indicated by the past Presidential Disaster Declarations, Westbrook (like most of Middlesex County and much of coastal Connecticut) are principally vulnerable to the following frequent severe weather hazards: 1) coastal flooding that occurs during hurricanes, tropical storms and nor'easters; 2) sea level rise; 3) severe winds due primarily to hurricanes, which can occur coincident with coastal flooding; and 4) heavy snowfall during winter nor'easters, which can occur coincident with coastal flooding. Climate change has the potential to amplify the intensity and frequency of each of these hazards.

Although less frequent (or effecting less area), Westbrook are also vulnerable to: 1) tornadoes; and 2) localized intense precipitation, resulting in localized urban flooding. The attribution of climate change to tornadoes frequency and intensity has not been established. Climate change effects on precipitation are well understood and significant, with the frequency and magnitude of intense precipitation events expected to increase significantly in the near future.

The population of Westbrook are also vulnerable to extreme heat events. Climate change effects on the frequency and intensity of extreme heat events is well-understood and significant, with the frequency and duration of heat waves expected to increase.

Although earthquakes are infrequent in the vicinity of Westbrook, their potential impacts are high. As discussed below, certain areas of Westbrook are more vulnerable to earthquake effects than others due to geologic soil conditions.

The Messerschmidt Pond and Wrights Pond dams presents a dam failure hazard.

Coastal Flood and Sea-Level-Rise Vulnerability

Westbrook is highly vulnerable to coastal flooding and the long-term effects of sea level rise. The Town's vulnerability to coastal flooding presents risk, including: economic, property, public safety and natural resources. These risks will likely impact all residents in the future, some of whom will be directly impacted by flooding and others whose risk will be limited to financial such as increased taxes.

Attachment 2 summarizes the results of a detailed evaluation of the Town's vulnerability to coastal flooding, including the effects of sea level rise. Coastal flood "risk" is defined as the product of the flood event, vulnerability and consequences (all in terms of probability of occurrence). Determination of the coastal flood risk is a necessary step in planning for resilience and adaptation and in identifying available and appropriate mitigation measures.

The vulnerability of Westbrook to coastal flooding is a function of the elevation of the ground surface relative to predicted flood elevations. **Figure 3-2** presents the Westbrook topography (ground elevation).

Topography (the ground surface elevation and land form, relative to sea level) is one of the most significant factors that contribute to the vulnerability of Westbrook to flooding due to tides, coastal storm surge and sea level rise.

This evaluation specifically looks at the vulnerability and consequences of the flood hazards detailed in **Attachment 2** of this plan**.** The vulnerability and consequences are evaluated categorically as follows:

- Essential Facilities
- Lifeline Facilities
- High Potential Loss Facilities
- Transportation Infrastructure
- Commercial and Industrial Districts
- Communities
- Support, High Occupancy and Vulnerable Populations facilities
- Natural Resources: Marshes
- Natural Resources: Beaches
- Historic Districts
- Shelter and Evacuation Requirements

Although not evaluated by FEMA for the National Flood Insurance program (NFIP), structures, businesses, property and residents located within flood inundation areas with recurrence intervals less than 100-years (i.e., more frequent flooding) are considered to be in areas with a very high flood vulnerability. The evaluation of coastal flood risk also considered the type of structure and its importance to public safety and loss potential.

The presence of waves, along with flood inundation, can significantly increase flood risk since waves are the primary cause of structural building damage and beach erosion. High flood hazard areas exposed to waves greater than 3 feet in height are located in a "high velocity" zone (i.e., large wave and hydrodynamic forces). Waves of 3 feet and greater height result in significant building damage.

The extent and depth of flooding, as well as the effects of waves, are predicted to get worse in the future, principally due to sea level rise. The current flood risk will increase (including the future limits of flood hazard areas defined by FEMA and the NFIP).

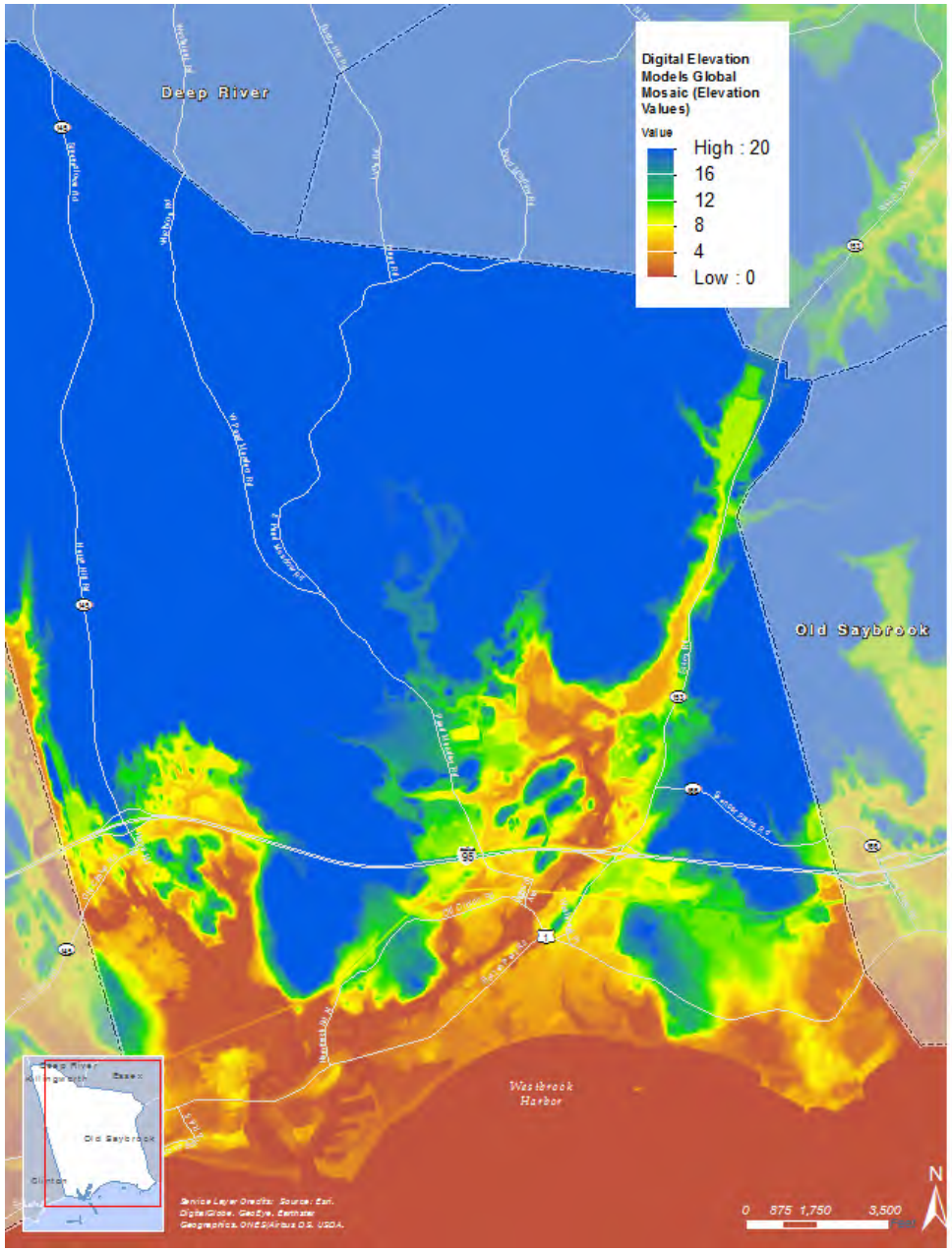


Figure 3-2: Digital Elevation Model Data based on NOAA Global Mosaic

Topography:

Topography (the ground surface elevation and land form, relative to sea level) is one of the most significant factors that contribute to the vulnerability of Westbrook to flooding due to tides, coastal storm surge and sea level rise.

Figure 3-2 presents color imagery reflecting the change in ground surface elevation within Westbrook based on the NOAA Global Mosaic digital elevation model. The colors are differentiated by ground surface elevation, relative to the North American Vertical Datum (NAVD88). NAVD88 is the datum used by FEMA, by the State, and by the Town of Westbrook. All elevations presented in this plan reference NAVD88.

The topographic elevation data presented in **Figure 3-2** clearly delineates the transition from the upland portions of Westbrook (which are defined by bedrock and the ice-laid glacial till hills and valleys) to the southern coastal low-lying areas which are defined by the coarse-grained glacial meltwater deposits (sand and gravel) and salt marsh and tidal marsh deposits (peat and muck interbedded with sand and silt). The low-lying areas (which are reflected by the red to yellow colors, corresponding to elevations ranging from less than 1 foot to about 8 to 9 feet NAVD88) are dominated by tidal marsh and wetlands systems and the low elevation land areas abutting the tidal marshes and wetlands. Certain low elevation areas (near the shoreline) consist of former marsh areas that have been artificially filled.

The tidal marsh and wetlands systems are developed around waterways (brooks, creeks and rivers), and are hydraulically connected to the Menunketesuck River, Patchogue River and the Long Island Sound. The tidal marsh and wetland systems are primarily irregularly flooded “high marsh”. These areas are periodically inundated due to astronomically high tides and storm-related flood events. The marshes are channelized, with the channels regularly inundated due to tides. The marshes are also primary points of entry for inland flooding due to coastal storm surge.

Beaches, including beach communities, also represent low-lying Town areas. These areas are directly inundated by coastal flooding, including tides, storm surge and waves.

ESSENTIAL FACILITIES

	FEMA Flood Risk
LOCATION	
Police Station at 866 Boston Post Rd (Town Hall)	High
Fire Department at 18 Main Street	High
Emergency Management at 1163 Boston Post Road	Low
Emergency Shelter at 105 Good-speed Drive (Daisy Ingraham Elementary School)	Low
Middlesex Health - Shoreline Medical Center 250 Flat Rock Pl	Low

Risk Profile of Westbrook Essential Facilities

The vulnerability of Westbrook's Essential Facilities was evaluated relative to coastal flooding up to the 500-year recurrence interval flood (FEMA BFE). Essential facilities are classified as Flood Design Class 4 per ASCE/SEI 24-14. Flood Design Class 4 structures are evaluated for risk relative to the 100-year recurrence interval flood (plus a minimum freeboard) or the 500-year recurrence interval flood, whichever is higher.

The High Risk classification of the Police and Fire Departments are due to portions of both facilities being located within the 500-year floodplain. Flood protection of the Police Station at Town Hall and the Fire Station HQ can be readily provided using building scale permanent or deployable measures. A detailed building Flood Vulnerability Assessment and Flood Emergency Response Plan (FERP) is recommended for both high risk Essential Facilities.

A significant, additional, risk is road flooding which will impact the capability of the Town to provide essential services (e.g., emergency response). Roadways near the Fire Department, Emergency Management, Shoreline Medical Center and Police Station are within the 500-year and/or 100-year floodplains.

Figure 3-3. Location of Police Station relative to FEMA special flood hazard areas

Figure 3-4. Location of Fire Station relative to FEMA special flood hazard areas

LIFELINE FACILITIES

	FEMA Flood Risk
LOCATION	
Electricity (Elm Street Substation only in neighboring Old Saybrook)	High
Heating Oil	Moderate
Natural Gas	Low
Water	Low
Sewer	High
Communication	Low

Risk Profile of Westbrook Lifeline Facilities

Figure 3-5: Vicinity of Eversource Elm Street Substation; Ground Surface Elevation +/- 14 feet NAVD88 (top image)

The vulnerability of Westbrook's Lifeline Facilities was evaluated relative to coastal flooding, up to the 500-year recurrence interval flood (FEMA BFE). Essential facilities are classified as Flood Design Class 4 per ASCE/SEI 24-14. Flood Design Class 4 structures are evaluated for risk relative to the 100-year recurrence interval flood (plus a minimum freeboard) or the 500-year recurrence interval flood, whichever is higher.

The flood risk of Westbrook's Lifeline Facilities is generally low except for:

- All of Westbrook properties are served by on-site sewage disposal systems. Properties located south of I-95 that are within to the FEMA special flood hazard area (SFHA) are vulnerable to coastal flooding.
- The Elm street electrical substation (see **Figure 3-5 and 3-6**) in Old Saybrook that provides power to Westbrook, which is the responsibility of Eversource.

Figure 3-6: Location of Eversource Elm Street Substation relative to effective FEMA FIRM Flood Hazard Zones

Screening Level Hazard Vulnerability Assessment cont.

Coastal Flood Vulnerability cont.

Transportation Infrastructure:

- Airports: None present
- Public Transit Stations: Not vulnerable
- Roads and Bridges: Vulnerable (Certain structures. See below)

Figures 3-7 present the roadways and the FEMA special flood hazard areas in Westbrook.

Based on the effective FEMA Flood Insurance Rate Map (FIRM), certain Town and State roads are vulnerable to coastal flooding including but not limited to:

- Antonie Rd
- Apogee Ln
- Avenue A, B, C
- Beach Ct and Way
- Bellstone Ave
- Beverly Road
- Blue Gill Ln
- Boston Post Road (Route 1)
- Broadway S and N
- Brookside Ave E and W
- Canton Rd
- Captains Dr
- Cedar Ln
- Chapman Avenue
- Chapman Beach Rd
- Cherry Street
- Dennison Rd.
- Dolphin Ave
- East and West Pond Meadow Roads
- Eckford Ave
- Elm Ave
- Fern St
- Fisk Lane
- Fox Lane
- Gerrard Ave
- Goodrich Ave
- Grove Beach Rd S and N
- Grove Ter
- Hogan Rd
- Indian Trail
- Leeway Dr
- Lilac Ln and Rd
- Linden Ave S and N
- Lynne Rd
- McVeagh Rd
- Meadow Point Rd
- Mels Rd
- Menunketesuck Rd
- Minnow Ln
- Mohawk Rd

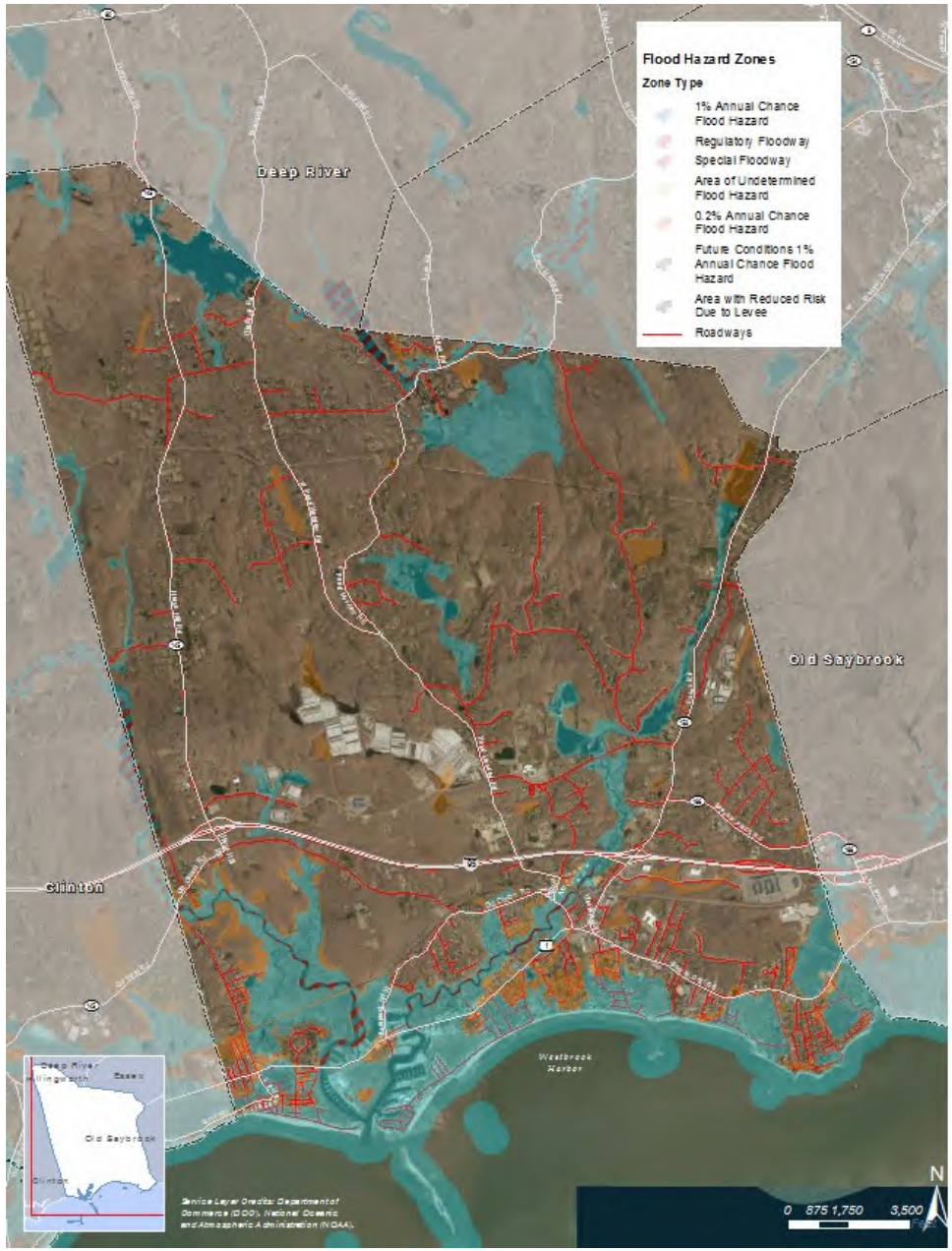


Figure 3-7: Westbrook Roadways located in the FEMA Special Flood Hazard Area (SFHA).

Screening Level Hazard Vulnerability Assessment cont.

Coastal Flood Vulnerability cont.

Transportation Infrastructure:

- Roads and Bridges: Vulnerable (Certain structures (Cont.). See below)

Figures 3-8 and **3-9** present the FEMA special flood hazard areas at Boston Post Road (Route 1). Google Earth street views are presented in **Figures 3-7 and 3-8** (facing).

Based on the effective FEMA Flood Insurance Rate Map (FIRM), additional certain Town and State roads are vulnerable to coastal flooding including but not limited to:

- Mohican Rd, Mohican Rd E
- Nolin Rd
- Oak Dr.
- Old Clinton Road (route 145)
- Old Kelsey Point Rd
- Old Mail Trail
- Old Pent Road
- Old Salt Works Rd
- Park Row
- Pepperidge Ave
- Pequot Rd
- Pilots Point Dr
- Pioneer Rd
- Pointina Rd
- Pond Meadow Road
- Portside Dr
- Post Ave
- Riverview Rd
- Sachem Road
- Sagamore Ter Drive
- Sagamore Ter E, S and W
- Salt Island Rd
- Seaside Ave
- Seascape Dr
- 2nd Ave
- Shore Ln
- South Ln
- South Main St
- Stannard Ct and Dr
- Stokes Ave
- Striper Ave
- Sunrise Rd
- Tarpon Ave
- Toby Hill Rd
- Trolley Ave
- Trout Lake Dr
- Uncas Rd, Uncas Rd E
- Underway Drive
- Wesley Ave
- Westbrook Rd
- Young Rd.

Figure 3-8: Portion of Boston Post Road located in the FEMA Special Flood Hazard Area that is inundated during the 100-yr recurrence interval flood.

Figure 3-9: Portion of Boston Post Road located in the FEMA Special Flood Hazard Area that is inundated during the 100-yr recurrence interval flood.

ROADS AND BRIDGES (Cont.)

Figure 3-9: FEMA Special Flood Hazard Areas (SFHAs) at Route 1Bridge over the Patchogue River.

Legend: Green shaded areas indicates FEMA Base Flood inundation area (100-year recurrence interval)
Brown shaded area indicates FEMA 500-year recurrence interval flood area
Red line indicates Limit of Moderate Wave Action (wave heights greater than 1.5 feet
VE zone indicates high velocity zone (wave heights greater than 3 feet)

Flood Vulnerability:

Based on the effective FEMA Flood Insurance Rate Map (FIRM), the Route 1 b deck (+/- Elevation 10 feet NAV-D88) is substantially lower than the FEMA BFE (Elevation 13 feet NAVD88). The low elevation of the causeway also makes it susceptible to flooding during 10 to 50-year recurrence interval floods. Adjacent sections of Route 1 are also within the FEMA special flood hazard areas.

ROADS AND BRIDGES (Cont.)

Figure 3-10: FEMA Special Flood Hazard Areas (SFHAs) at Route 1Bridge over the Menunketesuck River.

Legend:
Green shaded areas indicates FEMA Base Flood inundation area (100-year recurrence interval)
Brown shaded area indicates FEMA 500-year recurrence interval flood area
Red line indicates Limit of Moderate Wave Action (wave heights greater than 1.5 feet
VE zone indicates high velocity zone (wave heights greater than 3 feet)

Flood Vulnerability:

Based on the effective FEMA Flood Insurance Rate Map (FIRM), the two Route 1 bridge deck (+/- Elevation 10 feet NAVD88) is lower than the FEMA BFE (Elevation 12 feet NAVD88). The low elevation of the causeway also makes it susceptible to flooding during 10 to 50-year recurrence interval floods. Adjacent sections of Route 1 are also within the FEMA special flood hazard areas.

COMMERCIAL, INDUSRTIAL AND RESIDENTIAL DISTRICTS

	FEMA Flood Risk
LOCATION	
Commercial Boating	High
High Density Residential	High
Medium Density Residential	High
Commercial Town Center	Low to Medium
Industrial	Medium
Commercial	Low to Medium

Risk Profile of Westbrook Commercial and Industrial Districts

The vulnerability of Westbrook's commercial and industrial districts was evaluated relative to coastal flooding, up to the 100-year recurrence interval flood (FEMA BFE). Commercial and industrial structures (not containing hazardous materials) are typically classified as Flood Design Class 2 per ASCE/SEI 24-14. Flood Design Class 2 structures are evaluated for risk relative to the 100-year recurrence interval flood (i.e., FEMA Base Flood). The coastal flood risk of the commercial and industrial districts ranges from Low to High.

Due to their waterfront location and low ground elevation, the Commercial Boating, High and Medium Density Residential and the Neighborhood Commercial Districts have the highest coastal flood risk of the Westbrook's commercial and residential districts. The Industrial, Town Center and Commercial Districts are also effected by: 1) frequent roadway flooding, preventing customer access to the area; and 2) disruption of operations and resulting economic loss. The high real estate value, optimal waterfront location and re-development potential of these districts makes their flood protection a Town priority.

Figure 3-12: Commercial Boating, High & Medium Density Residential, Neighborhood Commercial districts relative to FEMA special flood hazard areas. Green indicates FEMA AE zones (100-year recurrence interval flood) and brown indicates the 500-year recurrence interval flood.

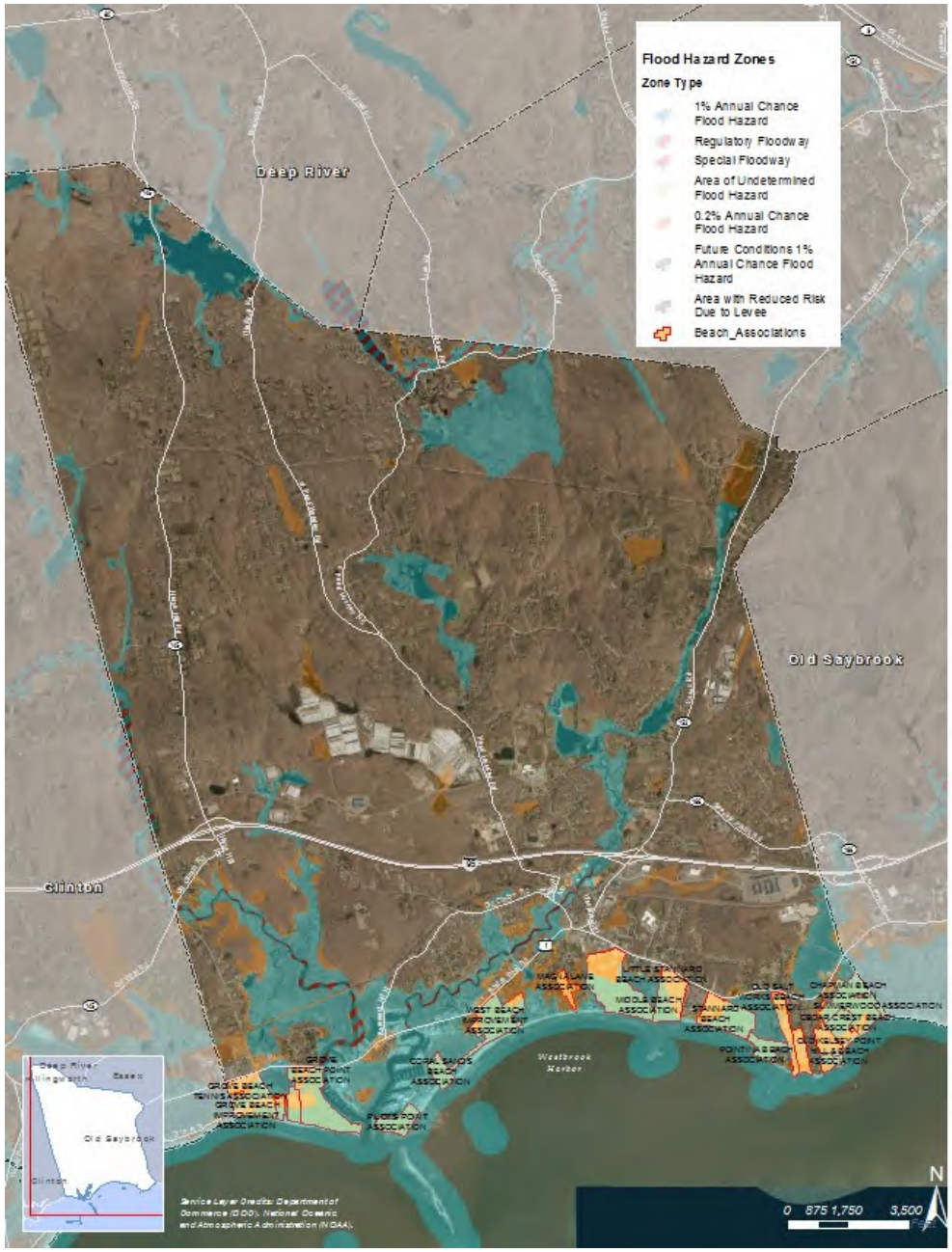
COMMUNITIES AND BEACH ASSOCIATIONS

	Current
LOCATION	
Beach Associations	High
Town Center	Low

Risk Profile of Westbrook Communities and Neighborhoods

The vulnerability of Westbrook's communities and neighborhoods was evaluated relative to coastal flooding, up to the 100-year recurrence interval flood (FEMA BFE). Different levels of risk apply to different types of Town assets. Communities primarily consist of residential and commercial structures, classified as Flood Design Class 2, and are evaluated for risk relative to the 100-year recurrence interval flood.

With frontage on Long Island Sound and surrounded by tidal marsh, the Beach Communities (including Chapman; Coral Sands; Grove; Grove Point; Island View; Kelsey Point; Little Stannard; Middle; Money Point; Pointina; Pilots Point; Qoutonset; Sagamore Terrace; Salt Works Bay/Long Beach Stannard; and West Beaches) are very vulnerable to coastal flooding and have a High Risk. These communities are located entirely within the FEMA AE zone and have developed beaches fronting on the Sound that are exposed to high waves and located within a FEMA VE zone. These communities are also vulnerable to frequent flooding, with a potential to be chronically inundated by mid-century.



Map of the Beach Communities relative to FEMA special flood hazard areas (above).

Support, High Occupancy and Vulnerable Populations

Five (5) of the Thirty-one (31)of the Support, High Occupancy and Vulnerable Populations facilities (SHOVPFs) are highly vulnerable to coastal flooding.

Figure 3– 13 shows the locations of the SHOVPFs relative to FEMA special flood hazard zones. The following are located within the FEMA AE special flood hazard zone (none of these are located within a Coastal AE zone):

Town Administrative Buildings:	Town Hall & Senior Center
Rehabilitation/Nursing Homes:	Tidal Lawn Manor & Robin's Den Adult Day Care
Fueling (Gas) Stations:	Mobile Gas Station

The following is located within a FEMA AE special flood hazard zone:

Rehabilitation/Nursing Homes:	Tidal Lawn Manor

These facilities are classified as Flood Design Class 3 per ASCE/SEI 24-14 and are evaluated for risk relative to the 100-year recurrence interval flood (i.e., FEMA Base Flood).

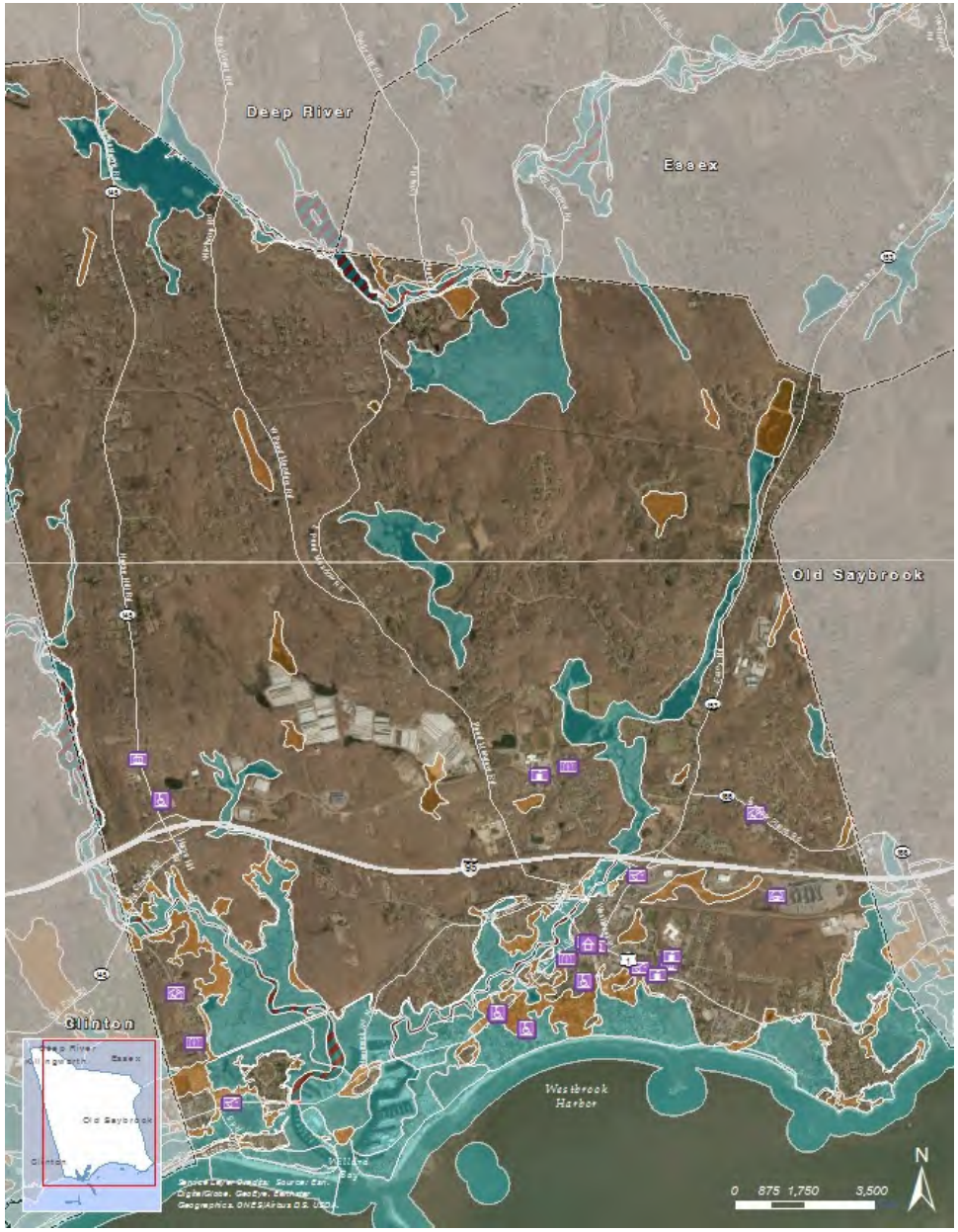


Figure 3-13 Westbrook SHOVP Facilities relative to FEMA Special Flood Hazard Zones

NATURAL RESOURCES: BEACHES

Westbrook's southern shoreline includes 17 beaches. Typical of the Connecticut coast, Westbrook's beaches consist of barrier spits and pocket beaches. Beach shoreline protection in the form of groins and jetties have been constructed along many of the beaches in Westbrook. About 4 miles of the Westbrook shoreline is potentially erodible, of which about 1 to 1.5 miles have been significantly affected by erosion. Areas from west to east that have been historically affected by shoreline erosion include: Grove Beach, West Beach (AKA Town Beach), Quonteset Beach, Middle Beach, Little Stannard Beach, Old Kelsey Point, Cedar Crest Beach and Chapman Beach. The "Analysis of Shoreline Change in Connecticut", completed by University of Connecticut (CLEAR), Sea Grant and the Connecticut Department of Energy and Environmental Protection (DEEP), analyzed how the Connecticut shoreline has changed between the late 1800s and 2006 through loss (erosion) and gain (accretion) over time. Shoreline statistics include:

<u>Westbrook – Long Island Sound Beaches</u>

Short-Term (1983 to 2006):

Net Shoreline Movement:

Minimum: -12.12 meters

Maximum: 19.51 meters

Average: 2.4 meters

End Point Rate (average): 0.10 meters/year

Long-Term (1880 to 2006):

Net Shoreline Movement:

Minimum: -39.7 meters

Maximum: 80.9 meters

Average: 2.5 meters

End Point Rate (average): 0.02 meter/year

The long term effects of sea level rise on the beaches will be increased erosion and migration of barrier beaches and spits landward. Over the past century, the sea level in Long Island Sound has risen approximately 10 inches. Landward beach migration can progress as long as there are glacial deposits available to replenish the sediment supply and infrastructure does not impede the natural movement of the beach. At Westbrook, sediment supply is limited, and the large number of coastal structures impedes natural sediment transport.

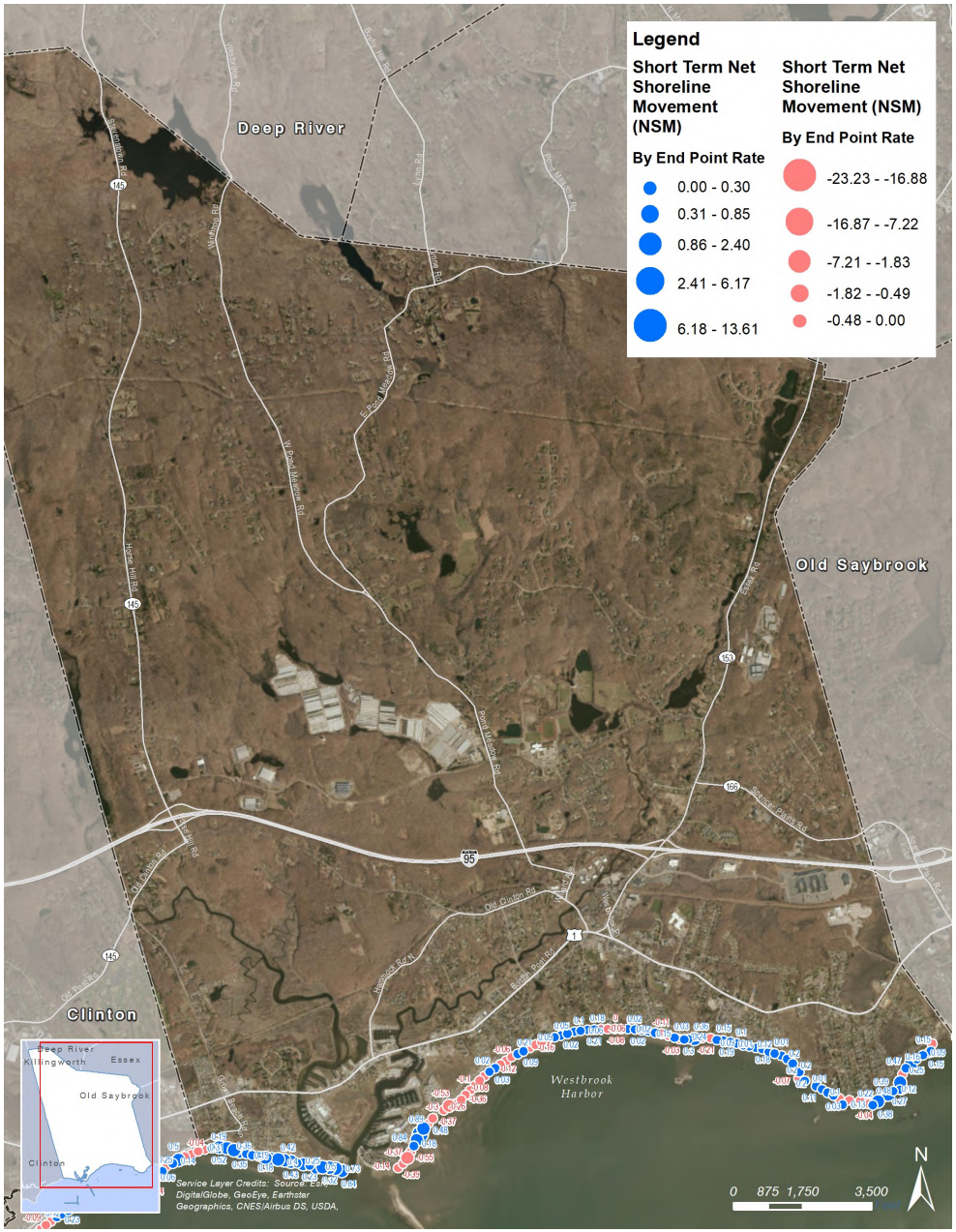


Figure 3-15: Observed net shoreline change (meters/year) for the period of

National Flood Insurance Program (NFIP) Repetitive Losses

According to the FEMA Flood Insurance Manual, Effective April 1, 2017, a Repetitive Loss Structure is defined as a National Flood Insurance Program (NFIP)-insured structure that has had at least 2 paid flood losses of more than $1,000 each in any 10-year period since 1978, and a Severe Repetitive Loss Building is any building that:

1. Is covered under a Standard Flood Insurance Policy made available under this title;
2. Has incurred flood damage for which:
    - 4 or more separate claim payments have been made under a Standard Flood Insurance Policy issued pursuant to this title, with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claims payments exceeding $20,000; or
    - At least 2 separate claims payments have been made under a Standard Flood Insurance Policy, with the cumulative amount of such claim payments exceed the fair market value of the insured building on the day before each loss.

As of 06/30/2019, there are 79 Repetitive Loss (RL) and zero (0) Severe Repetitive Loss (SRL) properties (SRLP) within the Town of Westbrook, based on NFIP data provided by the Connecticut NFIP Coordinator and per the 2019 Connecticut Natural Hazard Mitigation Plan Update. The addresses of the RL and SRL properties are protected under the Privacy Act of 1974, 5 U. S. C. section 552(a); however, it may be noted that flooding of these properties is likely associated with the Atlantic Ocean in Long Island Sound. The RL properties include mostly residential structures with a few commercial properties. About 84% or rather 66 of the total RL properties are within the FEMA Special Flood Hazard Area (SFHA).

Table 3-5 provides an overview of NFIP information for the Town of Westbrook. FEMA maintains a database on these flood insurance policies and claims, which can be found at https://www.fema.gov/policy-claim-statistics-flood-insurance.

Item	(as of 06/30/2019)
Flood insurance policies in force	557
Coverage amount of flood insurance policies	$151,258,600
Premiums paid	$1,079,265
Total losses (all losses submitted regardless of the status)	410
Closed losses (Losses that have been paid)	410
Open losses (Losses that have not been paid in full)	0
CWOP losses (Losses that have been closed without payment)	0
Total payments (Total amount paid on losses)	$8,444,186

Table 3-5: Westbrook Flood Insurance Policies and Claims

Coastal Flood Risk Summary

Westbrook is highly vulnerable to coastal flooding and the long-term effects of sea level rise. The Town's vulnerability to coastal flooding presents risk, including: economic, property, public safety and natural resources.

Likelihood/Frequency:

While coastal flooding occurs frequently at Westbrook (at least once per year), significant coastal flood events are associated with the 1% and 0.2 AEP.

Severity/Magnitude

As part of the Plan preparation, GZA completed a Level 1 HAZUS-MH damage analysis for flood scenario (based on FEMA flood hazard delineation). The results are presented at the end of this Attachment. The results predict about $240M to $882M building and content damage for the 1% AEP (100-year recurrence interval) and the 0.2% (500-year recurrence interval flood, respectively. As discussed below, these estimates do not include impacts to the Lifeline Systems in Westbrook.

Eighty-six (86) % of the total NFIP payments were made to properties located within the FEMA Special Flood Hazard Area (SFHA) at $7.28 Million. Forty-three (43) percent (%) of the total NFIP payments in Westbrook were RL payments at approximately $3.64 Million. About 91 % of those RL properties receiving insured payments were in the FEMA SFHA.

Impact Area:

As noted in **Table 3-5** there are currently 557 NFIP-subsidized flood insurance policies in place with 79 RL properties. 547 of the NFIP Policies in force are for residential properties in Westbrook with only 10 NFIP policies or just under 2 % of those are for non-residential properties.

The Level 1 HAZUS scenario analyses identified 73 and 136 buildings vulnerable to flood damage (ranging from slight to substantial) for the 1% AEP and 0.2% AEP, respectively (See **Attachment 4** for more details). Substantial damage will trigger specific flood regulations within the State Building Code, requiring that building repair or replacement be in compliance with current flood regulation.

Severe Winds

Westbrook is vulnerable to severe wind events due to hurricanes and tropical storms, nor'easters, thunderstorms and tornadoes. **Attachment 2** presents details about both community's wind hazards. Severe winds at Westbrook occur most frequently due to hurricanes and tropical storms which can occur coincident with coastal floods and heavy precipitation. Severe winds can also occur, although rarely, during tornadoes and more frequently during severe thunderstorms. High winds can also occur, frequently, during nor'easters (along with heavy rain and snow).

Likelihood/Frequency

The annual exceedance probability of experiencing sustained winds of 74 mph or greater at Westbrook is about 1.5% (+/-70-year recurrence interval). High wind events (defined as sustained winds of 40 mph and gusts of 58 mph) are expected to occur at least once a year at Westbrook.

Severity/Magnitude

Damages due to severe winds include: 1) damage to trees, often resulting in power outages and also potentially fatal accidents related to treefalls; 2) structure damage. **Table 3-7** presents the typical physical effects associated with different wind speeds. As shown on **Table 3-7**, significant, widespread damage can be expected due to sustained wind speeds of about 74 mph or greater.

The Connecticut State Building Code requires that structure be constructed in Westbrook to larger wind speeds (minimum wind gust for Risk Category I structures is 126 mph, the 0.3% AEP gust speed), so all recently constructed structures should expect minimal wind damage. Older, out-of-compliance structure may experience wind damage. As discussed in **Attachment 2**, since 1996, Middlesex County has experienced 17 days of "High Wind" events (an average of about 1 event per year) resulting in about $560,000 in property damage and no deaths.

As part of the Plan preparation, GZA completed a Level 1 HAZUS-MH damage analysis for hurricane scenario. The detailed results are presented in **Attachment 4**. The results predict about $7 Million dollars (M) to $49.5M in building and content damage, and business interruption losses for the 1% AEP (100-year recurrence interval) and the 0.2% (500-year recurrence interval flood, respectively.

Impact Area:

The Level 1 HAZUS scenario analyses identified 268 buildings (6.8% of total buildings) and 1,373 buildings (35% of total buildings) vulnerable to hurricane wind damage (ranging from minor damage to destroyed) for the 1% AEP and 0.2% AEP, respectively.

Other Extreme Wind Events

Thunderstorms contribute to Westbrook's wind risk. Ninety thunderstorm wind events have occurred in Middlesex County from 1966 to 2017, resulting in about $211k in property damage (about $2,350 per event) and 0 deaths. Twenty-five of these events resulted in damage and no event resulted in death or injury. Of these, two (2) thunderstorm events impacted the Town of Westbrook. The most severe thunderstorm, resulting in $1.5K in wind damages, occurred on May 27, 2010. Other severe thunderstorms were reported in Westbrook on October 14, 1995. Based on proportional land area, the estimated AEP at Westbrook is about 1 to 2% (+/- 50 year recurrence interval), with expected damage on the order of $4K to $8K per event. This risk is significantly less than the risk associated with hurricane winds.

Eight (8) tornadoes occurred in Middlesex County, the F3 tornado during August, 1951 resulted in the largest degree of damages at $250,000 and eight (8) injuries. The 6 other tornadoes combined accounted for less than $7.8 thousand in total damages where most of the tornadoes ranged in severity from F0 to F1. Based on proportional land area, the estimated tornado AEP at Westbrook is about 0.2% (+/- 500 year recurrence interval), with expected damage on the order of $10K per event. This risk is significantly less than the risk associated with hurricane winds. Westbrook would experience much greater damages during a major tornado; however, the probability of a major tornado tracking through Westbrook appears to be very low (less than 0.2% AEP). Westbrook's tornado wind risk appears to be is significantly less than the risk associated with hurricane winds.

Sustained Wind Speed	Annual Recurrence Interval (years)	Physical Effects
6-38 kts (30-44 mph)	<1	Trees in motion. Light-weight loose objects (e.g., lawn furniture) tossed or toppled.
39-49 kts (45-57 mph)	2 to 10	Large trees bend; twigs, small limbs break, and a few larger dead or weak branches may break. Old/weak structures (e.g., sheds, barns) may sustain minor damage (roof, doors). Building partially under construction may be damaged. A few loose shingles removed from houses. Carports may be uplifted; minor cosmetic damage to mobile homes and pool lanai cages.
50-64 kts (58-74 mph)	10 to 70	Large limbs break; shallow rooted trees pushed over. Semi-trucks overturned. More significant damage to old/weak structures. Shingles, awnings removed from houses; damage to chimneys and antennas; mobile homes, carports incur minor structural damage; large billboard signs may be toppled
65-77 kts (75-89 mph)	70 to 300	Widespread damage to trees with trees broken/uprooted. Mobile homes may incur more significant structural damage; be pushed off foundations or overturned. Roof may be partially peeled off industrial/commercial/warehouse buildings. Some minor roof damage to homes. Weak structures (e.g., farm buildings, airplane hangars) may be severely damaged.
78+ kts (90+ mph)	>300	Many large trees broken and uprooted. Mobile homes severely damaged; moderate roof damage to homes. Roofs partially peeled off homes and buildings. Moving automobiles pushed off dry roads. Barns, sheds demolished.

Table 3-7: Physical Effects associated with different wind speeds

Dam Failure

High potential loss are those facilities, such as dams, whose failure can result in catastrophic loss of human life and property damage to homes, businesses and local and major roadways The Connecticut Department of Energy and Environmental Protection (DEEP) requires the registration of all dams over six feet in height. As of 2019, there were twelve such dams in Westbrook:

Class C High Hazard Dam:	**Messerschmidt Pond Dam; Wrights Pond Dam**
Class B Significant Hazard Dams:	None
Class BB Moderate Hazard Dam:	Horse Pond Dam
Class A Low Hazard Dams:	Vincent Pond Dam; Trout Pond Dam; McVeagh Pond Dam; Johnson Pond Dam; Brook Pond Dam
Class AA Negligible Hazard Dams:	None
Unclassified:	Hall Pond Dam; Oxbow Pond Dam; Water Hole Dam; Rintoul Pond Dam

Dam classifications include:

Class C High hazard potential dams: Failure could cause any of the following: probable loss of life; major damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; damage to main highways; or great economic loss.

Class B Significant hazard potential dams: Failure could cause: possible loss of life; minor damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; damage to or interruption of the use of service of utilities; damage to primary roadways and railroads; or significant economic loss.

Class BB Moderate hazard potential dams: failure could result in: damage to normally unoccupied storage structures; damage to paved local roadways; or moderate economic loss.

Class A Low hazard potential dams: Failure could cause: damage to agricultural land; damage to unimproved roadways or minimal economic loss.

Class AA Negligible hazard potential dams: failure would result in: no measurable damage to roadways; no measurable damage to land and structures; and negligible economic loss.

In 2016 Connecticut's Department of Energy and Environmental Protection (DEEP) moved forward to fully implement provisions of state law Act 13-197 that for the purpose of this Plan Update require:

- Dam owners to have periodic inspections of their dams by a professional engineer (Regulation regulations, 22a-409-1 and 2). Requirements for the frequency of inspections are based on the hazard class assigned to a dam – from every two years for High Hazard Dams to every 10 years for Low Hazard Dams.
- Owners of dams categorized as high or significant hazard to prepare and submit an Emergency Action Plan (EAP) every two years. (Regulation 22a-411a). Dams are considered to be of High or Significant Hazard if their failure poses a risk to downstream residents and properties.

Westbrook has two (2) Class C dams that pose a risk to residents, businesses, property owners and the public if these high potential loss facilities are not properly maintained and comply with the DEEPs dam safety requirements as outlined above.

Preparing an EAP is intended to be a practical document that defines conditions which require a response, and provides clear direction for action in an emergency situation. An EAP provides the owner of a dam with a procedure to follow in making a determination when to alert local emergency response agencies that conditions are deteriorating at a dam and that an evacuation of the downstream area may be necessary. The local emergency management authority will have their own procedures in place to issue a warning or evacuation notice to downstream residents should that be necessary. As noted above, dam owners are now required to submit an EAP to the Commissioner of DEEP, the chief executive official of a city or town, and the emergency management officer of any municipality potentially impacted by an emergency involving the owner's dam.

DEEP is responsible for both Class C Dams that include the Messerschmidt Pond Dam and the Wrights Pond Dam. Both dams are in the northern part of the town located at higher elevations and are not influenced by impacts from coastal flooding.

In addition it will be critical that both dams update their EAPs every two years and make repairs and improvements as presented in inspection reports drafted by a professional engineer. These recommendations are included as high priority actions in this Plan Update.

DEEP notes on their Dam Safety website, that the vast majority of dam failures in Connecticut occur during flooding. Two of the most significant flood events in the state's modern history occurred in 1955 and 1982. As a result of rains in 1982, 17 Connecticut dams failed and another 31were damaged. There were 11 flood related deaths during this flooding and present day estimates put the cost of property damage at approximately $500 million.

A detailed assessment of dam failure risk is beyond the scope of this Plan Update. In general, coastal flooding can negatively impact dams by: 1) coastal floodwaters overtopping the dam spillway and/or dam crest; 2) scour or erosion, resulting in damage to the dam or spillway; 3) temporary changes to the hydrologic and geohydrologic conditions that could induce piping or stability failures.

Severe Winter Weather

Westbrook is vulnerable to frequent snowstorms, usually associated with nor'easters. The U.S. Northeast annually experiences about 20 to 40 nor'easters. Beginning in October and ending in April, the nor'easter season runs for seven months. Out of the 20 to 40 annual storms, at least two are severe. **Attachment 2** presents details about Westbrook's severe winter weather hazards.

Damages due to severe winter weather include: 1) damage to trees, often resulting in power outages and also potentially fatal accidents related to treefalls; 2) structure damage, including roof collapse; and 3) roadway issues including access limitations and vehicular accidents.

Likelihood/Frequency

Between 1996 and 2018, there were a total of 70 Heavy Snow events including 42 days in Middlesex County, 5 days with property damage and no injuries or fatalities. Estimated Westbrook snowfall frequency:

- 8 to 10 snow days per year
- Average annual snowfall of 23 inches
- 86% AEP or 1 year recurrence interval Heavy Snowfall (19 years with 1 or more events over 22 years)
- Reasonable estimate of average monthly snowfall: 6 to 8 inches
- Reasonably conservative monthly snowfall upper bound: 40 inches (maximum monthly upper bound of 60 inches)

Severity/Magnitude

The severity/magnitude of severe winter weather is a function of the type of vulnerability. Snowfall vulnerabilities generally include: 1) building damage (e.g., roof collapse) due to snow weight; 2) branch fall and power line failure due to snow and ice weight and wind; and 3) snow roadway clearance capabilities relative to snow fall rates.

Building Damage: The Connecticut State Building Code requires that structures be constructed in Connecticut , at a minimum, to snow loads of 30 pounds per square foot (psf). The relationship of snow load to snow depth is a function of the water content of the snow (i.e., wet snow is heavier) and can be variable. In general, 30 psf snow loads correlates to about 24 inches of snow. For weight snow events (saturated snow = +/- 2 pcf), 30 psf correlates to about 15 inches of snow. During periods of cold, snow will not melt on roofs and will accumulate due to multiple snowfall events. Ref. https://www.mutualbenefitgroup.com/insurance-101/storm-center/prevent-roof-collapse-on-your-home/

Tree and Powerline Damage: 1/2" of ice can add 500 pounds load on power lines and trees, resulting in extensive damage. Similarly, greater than 6 to 8 inches of heavy snow accumulation on tree branches can result in significant tree damage.

Roadway Clearance Requirements: the vulnerability of Westbrook's transportation system to snowstorms is a function of the Town's snow removal capabilities. Snowfall frequency data provides insight to the minimum recommended capability necessary to reduce the Town's vulnerability. Based on a limited analysis by GZA for purposes of Plan preparation, the Town's snowfall removal capabilities should include:

- Equipment and operator availability to remove snow for 20 days per year;
- Equipment, material and operator availability to sand/salt for 20 days per year; all paved roads;
- Equipment capability to remove up to 24 inches in 24 hours;
- Equipment and operator capability to remove up to 40 inches per month;
- Equipment, operator and communications capability to remove snow in blizzard conditions (i.e., high wind, drifting and low visibility);
- Back-up equipment and operator capability to remove up to 60 inches per month; and
- Service or close flooded roads. Assume coincident coastal storm surge along shoreline areas for roads at Elevation 12 and lower.

Impact Area: Townwide

Other Severe Winter Weather Events

Other Westbrook and severe winter events include ice storms and extreme cold. **Attachment 2** presents details for each of these.

Westbrook's vulnerability to ice storms is primarily loss of power and tree fall. The probability of damaging ice storms is low.

The vulnerability of residents to extreme cold during cold spells (polar vortex) and winter storms can be moderate to high in consideration of wind chill. The NWS issues Wind Chill Warnings when the wind chill index is expected to be -25° F or less. This can occur over a range of wind speed and temperature combinations. The average Winter low temperature at Westbrook is about 23°F, which will not cause wind chill conditions. However, periods of colder temperatures occur at Westbrook and can cause wind chill conditions. Wind chill example conditions:

- 0° F and 25 mph sustained wind speeds, 30-minute exposure
- 5°F and 55 mph sustained wind speeds, 30-minute exposure

Extreme Temperature - Heat

The residents of Westbrook are vulnerable to the effects of excessive heat. Heat effects include heat cramps, heat stroke, and death. Extreme heat also exacerbates preexisting chronic conditions, such as various respiratory, cerebral, and cardiovascular diseases. These serious health consequences usually affect more vulnerable populations such as the elderly, children, and those with existing cardiovascular and respiratory diseases. Socioeconomic factors, such as economically disadvantaged and socially isolated individuals, are also at risk from heat-related burdens.

Likelihood/Frequency

Excessive Heat Warnings are issued when the daytime heat indices reach 105° F or greater for 2 or more hours. A Heat Advisory is issued when the daytime heat indices reach 100-104°F for 2 or more hours. A Heat Wave is defined as 3 or more days of temperatures of 90° F or above. Connecticut currently experiences between 5 and 8 days per year when the Heat Index is expected to exceed 105° F. Between 2010 and 2018, there were a total of 4 events in Middlesex County with Excessive Heat, including 2 days with Excessive Heat and no fatalities or injuries. These included July 22, 2011 and July 1, 2018.

The results indicate that the probability of Excessive Heat near Westbrook and (Middlesex County) is:

- 25% AEP or 1 event every 4 years.

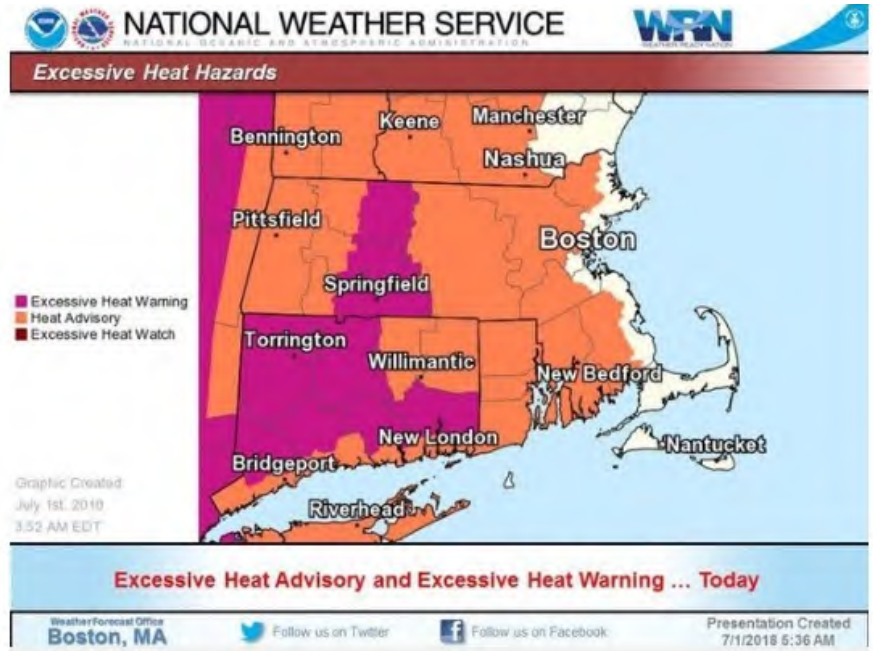
As described in **Attachment 2**, the number of days over 90°F and frequency of Heat Waves is expected to significantly increase in the near future due to climate change. By 2050, the number of Connecticut Heat Wave days may increase to about 20 to 40 per year. By 2050, the number of days with a Heat Index above 105° F could increase to 10 days per year. This may indicate that by the year 2050, the frequency of Excessive Heat events at Westbrook may increase from 1 ever 4 years on average to at least 1 every two years.

Severity/Magnitude

The severity and magnitude of extreme heat events at Westbrook is in part dependent upon: 1) demographics; and 2) the capability of residents to get cool (e.g. air conditioners in homes). Westbrook's demographic data indicates that about 35% of the population may be at a greater than average vulnerability.

- 25% of Westbrook's population is older than 65 years
- 4% of Westbrook's population is less than 5%
- 5% of Westbrook's population is at the poverty level

Impact Area: Town-wide



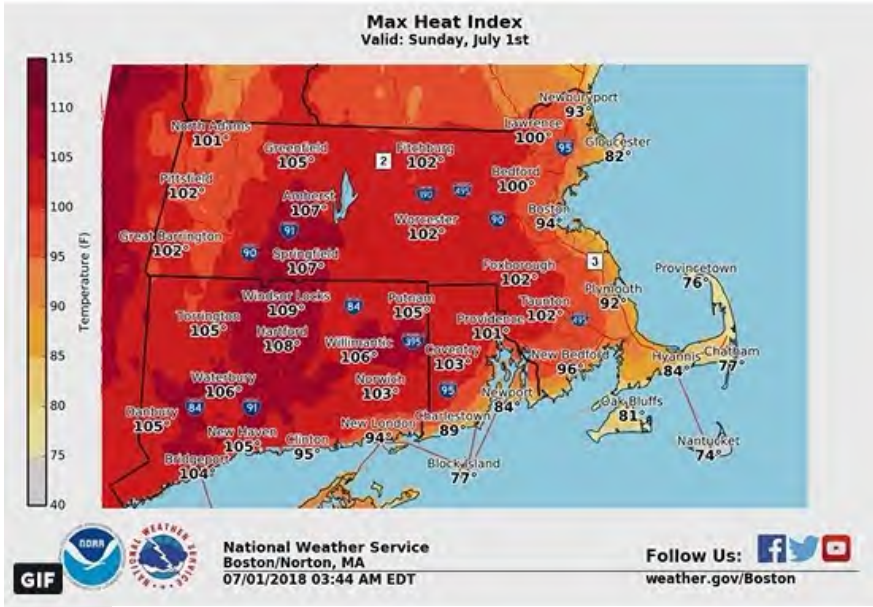


Figure 3-16: Heat Advisory at Westbrook during the first week of July, 2018, reference NWS

Earthquake

Westbrook is vulnerable to the effects of earthquakes. However, it is located in an area of relatively low predicted earthquake ground motion. The peak ground acceleration (acceleration on the bedrock surface) associated with the maximum Considered Earthquake for building design - the 2% in 50 years probability (about a 2,500-year recurrence interval) is 0.13g (where g equals the acceleration of gravity). In terms of felt effects and damage, ground motion at the level of several percent of gravity corresponds to the threshold of damage to buildings and houses (an earthquake intensity of approximately V). For comparison, reports of "dishes, windows and doors disturbed" corresponds to an intensity of about IV, or about 0.02g. Reports of "some chimneys broken" corresponds to an intensity of about VII, or about 0.10% to 0.20% of gravity. However, the seismic risk is not equally distributed throughout Westbrook. The presence of deposits of loose and/or soft soil above the bedrock located primarily in some areas south of Interstate 95 will cause an increase in ground acceleration at the ground surface relative to the ground motion felt at the bedrock (i.e., MCE peak accelerations will be greater than 0.13g). Loose soils can also experience a secondary earthquake effect, called liquefaction, which causes these soils to lose their shear strength during earthquakes.

Historical Occurrence

- Although rare, significant earthquakes (magnitude 6 or greater) have occurred near Westbrook, (within about 100 miles) over the last 350 years. These earthquakes would have resulted in moderate to strong ground motion in Westbrook.

Likelihood/Frequency

- 2% in 50 years PGA (2,5000-year recurrence interval; Maximum Considered Earthquake) in the vicinity of Westbrook is 0.13g
- 10% in 50 years PGA (500-year recurrence interval) in the vicinity of Westbrook is 0.03g

Severity/Magnitude

The Seismic Design Category for the majority of Westbrook is A or B indicating a low seismic hazard. The 10% in 50 years (500-year recurrence interval) ground motion would be experienced as light to moderate perceived shaking and none to very light damage. The 2% in 50 years (2,500-year recurrence interval) ground motion would be experienced as very strong perceived shaking and moderate damage.

Impact Area: Townwide

The Level 1 HAZUS scenario analyses identified 169 buildings (4.3% of total buildings) and 475 buildings (12.1% of total buildings) vulnerable to hurricane wind damage (ranging from minor damage to destroyed) for the 5% in 50 years (1,000-year recurrence interval) and 2% in 50 years (2,500-year recurrence interval) , respectively.

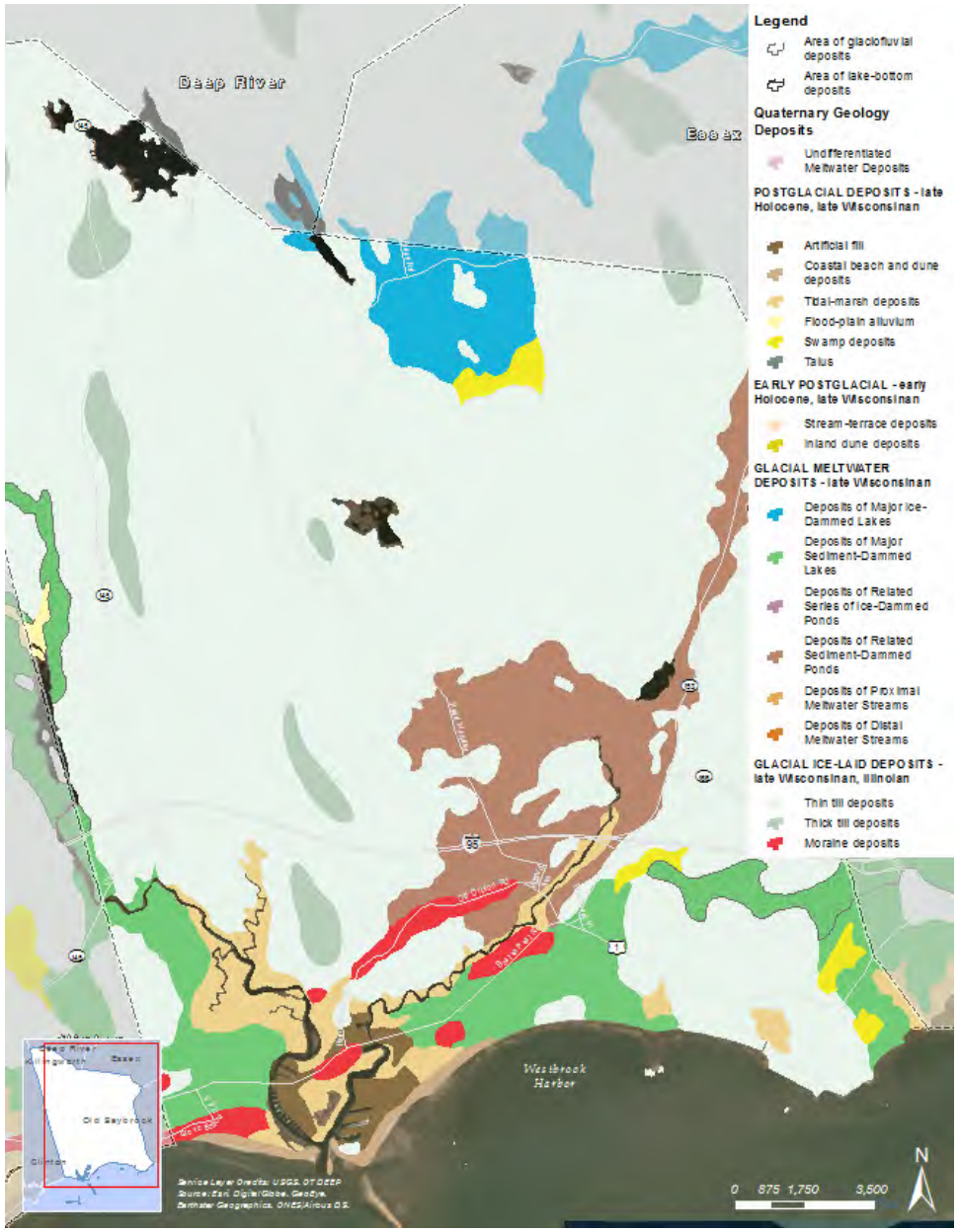


Figure 3-17: Westbrook Geologic Map

Attachment 4: FEMA HAZUS-MH Simulation Results

FEMA HAZUS-MH HAZARD SCENARIO ANALYSES

Scenario analyses predict the impacts of an event or particular type of an event. This level of analysis considers potential impacts to infrastructure, people, and cost, as well as likelihood or frequency of the event. Scenario analyses were performed using the FEMA Multi-Hazard HAZUS-MH software.

Level 1 HAZUS analyses were performed using the HAZUS Flood, Hurricane and Earthquake modules included in the HAZUS 4.2 software. A Level 1 HAZUS analysis calculates basic estimates of flood and hurricane wind losses based on national databases and expert-based analysis parameters included in the HAZUS 4.2 software. The data used for this analysis included the HAZUS "default" data included in the HAZUS software and 2010 US Census Data. Level 1 analyses are appropriate for initial loss estimation at the planning level, and is not intended for establishing the flood, earthquake, or hurricane related risk of any specific parcel or property.

Potential losses estimated by HAZUS include:

- **Physical damage,** to residential and commercial buildings, schools, critical facilities, and infrastructure;
- **Economic loss**, including lost jobs, business interruptions, repair, and reconstruction costs;
- **Social impacts**, including estimates of shelter requirements, displaced households, and population exposed to scenario floods, earthquakes, and hurricanes

https://www.fema.gov/HAZUS

There are 3,913 buildings in Westbrook (2010 census), with a total building replacement value (excluding contents) of $1,278 million (2014 dollars). **Table 4-1** presents the total building value in Westbrook. Approximately 92% of the buildings (representing about 72% of the total value) are residential. **Table 4-2** provides an overview of the expected damage and loss categories that will be the focus of this scenario analysis based on the results generated from the Flood and Hurricane HAZUS module runs.

Occupancy	Exposure ($1000)	Percent of Total
Residential	923,176	72%
Commercial	222,326	18%
Industrial	72,884	6%
Agricultural	7,488	<1%
Religion	13,798	1.1%
Government	7,647	<1%
Education	23,934	1.9%
Total	**1,278,253**	100%

Table 4-1: Westbrook Building Exposure and Occupancy Type

DIRECT DAMAGE
General Building Stock
Essential Facilities
DIRECT LOSSES
Shelter Needs
INDIRECT LOSSES
Economic Loss
Property Damage Business Interruption

Table 4-2: Damage and Loss Categories

Flood Scenario

The Town is vulnerable to coastal flood events. The flood scenario analysis used the default building stock from HAZUS as presented categorically in **Table 4-1** and the FEMA-defined flood hazard zones and flood depths. **Table 4-3** presents the estimated damages and losses for the 100-year (1%), and 500-year (0.2%) flood events for: 1) buildings; 2) essential facilities; 3) displaced people and sheltering; and 4) Economic Losses.

Building Damages

Forty-five (45) buildings in Westbrook would experience at least moderate damage from a 100-year recurrence interval flood event and 109 buildings would experience at least moderate damage from a 500-year recurrence interval flood event. Of these, 9 buildings (100-year event) and 23 buildings (500-year event) are predicted to be completely destroyed.

The associated economic losses (including business interruption) range from $70.21 million (100-year event) to $112.75 million (500-year event).

Essential Facilities

None of the essential facilities are expected to be moderately impacted during the 100-year interval flood events. One of the essential facilities (i.e. a police station) is expected to be at least moderately impacted, and will lose functionality for approximately one day during the 500-year interval flood events.

Sheltering Requirements

Based on the HAZUS flood analysis, 341 households would be displaced and 58 people would require shelter for the 100-year flood event and 612 households would be displaced and 111 people would require temporary shelter for the 500-year flood event.

Uncertainty

Loss estimations using HAZUS are highly uncertain, in particular relative to the predicted damage and resulting economic loss. The analysis is sensitive to flood depth and makes assumptions relative to: building floor elevations and percent damage (using generic depth-damage relationships). It also estimates loss based on a census block scale (i.e., not a building scale). HAZUS reasonably predicts the number of structures impacted. Significant uncertainty with economic loss analyses is also due to the uncertainty related to flood probability. Uncertainty can be reduced by performing more site-specific analysis (i.e., Level 2 and 3 analyses, using elevation certificates and building scale analyses).

	100-Yr*	**500-Yr***
Building Damages (# of Buildings)		
# of Buildings with Slight Damage (1-10%)	28	27
# of Buildings with Moderate Damage (11-50%)	38	86
# of Buildings with Substantial Damage (>50%)	7	23
TOTAL	**73**	**136**
Essential Facilities Building Damages (Lose of Use > 1 Day)	100-Yr	500-Yr
Emergency Operations Center	0	0
Fire	0	0
Hospitals	0	0
Police	0	1
Schools	0	0
TOTAL	**0**	**1**
Sheltering Requirements	100-Yr	500-Yr
Displaced Households (# Households)	341	612
Short-Term Shelter (# People)	58	111
Economic Losses (in $1,000s of dollars)	100-Yr	500-Yr
Residential Property	$17,330	$40,890
Total Property	$21,460	$60,400
Business Interruption	$48,750	$52,350
Total	**$70,210**	**$112,750**

Table 4-3: HAZUS Flood Scenario Results

Uncertainty can also be reduced by comparing results to observed impact and losses. Unfortunately, there is limited historical loss data that is relevant to low probability storms (i.e. 50-year, 100-year and 500-year recurrence interval floods) in Connecticut.

Hurricane Wind Scenario

The Town will likely experience increasing order of magnitude impacts from hurricane wind events with increasing intensity that have a lower probability of occurrence especially from hurricanes with storm tracks that move directly through or in close proximity to Westbrook. **Table 4-4** below shows the estimated damages for the 100-year (1%), and 500-year (0.2%) hurricane-wind events for: 1) buildings, 2) essential facilities, 3) displaced people and sheltering, and 4) Economic Losses from the 100-year and 500-year hurricane-wind events.

Building Damages

In Westbrook, 268 buildings and 2,326 buildings are predicted to experience damage, ranging from minor to destroyed, from a 100-year and 500-year recurrence interval wind event, respectively. The majority of damage is predicted to be minor.

The estimated economic losses are about $7 million and $49 million, for the 100-year and 500-year events, respectively.

Essential Facilities

Six of the essential facilities (i.e. 1 police station, 1 fire station and 4 schools) are expected to lose some functionality for less than one day during the 100 and 500-year interval flood events.

Sheltering Requirements

Based on the HAZUS wind analysis, 3 households would be displaced and 2 people would require shelter for the 100-year flood event and 31 households would be displaced and 16 people would require shelter.

Uncertainty

Loss estimations using HAZUS are highly uncertain, in particular relative to the predicted damage and resulting economic loss. The analysis is sensitive to wind damages and makes assumptions relative to: building floor elevations and percent damage (using generic depth-damage relationships). It also estimates loss based on a census block scale (i.e., not a building scale). HAZUS reasonably predicts the number of structures impacted. Significant uncertainty with economic loss analyses is also due to the uncertainty related to hurricane– wind probability. Uncertainty can be reduced by performing more site-specific analysis (i.e., Level 2 and 3 analyses, using building scale analyses). Uncertainty can also be reduced by comparing results to observed impact and losses. Unfortunately, there is limited historical loss data that is relevant to low probability storms (i.e. 50-year, 100-year and 500-year recurrence hurricane-wind events) in Connecticut.

	100-Yr	**500-Yr**
Building Damages (# of Buildings)		
# of Buildings with Minor Damage	246	1,017
# of Buildings with Moderate Damage	22	308
# of Buildings with Severe Damage	0	28
# of Buildings Destroyed	0	20
TOTAL	**268**	**1,373**
Essential Facilities Building Damages (Lose of Use <1 Day)	100-Yr	500-Yr
Emergency Operations Center	1	1
Fire	2	2
Hospitals	0	0
Police	2	2
Schools	4	0
TOTAL	**9**	**5**
Sheltering Requirements	100-Yr	500-Yr
Displaced Households (# Households)	3	31
Short-Term Shelter (# People)	2	16
Economic Losses (in $1,000s of dollars)	100-Yr	500-Yr
Residential Property	$5,977	$36,846
Total Property	$6,646	$44,063
Business Interruption	$376	$5,402
Total	**$7,022**	**$49,465**

Table 4-4: HAZUS Hurricane Wind Scenario Results

Earthquake Scenario

This earthquake analysis was conducted assuming a magnitude 5 earthquake on the Richter scale. **Table 4-5** summarizes the estimated damages for the 1,000-year and 2,500-year recurrence interval earthquakes for: 1) buildings, 2) essential facilities, 3) displaced people and sheltering, and 4) Economic Losses from the 1000-year and 2500-year earthquake events.

Building Damages

In Westbrook, 169 buildings and 475 buildings are predicted to experience damage, ranging from slight to complete, from a 1,000-year (aka 5% in 50 years) and 2,500 -year (aka 2% in 50 years) recurrence interval earthquake, respectively. The majority of damage is predicted to be slight.

The estimated economic losses are about $4.4 million and $17.84 million, for the 1,000 -year and 2,500-year events, respectively.

Essential Facilities

None of the essential facilities are expected to be impacted or lose functionality during either the 1,000-year and 2,500-year recurrence interval earthquake events.

Sheltering Requirements

Based on the HAZUS earthquake analysis, 1 households would be displaced and 0 people would require shelter for the 1,000-year flood event and 5 households would be displaced and 2 people would require shelter.

Uncertainty

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

	1,000-Yr	2,500-Yr
Building Damages (# of Buildings)		
# of Buildings with Slight Damage	133	354
# of Buildings with Moderate Damage	33	108
# of Buildings with Extensive Damage	3	12
Complete	0	1
TOTAL	**169**	**475**
	1,000-Yr	2,500-Yr
Essential Facilities Building Damages (Lose of Use > 1 Day)		
Emergency Operations Center	0	0
Fire	0	0
Hospitals	0	0
Police	0	0
Schools	0	0
TOTAL	**0**	**0**
	1,000-Yr	2,500-Yr
Sheltering Requirements		
Displaced Households (# Households)	1	5
Short-Term Shelter (# People)	0	2
Economic Losses (in $1,000s of dollars)	1,000-Yr	2,500-Yr
Residential Property	$1,599	$7,126
Total Property	$3,620	$15,248
Business Interruption	$800	$2,588
TOTAL	**$4,420**	**$17,836**

Table 4-5: HAZUS Earthquake Scenario Results

Attachment 5: Potential State and Federal Funding Sources

Attachment 5: Potential State and Federal Funding Sources

FEMA Hazard Mitigation Assistance and Disaster Recovery Grants

Several of the proposed hazard mitigation projects and actions may be eligible activities for funding under the three FEMA Hazard Mitigation Assistance (HMA) Grant Programs. The FEMA HMA Grant Programs include two non-disaster mitigation grant programs that include the Pre-Disaster Mitigation and Flood Mitigation Assistance grant programs, and one disaster mitigation grant program that is the Hazard Mitigation Grant Program. An overview of each program is outlined as follows.

Pre-Disaster Mitigation (PDM)

The purpose of PDM is to reduce overall risk to communities and structures from future hazard events including coastal flooding, while also assisting communities in recovering more quickly from future natural disasters. PDM funds mitigation planning and project grants designed to reduce future losses in advance of potential disaster. Funding for PDM and FMA is appropriated by Congress annually and awarded on a nationally competitive basis. Many of the proposed hazard mitigation projects and actions are eligible activities for funding under PDM.

FEMA announced the Fiscal Year (FY) 2019 application cycle on August 26, 2019. The application period is September 30, 2019 through January 31, 2020. The Notice of Funding Opportunity (NOFO) is posted on www.Grants.gov. The FY 2019 PDM Fact Sheet provides an overview of the agency's priorities for this year. FEMA will offer NOFO webinars for potential applicants prior to opening the application period. View the complete 2019 webinar schedule. https://www.fema.gov/pre-disaster-mitigation-grant-program (09/18/19)

Flood Mitigation Assistance (FMA)

The purpose of the FMA program is to reduce or eliminate insurance claims under the National Flood Insurance Program (NFIP). FMA provides funding to States, Territories, federally-recognized tribes and local communities for projects that reduce or eliminate long-term risk of flood damage to structures insured under the NFIP. FMA funding is available for flood hazard mitigation projects, plan development and management costs. Funding for PDM and FMA is appropriated by Congress annually and awarded on a nationally competitive basis. https://www.fema.gov/flood-mitigation-assistance-grant-program (09/18/19)

FEMA announced the Fiscal Year (FY) 2019 application cycle on August 26, 2019. The application period is September 30, 2019 through January 31, 2020. The Notice of Funding Opportunity (NOFO) is posted on www.Grants.gov. The FY 2019 Flood Mitigation Assistance Fact Sheet provides an overview of the agency's priorities for this year. FEMA will offer NOFO webinars for potential applicants prior to opening the application period. View the complete 2019 webinar schedule.

Hazard Mitigation Grant Program (HMGP)

FEMA's HMGP provides funding to municipalities, states, regional planning entities, and other eligible applicants to help communities implement hazard mitigation measures following a Presidential major disaster declaration. The most recent A declaration typically opens up a host of disaster recovery and mitigation programs to assist states in recovering from and mitigating the future impacts from all-natural hazards.

The funding for FEMA's HMGP is 15% of the total assessed damages for a given disaster for states that meet FEMA's standard Mitigation Plan requirements, which applies to the state of Connecticut. The HMGP application period is open for one year from the disaster declaration date. In 2012 to 2013, the Hurricane Sandy resulted in over $75 Million in Public Assistance (PA) and Individual Assistance (IA) Grants obligated, which is a FEMA Recovery grant program resulting in an additional $11..36 Million in HMGP funding available to the State for DR-4087. https://www.fema.gov/hazard-mitigation-grant-program (03/28/19)

The federal share of assistance is not less than 75 percent of the eligible cost. Each of these programs requires a 25% local match for traditional HMA projects. There is currently no open disaster declaration in Connecticut. The most recent open disaster was announced on December 5, 2018 - Connecticut Severe Storms and Flooding (DR -4410) and the application period closed on September 27, 2019. Future HMGP funding will become available during the next open disaster declaration.

Note that the application process for PDM and FMA is conducted through an online application process using FEMA's eGrants system. The application period for FY 2019 PDM and FMA is open and applications must be submitted using the FEMA eGrants on-line system no later than 3pm on Tuesday November 26, 2019.

All three HMA programs are managed by the Connecticut Department of Emergency Management & Homeland Security (DEMHS) with support from Department of Energy and Environmental Protection (DEEP). Contact DEMHS/DESPP at (860) 685-8543 for more information on each of these HMA grant programs.

Public Assistance (PA)

FEMA's Public Assistance (PA) grant program provides federal assistance to government organizations and certain private nonprofit (PNP) organizations following a Presidential disaster declaration. Through the program, FEMA provides supplemental federal disaster grant assistance for debris removal, life-saving emergency protective measures, and the repair, replacement, or restoration of disaster-damaged publicly-owned facilities, and the facilities of certain PNP organizations. The PA program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process. The federal share of assistance is not less than 75 percent of the eligible cost. The Recipient (usually the state) determines how the non-federal share (up to 25 percent) is split with the subrecipients (eligible applicants). https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit

HUD Disaster Recovery and Resiliency Grants

Community Development Block Grant – Disaster Recovery (CDBG-DR)

Similar to FEMA's HMGP, HUD provides disaster recovery grants to help municipalities like Somerset and the State recover from Presidentially-declared disasters, especially in low-income areas. The goal of these grants is to rebuild the impacted areas and provide critical funding to start the recovery process. The CDBG-DR program allows for the funding of a wide range of recovery activities including planning activities that aide communities and neighborhoods that may otherwise not recover because of a lack of resources.

US Department of Agriculture's (USDA) and other Federal Grants

Natural Resources Conservation Services (NRCS)

The NRCS is the US Department of Agriculture's (USDA) leading agency providing voluntary technical and financial assistance to conservation districts, private land-owners, tribal governments, and other organizations to help sustainably manage, conserve and improve natural resources at the local level. Two financial programs that offer funding support in response to natural hazards are outlined as follows.

Emergency Watershed Protection Program (EWP)

Congress established the EWP to assist public and private landowners in response to emergencies resulting from natural hazards including coastal flooding and storms. The mission of the EWP program is to assist people and conserve natural resources by reducing the future impacts to public safety and property caused by floods, coastal storms and other natural hazards. The NRCS is the managing agency for the EWP program that includes two focus areas which are: EWP-Recovery and EWP-Floodplain Easement (FPE).

The EWP-Recovery provides recovery assistance to public and private landowners as a result of a natural disaster that requires a 25% local match with the NRCS providing a 75% match for the construction cost for emergency measures. The EWP-FPE provides assistance to privately-owned lands or lands owned by a local or state government that have been damaged by flooding at least once within the previous calendar year or have been subject to flood damage at least twice within the previous ten years.

Watershed & Flood Prevention Operations (WFPO) Program

The Watershed Protection and Flood Prevention Act of 1954 authorizes the NRCS to provide technical and financial assistance to states, local and tribal governments (project sponsors) for the planning and implementation of approved watershed plans. The NRCS works with local sponsors to protect and restore watersheds from damage caused by erosion, floodwater and sediment, to conserve and develop water and land resources, and to solve natural resource and related economic problems on a watershed basis. In Connecticut , the project sponsor for watershed projects is the Connecticut Department of Energy and Environmental Protection (DEEP). The DEEP provides assistance for the implementation of measures outlined in approved plans, and is focusing their efforts on reducing flood damages.

NOAA Coastal Resiliency Grants

Communities use Coastal Resilience Grants to develop projects that save lives, protect property, reduce damage to infrastructure, and benefit ecosystems and the economy. These projects connect agencies and organizations across regions, include a variety of public- and private-sector partnerships, and require a nonfederal dollar match. The grants are structured so that each applicant can request the help most needed by their community.

Since 2015, NOAA received 411 proposals requesting $327 million in federal funds, while NOAA funded 48 projects totaling $35.8 million in federal funds, with $22.3 million in matching funds.

The following summarizes the most common aspects of the projects and showcases the forward-thinking solutions found at the state and local levels.

Natural and nature-based infrastructure. Wetlands, coral reefs, mangroves, and dunes provide natural protection for coastal communities as well as other economic benefits, including habitat for commercially important fish. Nature-based infrastructure approaches mimic natural processes. Many of the grant applications use some form of natural or nature-based infrastructure.

Post-disaster recovery. Communities are figuring out the coordination and processes needed to help people and the economy begin functioning as soon as possible. Ensuring that reconstruction efforts incorporate risk reduction is an important part of this planning effort.

Assessing risk, prioritizing actions. Widespread vulnerability is making detailed risk assessment a necessity. These assessments help communities determine which activities and locations are a priority for protection and recovery efforts. https://coast.noaa.gov/resilience-grant/

Federal Highway Administration; Nature-Based Resilience for Coastal Highways

The Federal Highway Administration (FHWA) is producing research and technical assistance that will enable transportation agencies to use natural and nature-based features, also called natural infrastructure or green infrastructure, to improve the resilience of transportation systems. FHWA sponsored five pilot projects to assess the potential for nature-based techniques to protect specific locations along coastal roads and bridges. FHWA is also developing a white paper, regional peer exchanges, and an implementation guide.

During 2016, FHWA awarded five applied research projects (pilots) in the amounts ranging from $50,000 to $100,000 for each project. The funds did require a local match. The non-federal share must be at least 20 percent and 50 percent is preferred. In-kind contributions may count as match. Additional information on this program can be found at: These five pilot projects were the result of a 2016 research funding opportunity to conduct assessments of green infrastructure solutions to improve the resilience of coastal highways and bridges to climate change impacts.

This program may be a source of future funding for similar transportation projects that would require that the Town of Westbrook partner with the Connecticut Department of Transportation, RiverCOG, etc. The funding recipient must be a state department of transportation, metropolitan planning organization, federally recognized tribal government, or Federal Lands Management Agency. However, partnerships with other organizations such as natural resource agencies, non-profit organizations, universities, etc. are encouraged. The scope includes US coastal areas (East Coast, West Coast, Gulf Coast, Great Lakes, Alaska, Hawaii, Puerto Rico, US Virgin Islands, and US territories in the Pacific Ocean). Eligible projects are those that analyze the feasibility of green infrastructure solutions to protect coastal roads.

Federal Highway Administration (FHWA) Surface Transportation Block Grant -- Transportation Alternatives Set-Aside — This program funds "transportation alternatives," including "off-road trail facilities for pedestrians, bicyclists, and other non-motorized forms of transportation."

Environmental Protection Agency Water and Green Infrastructure Grants

EPA Clean Water Act Nonpoint Source Grant (Section 319 Grants)—Congress amended the Clean Water Act in 1987 to establish EPA's Section 319 Nonpoint Source Management Program to provide greater federal leadership in focusing state and local nonpoint source efforts. Under Section 319, states, territories, and Indian tribes receive grant money to support a wide variety of activities, including:

- technical and financial assistance,
- education and training,
- technology transfer,
- demonstration projects, and
- monitoring to assess the success of projects implemented under the grant.

EPA Clean Water State Revolving Fund (CWSRF)—The CWSRF program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a wide range of water quality infrastructure projects, including stormwater and green infrastructure.

Learn more about the program in Green Infrastructure Approaches to Managing Wet Weather with Clean Water State Revolving Funds.

EPA Office of Wetlands, Oceans, and Watersheds (OWOW) Funding—OWOW has created this website to provide tools, databases, and information for practitioners that serve to protect watersheds.

Five Star and Urban Waters Restoration Grant Program—The US Environmental Protection Agency and the Urban Waters Federal Partnership are proud to co-sponsor the Five Star and Urban Waters Restoration Grants Program. This program seeks to develop community capacity by providing modest assistance to diverse local partnerships for river, wetland, riparian, forest and coastal restoration, and wildlife conservation.

EPA's Water Finance Clearinghouse—This tool is a one-stop-shop for all community water finance needs. The Clearinghouse allows you to search a database with more than $10 billion in water funding sources and over 550 resources to support local water infrastructure projects, including stormwater/ green infrastructure funding.

EPA's Water Infrastructure and Resiliency Finance Center (WIRFC)—WIRFC is an information and assistance center, helping communities make informed decisions for drinking water, wastewater, and stormwater infrastructure to protect human health and the environment

Department of Energy Grants

DOE Energy Efficiency Savings EXIT-Green infrastructure can be integrated into project design to claim tax incentives and rebates. For example, in Eugene, Oregon, a new biofuel station built on an abandoned gas station site included a green roof, bioswales and rain gardens. Nearly $250,000 worth of tax credits reduced income and sales tax for the private company that built and operated the project.

State of Connecticut Grants

Connecticut Institute for Resilience & Climate Adaptation (CIRCA) Municipal Resilience Grant Program

CIRCA provides grant funding to municipal governments and councils of government for initiatives that advance resilience, including the creation of conceptual design, construction (demonstration projects or other) of structures, or the design of practices and policies that increase their resilience to climate change and severe weather. This program is focused on implementation and proposals must review and consider integration of CIRCA's research products (see link to CIRCA Research Projects report below) into proposed projects. The CIRCA Executive Steering Committee made up to $100,000 in funds available to municipal governments and councils of government in 2016 and 2017 for the execution of resilience initiatives. The committee will review proposals and expects to award 2 -5 projects on this round.

https://circa.uconn.edu/funds-muni/

Connecticut Institute for Resilience & Climate Adaptation (CIRCA) Matching Funds Program

CIRCA provides grant funding to Connecticut municipalities, institutions, universities, foundations, and other non-governmental organizations for matching funds for projects that address the mission of the Institute. CIRCA matching funds are intended for grant proposals in preparation. You are not eligible to apply if primary funds have already been awarded.

To be funded, a successful Matching Funds Request Form must have a commitment of primary funding within 6 months of the CIRCA award announcement, or have received a waiver from the CIRCA Executive Steering Committee. CIRCA Matching Funds will provide up to 25% of the primary funder's contribution other than municipal or State of Connecticut funds to enhance the likely success of project proposals that advance CIRCA research and implementation priorities. Proposals are required to leverage independent funding awarded through a competitive process.

https://circa.uconn.edu/funds/

Attachment 5: Potential State and Federal Funding Sources

State of Connecticut Transportation Capital Infrastructure Program

The U.S. Department of Transportation announced on September 7th, 2017 the opportunity for state and local stakeholders to apply for $500 million in discretionary grant funding through the Transportation Investment Generating Economic Recovery (TIGER) program. Connecticut transportation funding such as the TIGER Discretionary Grant program (which includes federal funds from U.S. DOT or Federal Highway Administration) are potential sources of funding for resiliency projects that have a transportation component. This includes typical State-owned transportation systems (roads, bridges, rail and bus) as well as pedestrian trail corridors. Certain maritime uses, including port infrastructure projects are also included. Connecticut DOT also has funding to conduct planning studies to address the impacts of climate change and extreme weather.

"The TIGER grant program is a highly competitive program whose winners will be awarded with the funding they need to rebuild the infrastructure of their communities," said Secretary Elaine L. Chao. "TIGER grants will continue to fund innovative projects that will improve the safety of America's passengers and goods."

The Consolidated Appropriations Act, 2017 appropriated $500 million, available through September 30, 2020, for National Infrastructure Investments otherwise known as TIGER grants. As with previous rounds of TIGER, funds for the fiscal year (FY) 2017 TIGER grants program are to be awarded on a competitive basis for projects that will have a significant impact on the Nation, a metropolitan area, or a region. The FY 2017 Appropriations Act specifies that TIGER Discretionary Grants may not be less than $5 million and not greater than $25 million, except that for projects located in rural areas the minimum TIGER Discretionary Grant size is $1 million. Additional information on the TIGER Program can be found at:

https://www.transportation.gov/tiger

Attachment 6: Public Meeting Documentation

Public Notice

Natural Hazard Mitigation Plan Update Public Meeting:
July 29, 2019
7:00 PM – Multi-Media Room, Mulvey Municipal Center
866 Boston Post Road, Town of Westbrook

The Town of Westbrook is in the process of updating the Town's Natural Hazard Mitigation Plan (HMP Update). The purpose of the HMP Update is to update the hazards risk assessment, mitigation strategies and actions to reduce the loss of life and property resulting from natural and climate-related hazards. In addition, a key part of this update is to document the progress made in implementing actions outlined in the 2014 MHMP.

As a part of the planning process, the Town created a local planning team made up of local officials to assist in leading the development of the plan. The Town has retained GZA GeoEnvironmental, Inc. to assist the planning team in the preparation of the HMP Update. Funding for this activity is being provided by the Town of Westbrook.

A critical component of the planning process is open public involvement where the Town will provide the public with the opportunity to provide input and comments at two public meetings. The first public meeting will be held on July 29, 2019, at 7:00 PM at the Town of Westbrook Mulvey Municipal Center, 866 Boston Post Road.

The focus of the first public meeting is to present: 1) the planning framework, 2) identified Town critical assets and 3) natural and climate-related hazard characterizations for the Town of Westbrook. During the meeting, the public is invited to make comments or suggestions. All comments received from the public will be documented and considered for inclusion in the HMP Update.

Westbrook Planning Commission
Special Meeting Minutes
July 29, 2019
7:00 p.m.
Mulvey Municipal Center, 866 Boston Post Road
Multi-Media Room

MEMBERS PRESENT: Marilyn Ozols, Chair; Bill Neale (Regular Member), Tammy Niedzwicki (Regular Member) Sheryl Becker (Alternate Member), Marie Farrell (Alternate Member) and

MEMBERS ABSENT: Phil Bassett, Secretary; Eric Reeve (Regular Member), Richard Newberg (Alternate Member)

STAFF PRESENT: Eric Knapp, Planning, Zoning and Development Coordinator

GUEST PRESENTER: Samuel Bell, Senior Resiliency Planner, for GZA

M. Ozols called the meeting to order at 7:00 p.m.

Natural Hazard Mitigation Plan Update - public session:

Presentation by Planning, Zoning and Development Coordinator and Samuel Bell, Senior Resiliency Planner
E. Knapp explained that the goal is to get the NHMP adopted by late autumn. It's very important that the plan is adopted in order for the town to be eligible for FEMA funds in the event of a natural disaster. The next public input meeting for the NHMP will be Monday, September 16, 2019.

S. Bell introduced and presented a PowerPoint presentation of approximately 50 slides showing features of the new Plan and some highlights from the 2014 Plan for comparison.

S. Bell who previously worked for FEMA, spoke about his professional experience. He said the main focus areas of the NHMP would be discussed, and then the planning team would be introduced.

S. Bell, E. Knapp and M. Ozols worked to create a large and diverse team. There were people from emergency management, water pollution control, the health department, planning and others included on the team. There will be more meetings, and more input will be gathered from other town departments.

S. Bell talked about the 2014 Natural Hazard Mitigation Plan. The plan must be updated every 5 years. The progress documents are due next week. They must include a revised strategy and actions from the 2014 plan which was developed by RiverCOG. The actions need to be implementable. The final review of the plan will be done by the State in late fall.

E. Knapp explained that as the water rises, there will be more issues with well, septic, infrastructure, dredging, seawalls and things that individual property owners cannot address. The goal is to help Westbrook as a whole be as resilient as possible. There is a regional plan and a state plan. The town plan should line up with the state plan.

The culverts and bridges were designed 50 years ago, and they can't handle the rain deluge of today's storms. The rainstorms we get now are not the rainstorms of 50 years ago. Drainage has to be addressed. The infrastructure needs to match the storms. Planned inventory and replacement of these things is part of the plan.

Input from Public

There were comments and concerns expressed by members of the public. Much of the conversation was about the beaches in Westbrook. Also, there was discussion about dredging. The location where the sand and silt from the dredging would be brought to after it was dredged would have to be acceptable to FEMA.

Additional comments addressed the dams in town, specifically Messerschmidt Dam and how much of the town below the Town might be at risk in the event of a failure.

E. Knapp thanked the public for its input and reminded them of the September follow-up meeting.

ADJOURNMENT:
The meeting was adjourned at 8:40 p.m.

Respectfully submitted,

Kathleen King

Kathleen King, Recording Secretary

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Today's Meeting

- Introduce Planning Team
- Present Project Overview
- Review Planning Process
- Present Community Profile Overview
- Present Assets Inventory Update
- Provide Natural Hazard Characterization Update
- Discuss Next Steps

Second Public Meeting: September 16, 2019

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Westbrook Local Planning Team (Working Group)

Local Planning Team	
Town Planner, Land Use Department	Eric Knapp
First Selectman, Board of Selectmen	Noel Bishop
Char, Planning Commission	Marilyn Ozols
Chair, Economic Development Commission	James Crawford
Director, Emergency Management	Donald Izzo
Director, Health Department	Sonia Marino
Environmental Health Technician, Water Pollution Control Office	Shirley Mickens

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Local Planning Team (Working Group) Meetings

Planning Team Meetings	Date
Project Initiation Meeting	10/25/18
Working Group Meeting	4/30/18
Working Group Meeting	7/23/2019

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Project Hazard Planning Consultant

About GZA

32 offices, 7000 Engineers, Scientists, Planners and Technical Specialists providing expert , risk-informed and pragmatic advice and solutions in the following ***Core Service*** *areas....*

5

Project Overview

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HAZARD MITIGATION PLANNING BACKGROUND

PURPOSE: Hazard Mitigation planning is a proactive effort to identify actions that can reduce the dangers to life and property from natural hazard events, such as hurricanes, tornadoes, winter storms and earthquakes.

REQUIREMENTS: The Federal Disaster Mitigation Act of 2000 requires all municipalities that wish to be eligible to receive FEMA funding for hazard mitigation grants, to adopt a local multi-hazard mitigation plan and update this plan in five year intervals.

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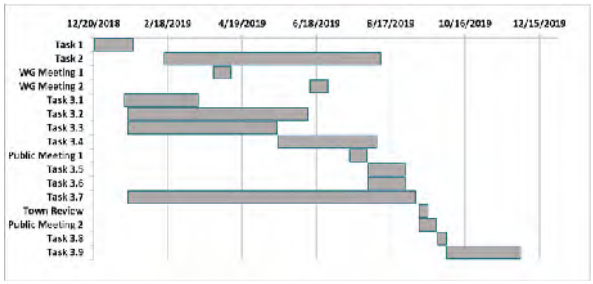
Plan Schedule



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Natural Hazard Mitigation Plan Update

Planning Goals:

- ✓ Document progress made per the 2014 Plan Update
- ✓ Update Town asset inventory
- ✓ Characterize the natural hazards and climate-change effects updates
- ✓ Assess current and future hazard vulnerability
- ✓ Provide public education and outreach throughout the planning process
- ✓ Revise and develop strategies and actions to mitigate the hazard risks
- ✓ Adopt the Plan Update

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Planning Process

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Project Overview

Planning Tasks:

1. Project Initiation
2. Conduct Working Group Meetings
3. Planning Process Documentation
4. Multi-Hazard Mitigation Plan Update Development
5. State and Federal Plan Review Revisions and Local Adoption

Harvey's Beach

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Planning Process

- Assess Risk:
  - Community Demographics/Social Vulnerability
  - Asset Inventory
  - Natural Hazards Characterization
  - Risk Assessment
- Mitigation Strategy and Actions
- Plan Adoption and Maintenance

Figure credit FEMA/Jenny Burmeier – Aug 21, 2017

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Plan Components

Table of Contents

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Town Setting

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Project Approach: GIS Data Management

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Westbrook – Town Setting

1. Uplands bordered by low-lying areas
2. 4 to 5 miles of coastline
3. Beaches – southern shoreline
4. Tidal Wetlands and Marshes
5. Brooks and Creeks
6. 21.4 sm: 15.7 sm land, 5.7 sm water

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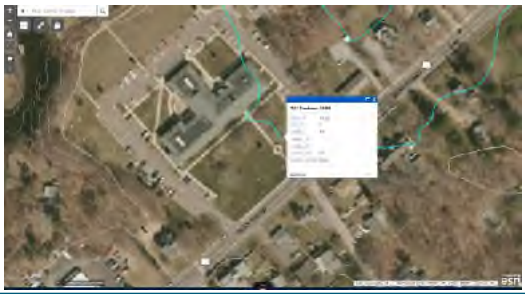
Topography and Available Lidar Data



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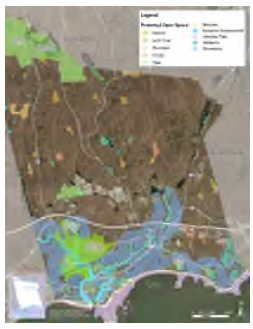
Town Setting

- topography/bathymetry
- shoreline features
- land cover
- geology
- natural resources
- ecology
- socioeconomic data



Buildings and Property

Buildings:

- Residential: 3861
- Commercial/Industrial: 213
- Vacant: 847 parcels

Median Housing Cost: $378,900

Public Schools: 3 (775 total enrollment)

Historic Properties: 27

- Federal: 1
- State: 26

Community Profile

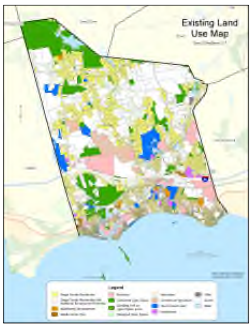
Land Use

People

- Population: +/- 6,956 people
- Land Area: about 15.7 square miles
- Population Density: about 439.6 people per square mile
- Median Age: about 46.6 years (compared to median age of 39 for the State)
- Households: 2,873
- Median household income: $95,583 (compared to State average of $73,433)

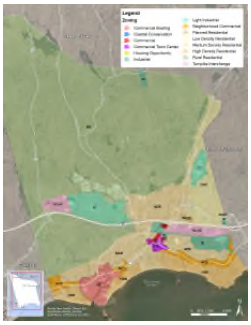
Land Use

- Single-Family Residential
- Single-Family Residential w/ Additional Development Potential
- Multi-family Development
- Mobile Home Park
- Business
- Dedicated Open Space
- Managed Open Space
- Agriculture
- Commercial/Agriculture
- Town Owned Land
- Institutional



Zoning Districts

- Commercial Boating (CB)
- Commercial Conservation (CC)
- Commercial (CD)
- Commercial Town Center (CTC)
- Housing Opportunity (HOD)
- Industrial (ID)
- Light Industrial (LI)
- Neighborhood Commercial (NCD)
- Planned Residential (PRDD)
- Low Density Residential (LDR)
- Medium Density Residential (MDR)
- High Density Residential (HDR)
- Rural Residential (RR)
- Turnpike Interchange (TIC)



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Coastal Structures

- Breakwater
- Bulkheads
- Seawalls
- Jetties
- Groins
- Docks and Piers
- Reinforced bluffs/revetments

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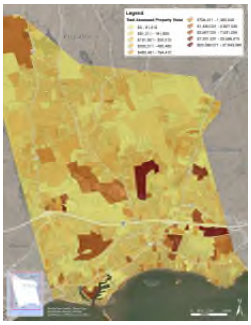
Property Assessed Value (2018)

- Real Estate Regular Net – $1.03 Billion
- Elderly Home Owners Net- $17.85 Million
- Motor Vehicle Net- $60.96 Million
- Personal Property Net - $42.09 Million
- Total Net Assessment - $1.15 Billion



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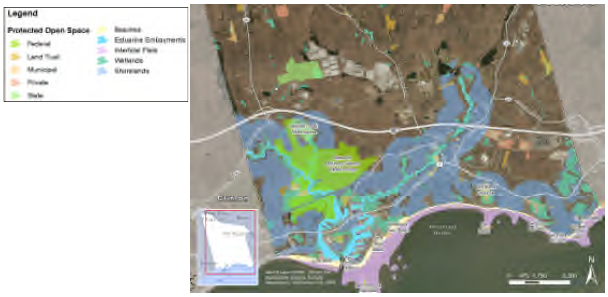
Coastal Wetlands & Critical Habitat



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Shoreline Features and Natural Resources

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Assets Inventory

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2014 Plan Asset Categories

Critical Facilities:
- 10 Facilities

Economic and Cultural Resources:
- Real estate (90.5% of total assessment)
- Top 4 Uses include:
  - Residential (36%)
  - Commercial/industrial (12%)
  - Preserved Open Space (19%)
  - vacant land (33%)
- Personal property (3.3% of total)
- Motor vehicles (4.7% of total)

Environment and Ecological Resources:
- Beaches
- Tidal and inland wetlands
- Long Island shoreline

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2014 Plan Asset Categories

Critical Facilities (10 Total)
- Public Works Garage
- Transfer Station
- High School & Middle School
- CT State Troop F
- Emergency Medical Facilities
- Emergency Shelter
- Library
- Ambulance
- Fire Department EOC
- Mulvey Municipal Center/ Police Department

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2019 Plan Update Asset Categories

1. Essential Facilities
2. Lifeline Utility Systems
3. Hazardous Material Facilities
4. High Potential Loss Facilities
5. Transportation Systems
6. Support, High Occupancy and Vulnerable Populations
7. Natural Resources
8. Shoreline Structures

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Essential Facilities

1. Hospitals/Healthcare
2. Emergency Shelters
3. Fire and Rescue
4. Emergency Response Centers
5. Police
6. Emergency Vehicle Garages
7. Aviation

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Essential Facilities

- Medical Centers/Healthcare Facilities: 2
- Police Station: 2 (1 local and 1 state)
- Fire/Rescue: 3
- Emergency Shelter: 2 (1 primary and 1 back-up)

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Lifeline Systems

- Electric Power Generation
- Electric Power Transmission
- Natural Gas
- Heating Oil
- Water Supply
  - Public
  - Private Wells
- Wastewater Distribution
  - On-site wastewater disposal
- Telecommunications

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Transportation Systems

ROADWAYS

- 1 Key Federal Roadway
  - Interstate -95
- 5 Key State Highways
  - Route 1 (Boston Post Road)
  - Route 145 (Old Post Road, Old Clinton Road, Horse Hill Road, Stevenstown Road)
  - Route 153 (Essex Road)
  - Route 166 (Spencer Plain Road)
  - Route 625 (Grove Beach North)
- 32 Key Local Roads that are subject to nuisance flooding and more significant coastal flooding based on the 2014 NHMP

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Support, High Occupancy and Vulnerable Population

- Community Centers
- Fueling Stations
- Hotels and Inns
- Pre-school and Childcare Facilities
- Religious Institutions
- Schools
- Theaters
- Town Administration Buildings

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Transportation – Key Local Roadways

Sample of Key Local Roadways:

- Winthrop Road Bridge,
- East Pond Meadow Road,
- Doc's Hill Road
- Salt Island Road,
- Pepperidge Ave.,
- Stokes Ave., Gerard Ave.
- Chapman Beach Rd.,
- Waldron Dr.
- Dolphin Ave.
- Striper, Tarpon Ave.
- Toby Hill Road
- McVeagh Road
- Meetinghouse Lane
- Willard Avenue
- Pond Meadow Road
- E. Pond Meadow Road
- Boone Circle
- Old Clinton Road
- Boston Post Road
- Hammock Road N.
- Grove Beach Road S.
- Elm Ave.
- Menunketesuck Road

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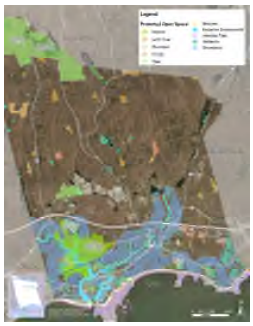
Natural/Ecological Resources

- Beaches
- Marshes and Intertidal Flats
- Estuary Embayments
- Wetlands
- Shorelands



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Transportation Systems

BRIDGES

- I-95 Menunketesuck River Bridge
- I-95 Patchogue River Culvert
- Route 145 (Horse Hill Road) over I-95
- Route 153 (Essex Road) over I-95
- Chapman Mill Pond Road over I-95
- Route 1 Menunketesuck River Bridge
- Route 1 Patchogue River Bridge
- Amtrak Menunketesuck River Bridge
- Amtrak Patchogue River Bridge
- Route 145 (Old Clinton Road) Patchogue River Bridge
- Route 145 (Old Clinton Road) Menunketesuck River Bridge
- Wesley Avenue over Patchogue River Bridge
- Grove Beach Road N. over Amtrak

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High Loss Potential Facilities: Dams

High Loss Potential Facilities:

- Dams: 3
  - Chapman Pond Dam
  - Wrights Pond Dam
  - Messerschmidt Pond Dam

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Natural Hazards

Characterize Flood Hazards

- ✓ Coastal flooding:
  - tides
  - storm surge
  - waves
- ✓ Coastal erosion/sediment transport
- ✓ Precipitation (river flood, storm water, building damage)
- ✓ Riverine Flooding
- ✓ High wind
- ✓ Effects of sea level rise

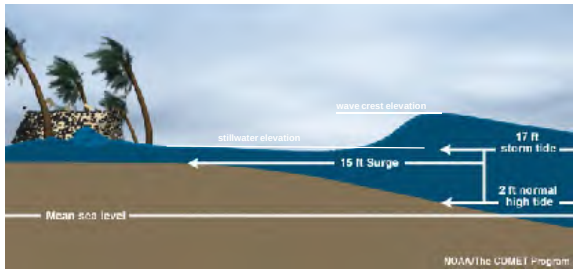
Accurate, scientifically sound and probabilistic characterization of coastal hazards is important

Flooding in Westbrook on Beach Way (image ref. https://fox61.com/2018/03/02/noreaster-pays-a-visit-to-westbrook/

2014 Plan Natural Hazard Categories

- ✓ Flooding
- ✓ High Wind & Tornado
- ✓ Drought
- ✓ Winter Storms
- ✓ Earthquake
- ✓ Hurricane & Tropical Storm
- ✓ Summer Storm
- ✓ Wildfire
- ✓ Tsunami

Coastal Flooding



GEOGRAPHICAL FACTORS

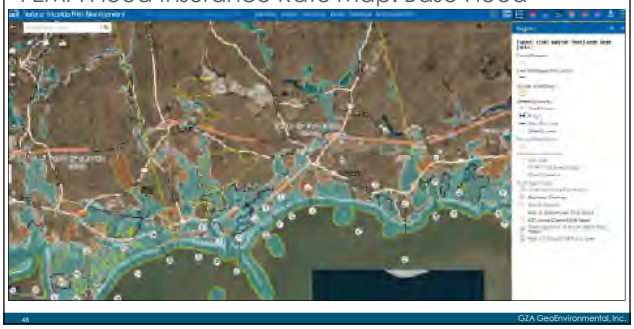
STORM FACTORS

2019 Plan Update Natural Hazard Categories

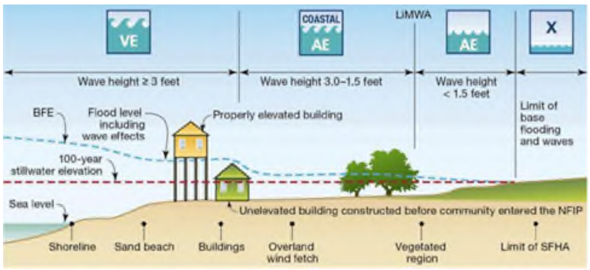
- 19 natural hazards identified as applicable to Town
- Four hazard categories:
  - ✓ Severe Weather Hazards
  - ✓ Climate-Related Hazards
  - ✓ Geologic Hazards
  - ✓ Secondary Hazards

Severe Weather Hazards:
Severe Wind:
Hurricanes/Tropical Storms
Thunderstorms
Tornadoes
Lightning
Hail
Flood:
Storm Surge
Sea Level Rise
Urban Drainage Flooding
Riverine Flooding
Intense Rainfall
Severe Winter Weather
Snowfall
Ice Storms
Climate-Related Hazards:
Extreme Temperature:
Heat
Cold
Drought
Wildfire
Geologic Hazards:
Earthquake
Landslides
Tsunami
Secondary Hazard:
Dam Failure

FEMA Flood Insurance Rate Map: Base Flood



FEMA Flood Hazard Zones



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Examples of Coastal Flooding Vulnerability

✓ Property Damage

Waves during Tropical Storm Irene in Westbrook
image from https://www.courant.com/courant-250/moments-in-history/hc-250-hurricanes-weather-story-htmlstory.html

Coastal Flooding at Grove Beach
image from #Stormhour @ryanhanrahan @RachelFrank_CT @KaitMcGrathNBC @gilsimmons/

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Examples of Coastal Flooding Vulnerability

✓ Impacted Essential Facilities
✓ Evacuation and Sheltering Impacts

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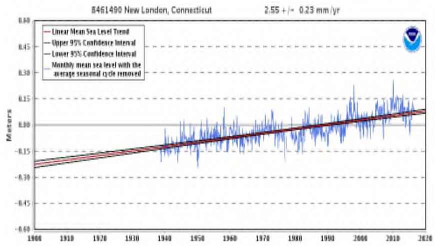
Sea Level Rise – Historical New London Tide Gage



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Planning Implications of Sea Level Rise

State of Connecticut Guidance and Regulation:
- PA 12-101
- PA 13-179

Must Consider RSLC:
- Plans of Conservation and Development
- Hazard Mitigation Plans
- Coastal Management
- Inconsistencies in definition of sea level rise
- Does not consider structure criticality

State Guidance: UCONN/CIRCA:
- Mid-range Planning 1.7 feet by 2050
- Long Term – be aware 3.25 feet by 2100
- Updated every decade

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Climate Change Effects

Projected Sea Level Rise Near Westbrook:
2040: 0.05 to 1.23 feet
2065: 0.24 to 2.96 feet
2100: 0.5 to 6.46 feet

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Examples of Coastal Flooding Vulnerability

- ✓ Shoreline Change

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Implications of Sea Level Rise

1. Increased frequency, extent and depth of coastal flood inundation
2. Larger wave effects
3. Increased rate of shoreline erosion
4. Long term effects on salt marshes
5. Increased amount of property damage and economic losses
6. Long term effects to economic development
7. Long term reduction to Muni Bond Rating
8. Loss of future real estate tax revenue

Street flooding in Westbrook following March 2, 2018 Nor'easter)Image from: https://www.youtube.com/watch?v=06obs2Gog3s)

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Next Steps

1. Complete Risk Assessment
2. Update Mitigation Strategy and Actions
3. 2nd Public Meeting – September 16, 2019
   - Risk Assessment Results
   - Updated Mitigation Strategy & Actions
4. Provide Draft Natural Hazards Mitigation Plan Update for review

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Thank you for attending!

Questions? Comments?

Samuel J. Bell: samuel.bell@gza.com
O: 781.278.3847 or M: 781.223.7091

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Public Notice

Natural Hazard Mitigation Plan Update Public Meeting:
September 16, 2019
7:00 PM – **Meeting Room A**, Mulvey Municipal Center
866 Boston Post Road, Town of Westbrook

The Town of Westbrook will hold a second public meeting on Monday, September 16, 2019 at 7pm at Town of Westbrook Mulvey Municipal Center, 866 Boston Post Road focused on the Town's Natural Hazard Mitigation Plan Update (HMP Update). The purpose of the second meeting is to present the results of the risk assessment and the proposed natural hazard mitigation strategy and actions for Westbrook. The Town designed the proposed strategy and actions to reduce the loss of life and property from natural hazards including but not limited to coastal flooding, sea-level-rise, severe wind resulting from hurricanes, and other natural and climate-related hazards.

A critical component of the planning process is open public involvement where the Town will provide the public with the opportunity to provide input and comments on the risk assessment results and the proposed natural hazard mitigation strategy and actions. All comments received from the public will be documented and considered for inclusion in the HMP Update. All members of the community are encouraged to attend.

For more information on this project please contact Eric Knapp, Planning, Zoning and Development Coordinator, Land Use Department, at (860) 399-3041 or by email at eknapp@westbrookct.us. Soon after this public meeting, the Town will post the Final Draft HMP Update online for additional review and feedback by members of the community and stakeholders.

Westbrook Planning Commission SPECIAL Meeting
AGENDA
September 16, 2019 - 7:00 PM
Mulvey Municipal Center, 866 Boston Post Road
Meeting Room A

1. **CALL TO ORDER**.
2. **Natural Hazard Mitigation Plan Update public session**
   - **a.** Presentation by Planning, Zoning and Development Coordinator and GZA consultant, Samuel Bell
   - **b.** Input from Public
3. **ADJOURNMENT**

   Attested to: Eric Knapp, Planning, Zoning and Development Coordinator

Town of Westbrook
Natural Hazard Mitigation Plan Update
Public Meeting
September 16, 2019

SIGN-IN SHEET

NAME	DEPARTMENT	EMAIL
Marc + Christine Rizzo		Storei95@yahoo.com
Rich + Leah Stancil 8 Tarpon Ave		RTSTANCIL@GMAIL.COM
Louise Baldwin 8 Dolphin Ave		lbaldwin@gmail.com
Maria Botelho + Ron 47 Striper Ave		MEABotelho@gmail.com
Noel B.E. Hop Fish + Selectm		
WALTER CWIKLA 55 TARPON AVE		
Alan Stewart 39 Tarpon Ave		
David Bongiorno 11 Tarpon Ave		
Shirley Mickens	WPCC	SMickens@westbrookct.us
Hiram Fuchs		
Alberta Jane Gould		janegould2@comcast.net
Donald Hodgdon		Donhodgdon@Shaw.com

PLANNING COMMISSION

SIGN IN 9/16/19

NATURAL HAZARD MITIGATION PLAN WORKSHOP

Peter Wiese	49 Dolphin
Bruce Monahan	20 Striper Ave
Mary Jane Monahan	20 Striper Ave
Joe Balducci	25 STRIPER AVE
Tom Santello	35 Dolphin Ave
Anne-Marie Cerra	26 Striper AVE
Deborah Belfiore	34 Striper Ave
Robert Belfiore	34 Striper Ave.
Dario Hospen	12 Striper Ave.
[illegible]	55 Tarpon Ave
Deb Polun & Ian Polun	40 Dolphin Avenue
David Carey	70 Post Avenue
Donna & Gary Aiken	38 Striper Ave
Janet Perry	857 Boston Post Rd
Donald Hodean	373 Seaside ave

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Today's Meeting

- Natural Hazard Mitigation Plan Overview
- Risk Assessment Results
- Mitigation Strategy and Actions
- Next Steps

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Plan Overview

Natural Hazard Mitigation Plan Overview

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Planning Goals:

- ✓ Document progress made per the 2014 Plan Update
- ✓ Update Town asset inventory
- ✓ Characterize the natural hazards and climate-change effects updates
- ✓ Assess current and future hazard vulnerability
- ✓ Provide public education and outreach throughout the planning process
- ✓ Revise and develop strategies and actions to mitigate the hazard risks
- ✓ Adopt the Plan Update

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Why it matters…

- Eligibility for grant funding
- Public Safety
- Prevent Town losses and operating costs
- Prevent private property loss
- Maintain tax base
- Support Economic Development and Conservation Planning (Plan of Conservation and Development Update)
- Maintain municipal bond rating

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Plan Outline

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Planning Process

1. Assess Natural Hazard Risk:
   - Community: Demographics/Social Vulnerability
   - Asset Inventory
   - Natural Hazards Characterization
   - Risk Assessment
2. Mitigation Strategies and Actions
3. Plan Adoption and Maintenance

Figure credit: FEMA/Jenny Burmester – Aug 21, 2017

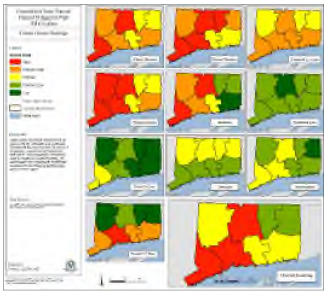
Overview of Findings

Risk Assessment Results

Significant Natural Hazards – 2019 State Plan Update

Top-ranked hazards include:

- Tropical Cyclone (Hurricane and Tropical Storm)- MH
- Sea Level Rise - MH
- Thunderstorm-Related Hazards – MH
- Flood Related Hazards - M
- Winter Weather - M
- Drought - ML
- Wildland Fire - ML
- Earthquake - ML
- Dam Failure - L
- Tornado - L



2014 Plan Natural Hazard Categories

- ✓ Flooding
- ✓ High Wind & Tornado
- ✓ Drought
- ✓ Winter Storms
- ✓ Earthquake
- ✓ Hurricane & Tropical Storm
- ✓ Summer Storm
- ✓ Wildfire
- ✓ Tsunami

GZA Plan Natural Hazard Classification and Ranking

1. Likelihood/Frequency
2. Severity/Magnitude
3. Impact Area

Natural Hazard Characterization and Ranking

Frequency:

Very Low: Events that occur less frequently than once in 1,000 years (less than 0.1% per year).

Low: Events that occur from once in 100 years to once in 1,000 years (0.1% to 1% per year)

Medium: Events that occur from once in 10 years to once in 100 years (1% to 10% per year).

High: Events that occur more frequently than once in 10 years (greater than 10% per year).

Natural Hazard Characterization and Ranking

Severity:

Minor: Limited and scattered property damage; no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e., 1 or 2 communities); essential services (utilities, hospitals, schools, etc.) not interrupted; no injuries or fatalities.

Serious: Scattered major property damage (more than 50% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services are briefly interrupted; some injuries and/or fatalities.

Extensive: Consistent major property damage; major damage to public infrastructure (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and fatalities.

Catastrophic: Property and public infrastructure destroyed; essential services stopped, thousands of injuries and fatalities.

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Natural Hazard Characterization and Ranking

Likelihood/Frequency		
Point Value	Category	Characteristics and Frequency
1	Very Low	Events that occur or are exceeded less often than once in 100 years (less than 1% probability)
2	Low	Events that occur or are exceeded from once in 50 years to once in 100 years (1% to 2% probability)
3	Medium	Events that occur or are exceeded from once in 5 years to once in 50 years (2% to 20% probability)
4	High	Events that occur or are exceeded more frequently than once in 5 years (greater than 20% probability)
Severity/Magnitude		
Point Value	Category	Characteristics
1	Minor	Limited and scattered property damage; no damage to public infrastructure (roads, bridges, trains, airports, public parks, etc.); contained geographic area (i.e., 1 or 2 communities); essential services (utilities, hospitals, schools, etc.) not interrupted; no injuries or fatalities.
2	Serious	Scattered major property damage (more than 50% destroyed); some minor infrastructure damage; wider geographic area (several communities); essential services are briefly interrupted; some injuries and/or fatalities.
3	Extensive	Consistent major property damage; major damage to public infrastructure (up to several days for repairs); essential services are interrupted from several hours to several days; many injuries and fatalities.
4	Catastrophic	Property and public infrastructure destroyed; essential or lifeline services stopped; thousands of injuries and fatalities.
Impact Area Assessment		
Point Value	Category	Characteristics
1	Small	In localized, unpopulated or lightly areas of Town, without structures or critical facilities
2	Medium	Impacting only portions of the Town
3	Large	Town-wide and/or essential and lifeline facilities

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Plan Update Hazards Rankings

- 19 natural hazards identified as applicable to Town
- Four hazard categories:
  - ✓ Severe Weather Hazards
  - ✓ Climate-Related Hazards
  - ✓ Geologic Hazards
  - ✓ Secondary Hazards

Severe Weather Hazards:	Rank
Severe Wind:	
Hurricanes/Tropical Storms/Nor'easter	3
Thunderstorms	6
Tornadoes	5
Lightning	8
Intense Rainfall	5
Hail	7
Flood:	
Storm Surge	1
Sea Level Rise	2
Urban Drainage Flooding	5
Riverine Flooding	4
Severe Winter Weather	
Snowfall	4
Ice Storms	6
Climate-Related Hazards:	
Extreme Temperature:	
Heat	8
Cold	8
Drought	7
Wildfire	9
Geologic Hazards:	
Earthquake	7
Landslides	0
Tsunami	0
Secondary Hazard:	
Dam Failure	4

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Top-Ranked Town Hazards

1. Flooding due to coastal storms
2. Sea Level Rise
3. Hurricanes/Tropical Storm/Nor'easters (Severe Wind)
4. Severe Winter Weather

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Example – Severe Wind

Nor'easters, Tropical Storms and Hurricanes

Tornadoes

Thunderstorms: macrobursts and microbursts

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Example – Severe Wind

- **Wind Advisory**: 1) sustained winds of 31 to 39 mph for an hour or more; and/or 2) wind gusts of 46 to 57 mph for any duration.
- **High Wind Watch/Warning**: 1) sustained winds of 40 mph for one hour or more; or 2) wind gusts of 58 mph or higher for any duration.
- **Hurricane Warning**: sustained winds of 74 mph or higher or frequent (for more than 2 hours) gusts of 74 mph or greater associated with a tropical cyclone.
- **Extreme Wind:** 1) surface winds of 115 mph or greater associated with a derecho or sustained hurricane winds.

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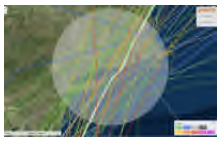
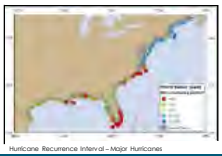
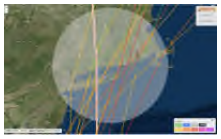
Example – Severe Wind (Hurricanes and Tropical Storms)


Hurricane Recurrence Interval – All Hurricanes


Hurricanes and Tropical Storms within 100 miles of Westbrook


Hurricane Recurrence Interval – Major Hurricanes


Hurricanes within 100 miles of Westbrook

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Example – Severe Wind

Town of Westbrook Natural Hazard Mitigation Plan Update

Natural Hazard	Likelihood/Frequency	Severity/Magnitude	Impact Area
SEVERE WEATHER HAZARDS			
Severe Wind:			
Hurricanes/Tropical Storms/ Nor'easters	• High Wind Warning (>40mph): +/- 100% AEP (1-year recurrence interval); **High** • Hurricane Wind Warning (>74mph): 1% AEP (100-year recurrence interval); **Medium to Low** • Extreme Wind Warning (>115 mph) <0.2% AEP (>500-year recurrence interval); **Very Low**	Minor Extensive Catastrophic	Town-wide
Thunderstorms (wind >58 mph)	• Within Middlesex County: 54% AEP or minimum of 1-year to 2-year recurrence interval. (26 years with 1 or more events over 52 years). Probability of occurrence within Westbrook is likely lower; **Medium to High**	Minor	Town-wide or portions of town
Tornadoes	• Tornadoes within Middlesex County: 12% AEP or 8-year recurrence interval (8 years with 1 or more events over 88 years); **Medium** • Major tornado within Middlesex County: 1.3% AEP or 70-year recurrence interval; **Low** • Based on the proportional land area, the Westbrook tornado AEP is about 0.2% and the Westbrook major tornado AEP is very low (less than 0.2%). **Very Low**	Serious to Catastrophic	Town-wide or portions of Town

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Strategies and Actions

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Mitigation Strategy Approach

1. Hazard Risk Mitigation Goals
2. Hazard Mitigation Implementation and Progress
3. Existing Hazard Mitigation Capabilities
4. Hazard Risk Mitigation Measures/Actions

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2019 Plan Update **Goals**

1. Reduction or elimination of injury to or loss of life and property, loss of natural environments, the associated economic impacts from natural hazards
2. Promote Implementation of sound Floodplain Management and Other Natural Hazard Mitigation Principals on a Local Level;
3. Implementation of Effective Natural Hazard Mitigation Projects on a Local Level
4. Increase Research and Planning Activities for the Mitigation of Natural Hazards on a Local Level
5. Increase and Promote Response Preparedness

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2014 to 2019 Hazard Mitigation **Accomplishments**

Natural Hazard Mitigation Plan Implementation, Maintenance & Review

- ✓ The Town's lead agencies report on implementation of the Plan throughout its annual report.
- ✓ 5-Year Review and 2019 Plan Update.
- ✓ Participated in annual updates to the 5-year capital improvement programs at the State, Regional and municipal levels that resulted in funding hazard mitigation actions.

Planning & Regulatory Standards

- ✓ Maintained, and strengthened (as needed), subdivision and zoning regulations to make safer new roads, lots and structures to natural hazards (NHs) such as flooding, wind-related hazards, etc..
- ✓ Evaluated land use proposals within the Coastal Boundary for consistency with the CT Coastal Management Act.

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2014 to 2019 Hazard Mitigation **Accomplishments**

Information Systems, Data Management & Analysis

- ✓ Completed an inventory of storm water catch basins and outfalls in the MS4 area as a part of the asset management program to facilitate maintenance of stormwater systems, develop estimates for upgrades and assess repair costs in the event of damage from NHs.
- ✓ Upgraded existing Permitting Tracking System to enable collection of data regarding development activities in Flood Hazard Areas.
- ✓ Converted paper records maintained by the Land Use Dept. to an electronic format, consistent with any State recommendations.
- ✓ Required structural engineering reports for expansion or alteration of buildings within the V zone from 2014 to 2019.

2014 to 2019 Hazard Mitigation **Accomplishments**

Physical & Infrastructure Improvements

- ✓ Completed the replacement of the Winthrop Rd. Bridge in 2017.
- ✓ Evaluated the Old Mail Trail, Grove Beach Rd. S, Riverview, Menunketesuck, Elm Ave. and other town locations

Natural Systems Protection Improvements

- ✓ AQUIFER RECHARGE: Continued to protect areas of high groundwater recharge potential as identified in the Recharge Mapping Study.
- ✓ Promoted the implementation of riparian buffers for existing and new waterfront development utilizing the Coastal Riparian Landscaping Guide for Long Island Sound

2014 to 2019 Hazard Mitigation **Accomplishments**

Public Information and Outreach

- ✓ OEM WEBPAGE/FACEBOOK/TWITTER: Continued to maintain and update the OEM website and Facebook page with Natural Hazard Preparedness & Recovery Information.
- ✓ ON-LINE MAPPING: The Town continued to publicize the availability of GIS hazard mapping on the town website.

Actions to Reduce Risk and Minimize Impacts During NH Events

- ✓ GROUP HOMES DISASTER PLANS: Westbrook continued to work with Group Homes and other facilities housing populations with unique vulnerabilities.
- ✓ FIREFIGHTER TRAINING AND EDUCATION: The Westbrook Fire Department completed annual training and education of firefighters for brush and forest fires, with consideration for large areas of phragmites.

Updated Town Hazard Mitigation **Capabilities**

26 EXISTING PROGRAMS IN PLACE

- Highlights:
  - General Multiple Hazards
    - ❑ 12 Mitigation Capabilities
  - Severe Weather Hazards - Flood Related Hazards
    - ❑ 8 Mitigation Capabilities
  - Severe Weather Hazards – Severe Wind, Snowfall and Ice Storms
    - ❑ 3 Mitigation Capabilities
  - Climate Related Hazards – Fire Related Hazards -
    - ❑ 3 Mitigation Capabilities

Multiple Hazards Mitigation **Capabilities**

- ✓ Design Standards (i.e. enforcement of State Building & Fire Codes)
- ✓ Local Emergency Operations Plan
- ✓ Land Use Regulations: Subdivision and Zoning Regulations
- ✓ Emergency Management Public Notifications
- ✓ Emergency Generators
- ✓ Group Homes Permitting
- ✓ Geographic Information Systems
- ✓ Electronic & Paper Records Preservation

Severe Weather Hazards: Flood Related Hazards Mitigation **Capabilities**

- ✓ Participation in the National Flood Insurance Program (NFIP)
- ✓ Dam Emergency Action Plans
- ✓ Design Standards (Flood Regulatory Enforcement)
- ✓ Stormwater Management
- ✓ Water Quality Monitoring
- ✓ Street Sweeping and Leaf Removal

Coastal Flooding at Grove Beach
image from #Stormhour @ryanhanrahan @RachelFrank_CT @KaitMcGrathNBC @gilsimmons/

Severe Weather Hazards: Wind and Winter Weather Mitigation **Capabilities**

- ✓ Mandatory Wind Code Compliance
- ✓ Tree Trimming
- ✓ Roadway Treatments

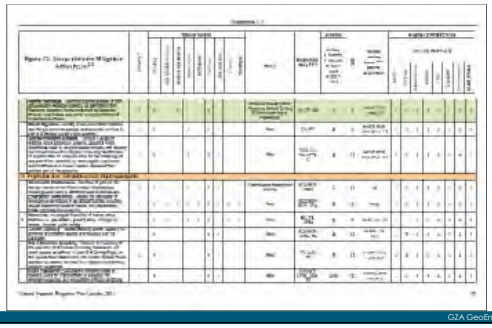
Climate Related Hazards: Fire Related Hazards Mitigation **Capabilities**

- ✓ Permits Required for Outdoor Burning
- ✓ Fire Hydrant Regulations
- ✓ Subdivision Review

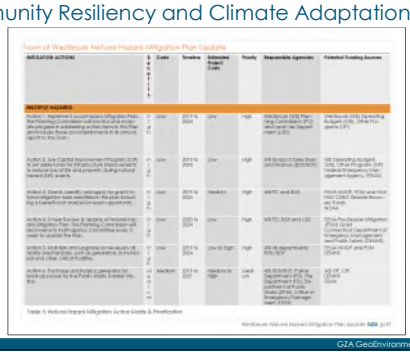
Mitigation Actions **Approach**

1) Identified and integrated ongoing and yet to be completed actions from 2014 HMP Update
2) Focused development of new actions on top ranked hazards
3) Conducted a Benefit/Cost Review to Prioritize Actions
4) Proposed Estimated Timeline for Implementation
5) Prepared Planning Level Estimated Project Costs
6) Identified Responsible Department(s) for Town
7) Identified Potential Funding Sources

2014 Mitigation **Actions**



Coastal Community Resiliency and Climate Adaptation Study **Actions**



Plan Update Mitigation and Resilience **Actions**

65+ mitigation actions:

- 30 Multiple Hazards Actions
  - o 15 High Priority Actions
- 20 Flood-Related Hazards Actions
  - o 13 High Priority Actions
- 12 Sea Level Rise Hazards Actions
  - o 8 High Priority Actions
- 3 Secondary Hazards: Dam Failure
  - o 3 High Priority
- 8 Climate Related Hazards: Drought, Wildfire & Extreme Temperatures
  - o 6 High Priority Actions
- 2 Severe Winter Weather
  - o 1 High Priority Action

Multiple Hazards **High Priority Actions**

- ✓ **Local Hazard Mitigation Plan**: The BOS/BOF will monitor and evaluate progress in implementing action items in this Plan and include those accomplishments in its annual report to the Town.
- ✓ **5-Year Review & Update of Natural Hazard Mitigation Plan**
- ✓ **Maintain and upgrade as necessary for all facility mechanicals, such as generators, in municipal and other critical facilities.**
- ✓ **Keep up-to-date inventory of town assets** in the Town's comprehensive GIS database including asset categories outlined in this 2019 NHMP Update.

Multiple Hazards **High Priority Actions**

- ✓ **Capital Improvement Program (CIP)**: Set aside funds for infrastructure improvements to re-duce loss of life and property during natural hazard (NH) events.
- ✓ **Grant Application and Administration Plan (GAAP):** Prepare detailed application plan for grant opportunities, including FEMA Hazard Mitigation Grant, USACE, NOAA, HUD, CIRCA, DOT, DECD and EPA programs. Initiate grant applications.
- ✓ **Recovery and Reconstruction Plan**: Prepare a post-disaster recovery and reconstruction plan to re-establish infrastructure and public services, etc. damaged or destroyed by any NH event, including establishment of a "rainy day" fund in case Federal assistance is insufficient or delayed.

Multiple Hazards **High Priority Actions**

- ✓ Establish a **Disaster Recovery and Reconstruction Rainy Day Fund** in case federal disaster assistance funding is not sufficient or delayed.
- ✓ **Multi-Hazard Public Awareness Program.** Develop and implement a multi-hazard public awareness program. Provide information on all types of hazards, preparedness and mitigation measures, responses during hazard events and financial assistance programs.

Multiple Hazards **High Priority Actions**

- ✓ **Education and Outreach to residents and community stakeholders to:**

  1) promote owner participation in mitigation efforts to protect their property;

  2) educate public on how the Town uses conservation planning, regulations to mitigation natural and climate related hazards;

  3) educate residents and community stakeholders at high risk to impacts from natural hazards on the hazards relative to where they live.

Multiple Hazards **High Priority Actions**

- ✓ **Tenant Notification:** Develop a mechanism for tenants to register for disaster notifications.
- ✓ **Conduct Natural Hazard Mitigation Training on an annual basis.**
- ✓ **Immobile Evacuees Planning**: Review annually the program to evacuate persons without means of transportation, including registration and house numbering.
- ✓ Conduct a **municipal buildings capabilities assessment**. The purpose of the assessment will be to identify buildings for future investment for renovation or new construction to ensure the candidate buildings are in compliance with standards for use as a shelter.

Flood Related Hazards **High Priority Actions**

- ✓ **Continue to participate in National Flood Insurance Program (NFIP)** (or other) training offered by the State and/or FEMA that ad-dresses flood hazard planning and management.
- ✓ Participate in **reviews of regulatory floodplain maps updates** and revisions.
- ✓ Obtain **updated aerial imagery** and planimetric data in order to allow for assessment of such factors as extent of damage from NHs, compliance with building standards, identification of shoreline hardening and shoreline erosion and accretion.
- ✓ **Encourage Repetitive Loss Property Owners to pursue flood mitigation funding** for actions such as elevation or acquisition of structures where appropriate on a voluntary basis.

Flood Related Hazards **High Priority Actions**

- ✓ **Town Beach Dune Restoration.** Evaluate potential alternatives for the restoration of dunes along West Beach to develop a range of solutions that will renew the coastal beach and dune system, provide storm damage protection for local residents, increase flood control for adjacent properties, and restore an important Town resource.
- ✓ **Patchogue & Menunketesuck River Mitigation Plan.** Develop and implement mitigation plans for previously identified nutrient and sediment nonpoint source pollution sites to reduce vulnerability to coastal storms, sea level rise, flooding, and erosion.
- ✓ **Shore Protection and Dune Restoration Systems.** Conduct a study of existing shore protection systems along the entire Westbrook coast to analyze overall impacts and develop recommendations for mitigation including identification of opportunities for compensation for the hardening of one part of the shoreline by removing the equivalent extent of flood and erosion control structures from another part of the shoreline.

Flood Related Hazards **High Priority Actions**

- ✓ **Floodplain Management Studies.** Update Floodplain Management studies for Patchogue River, Town Center and Cold Springs Brook Watersheds.
- ✓ **Road Evaluation:** Evaluate roads to develop plans for improvement or elevation for emergency access and evacuation.
- ✓ **Develop conceptual plans and prioritization for pursuing engineering, design and construction funding of roadways** identified in the 2014 Plan Update.

Flood Related Hazards **High Priority Actions**

- ✓ **Repetitive Loss Area Analysis (RLAA).** Many repetitive loss (RL) structures have been demolished and rebuilt or elevated to higher standards than minimum FEMA requirements. Based on this ex-tensive and successful effort by the Town and residents, it is recommended to perform a formal RLAA to identify the impact to Town's NFIP insurance rate due to repetitive loss. The results from the RLLA will help further support Town and property owner resilience and mitigation activities, including acquiring, relocating and/or flood mitigation of RL properties.
- ✓ **STORMWATER. Analyze the existing stormwater infrastructure under precipitation only and combined coastal flood-precipitation events.** This data is necessary to comprehensively characterize the Town's flood risk and to identify the need for additional catch basins/pump stations/additional tide gates/green infrastructure.

Sea-Level-Rise Hazards **High Priority Actions**

- ✓ **Sea Level Rise.** Seek grants funds or collaborate with an academic institution to research and study the social, economic, environmental and policy-related impacts from SLR.
- ✓ Prepare a **Coastal Community Resilience and Climate Adaptation Study**.
  - ✓ Include development of a **roadway improvement plan** that includes a strategy of improving the portions of key roads that are subject to chronic and high probability floods in the near-term.
  - ✓ Include a **Marsh Migration Analysis** to Identify areas where tidal marshes are likely to advance upslope as sea levels continue to rise and develop conservation strategy.

Sea-Level-Rise Hazards **High Priority Actions**

- ✓ NATIONAL FLOOD INSURANCE PROGRAM (NFIP). Until FEMA changes their mapping guidelines to address sea level rise, provide residents with **Town-specific flood hazard maps** reflecting sea level rise projections for 2050 and 2100, in line with the State of Connecticut.
- ✓ Every 10-years, update future coastal flood risk overlay maps and sea level rise projections.

Sea Level Rise Hazards **High Priority Actions**

- ✓ **Develop program to evaluate and maintain existing groins and sea walls.**
- ✓ Evaluate of the technical **feasibility of constructing dunes and berms** into the plan.
- ✓ **Coordinate with USACE relative to pro-posed, future dredge projects and re-use of dredge materials for Town beach nourishment, salt marsh maintenance and restoration projects.**
- ✓ **Barrier Island Stabilization/Restoration.** Develop and implement plans, in cooperation with local, state and federal landowners, to stabilize and restore Westbrook's three barrier islands; Salt Island (local), Duck Island (CTDEEP) and Menunketesuck Island (USFW).
- ✓ **Salt Island Overlook Habitat Restoration -** Develop & Implement Forest Tree Planting Plan for Salt Island Overlook to restore a coastal forest habitat and increase coastal storm resiliency.

Hurricane-Wind Hazards **High Priority Actions**

- ✓ **Debris Management Plan.** Develop plan to facilitate and coordinate the removal, collection, and disposal of debris following a disaster, to mitigate against any potential threat to the health, safety, and welfare of the impacted citizens, expedite recovery efforts in the impacted area, and address any threat of significant damage to improved public or private property.
- ✓ **Boats.** Identify places where people could store their boats during flooding and hurricane events that would reduce the damages.

Secondary Hazards: Dam Failure **High Priority Actions**

- ✓ **Dam Owners responsible for review and update of Emergency Action Plans (EAP) and Maintenance and Operations Plans** for the 3 High Hazard Dams per state requirements to ensure the plans are up to date & have protocols in place to maintain safe operations of the Dams.
- ✓ **Per the EM emergency operations plan** assess downstream risks due to catastrophic failure.

Climate Related Hazards **High Priority Actions**

DROUGHTS

- ✓ **Coordinate with the CWC on public education and public service** announcements in anticipation of and during times of drought.

Climate Related Hazards **High Priority Actions**

WILDFIRE

- ✓ **Firefighting Infrastructure Analysis**: Evaluate existing firefighting infrastructure to identify needs for improvement to cover gaps in availability.
- ✓ **Forest Management Plans.** Include provisions in existing and future forest management plans to provide emergency access to fire-fighters in the event of wildfires in Town-owned Open Space.
- ✓ **Wildfire Management Plan. Evaluate and consider development** a wildfire management plan and protocol.

Severe Winter Hazards **High Priority Actions**

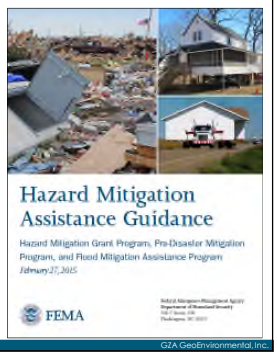
- ✓ **Maintain adequate supply of sand, salt and other road treatment materials.**

Federal **Funding Opportunities**

- **FEMA Hazard Mitigation Assistance Grants**
  - Hazard Mitigation Grant Program (HMGP)
    - **DR-4385 & 4410 - $275k**
  - Flood Mitigation Assistance (FMA)
    - **FY18- $160 Million**
  - Pre-Disaster Mitigation (PDM)
    - **FY18- $235 Million**

  https://www.fema.gov/hazard-mitigation-assistance
- **HUD Disaster Recovery and Resiliency Grants**
  - Community Development Block Grant (CDBG) Disaster Recovery

  https://www.hudexchange.info/programs/cdbg-dr/



Federal **Funding Opportunities**

- **EPA Water Infrastructure Finance and Innovation Act**
  - $6Billion in credit that could finance $12Billion in water infrastructure projects – FY2019
- **NOAA Coastal Resilience Grant Program**
  - $12 Million available annually 2015 to 2017
  - Focus Areas
    - Natural and nature-based infrastructure
    - Post-disaster recovery
    - Assessing risk, prioritizing actions

  https://www.coast.noaa.gov/data/resilience/factsheet-resilience-grants.pdf

State and Additional **Funding Opportunities**

- **Connecticut Resilience Programs**
  - **CIRCA Grants -** $100-$300k annually
    - Municipal Resilience Grant Program
    - https://circa.uconn.edu/funds-muni/
    - Matching Funds Program
    - https://circa.uconn.edu/funds/
  - **Connecticut's Clean Water Fund**
  - **Non-point Source (Section 319) Grant Program**
- **Tax Increment Financing**
- **Local and State Tax Revenue**
- **Resilience Bonds**

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Next Steps

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Next Steps

1. Provide Draft Plan to Town for Town and Public Review
2. Revise Draft Plan and submit to CT DEMHS/FEMA for review
3. Revise Draft Plan submitted to CT DEMHS/FEMA, as needed
4. Submit Final Plan to CT DEMHS/FEMA for final review, as needed
5. Plan Adoption

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Attachment 7: References and Resources

Attachment 7: References and Resources

- Connecticut 2019 State Natural Hazard Mitigation Plan. (https://portal.ct.gov/-/media/DEMHS/_docs/Plans-and-Publications/State-of-Connecticut-Natural-Hazard-Mitigation-Plan---2019.pdf)
- Connecticut 2018 State Building Code. (https://portal.ct.gov/DAS/Office-of-State-Building-Inspector/Connecticut-State-Building-Code/Regulations)Connecticut Confronting Climate
- Change in the U.S. Northeast, Union of Concerned Scientists 2007 https://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/pdf/confronting-climate-change-in-the-u-s-northeast.pdf
- Federal Emergency Management Agency (FEMA), Local Mitigation Plan Review Guide, October 2011. https://www.fema.gov/media-library-data/20130726-1809-25045-7498/plan_review_guide_final_9_30_11.pdf
- FEMA, Mitigation Ideas, January 2013. https://www.fema.gov/media-library-data/20130726-1904-25045-2423/fema_mitigation_ideas_final_01252013.pdf
- FEMA, Hazus-MH 2.1 Earthquake Model Technical Manual, July 2013. https://www.fema.gov/media-library-data/20130726-1820-25045-6286/hzmh2_1_eq_tm.pdf
- FEMA, Hazus-MH Flood Model Technical Manual, July 2013. https://www.fema.gov/media-library-data/20130726-1820-25045-8292/hzmh2_1_fl_tm.pdf
- FEMA, Hazus-MH 2.1 Hurricane Model Technical Manual, July 2013. https://www.fema.gov/media-library-data/20130726-1820-25045-9850/hzmh2_1_hr_tm.pdf
- FEMA, Local Mitigation Planning Handbook, March 2013. https://www.fema.gov/media-library-data/20130726-1910-25045-9160/fema_local_mitigation_handbook.pdf
- FEMA, Hazard Mitigation Assistance Guidance, February 2015. https://www.fema.gov/media-library-data/1424983165449-38f5dfc69c0bd4ea8a161e8bb7b79553/HMA_Guidance_022715_508.pdf
- FEMA, National Flood Insurance Program Flood Insurance Manual, April 2018. https://www.fema.gov/media-library/assets/documents/162601
- FEMA, Flood Insurance Rate Maps (12 panels) for Westbrook effective August 28, 2008 (5 panels) and February 6, 2013 (7 panels).
- FEMA, Middlesex County, MA Flood Insurance Study No. 09007CV001B, 09007CV002B, 09007CV003B, February 6, 2013.
- Middlesex Health Urgent Care Website (https://middlesexhealth.org/urgent-care)
- Mitigation Action Plan, City of Portland, Oregon (ftp://ftp02.portlandoregon.gov/pbem/MitigationActionPlan-FullText/2016_PortlandMAP_AgencyReviewDraft_2016-09-29.pdf), 2016
- National Oceanic and Atmospheric Administration (NOAA), NOAA Storm Events Database https://www.ncdc.noaa.gov/stormevents/
- The Nature Conservancy and Clark University Adapting to Coastal Storms and Flooding (https://www.rivercog.org/Documents/SaltMarshAdvancementZoneAssessmentOS092313.pdf) 2014
- The Nature Conservancy A Salt Marsh Advancement Zone Assessment of Westbrook (https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/Westbrook%20Salt%20Marsh%20Advancement%20Zone%20Assessment_Small.pdf 2013
- Town of Westbrook Zoning By-Laws, Effective May 1, 2019 https://westbrookct.us/DocumentCenter/View/2706/Adopted-Zoning-Regulations---Effective-05-01-2019
- Town of Westbrook, Natural Hazards Mitigation Plan Update (https://westbrookct.us/DocumentCenter/View/129/Natural-Hazard-Mitigation-Plan---2014-PDF), 2014
- Town of Westbrook Plan of Conservation and Development (https://westbrookct.us/DocumentCenter/View/135/Plan-of-Conservation-and-Development---2011-PDF) 2011
- Town of Westbrook Harbor Management Plan (https://westbrookct.us/DocumentCenter/View/63/Westbrook-Harbor-Management-Plan-PDF) May 2014
- U.S. Army Corps of Engineers, North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk, January 2015 http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_main_report.pdf

Attachment 7: References and Resources

- U.S. Census. 2010 https://www.census.gov/data.html

- U.S. Fire Death Rates by State, National Fire Protection Association (NFPA), September 2018 https://www.nfpa.org/News-and-Research/Fire-statistics-and-reports/Fire-statistics/Fires-in-the-US/Overall-fire-problem/Fire-deaths-by-state

Attachment 8: Key Contacts

KEY CONTACTS

CONNECTICUT DIVISION OF EMERGENCY MANGEMENT AND HOMELAND SECURITY (DEMHS)

Headquarters
360 Broad Street, Hartford, CT

Ken Dumais (**Primary point of contact)**
State Hazard Mitigation Officer
Office (860) 256-8151
Email: kenneth.dumais@ct.gov

Natalie Simoneau (Regional point of contact)
Regional Secretary
860-685-8104

DEMHS Headquarters
860-529-6893

DEMHS Region II Office
860-685-8105

https://portal.ct.gov/DEMHS/Emergency-Management/Resources-For-Officials/Regional-Offices
https://portal.ct.gov/demhs

TOWN OF WESTBROOK OFFICE OF EMERGENCY MANAGEMENT

Town Office of Emergency Management
866 Boston Post Road
Westbrook, CT 06498
Staff Contact: Mr. Donald Izzo, Director
860-577-0622

- Emergency Management
  866 Boston Post Road
  Westbrook, CT 06498
  860-577-0622
- Fire Department HQ
  318 S. Main Street
  Westbrook, CT 06498
  860-399-9492
- Police Department
  866 Boston Post Road
  Westbrook, CT 06498
  860-399-7304
- Public Works
  Transfer Station
  154 McVeagh Road
  Westbrook, CT 06498
  860-399-6356
- Water Pollution Control Commission
  866 Boston Post Road
  Westbrook, CT 06498
  (860) 399-3091

911

KEY CONTACTS

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA):

Connecticut Contacts

Region I

99 High St.
Boston, MA 02110
1-877-336-2734

fema-r1-info@fema.dhs.gov

Melissa A. Surette, Senior Planner
Risk Analysis Branch, Mitigation Division

Melissa.Surette@fema.dhs.gov
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DEPARTMENT OF ENERGY & ENVIRONMENTAL PROTECTION

DEEP Land & Water Resources Division,
79 Elm Street, Hartford, CT 06106-5127
Main Office: 860-424-3000

State National Floodplain Insurance Coordinator

Diane Ifkovic
Bureau of Water Protection and Land Reuse, Land & Water Resources Division,
Connecticut Department of Energy and Environmental Protection
79 Elm Street, Hartford, CT 06106-5127
P: 860.424.3537|F: 860.424.4075 |E: diane.ifkovic@ct.gov

AMERICAN RED CROSS:

Connecticut Contacts

1031 Route 32
Uncasville, CT 06382

1-877-287--3327
(855) 891-7325 (24/7)
https://www.redcross.org/about-us/our-work/disaster-relief.html
https://www.redcross.org/get-help.html
https://www.redcross.org/local/connecticut/about-us/our-work.html

SALVATION ARMY

Connecticut Emergency Disaster Relief

11 Governor Winthrop BLVD
New London, CT 06320
(860) 702-0003
Carol.Duperree@use.salvationarmy.org

https://ctri.salvationarmy.org/SNE/EDS
https://ctri.salvationarmy.org/SNE/I-Want-To-Volunteer-For-The-Salvation-Army