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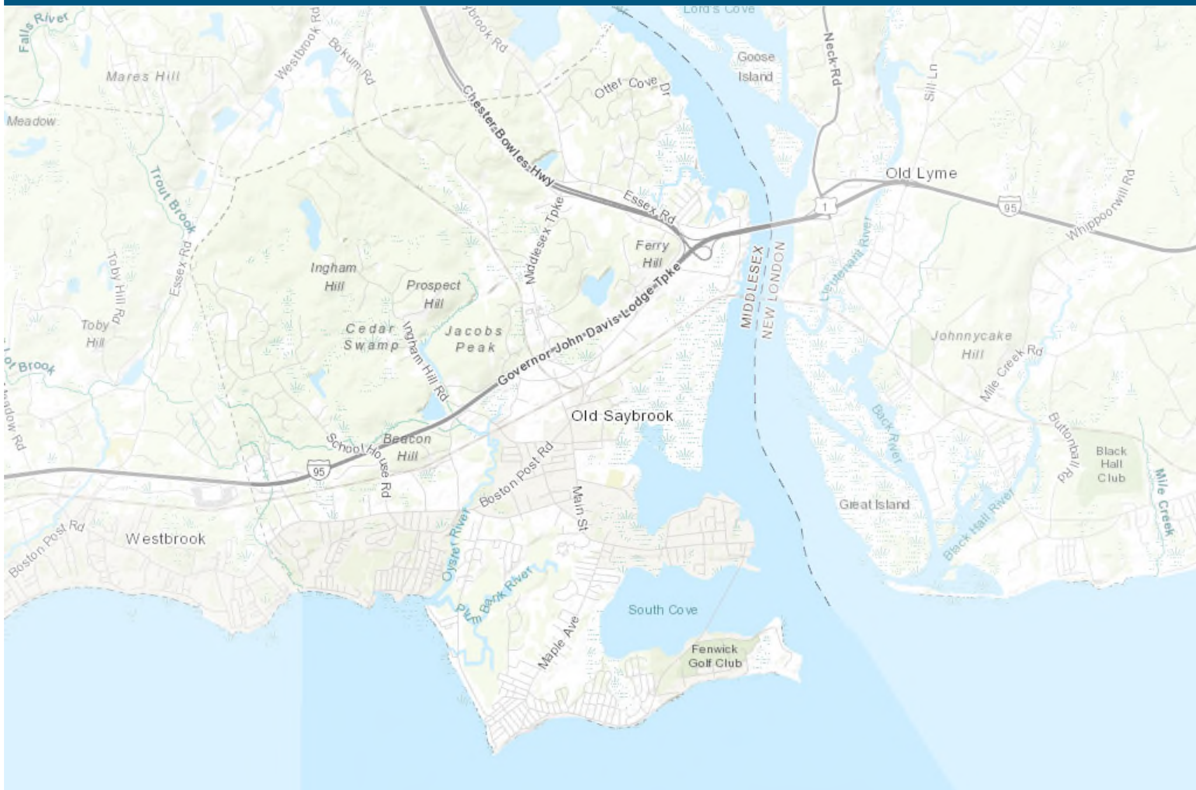


Old Saybrook Coastal Resilience and Adaptation Study

Old Saybrook, Connecticut

Prepared by:
GZA GeoEnvironmental, Inc.
with: Stantec; Alex Felson Landscape Architect

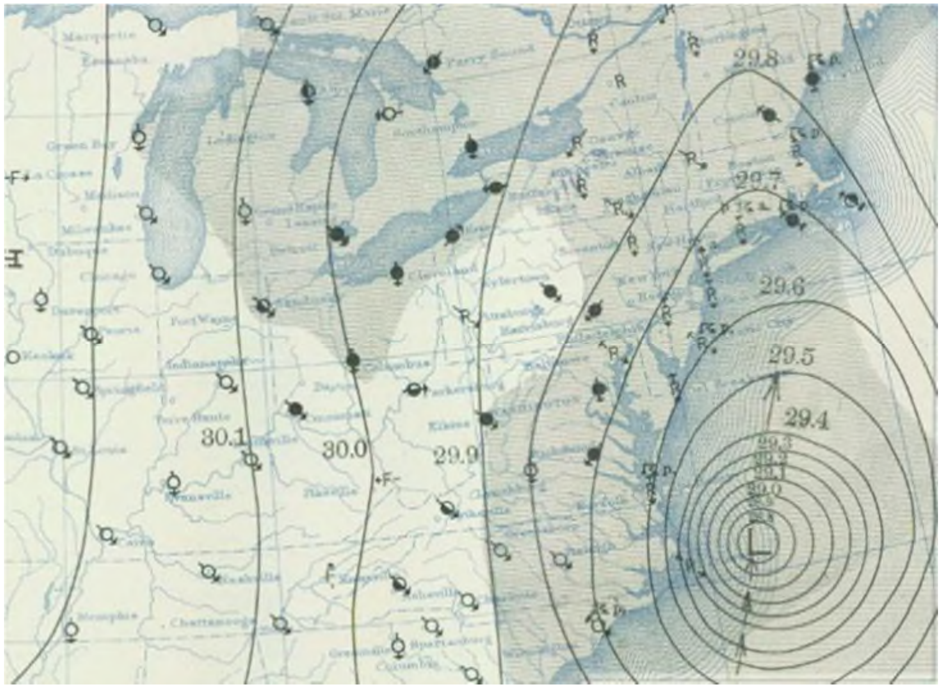
Prepared For:
The Town of Old Saybrook, Connecticut
Planning Department

March, 2018

GZA GeoEnvironmental, Inc.

Table of Contents

INTRODUCTION



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

Old Saybrook 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.

The Old Saybrook Coastal Resilience and Adaptation Study, funded by a Department of Housing and Urban Development (HUD) Community Development Block Grant (CDBG), was performed to: 1) characterize the coastal flood hazards, including sea level rise; 2) evaluate the Town's coastal flood vulnerability and risk; 3) inform and educate Town professionals and residents about sea level rise and coastal flooding; 4) solicit stakeholder feedback (principally from Town residents); 5) evaluate the feasibility of different coastal flood mitigation strategies; and 6) recommend actions to implement coastal resilience and adaptation measures.

The future for Old Saybrook will be stormier, more disruptive and wetter. The Town has been proactive in planning for this future, but transformation to a fully adaptive community will take decades. Let's get started.

ACKNOWLEDGEMENTS

TOWN OF OLD SAYBROOK LAND USE DEPARTMENT
Christine Nelson, AICP, Director; Christina Costa, CZEO, CFM Zoning Enforcement Officer; Sandy Prisloe, Environmental Planner

TOWN OF OLD SAYBROOK SEA LEVEL RISE CLIMATE ADAPTATION COMMITTEE
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TOWN OF OLD SAYBROOK PLANNING COMMISSION
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TOWN OF OLD SAYBROOK ZONING COMMISSION
Robert Friedmann, Chairman

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LOWER CONNECTICUT RIVER VALLEY COUNCIL OF GOVERNMENTS (RiverCOG)
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TOWN OF OLD SAYBROOK
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Also… Larry Bonin, Director of Public Works; Ray Allen, Director of Parks and Recreation; Don Lucas, Building Official; Ted Levy, Historical Society of the Town of Old Saybrook; Jim Monopoli, Health Director, Connecticut River Area Health District (CRAHD); Robbie Marshall, Coordinator and Jim Vanoli, Site Manager at the Old Saybrook WPCA; Margot Burns, RiverCOG; Rebecca French, UCONN Connecticut Institute for Resilience and Climate Adaptation (CIRCA); Juliana Barrett, UCONN CT Sea Grant; Amanda Ryan, UCONN Center of Land Use Education and Research (CLEAR); David Kozak, Senior Coastal Planner, Diane Ifkovik, State NFIP Coordinator, Carlos Esguerra, Sanitary Engineer, Marcy Balint, CT Dept. of Energy and Environmental Protection (DEEP); and Jeff Jacobson, consulting Town Engineer.

The residents of Old Saybrook.

STUDY APPROACH AND METHODOLOGY

This study is part of an on-going process that the Town has embarked on to proactively reduce coastal flood risk and prepare for the future effects of sea level rise. **Attachment 1** presents a detailed description of the approach and methodology used. In brief, this study, applied "State-of-the-Science", realistic predictions of sea level rise and risk-based coastal flood hazard characterization, and took a detailed look at the Town's potential vulnerability and risk to coastal flooding - now and in the future. This understanding of coastal flood risk, as well as feedback from the community and Town and State professionals, formed the framework for identification of appropriate resilience and adaptation strategies and implementation steps.

STUDY APPROACH

The Study used:

- Industry-accepted "State-of-the-Science" sea level rise projections that are also consistent with current State of Connecticut guidance.
- A "risk-based" approach, including defining coastal flood hazards in terms of probability of occurrence, consistent with methods currently being used by state and federal agencies.
- High resolution, hydrodynamic computer flood modeling to supplement flood hazard analyses performed by FEMA and the US Army Corps of Engineers (USACE).
- ESRI ArcGIS geographic information system (GIS) software, also used by the Town.
- Resilience and adaptation strategies, actions and measures that are consistent with Old Saybrook's current vision and plans for development.

STUDY METHODOLOGY

The preparation of the Study included:

Step 1: Characterization of the Coastal Flood Hazards

Step 2: Assessment of the Vulnerability of Town Infrastructure, Neighborhoods, Buildings, and Natural Resources

Step 3: Identification of Coastal Resilience and Adaptation Strategies, Actions and Measures

Step 4: Public and Town Professionals Outreach

Step 5: Identification of steps to implement resilience and adaptation strategies.

TOWN FACTS, PLANS, POLICIES AND REGULATIONS

The implementation of strategies and measures to achieve resilience to coastal flooding and adapt to sea level rise should take place within the framework of existing Town plans, policies and regulations. These strategies and measures will only be successful if they are in alignment with the overall Town planning goals and budget.

Attachment 3 provides, for reference, a summary of the applicable plans, policies and regulations including:

- The State and Town Natural Hazard Mitigation Plan
- Plan of Conservation and Development
- Conservation Plan
- Municipal Coastal Program
- Sea Level Rise Climate Adaptation Report of Findings (SLRCC, 2015)
- Coastal Zone Management Act
- Federal and State flood regulations
- Local floodplain ordinances
- Local zoning regulations
- Federal Coastal Barriers Act
- National Flood Insurance Program
- State and federal permits related to coastal resilience and adaptation measures.

A brief overview of relevant Town details is also provided in **Attachment 3.**

COASTAL FLOOD RISK

Detailed analyses of the coastal flood hazards and associated vulnerability and risk were performed. The results are presented in **Attachment 2** and **Attachment 4**.

COASTAL FLOOD HAZARDS

Coastal flood hazards include:

- tides;
- extreme water levels and resulting flood inundation due to storm surge;
- waves; and
- coincident high wind and precipitation.

These coastal hazards are typically described (by FEMA and other flood planners and engineers) in terms of their likelihood of occurrence. Specifically, coastal floods, waves, precipitation and wind intensity are characterized by their “annual exceedance probability [AEP]” and, similarly, their “recurrence interval”. The AEP defines the probability that a certain condition (say, flood water level) will be encountered or exceeded at least once in any given year. The FEMA base flood elevation (shown on FEMA Flood Insurance Rate Maps [FIRMs]) represents the predicted 1% AEP (aka 100-year recurrence interval) flood. This flood water level has a 1 in 100 chance of being met or exceeded in any given year. Since it is important (for Town planners as well as homeowners) to consider all coastal flood risks, conditions associated with other occurrence probabilities are also important. Due to their importance for public safety, Essential Facilities (police, emergency responders) conservatively consider lower probability floods (i.e., the 500-year recurrence interval flood). At the other end of the spectrum, although less intense, high probability floods (such as the 2-year and 10-year recurrence interval floods) are important because they are predicted to occur frequently.

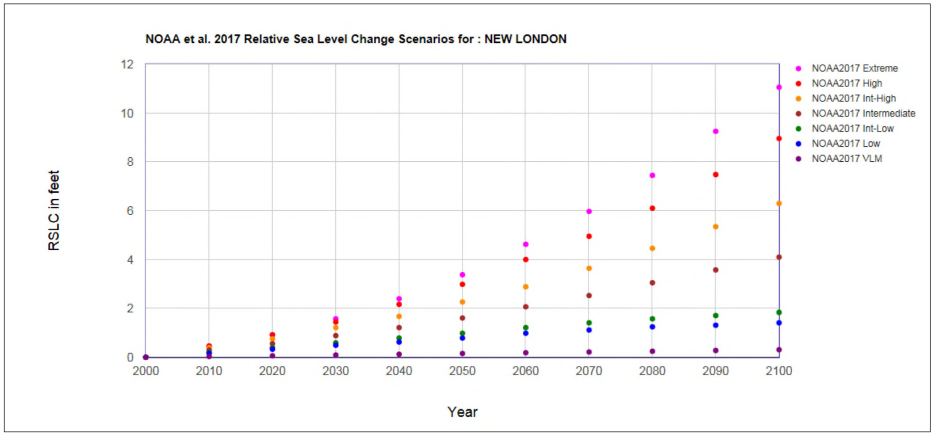
The recurrence interval (for example the 100-year recurrence interval flood) does not mean that it will only occur every 100 years - rather it is a statistical probability that reflects the chance of that flood (or a greater flood) occurring in any year. However, over a specific length of time (30-year mortgage, 100-year design life of a bridge) the chance of experiencing that flood (or greater flood) at least once is greater than the annual probability. For example, the 100-year recurrence interval flood has about a 25% chance (1 in 4) of occurring at least once in a 30-year period. **Attachment 1** and **Attachment 2** provides additional explanation.

There are a number of sources of information predicting the probability of coastal flooding in the vicinity of Old Saybrook. These include: 1) FEMA Flood Insurance Studies; 2) statistical analyses of NOAA tide station water level data (+/- 80 year record); and 3) the USACE North Atlantic Coast Comprehensive Study (NACCS). **Attachment 2** discusses each of these in detail.

Sea Level Rise

Sea level rise complicates the characterization of Old Saybrook’s future coastal flood risk. Overall, sea level rise increases the flood risk. For a given flood water level, it increases the probability of experiencing that same flood in the future relative to today. Conversely, for a given occurrence probability it increases the associated flood water level. This means that tides will get higher, storms like Hurricane Sandy will be both more frequent and worse, and catastrophic storms will be more likely.

On average, over the last +/- 80 years the observed mean rate of sea level rise at New London has been about 2.6 millimeters per year (about 0.1 inch/year or about 10 inches in 100 years). However, the rate of sea level rise has been observed to be increasing and is predicted to substantially increase during the next 25 to 100 years. As of the date of this report, the most current industry-accepted sea level rise projections for Old Saybrook are those published by NOAA in 2017. The figure shown below presents NOAA 2017 sea level rise projections (relative to the year 2000) for New London. Several projections are indicated, representing different probabilities. The projections are fairly closely grouped in the near-term (+/- 2040) but become quite varied toward the end of the century, reflecting the significant uncertainty associated with predicting long-term sea level rise. For planning studies , it can be assumed that the Interrnediate-Low projection shown below has a high likelihood of occurrence (50% to near 100%) and the Intermediate projection is a reasonable planning upper bound. This means that (relative to the year 2000), sea levels will rise by 1 to 1.6 feet by the year 2050 and 1.8 to 4.1 feet by the year 2100. It could be higher or lower, but at this time these are reasonable projections for planning purposes. The Intermediate projections are in-line with projections currently recommended by the State. Extreme projections (currently predicted to have very low probability) have sea levels rising at Old Saybrook on the order of 3.4 feet and 11.1 feet (2050 and 2100, respectively).



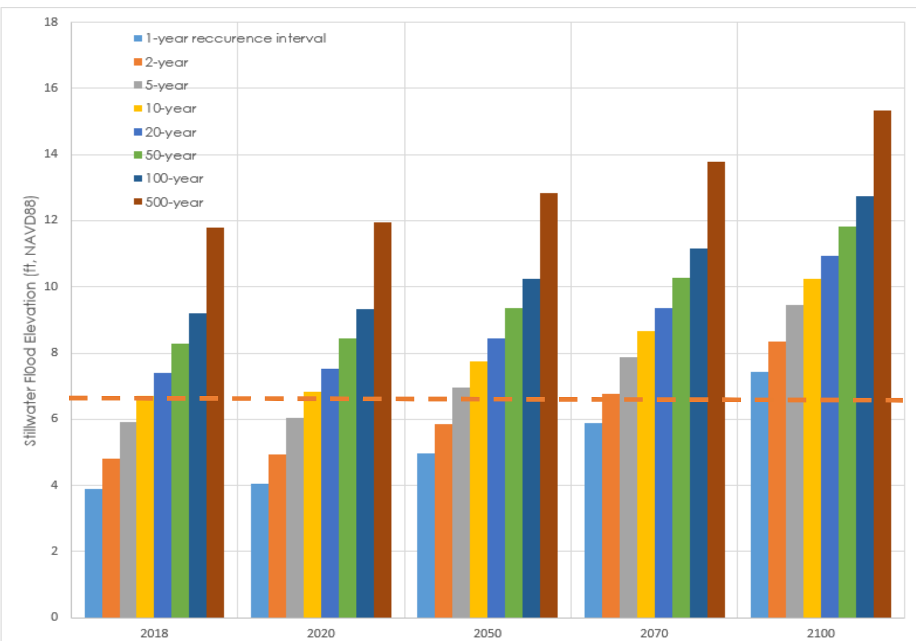
NOAA 2017 Relative Sea Level Rise Projections at New London

COASTAL FLOOD HAZARDS

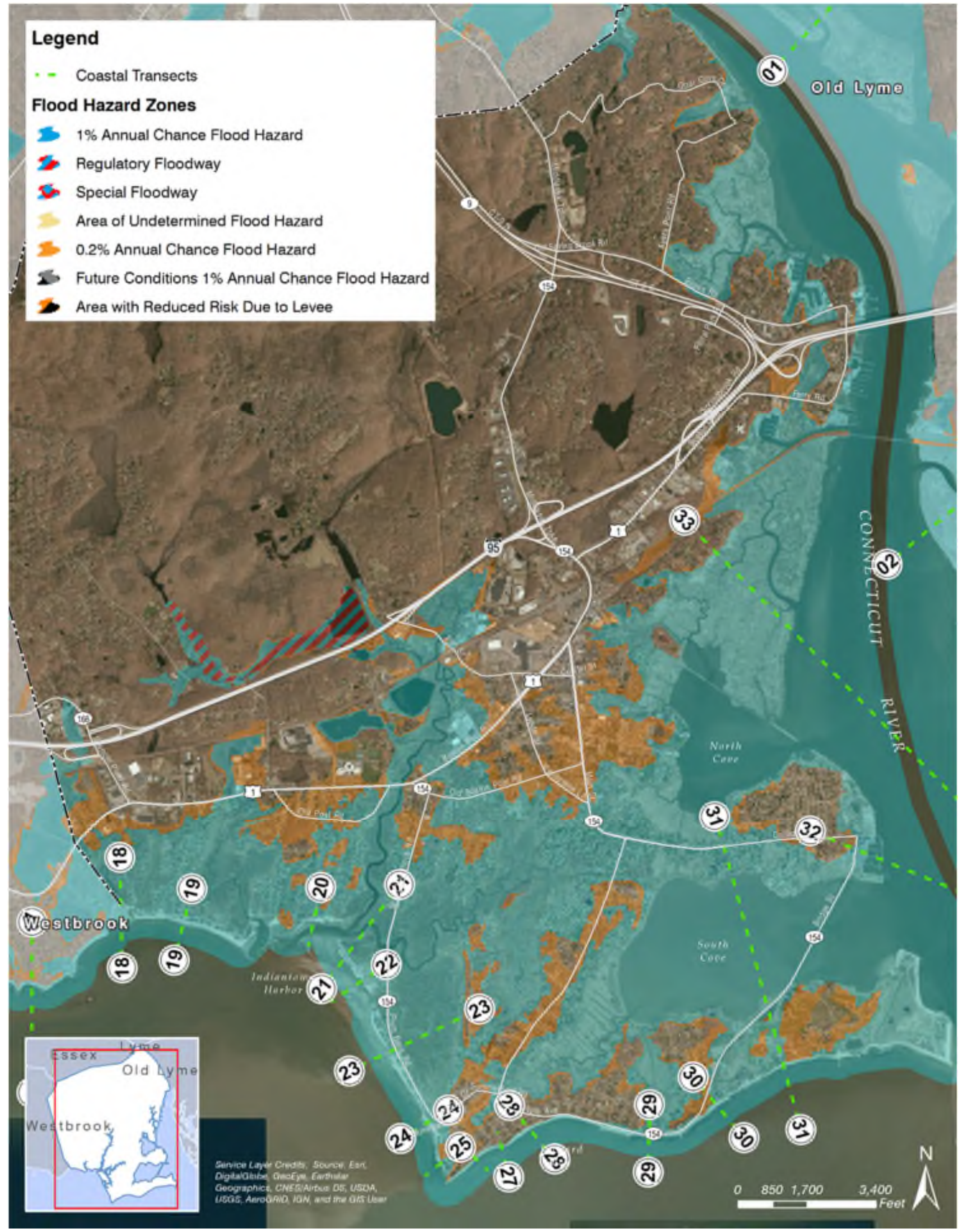
As detailed in **Attachment 2**, the extent and elevation of different probability flood events at Old Saybrook were evaluated using available sources (including FEMA, NOAA and NACCS). GZA supplemented these by performing numerical computer storm surge and wave simulations.

The figure (across) presents the special flood hazard areas as currently defined by FEMA. (note that FEMA does not consider sea level rise for hazard mapping). As shown on the this figure, essentially all of the land area located below Interstate 95 and the Amtrak rail line is flooded during the 100-year recurrence interval coastal flood. So, obviously, the coastal flood risk of Old Saybrook is high. The figures on the following pages present the flood limits associated with higher probability floods. As presented in these figures, even the high probability coastal floods inundate large areas of Town, including extensive stretches of Town roads.

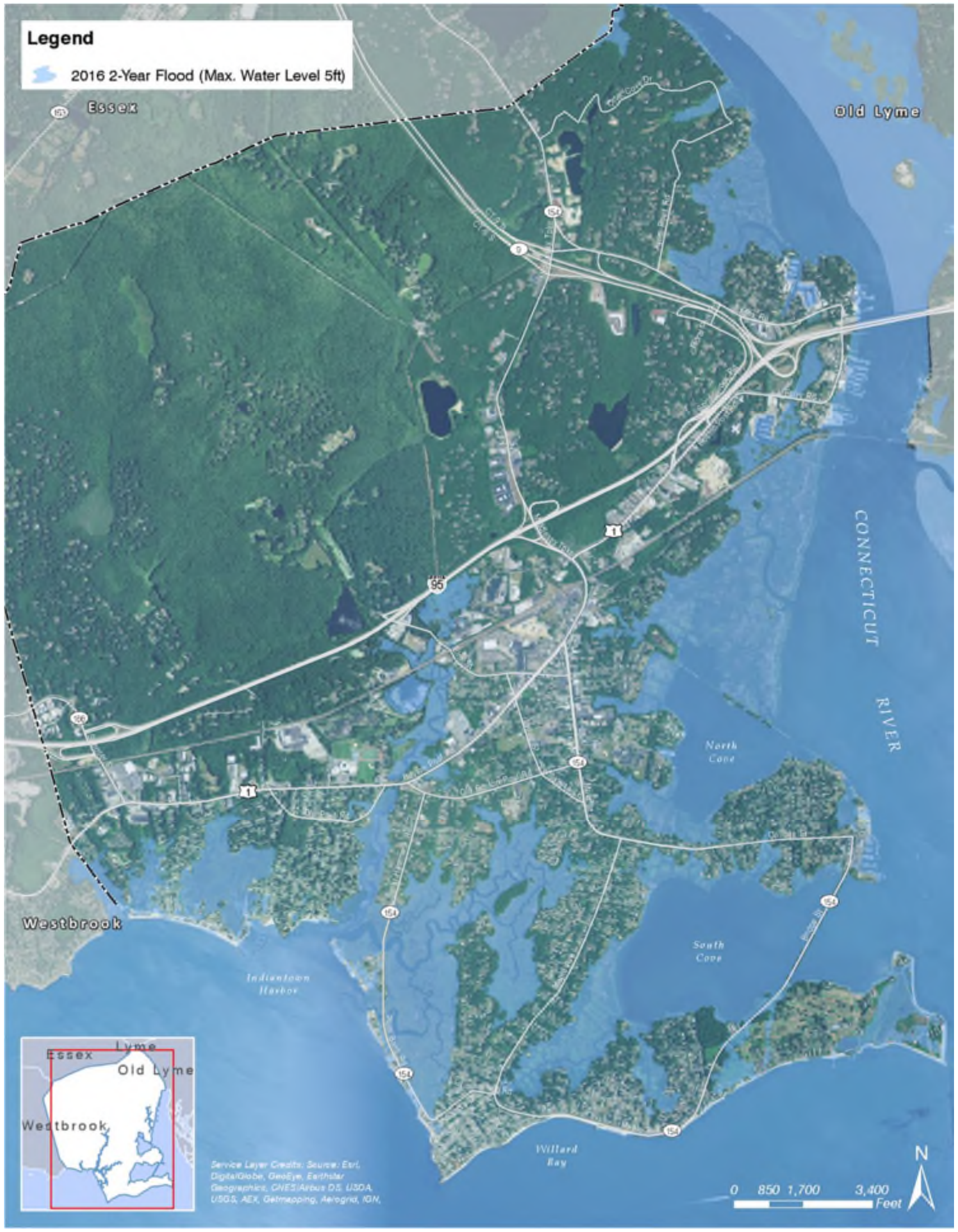
The following chart shows the effect of sea level rise on water levels associated with different probability floods. The NOAA 2017 Intermediate projection is assumed. The horizontal orange line is the typical elevation of low-lying Town areas. To get a perspective on the implications of the flood elevations presented in this chart, refer to the ground elevations shown in **Attachment 2, Figure 2-3**.



Effect of sea level rise on different probability floods. NOAA 2017 Intermediate sea level rise



Current FEMA Special Flood Hazard Areas. The 100-year recurrence interval flood shown. in green and the 500-year recurrence interval flood shown in brown,

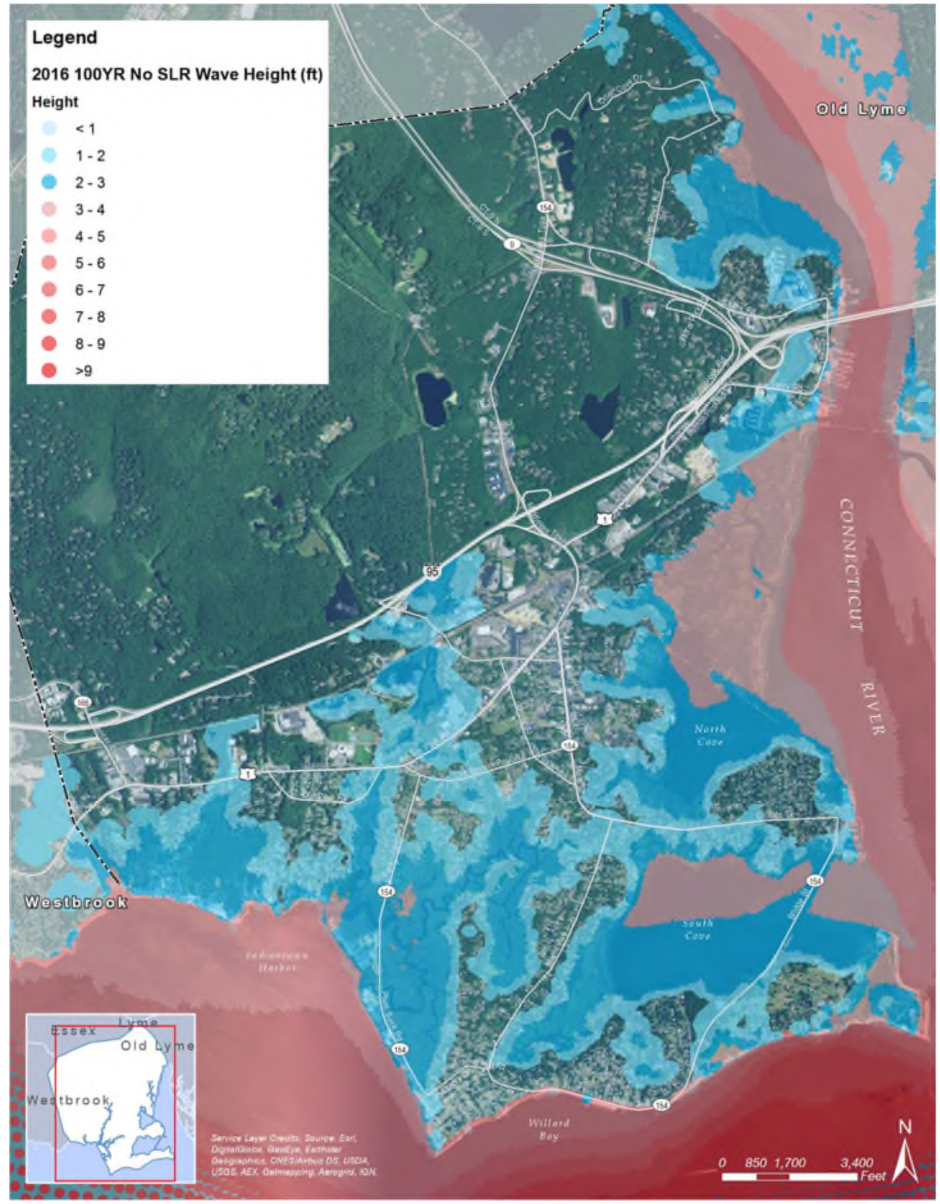


Current 2-year recurrence interval flood,

Current 10-year recurrence interval flood,

Current 50-year recurrence interval flood.

Coastal flood risks include waves. The modeled current 100-year recurrence interval waves are shown below. Waves over 1.5 feet in height can cause significant wave damage.



Current 100-year recurrence interval wave heights.

COASTAL FLOOD RISKS

A detailed analysis of the Town's vulnerability to coastal flooding was completed and is presented in **Attachment 4.** Consistent with FEMA, coastal flood vulnerability is characterized as follows:

- property and residents located within the limits of the 100-year recurrence interval flood are considered to be in a high flood hazard zone;
- property and residents located in the area between the 100 and 500-year recurrence interval floods are considered to be in a low to moderate flood hazard zone;
- property and residents located outside the limits of the 500-year recurrence interval flood are considered to be in a low flood hazard zone.

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. ASCE/SEI 24-14 "Flood Resistant Design and Construction" categorizes buildings and structures into one of four Flood Design Classes based on use and occupancy. The Flood Design Class dictates the level of acceptable risk and appropriate level of flood protection. The Flood Design Class was used to assess vulnerability in this study.

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. Areas exposed to waves greater than 1.5 feet but less than 3 feet (Limit of Moderate Wave Action) can also experience building damage, in particular to timber-framed structures such as typical houses.

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).

The term "chronic flood inundation" is used to characterize areas with very high frequency flooding. Specifically, this term describes coastal flooding that occurs on average 26 times per year over 10% of a communities developed land area. These represent areas where people and business begin to leave permanently, with impact to property values and tax revenue. **Attachment 2** and **Attachment 4** identify areas that are predicted to meet this criteria in the future.

Fire damage to beach home on Saye Street in Old Saybrook after Sandy (Image from http://www.theday.com/article/20121030/NWS01/121039993)

The following pages summarize the coastal flood risk of the Town's key assets including:

- Economic Risk
- Commercial and Industrial Districts
- Essential Facilities
- Lifeline Facilities
- High Potential Loss Facilities
- Shelter and Evacuation Requirements
- Historic Districts
- Transportation Infrastructure
- Natural Resources: Marshes

  Natural Resources: Beaches

See **Attachment 4** for the complete, comprehensive vulnerability and risk evaluation.

ECONOMIC RISK FOR PROPERTY OWNERS, THE TOWN AND TAXPAYERS

The following summarizes economic risk in terms of: 1) estimated loss potential; and 2) property owner participation in the National Flood Insurance Program (NFIP). The loss potential analysis was performed using the FEMA Hazus program and simulating multiple coastal flood hazard risk scenarios. The NFIP analysis was based on information provided by the Town relative to properties located within FEMA special flood hazard areas (SFHAs). The predicted economic loss potential is characterized in terms of the Average Annualized Loss (AAL). The AAL is the expected loss per year if averaged over many years. The AAL predicted by FEMA for Middlesex County is $77.4M. The current Old Saybrook AAL is $16M. On a per capita basis, the predicted $16M AAL for Old Saybrook is about $1,500 per person compared to about $500 per person for the County, reflecting the high risk associated with Old Saybrook's coastal location. The Town has been proactive with improving the NFIP compliance by property owners. However, the analysis indicates that, while continuing to improve, property value overall within the Town is underinsured for coastal flooding. The analysis also indicates that paid claims are disproportionately weighted toward certain properties and overall risk is weighted towards properties located within VE zones.

ECONOMIC LOSS POTENTIAL

- Current Town Asset Value is about $2.3B:
    - i. Number of structures: +/- 5,900
    - ii. Residential: 70% to 80% ($1.5B to $2B)
    - iii. Commercial: 10% to 20% ($250M to $400M)
    - iv. Industrial: 1% to 5% ($22M to $90M)
- Predicted Average Annualized Loss (AAL) due to coastal flooding is $16M

The "Averaged Annualized Loss" (AAL) is the expected loss per year if averaged over many years. The current predicted AAL is $16 million. Assuming a Town population of about 10,200 people (based on 2010 Census data), this translates to a per capita AAL of about $1,569. For comparison, FEMA (FEMA's HAZUS Average Annualized Loss Viewer, 2016) has estimated the total AAL for Middlesex County to be $77.4M, which represents a per capita average AAL within Middlesex County of $467. Damage to residential buildings accounts for a majority of the total loss, with privately-owned commercial and industrial buildings accounting for about 35% of the loss. The economic risk applies to property owners, taxpayers and the Town Budget and indicates the potential for increased property damage, Town costs for public works and public safety, decrease in property tax revenue and increase in the borrowing rate for municipal bonds. See figures on following page for the appraised property value and the predicted distribution of loss.

NATIONAL FLOOD INSURANCE PROGRAM

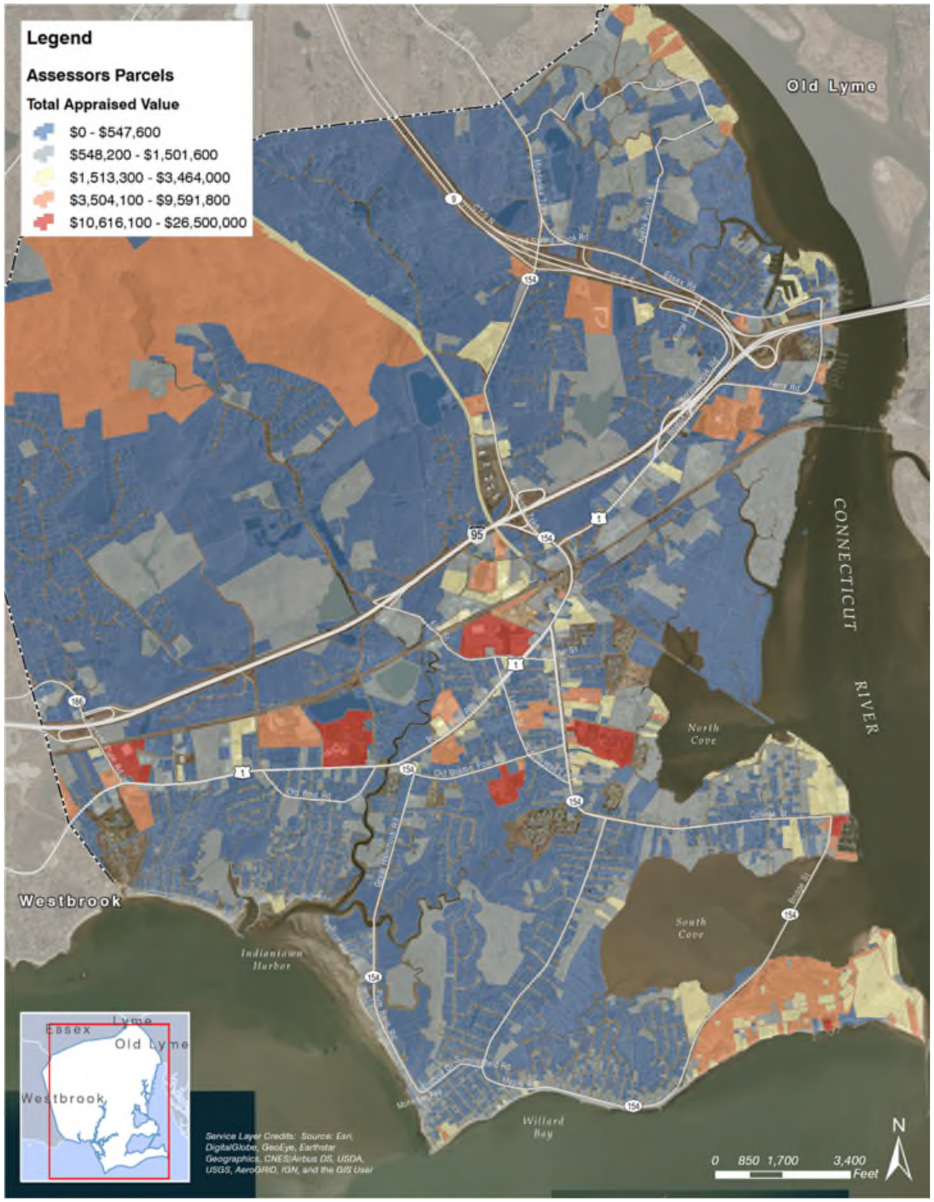
- 1,492 NFIP Insurance Policies in Force
    - i. Residential: 97% of policies
    - ii. Non-Residential: 3% of Policies
    - iii. SFHA Properties: 62% of policies (61 in Zone V/VE)
- 628 claims paid since 1978
    - i. $14.2M of Closed Paid Losses
    - ii. SFHA properties: 92% of insured claims paid
    - iii. Repetitive Loss properties: 28% of insured claims paid
- $385.5M of NFIP Insurance in force

The number of total NFIP policies includes 44% of the total number of buildings located within FEMA SFHAs (56% of buildings located within SFHAs are not covered by NFIP policies). 97% of NFIP policies are for residential structures. Damages to residential buildings located within SFHAs account for the majority of paid losses at 92%.

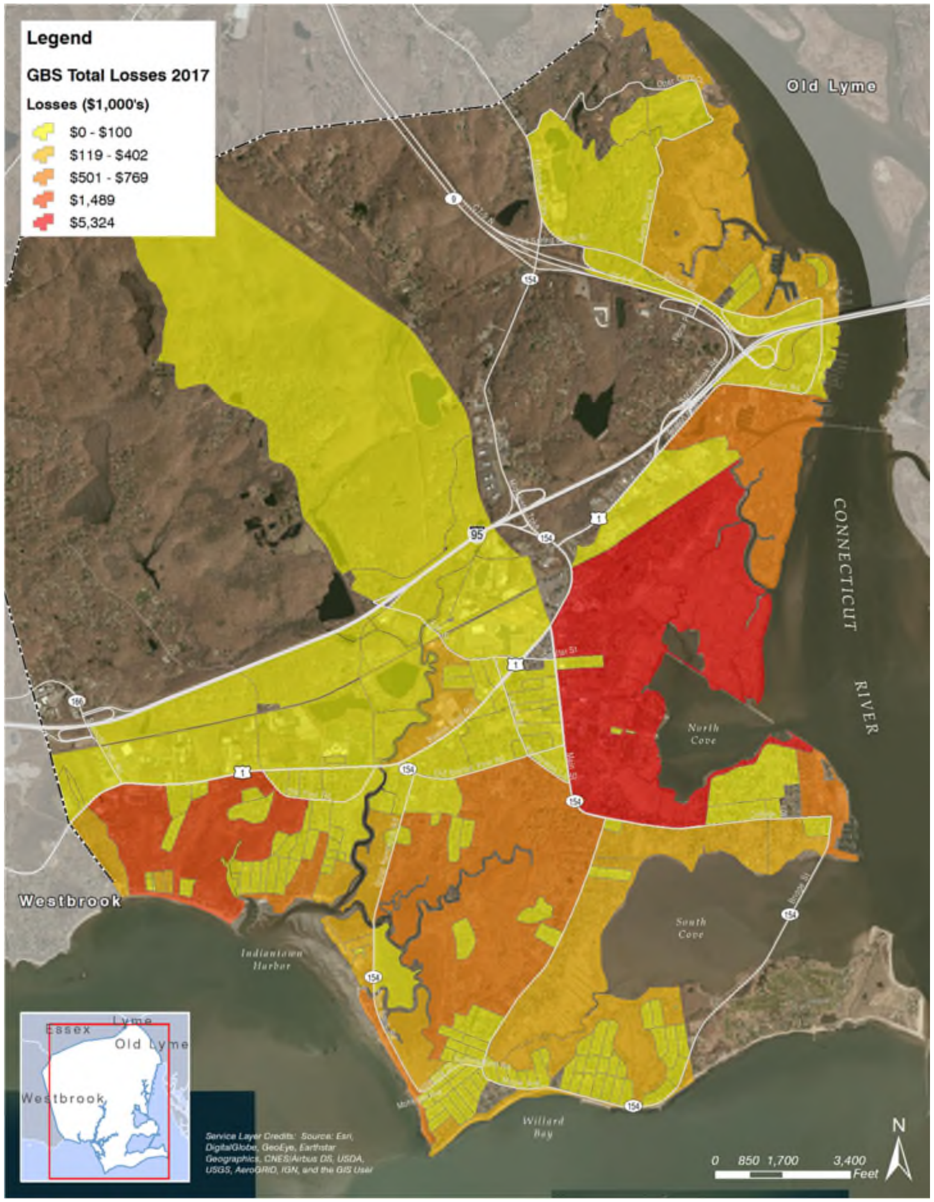
The number of NFIP policies for properties located within VE zones is less than 50% of the total number of buildings located within VE zones. Buildings located within VE/V zones accounted for 30% of the total Town claims, totaling close to $4.4M. 68 Repetitive Loss Properties accounted for about 29% of the total Town claims, at just over $4M.

Buildings located within AE/A zones have accounted for over 60% of the total Town claims, totaling over $8.7M.

Repetitive loss properties represent an economic risk to both property owners and Town insurance rates.



Property Appraisal Values throughout Old Saybrook



Predicted Distribution of Economic Loss (by AAL) due to Property and Content Damage

ESSENTIAL FACILITIES

	Current	2041	2066	2116
LOCATION				
Police Station at 36 Lynde Street	Low	Moderate	Moderate	Moderate
Fire Department at 310 Main Street	High	High	High	High
Emergency Management at 302 Main Street (Town Hall)	High	High	High	High
Ambulance Association at 316 Main Street	High	High	High	High
Emergency Shelter at 1111 Boston Post Road (Old Saybrook Senior High School)	Low	Moderate	High	High

Risk Profile of Old Saybrook Essential Facilities

Location of Fire, Police, Emergency Management rand Ambulance relative to FEMA special flood hazard areas

The vulnerability of Old Saybrook'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 Fire and Emergency Management is due to portions of these structures being located within the 500-year floodplain. Flood protection of these structures 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 each of the high risk Essential Facilities. The ambulance facility is located within a FEMA AE zone and relocation of this facility should be planned for.

A significant, additional, risk is road flooding which will impact the capability of the Town to provide essential services (e.g., emergency response).

See **Attachment 4** for a detailed description of the flood risk of each of Old Saybrook's Essential Facilities.

LIFELINE FACILTIES

	Current	2041	2066	2116
LOCATION				
Electricity (Elm Street Substation only)	Moderate	Moderate	Moderate	Moderate
Natural Gas	Low	Low	Low	Low
Water	Low	Low	Low	Low
Sewer	High	High	High	High
Communication	Low	Low	Low	Low

Risk Profile of Old Saybrook Lifeline Facilities

The vulnerability of Old Saybrook'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 Old Saybrook's Lifeline Facilities is generally low except for:

- The Elm street electrical substation, which is the responsibility of Eversource; and
- The on-site subsurface sanitary wasewater treatment at certain communities. The Old Saybrook Water Pollution Control Authority (WPCA) recently completed the "Old Saybrook Wastewater Pollution Control Authority [WPCA]) Draft Study" (2016-17) study to evaluate the use of Community Systems for high risk communities.

See **Attachment 4** for a detailed description of the flood risk of each of Old Saybrook's Lifeline Facilities.

Location of Lifeline Facilities 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.

HIGH LOSS POTENTIAL FACILITIES

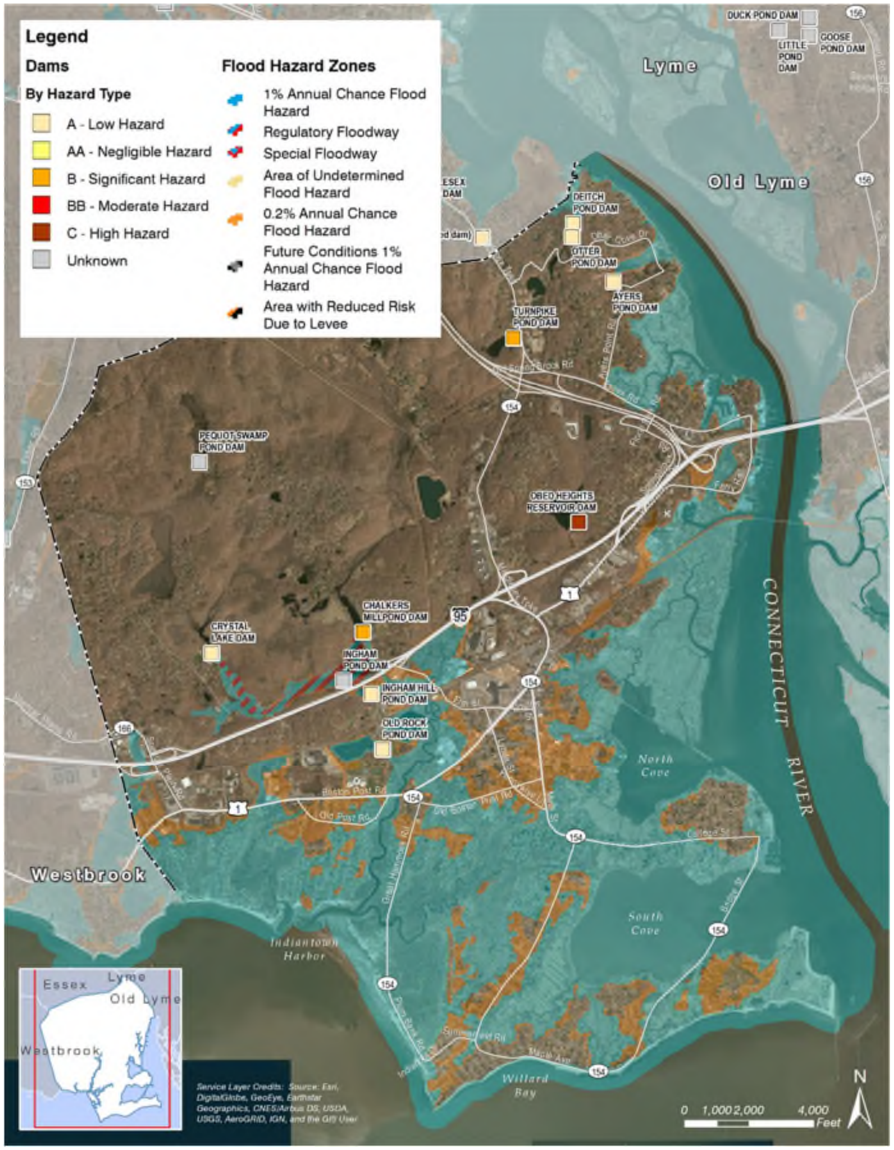
High potential loss facilities are those facilities that would result in significant loos of property of life should they fail. The only facilties located within Old Saybrook are dams, two of which are classified as high hazard or significant hazard dams (Class C and Class B). High Loss Potential Facilities are not classified or regulated using ASCE/SEI 24-14. At a minimum, Class C and B dams should be evaluated for risk relative to the 500-year recurrence interval flood.

A detailed assessment of dam failure risk was beyond the scope of this study. 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; and/or 3) temporary changes to the hydrologic and geohydrologic conditions that could induce piping or stability failures.

A preliminary determination of the location of the dams relative to the limits of coastal flood inundation was performed. The following describes the coastal flood conditions in the vicinity of the Old Saybrook Class C and B dams.

- Obed Heights Reservoir Dam: the Obed Heights Reservoir and Dam are located at a high ground elevation, approximately 60 feet NAVD88 and outside the limits of current and future coastal flooding.
- Chalkers Millpond Dam: The Chalkers Millpond Dam is a low earthen dam located at the southern extent of the Chalkers Millpond. The spillway is located at the east end of the dam. Based on recent Lidar data, the crest elevation of the dam appears to be about Elevation 20 to 22 feet NAVD88. The spillway discharges to a drainage swale that appears to be hydraulically connected to the Oyster River via several roadway drainage culverts. The area immediately downgradient from the dam is classified as a FEMA A zone. Although the risk to the dam due to coastal flooding appears low, further investigation is required to evaluate the potential effect of coastal flooding at the spillway.
- Turnpike Pond Dam: The Turnpike Dam is located at a high ground elevation, approximately 56 feet NAVD88 and outside the limits of current and future coastal flooding.

See **Attachment 4** for a detailed description of the flood risk of each of Old Saybrook's High Loss Potential Facilities.



Location of Old Saybrook Dams relative to FEMA special flood hazard areas

SHELTERING AND EVACUATION

GZA completed a FEMA Hazus analysis to evaluate flood-related losses resulting in the following predictions for shelter requirements. This analysis relates displacement and shelter needs to building damage. The following summarizes predicted displaced people and shelter needs for different recurrence interval floods:

- 10-year return period flood: 256 households displaced, 648 people seeking temporary shelter
- 25-year return period flood: 305 households displaced, 801 people seeking temporary shelter
- 50-year return period flood: 431 households displaced, 1,161 people seeking temporary shelter
- 100-year return period flood: 1,166 households displaced, 3,096 people seeking temporary shelter
- 500-year return period flood: 1,811 households displaced, 4,709 people seeking temporary shelter

Old Saybrook Public Emergency Shelter (Old Saybrook High School) 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.

A detailed analysis of New England hurricane evacuation needs and capabilities was also performed by the USACE and FEMA and presented in "New England Hurricane Evacuation Study, Technical Data Report", dated June 2016. Per this study, evacuation statistics were developed for three evacuation zones within Old Saybrook:

- Zone 1 (Category 1 and 2 hurricanes flood inundation): about 8,200 to 10,750 people are vulnerable, will be impacted and may require evacuation;
- Zone 2 (Category 3 and 4 hurricanes flood inundation): about an additional 90 to 260 people may require evacuation; and
- Zone 3 (areas located outside of coastal flood inundation): about an additional 440 to 800 people may require evacuation.

For comparison, the 10 through 50-year recurrence interval floods can be considered to be analogous to Zone 1, and the 100 to 500-year recurrence interval floods can be considered to be analogous to Zone 2.

A percentage of evacuating people will require shelter within Old Saybrook and the remainder of evacuating people will shelter out-of-town. Old Saybrook's current public shelter capacity is about 450 to 500 people. "Sheltering at home" is also an alternative, in particular for smaller, higher frequency flood events.

A key consideration for evacuation is the predicted road flooding which will restrict residents' ability to evacuate once flooding occurs.

See **Attachment 4** for a detailed description of the flood risk of each of Old Saybrook's Sheltering and Evacuation needs and capabilities.

COMMUNITIES

	Current	2041	2066	2116
LOCATION				
Low Beach Communities	High	High	High	High
Cornfield Point to Fen-wood	Moderate	Moderate to High	High	High
Saybrook Point and Town Center	High	High	High	High

Risk Profile of Old Saybrook Communities and Neighborhoods

The vulnerability of Old Saybrook'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. See **Attachment 2** for explanation of Flood Design Classes per ASCE/SEI 24-14.

With frontage on Long Island Sound and surrounded by tidal marsh, the Low Beach Communities (including Chalker Beach; Indiantown; Saybrook Manor; Great Hammock Beach and Plum Bank) 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.

See **Attachment 4** for a detailed description of the flood risk of each of Old Saybrook's communities and neighborhoods. .

Images of the Low Beach Communities relative to FEMA special flood hazard areas (above). Green indicates FEMA AE zones (100-year recurrence interval flood) and brown indicates the 500-year recurrence interval flood. Higher probability flooding, represented by the 10-year recurrence interval flood is shown below.

COMMERCIAL AND INDUSTRIAL DISTRICTS

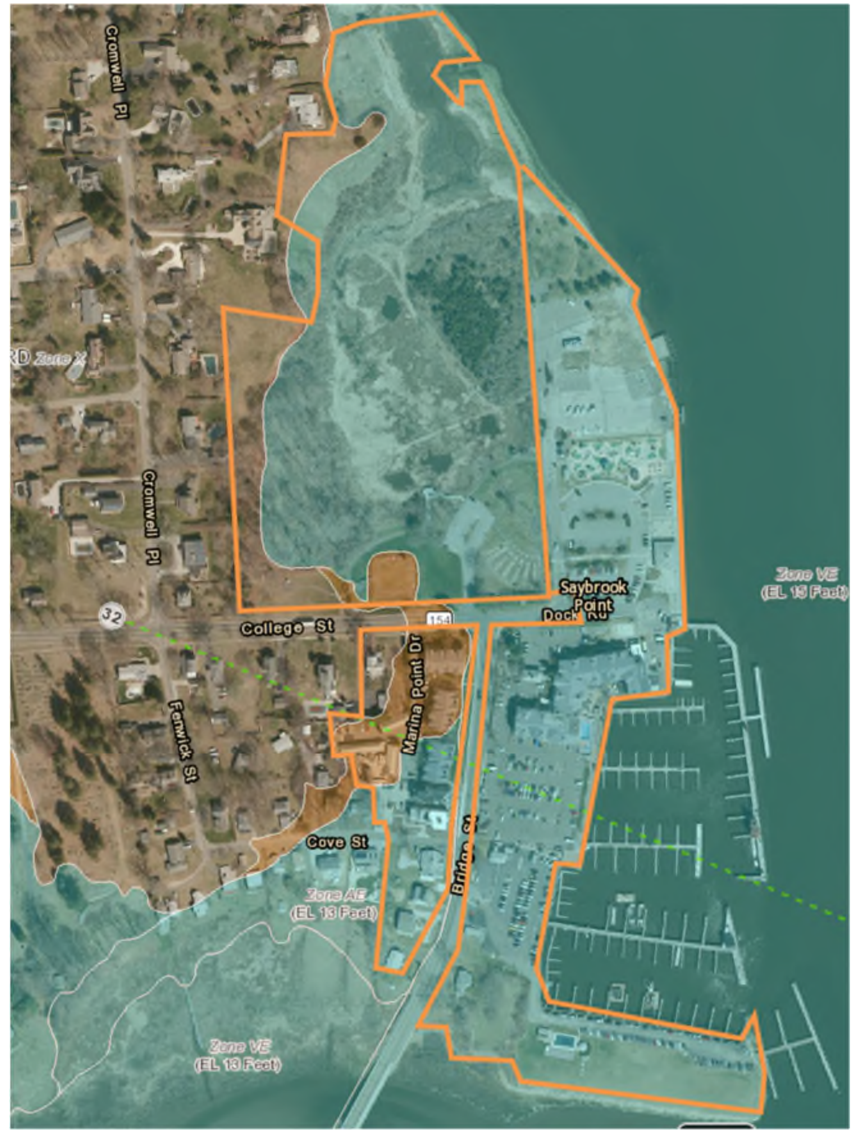
	Current	2041	2066	2116
LOCATION				
Saybrook Point SP-1 through SP-3	High	High	High	High
Central Business B-1	Low	Moderate	Moderate	Moderate
Shopping Center B-2	High	High	High	High
Restricted Business B -3	High	High	High	High
Gateway Business B-4	Low	Moderate	High	High
Industrial I-1	Low	Moderate	High	High
Marine Commercial District	Low	Moderate	High	High

Risk Profile of Old Saybrook Commercial and Industrial Districts

The vulnerability of Old Saybrook'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 Saybrook Point SP-1 through SP-3 Districts and the Marine Commercial Districts have the highest coastal flood risk of the Old Saybrook's commercial districts. SP-1 to SP-4 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.

See **Attachment 4** for a detailed description of the flood risk of each of Old Saybrook's commercial and industrial districts.



Saybrook Point Districts SP-1 to SP-3 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.

HISTORIC DISTRICTS

Type of Historic Property	Total Number	Total Number in VE/V Zone	Total Number in AE/A Zone
National Register Federal Historic Properties	17	3	3
State Register Historic Properties	76	1	17
Locally Significant Historic Properties	236	2	38
Other Significance	6	None	None
Total	335	6	58

Vulnerability Profile of Old Saybrook Historic Properties

Location of Old Saybrook Historic Properties 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.

There are three historic districts and 335 historic properties located within Old Saybrook. The Historic Districts include: 1) the North Cove Historic District; 2) the South Green Historic District; and 3) the Fenwick Historic District. The first two historic districts were evaluated by this study.

The 335 historic properties located within Old Saybrook include:

- 17 National Register Federal Historic Properties;
- 76 State Register Federal Historic Properties;
- 236 Locally Significant Historic Properties; and
- 6 Historic Properties with Other Significance.

Historic properties are classified as Flood Design Class 2 per ASCE/SEI 24-14 and are evaluated for risk relative to the 100-year recurrence interval flood (i.e., FEMA Base Flood). As summarized in the table, 64 of Old Saybrook's historic properties are located within FEMA special flood hazard zones.

Historic properties, however, are exempt from certain requirements of federal and State flood regulations, providing greater flexibility relative to available flood mitigation alternatives.

See **Attachment 4** for a detailed description of the flood risk of each of Old Saybrook's Historic Districts.

National Register Historic Property
State Register Historic Property
Locally Significant Property
Other Significance

ROADS, BRIDGES AND CULVERTS

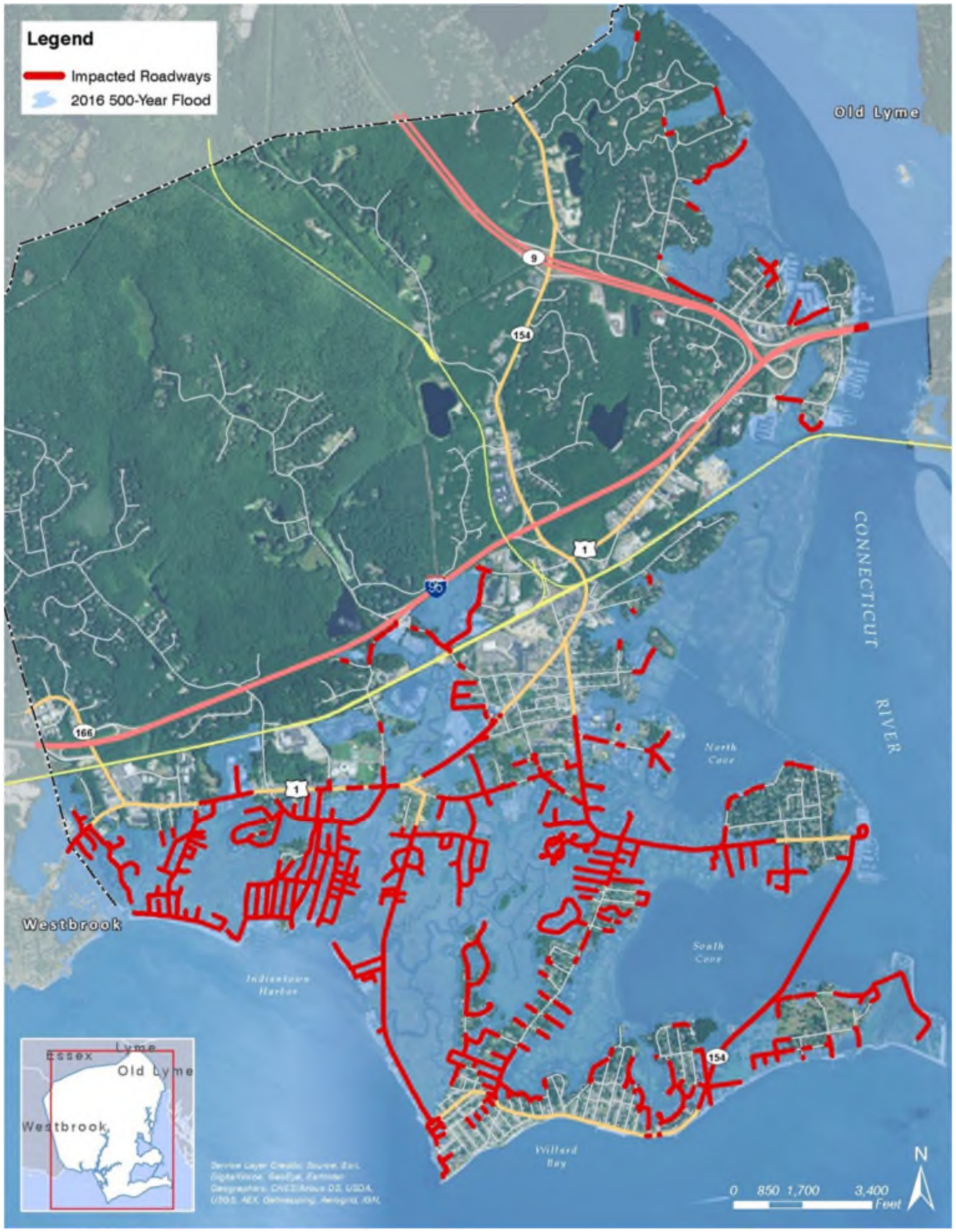
	2-yr	10-yr	20-yr	50-yr	100-yr	500-yr
State (%)	2.9	7.4	9.6	11.3	13.1	16.9
State (miles)	1	2.4	3.2	3.7	4.3	5.6
Municipal (%)	3	8.5	12.4	16.2	20.6	32.3
Municipal (miles)	2.6	7.4	10.7	14.0	17.9	28.0
Private (%)	3.6	10.5	15	23.7	50.4	71.4
Private (miles)	0.1	0.3	0.4	0.7	1.5	2.1
Total (miles)	**+/-4**	**+/-10**	**+/-14**	**+/-18.5**	**+/-24**	**+/-36**

Vulnerability Profile of Old Saybrook Roads

A detailed analysis of roadway impacts due to coastal flooding was performed and is presented in **Attachment 4.** There is a total of approximately 135 miles of roadway in Old Saybrook including about 47 miles of State roads and 88 miles of Town roads. There are 22 bridges including highway and railroad bridges, river crossing and the causeway. There are 11 drainage culverts.

GZA estimated the location and extent of roadway inundation under current coastal flood conditions, including storm events corresponding to the following recurrence intervals: 2-year; 10-year; 20-year; 50-year; 100-year; and 500-year recurrence interval floods - see table above. About 24 miles and 36 miles of roadway are vulnerable under the current coastal flood risk scenarios of the 100-yr and 500-yr recurrence interval floods, respectively. These flood recurrence intervals represent the appropriate evaluation risk levels for transportation infrastructure investment planning at State and municipal levels. The total impacted roadway under these coastal flood scenarios represent about 24% to 36%, respectively, of the roads within the Town. More frequent flood events, such as the 2-year and 10-year return periods should be specifically considered as important due to their high frequency and "chronic flood inundation" potential.

See **Attachment 4** for the comprehensive analysis of roadway flood risks.



Inundated roads during the 500-year recurrence interval flood

ROADS, BRIDGES AND CULVERTS cont.

Overtopped Bridges	Approximate Bridge Deck Elevation (feet, NAVD88)[1]	Estimated current 100-year recurrence interval stillwater elevation (feet, NAV-D88)	Estimated 100-year recurrence interval wave crest elevation (feet, NAVD88)
South Cove Causeway:			
North Bridge over South Cove	6	10	15 (VE)
Middle Bridge over South Cove	6	10	15 VE)
South Bridge over South Cove	8	10	15 (VE)
Great Hammock Road Bridge over Back River	6	10.5	13 (Coastal AE)
Nehantic Trail Bridge over Hagar Creek	10	10.5	14 (VE)
Plum Blank Road Bridge over Plum Blank Creek	7	10	14 (VE)
Route 1 Bridge over Oyster River	13	11.5	12.5
Sequassen Avenue Bridge over tidal	6	10	13 (VE)

Vulnerability Profile of Old Saybrook Bridges. Estimated deck elevations, flood stillwater elevations and wave crest elevations are shown.

A detailed analysis of roadway impacts due to coastal flooding was performed and is presented in **Attachment 4.** Based on the flood elevations relative to bridge deck elevations, a preliminary evaluation of bridge damage potential during the current 100-year recurrence interval flood is:

- South Cove Causeway Bridges: High
- Great Hammock Road Bridge over Back River: High
- Nehantic Trail Bridge over Hager Creek: Moderate
- Plum Bank Road Bridge over Plum Bank Creek: High
- Route 1 Bridge over Oyster River: Low
- Sequassen Avenue Bridge over tidal creek: High

Bridge damage potential is a function of: 1) deck elevation relative to stillwater and wave crest elevations (resulting in hydrostatic and hydrodynamic loads); 2) debris impacts to substructure and superstructure; 3) hydrodynamic loads to piers ; and 4) scours around piers. The potential for bridge overtopping or damage, and the very high cost to elevate or replace the bridges, is a key transportation issue for the Town. Due to the low deck elevation of many of the Town bridge, bridge flooding and temporary loss of use will occur frequently in the future.

South Cove Causeway during Irene showing wave overtopping bridge deck. This photo, by Mara Lavitt, won a first-place award in the Connecticut SPJ contest. "Thrill seekers on the causeway between Old Saybrook and Fenwick Point during Tropical Storm Irene, on Aug. 28, 2011." The tide gage data indicated a peak water level during Irene of about Elevation 6.5 feet NAVD (about or slightly higher than the bridge deck elevation). In comparison, the same tide gage measured a peak water level of about Elevation 8 feet NAVD during Sandy.

ROADS, BRIDGES AND CULVERTS cont

100-year Recurrence Interval	Number of Culverts
2016	18
2041	18
2066	19
2116	22

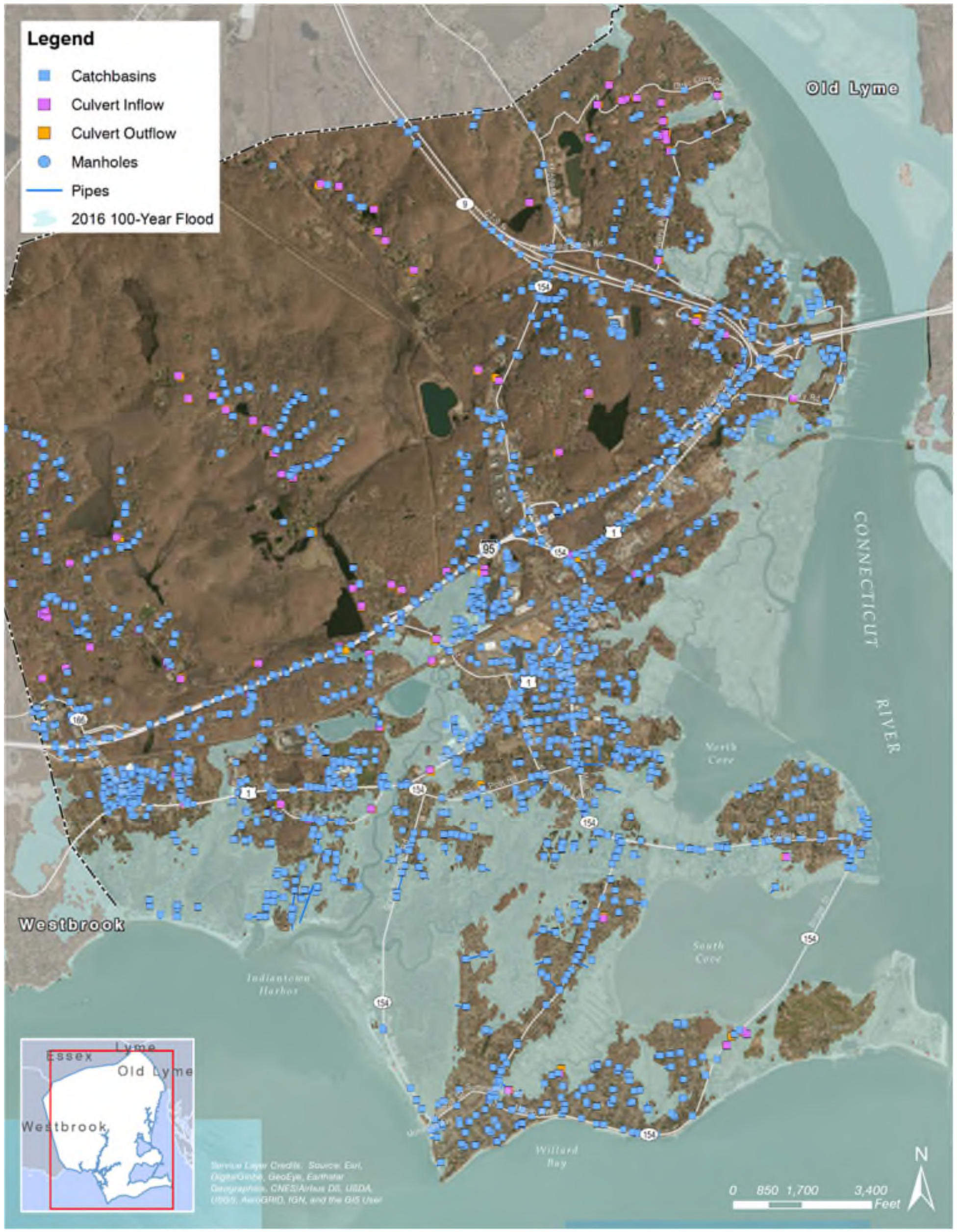
Vulnerability Profile of Old Saybrook Culverts indicating the number of culverts inundated during the 100-year recurrence interval flood.

GZA's evaluation identified roadway culverts located within roadway sections that are inundated during the 100-yr recurrence interval flood under current and future (2041, 2066 and 2116) conditions. This information provides an initial assessment of roadway culverts at risk. GZA has not evaluated the hydraulic capacity of the culverts as part of this study and additional analysis is recommended to evaluate the hydraulic performance of the culverts under different flood conditions.

In addition to the culverts used or river crossings, the overall stormwater management system includes (based on data provided by the Town):

- 108 Culvert Inflows
- 101 Culvert Outflows
- 2,217 storm water catch basins
- 204 outfalls
- 8 stormwater manholes

Stormwater runoff is collected via catch basins and pipes and discharged via gravity flow to drainage outfalls to the Connecticut River, Long Island Sound and local waterways. The Town does not have any stormwater pump stations. Based on the available information, existing outfalls do not have tide gates or backflow preventers. (There are two tide gates in town that are used for control of tidal flow: one at Chalker Beach and another on the Oyster River just south of I-95 near Elm Street. The Chalker Beach tide gate is owned and managed by the Chalker Beach Association and Summerwood Condominiums. The Chalker Beach tide gate functions as a backflow reducer without manual controls. The Oyster River tide gate is owned and operated by the State of Connecticut and can be manually opened and closed.)



Inundated culverts and catch basins relative to the 100-year recurrence interval flood

NATURAL RESOURCES: MARSHES

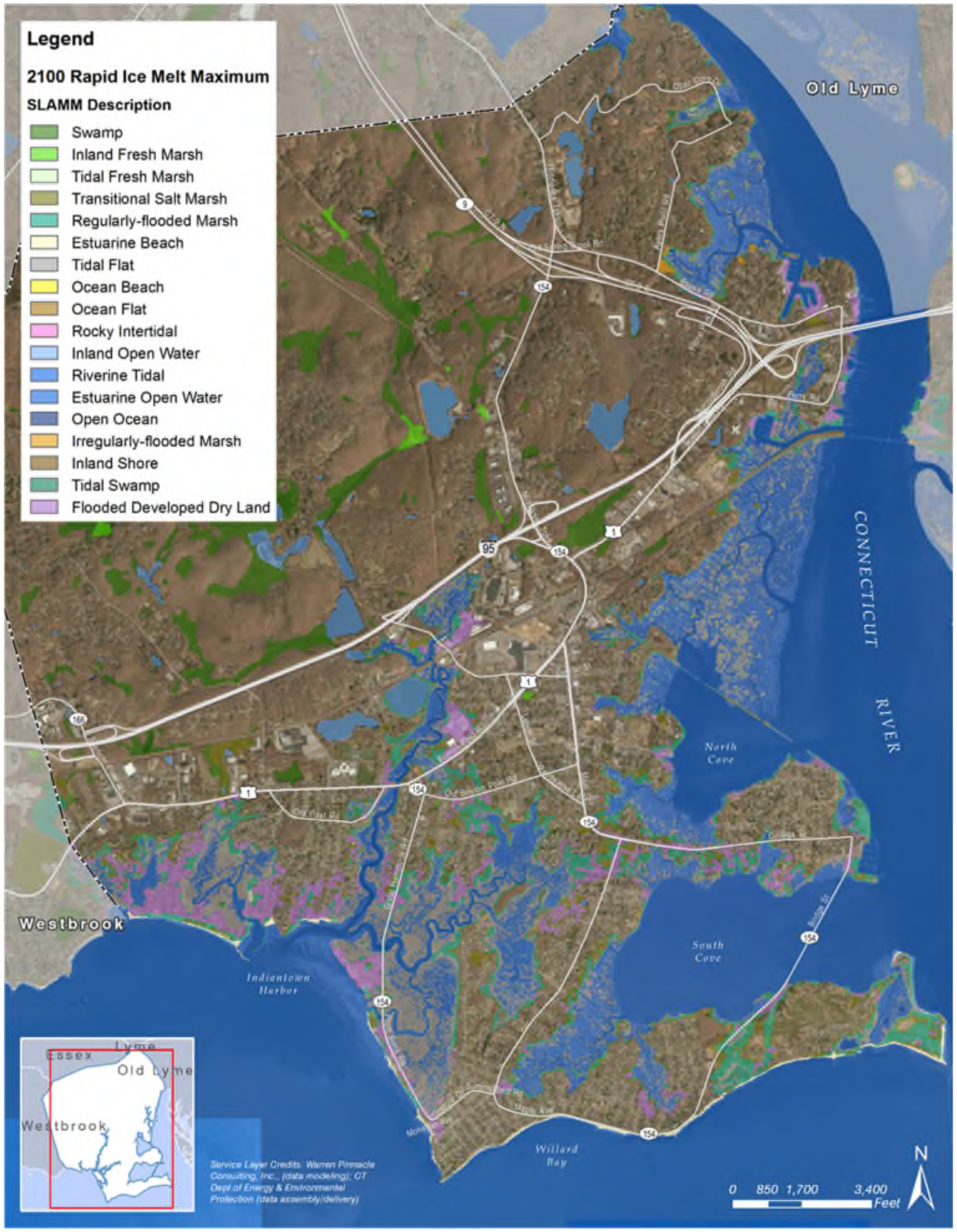
The "Application of the Sea-Level Affecting Marsh Model to Coastal Connecticut", prepared for the New England Interstate Water Pollution Control Commission by Warren Pinnacle Consulting, Inc. provides insight into the behavior of Old Saybrook's marshes when subject to sea level rise. The marshes provide ecological and human benefits, including habitat for fish, shellfish, birds, and other wildlife as well as recreational value and some protection for inland areas from coastal flooding. However, they are highly susceptible to sea level rise and climate change due to:

- land subsidence;
- rapid changes to water depth;
- marsh substrate;
- sea level rise rate relative to sedimentation rate;
- frequency of inundation;
- changes in tidal flow patterns;
- landward migration of tidal waters;
- changes in salinity, water acidity and oxygen content;
- increased flood vulnerability; and
- species diversification.

Because of the complexity of the various factors affecting a marsh's fate, a simple comparison of current marsh elevations to future projections of sea level does not accurately predict wetland vulnerability to sea level rise. Model evaluations of Connecticut's tidal wetlands have been performed (by others) using the Sea Level Affecting Marshes Model (SLAMM). SLAMM simulations were performed starting from the date of the initial wetland cover layer through 2100. Maps and numerical data were output for the years 2025, 2055, 2085, and 2100.

The SLAMM model results for the Rapid Ice Melt maximum sea level rise scenario, which is a reasonable characterization of the predicted sea level rise for Old Saybrook. Under this scenario, significant changes to the marshes begin between 2025 and 2055, at which point most of Old Saybrook's marshes have converted into Low Marsh. Significant loss of beach has also occurred. By 2085, much of the marsh has converted to tidal flat. By 2100, almost all of the marsh is lost and has converted to open estuary water and tidal flat, with almost no beach barrier.

The analysis also indicates that the effect of sea level rise is not just a function of the total amount of sea level rise but also the rate of relative sea level change. The higher rate of sea level change under the SLAMM Rapid Ice Melt maximum sea level rise scenario, relative to scenarios with lower sea level rise projections results in more significant marsh transformation since the rate of sea level rise under the this scenario is occurring faster than the natural marsh accretion rates. See **Attachment 4** for a detailed description the predicted marsh response to sea level rise.



SLAMM Rapid Ice Melt maximum simulation of marsh response at Old Saybrook.

NATURAL RESOURCES: BEACHES

Old Saybrook's southern shoreline includes 14 beaches. Typical of the Connecticut coast, Old Saybrook's beaches consist of barrier spits and pocket beaches. Beach shoreline protection in the form of groins and jetties have been constructed along most of the beaches in Old Saybrook. About 8 miles of the Old Saybrook shoreline is potentially erodible, of which about 2 miles have been significantly affected by erosion. Areas that have been historically affected by shoreline erosion include: Chalker Beach, Chapman Beach, Westbrook, Plum Beach and Great Hammock 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:

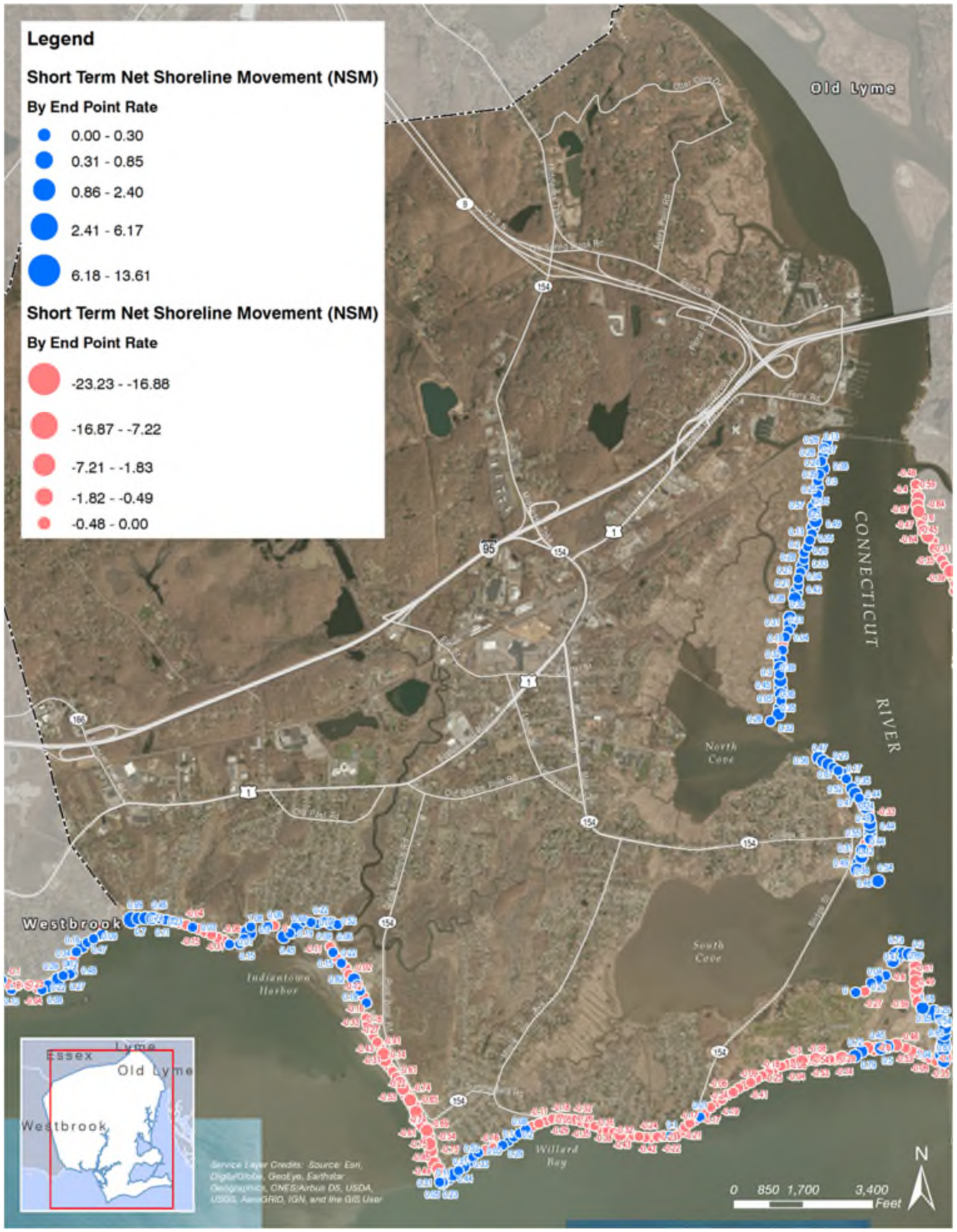
<u>Old Saybrook – Long Island Sound Beaches</u>
Short-Term (1983 to 2006):
- Net Shoreline Movement:
  - Minimum: -19.9 meters
  - Maximum: 23.8 meters
  - Average: -2.6 meters

End Point Rate (average): -0.12 meters/year

<u>Old Saybrook – Connecticut River Shoreline</u>
Short-Term (1983 to 2006):
- Net Shoreline Movement:
  - Minimum: -20.5 meters
  - Maximum: 2.8 meters
  - Average: 6.2 meters
- End Point Rate (average): 0.28 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 Old Saybrook, sediment supply is limited, and the large number of coastal structures impedes natural sediment transport. By 2100, the barrier spits, in particular Plum Bank, may have disappeared entirely.

See **Attachment 4** for a detailed description shoreline change along the Old Saybrook shoreline.



Observed net shoreline change (meters/year) for the period of 1983 to 2006

OUTREACH: COMMUNITY AND TOWN AND STATE PROFESSIONALS

Community and Town outreach was a fundamental part of the study. The Resilience Team conducted a series of Town-wide presentations for information sharing and targeted community workshops for discussion and feedback. Meetings were also held with Town and State professionals to discuss operational issues and regulation. The community workshops were focused on two areas: 1) Chalker Beach, representing the challenges faced by the Low Beach Communities; and 2) the Route 54 (Main Street and College Street) and Maple Avenue "Resilient Corridor", representing the challenges associated with flooded community arterials.

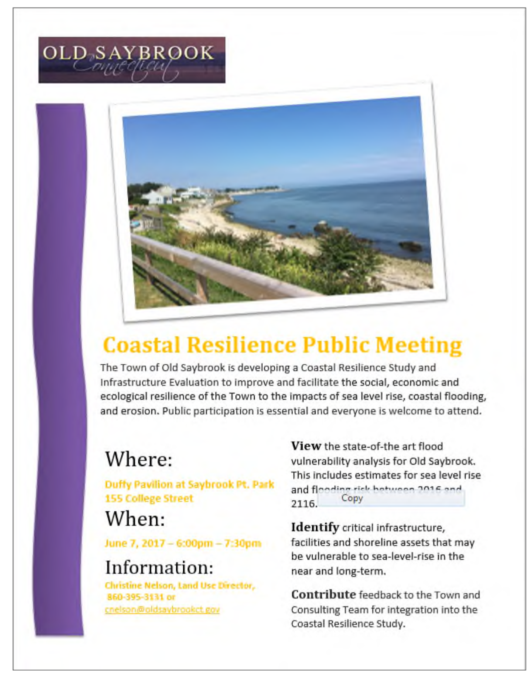
Resilient Corridor Workshop during August, 2017

Chalker Beach Workshop during August, 2017

Public Presentations, Workshops and Team Meetings

Town-wide presentations, community workshops and Resilience Team Meetings were conducted during the following months. Community presentations and workshops are highlighted.

- February, 2017: Resilience Team Meeting
- March, 2018: Resilience Team Meeting with Town and State Professionals
- May, 2017: Planning Commission Meeting
- **June, 2017: Town-wide Presentation**
- **November, 2017: Town-wide Presentation**
- **June, 2017: Neighborhood Workshop: Resilient Corridor**
- **August, 2017: Neighborhood Workshop: Resilient Corridor**
- **August, 2017: Neighborhood Workshop: Chalker Beach**



FEEDBACK: TOWN AND STATE PROFESSIONALS

Representatives from the Connecticut Department of Energy and the Environment (DEEP), University of Connecticut (UCONN) and Town Professionals representing coastal management, land use, building code and zoning regulation enforcement, public works and state representation attended a workshop during March, 2017 to discuss coastal flood risk and sea level rise. Discussions were organized around specific categories and issues. The following summarizes the feedback.

What is the current progress of implementing/maintaining your program in Old Saybrook?

Sanitary Wastewater Treatment:

- There are approximately 2,100 residential properties within Wastewater Management District. About 100 properties have compliant or upgraded systems. About 400 residential properties will be addressed with conventional system upgrades, done in 10 to 15 non-contiguous areas by the end 2018. Currently installing about 250 conventional upgraded systems at Cornfield Point. The remaining 5 areas (approximately 800 properties, including the Low Beach Communities of Chalker Beach, Indiantown, Saybrook Manor, Great Hammock Beach an Plum Island) are difficult to upgrade due to shallow groundwater, poor draining soils and coastal flood vulnerability. The Town is currently performing and engineering study to evaluate use of community treatment systems for these remaining 5 areas.
- Conflicts between health regulations (Connecticut River Area Health District [CRAHD]), Water Pollution Control Authority (WPCA) and FEMA flood data relative to system elevation goals.

Regulations:

- Updating and strengthening of flood ordinances, zoning and other land use regulations is needed on a continual basis as building codes and flood maps change.
- The Connecticut Coastal Management Act (CCMA) now includes sea level rise as a policy consideration when preparing municipal land use plans and the CT DEEP Land and Water Resources Division will continue to push for flood compliance, septic compliance, coastal resource protection, and promote natural and nature-based solution such as Living Shorelines and discourage “grey” structural shoreline protection.
- The Connecticut Department of Energy and the Environment (DEEP) maintains an excellent working with the Town relative to coastal management and intends to be an on-going partner with the Town relative to adapting to sea level rise, shoreline change and coastal flood issues.

Land Use:

- The Town, State, land trusts and the Nature Conservancy have “set aside” land for marsh expansion through land purchase and various land use regulations and will continue to do so.
- The Beach Associations (having some governance authority) and the Town manage beaches for recreation and shoreline/water access including overlooks, boat ramps, docks, mooring fields, etc.
- Existing coastal structures are a mix of private, State and Town, including jetties, groins and revetments.

National Flood Insurance Program:

- The Town has been a participating community in the National Flood Insurance Program since the late 1970s and continues to improve compliance (based on number of compliant properties, a progressive implementation program and proactive enforcement).

Infrastructure:

- There is an on-going request/demand for on-road bikeways, in particular for recreational use and touring the waterfront/shoreline (see 2006 Sidewalk Plan and Transportation section of Plan of Conservation and Development).
- New MS4 (stormwater) permit considerations.

Historic Districts/Properties:

- Incomplete inventory of historic properties.

FEEDBACK: TOWN AND STATE PROFESSIONALS

What current impediments are you experiencing?

Sanitary Wastewater Treatment:

- Incorporating sea level rise projections, coastal flooding and federal and State flood regulations into wastewater treatment planning with CRAHD and WPCA.
- The Town government and residents may not take sea level rise and its implications seriously enough.
- The Low Beach Community properties present both technical and economic challenges. The cost of upgrading an on-site subsurface disposal system for coastal low-lying properties is about $70,000, including retaining walls, use of suitable fill, use of proprietary leaching products, use of efficient pumping, etc.
- Town funding for community systems as well as system upgrades is required. The Town will need to approve a funding referendum. However, user funding by the property owners will also be required.

Regulations:

- Conflicts between different codes; for example, the health code requires mounded septic systems on lots in low lying areas. FEMA codes require no obstruction to flood waters. This is problematic for smaller non-conforming lots.
- There is no permitting process currently in-place for advanced on-site subsurface wastewater treatment systems for individual residential properties in Connecticut.

Land Use:

- Increased desire/request from homeowners to construct hard structures such as seawalls for both property flood protection and construction of on-site subsurface disposal systems. This conflicts with DEEP policy to use natural and nature-based systems versus “grey” structures and fill placement in floodplains.
- Increasing flood damage of coastal waterfront properties including loss of driveways and yard areas as well as storm-related scouring around building piles.
- There is not, currently, resident support for “Retreat” as an adaptation and resilience strategy.
- Although promoted by the DEEP, there is reluctance on the part of local zoning commissions and their legal advisors to consider not allowing limitations to living square footage for “tear-downs” and rebuilds (i.e., a position that CCMA policies cannot be used to stop expansion). The Zoning Board of Appeals promotes reduction of building and structure coverage when reviewing variance appeals.
- On-site systems (including advanced systems) are not advisable on low-lying coastal waterfront properties (e.g., the beach communities) due to concerns about rising sea levels/rising groundwater levels and coastal flooding.
- Suitable sites for community systems (e.g., leaching, discharge points) must be identified and consider coastal flood and sea level rise risks.
- Damage, including repetitive losses, of community buildings die to coastal flooding.
- Invasive species is an issue and may become worse due to climate change.

Infrastructure:

- Roadway lane widths are too narrow and certain roads flood frequently.
- Inventory and analysis of existing stormwater infrastructure system is required. Funding resources are not currently available for this.

How will future SLR affect your program/exacerbate those impediments?

Sanitary Wastewater Treatment

- Use of on-site systems in coastal setting (in particular the beach communities) will become impossible and should be prohibited. On-site systems that are allowed, within floodplains) should consider coastal flood conditions (e.g., scour, flood loads).

Natural Resources:

- Beach migration and storm-induced erosion is causing sand to impact marshes by sedimentation.

Economic:

- The Town needs to evaluate the long term effects of sea level rise, in particular loss of taxable properties; loss of population; and overall loss of tax base/reduction in tax revenue.

Infrastructure and Emergency Response:

- Future projections of road flooding will need to be incorporated into emergency management plans, specifically: 1) delineation of ingress/egress roads; 2) maintenance of access/egress to roads; 3) specialized vehicles for Police, Fire and EMS; 4) increase capacity of emergency public shelters; and 5) Evacuation Planning.
- Beach migration and storm-induced erosion is causing sand to impact roads.

FEEDBACK: TOWN AND STATE PROFESSIONALS

Planning/Land Use:

- Sea level rise will add an additional level to Town planning and sea level rise needs to be included in future planning decisions. Zoning regulations do not include set-backs for tidal wetlands. As wetland area increases, there will be less buildable area and an increased need for variances.
- Sea level rise raises issues of cost and environmental benefit that will have to be addressed.
- There will be an increased demand for "grey" structural shoreline protection.
- Without adequate planning and regulation, development will continue within areas of the Town that are the most vulnerable to coastal flooding and the effects of sea level rise.
- Identifying a planning pathway to success in the face of sea level rise, so resources and investment can be appropriately applied.

Historic Districts/Properties:

- Not enough attention is being paid to flood protection of historic structures.

National Flood Insurance Program/ Disaster Relief Funding:

- FEMA Flood Insurance Rate Maps, limits of special flood areas and Base Flood Elevations will continue to change with rising sea levels.
- Eligibility for public assistance funding generally requires documenting pre-and post-storm to demonstrate what needs to be repaired or replaced. The need for this level of documentation will increase.

At what future point do you anticipate having to modify your program?

Sanitary Wastewater Treatment:

- The plan for addressing wastewater treatment in the Town has defined end dates, but is a continual concern impacting property owners – in particular, those that have failing systems.
- The Town is under a court order to improve water quality and wastewater management. However, the approval for community systems rests primarily with the DEEP.
- Support from the Board of Selectmen, and ultimately the voting residents, is also required to move forward with community systems.

Infrastructure:

- Flooding of infrastructure needs to be addressed Now.
- At what point (i.e., what sea level) do we raise roads and by how much to stay ahead of futures increases in sea level?

Regulations:

- All planning programs and regulations (included local building codes and flood-plain ordinances and zoning regulations) need to be continually modified to incorporate higher sea level rise standards.

Public Health:

- Climate change will likely introduce new public health issues such as increased temperatures, northern migration of disease vectors. These will have to be addressed.

National Flood Insurance Program:

- Need updated flood regulations – soon.

FEEDBACK: COMMUNITIES

Attachment 5 presents the details of a Neighborhood Resilience and Adaptation assessment of two "neighborhoods", including Chalker Beach and the Rt. 154 Main Street, College Street and Maple Avenue intersection. This effort resulted in extensive feedback by residents during the several workshops. The feedback generated during the community workshops is summarized below.

Top resilience and adaptation priorities - Chalker Beach:

1. Town and beach community investment in resilience and adaptation should be focused on infrastructure and flood protection measures such as perimeter flood protection berms and beach nourishment.
2. Investment should be prioritized in the most vulnerable, low-lying areas.
3. Roadway investment should be made to ensure that community ingress and egress is available, at a minimum for nuisance and high probability floods (e.g., 2 to 10 year recurrence interval floods).
4. Evacuation is acceptable for larger, less frequent flood events.
5. Perimeter flood protection berms of up to six feet in height would be acceptable (from an aesthetics, water access perspective).
6. At this time, interest in voluntary buyouts and relocation is limited.
7. There is a community willingness to contribute to an adaptation fund of an amount no more than $10,000 per household for "one-time" measures and $1,000 per household on a recurring 10-year basis.

Topics without a clear consensus - Chalker Beach:

- The appropriate legal mechanism for implementing a perimeter berm flood protection strategy (i.e., voluntary, mandatory, easements, design guidelines, etc.)
- If perimeter flood protection berms are located on private property, should they also be available to be used as recreational, public access greenways.
- Whether or not property should be dedicated for Town buyback or as regulatory setbacks to allow for lateral advancement of tidal marsh (or whether marsh advancement is important to the residents).
- Whether zoning regulations should dictate the visual and aesthetic requirements for elevating houses.

Top resilience and adaptation priorities - Resilient Corridor (Main Street):

- Implementing a roadway infrastructure program that elevates as many roads as possible to provide access to the largest number of homes.
- Providing egress and mobility during frequent Sandy-sized storms, but not necessarily during the 100-year recurrence interval floods.
- Having evacuation policies for larger storms.
- Providing sloped access to private driveways off of raised roads.
- Creating floodable (green) streets for non-critical routes.
- Creating recreational trails along the marshes, either with or without perimeter flood protection berms, and/or along rights-of-way.
- Building perimeter berms two to six feet tall.
- Leaving the responsibility of elevating structures up to owners.

Topics without a clear consensus - Resilient Corridor (Main Street):

- The appropriate legal mechanism for implementing a perimeter berm flood protection strategy (i.e., voluntary, mandatory, easements, design guidelines, etc.)

FROM FEEDBACK TO STRATEGIC PRIORITIES...

The feedback provided by the residents and Town and State professionals was used to define strategic priorities for resilience and sea level rise adaptation:

INGRESS AND EGRESS - ROADS AND BRIDGES

The Town's roads are vulnerable to coastal flooding, as experienced during recent storms. Nuisance flooding is already encountered on some roads. Larger storms create isolated "islands" with no means of ingress and egress during the flood event.

PUBLIC SAFETY

Ensure that the Town's Essential and Lifeline facilities are protected to the 500-year recurrence interval flood. Ensure evacuation during flood levels greater than the 10-year recurrence interval flood, including access to the Town's public shelter.

SANITARY WASTEWATER TREATMENT

Low-lying, poor draining areas (in particular the Low Beach Communities) are becoming completely unsuitable for individual on-site subsurface disposal systems due to small lot sizes, shallow groundwater and vulnerability to flooding. Sea level rise will make this condition worse in the future. Different applicable regulations have conflicting requirements. Funding to pay for new systems will have to be identified.

NATIONAL FLOOD INSURANCE PROGRAM

The Town is a participating community in the National Flood Insurance Program and has been proactive in achieving compliance. However, due future sea level rise, updates to FEMA Flood Insurance Rate Maps are expected - probably about every ten years or so - increasing the limits of special flood hazard areas and base flood elevations.

PROTECTION OF PRIVATE PROPERTY

Protection of private property is a key priority of the Town's residents. Maintaining property value is equally important. A flood protection approach that uses several, integrated strategies and measures is preferred. Perimeter flood protection using earthen berms was discussed as an alternative for protection of areas abutting the tidal marshes. However, the berms would have to be on private property. Also, the conditions are not conducive to constructing berms that would qualify as FEMA-accredited levees (i.e., would not change flood insurance or building code requirements. Elevating houses in accordance with current federal, State and local building codes is another alternative - one currently being used by residents.

INGRESS AND EGRESS

Elevate roads, at a minimum, to provide ingress and egress under nuisance flood conditions (e.g., astronomical high tides) and high probability floods (e.g., at least to the 10-year recurrence interval flood predicted over the next 50 to 100 years).

PUBLIC SAFETY

Provide flood protection for at-risk Essential and Lifeline Facilities. If all roads cannot be elevated, develop alternative emergency response capabilities such as amphibious emergency vehicles for use during storms when roads are flooded. Establish and communicate evacuation guidance and protocols.

SANITARY WASTEWATER TREATMENT

Two strategic alternatives: 1) Retreat from these areas; or 2) provide alternative wastewater treatment systems. The Old Saybrook Water Pollution Control Authority has developed, and is implementing, a wastewater management program that will use centralized community systems for treatment of wastewater from the most vulnerable communities (i.e., the beach communities), allowing these homeowners to remain in.-place. A priority is to design these treatment systems to accommodate coastal flood vulnerabilities and sea level rise for the through 2100 years or their design life. Identify funding opportunities including grants, bonds, general taxes and/or use fees.

NATIONAL FLOOD INSURANCE PROGRAM

Continue to proactively achieve compliance and evaluate the benefits of investing to improve the Town's Community Rating System score. Until FEMA changes their mapping guidelines to address sea level rise, provide residents with Town-specific flood hazard data reflecting sea level rise projections for 2050 and 2100, in line with the State of Connecticut.

PROTECTION OF PRIVATE PROPERTY

Prioritize the protection of homes, on an individual property basis, using methods available under the existing federal and State flood regulations and local ordinances (such as elevating houses). Provide guidance to homeowners on floor elevations considering sea level rise. Evaluate the use of community-wide standards for elevating buildings to: 1) provide community aesthetic consistency; and 2) reduce the challenges of elevating roads (i.e., multiple, differing entry elevations).

FROM FEEDBACK TO STRATEGIC PRIORITIES...

LAND USE

"Set-asides" and land acquisition are used for the preservation and enhancement of natural resources. The beach communities and the Town manage the beaches. There is ongoing demand for public access to scenic views, the waterfront and the tidal marshes, including dedicated bikeways on public roads. The additional use of perimeter flood protection berms as public greenways was discussed; however, there are concerns by abutting property owners about this use. It is the goal of beach community residents (in particular those located on the beach) to stay in the community (i.e., not retreat) and use a strategy of flood protection at the property scale (i.e., elevated structures, consistent with existing building codes).

HISTORIC PROPERTIES

There are several historic districts and numerous historic properties located with the Town. These properties are significant to maintaining the character of the Town. Many of these properties are vulnerable to coastal flooding. Ownership is a mix of private and public. These properties are not well-suited to typical flood mitigation measures presented in the flood regulations (e.g., elevating houses).

SHORELINE PROTECTION

Old Saybrook's shorelines, for the most part, are eroding. Maintaining shorelines is a key component of resilience and adaptation. The State is promoting the use of natural and nature-based measures (e.g., Living Shorelines, beach nourishment) and is discouraging (including new legislation) the new construction of "grey" structures (e.g., seawalls, revetments, groins). Much of the Old Saybrook shoreline is exposed to large waves limiting the use of Living Shorelines. The tidal marshes and river mouths are good environments for Living Shorelines. Beach nourishment is very expensive and sand sources are becoming limited. Much of the shoreline access is limited to community residents.

ECONOMIC CHALLENGES

Coastal flooding and sea level rise will result in increasing costs to the Town and Town residents. Federal grants and public assistance funds are limited and historically linked to emergency public assistance funding. These federal programs are insolvent; the future availability of this source of funding is uncertain.

LAND USE

The importance and complexity of these issues makes revisiting Town land use planning goals and regulations (in the context of coastal flooding and sea level rise) a top priority. Achieving a balance of public and private land use in a manner that also reduces the risks of coastal flooding is an obvious goal. While retreat may not currently be a preferred strategy by Town residents, some amount of retreat will be inevitable in the future and should be a priority for long-term planning. Future land use planning should focus on promoting new development in non-vulnerable areas of Town.

HISTORIC PROPERTIES

Provide flood protection for Historic Properties. These properties are exempt from the federal flood regulations, allowing flexibility in the types of flood mitigation measures that can be used.

SHORELINE PROTECTION

It is a priority for the Town and the DEEP to continue to work together to find shoreline protection solutions that are compliant with regulation and also meet the needs of the Town residents, possibly involving an integrated approach of Living Shorelines, beach nourishment, natural and nature-based tidal marsh borders and upland (above the CJL) flood protection structures. Town-wide and regional beach nourishment planning is also a priority, providing the regional critical mass to promote nourishment projects and coordinate with the USACE.

ECONOMIC CHALLENGES

Identifying the resilience and adaptation cost liability associated with: 1) increased public works and public safety costs; 2) potential erosion of tax base; 3) effect of Town tax rate; and 4) effect on Town municipal bond credit rating, should be a priority. Contingency cost planning should be considered as part of the General Budget. Land use planning and policy should preserve the tax base by encouraging land development (including relocation) in non-vulnerable areas of Town.

RESILIENCE AND ADAPTATION STRATEGIES

INTRODUCTION

Creating adaptive communities typically requires application of several different and integrated strategies. Strategies also evolve over time. Three coastal resiliency strategies are recommended for the Town. These include: Retreat, Protect and Accommodation.

- **Protect**: A range of interventions designed to hold back flooding from inundating developed areas and preventing erosion and loss of land.
- **Accommodate:** Allowing inundation to occur, but protecting infrastructure, property and natural resources from damage through permanent and interim measures implemented on an on-going basis.
- **Managed Retreat:** Managed withdrawal from coastal areas, most often accompanied by adaptive land use and managed relocation.

The time frames used for resilience and adaptation planning fall into “near-term” and “long-term”. Near term goals are those that should be planned for and achieved over the next 5 to 20 years. For this period of time, the confidence level about sea level rise projections and flood risk is high. Long-term goals are those that are planned for over the next 50 to 100 years (say, the year 2100). Over this period of time, there is significant uncertainty as to the amount of sea level rise that will occur. However, there is confidence that it will be significant and highly impactful to Old Saybrook.

Each of the strategies presented above utilize different resilience and adaptation measures, which are categorically: 1) structural, 2) non-structural, and 3) natural and nature-based features.

- **Non-structural:** Non-structural measures reduce human exposure or vulnerability to a flood hazard without altering the nature or extent of the flooding. Non-structural measures are consistent with the resiliency strategies of Accommodation and Retreat and range from removing an entire structure from the floodplain to adapting or constructing the structure to meet flood protection standards. These measures include measures that range from elevating house to changes to policies, plans and regulations.
- **Structural**: Structural measures are designed to protect (i.e., prevent flooding) and are consistent with a resiliency strategy of Protection. Specifically, they prevent flood inundation of developed areas
- **Natural and Nature-Based Features (NNBF)**: NNNBs are features that are created and evolve over time through the natural actions of physical, biological, geological and chemical processes. These features “mimic” natural features but are created by human design, engineering and construction to provide flood mitigation and shoreline protection.

LOOKING BACK

Looking back at the development of Old Saybrook (from the colonial era to current) is informative to planning for the future.

Excerpted image from 1870’s historical map of Old Saybrook

The image presented above was excerpted from an 1870s map of Old Saybrook. While the alignment of roadways is similar to today, the early residents generally:

- settled in areas of high elevation
- used low-lying land as salt hay fields; and
- avoided development right on the beaches and adjacent to marshes.

Around the turn of the 20th century, development expanded to the beaches and areas near the marshes - areas that were vulnerable to coastal flooding. Certain areas of marsh were filled and developed. Major arterials within the Town were created (from the original roads) and connected to the State’s rail and road system.

Image of Chalker Beach circa 1916 (public domain image from CardCow)

Images of Chalker Beach and Plum Island after the Hurricane of 1938

During this time, summer housing was developed along the coastal waterfront including right on the beaches. Beach communities were formed. Dunes had been naturally present, but were demolished to construct houses, and the houses were constructed just feet from the ocean. The collective memory of the major 1700s and 1800s hurricanes (some of the largest in the New England historical record) was lost to this generation. Also many new residents came from “out of town” and did not have a fishing and seafaring background, with its experience with coastal storms.

The Hurricane of 1938 devastated much of Old Saybrook, in particular the waterfront properties. Since the 1930s, Old Saybrook has been extensively developed to the south of Interstate 95 and the Amtrak rail line, resulting in significant property value invested in areas that are vulnerable to coastal flooding. There have been a number of memorable storms (most recently Hurricanes Sandy and Irene). However, these storms were relative minor (in terms of impact to Old Saybrook) and had flood water levels on the order of about 10 to 20-year recurrence interval floods. While a few remain that experienced the Hurricane of 1938, no storms since then have come close. The Hurricane of 1938 flood elevations were similar to those now predicted for a 100-year recurrence interval flood (i.e., similar to the FEMA Base Flood). No one alive in New England has experienced a 500-year recurrence interval flood, which would be catastrophic to Old Saybrook should it happen.

Much of the Town land area to the north on Interstate 95, which is not vulnerable to coastal flooding, remains undeveloped.

LONG-TERM STRATEGIES

Long term strategies are, in certain respects, easier to plan for than near-term strategies since they do not immediately effect people. Given the significant future coastal flood risk to property owners and the Town, including the likelihood of repetitive loss, chronic flood inundation and increasing cost, logical long-term strategies include the following:

1. Retreat from development on the beach (effectively, development within current and predicted future V zones).
2. Encourage relocation and redevelopment in areas that are not vulnerable to coastal flooding including to the north of Interstate 95.
3. Protect key areas like Town Center, Saybrook Point and established communities and historic districts. These areas are essential to the character of Old Saybrook and could be protected with a combination of elevated structures and perimeter levees that could also serve as public greenways.
4. Create resilient corridors to connect these protected areas (which may become "island-like" by the year 2100) to each other and to the State rail and road system.
5. Construct these resilient corridors as combinations of raised roadways, bridges and greenways.
6. Create and maintain a natural buffer at marsh edges.
7. Allow natural coastal processes to occur along beaches and within marshes, and return these areas to public use.

Over the long-term it is likely that homeowners located within chronically inundated areas (flooding on average of 26 times per year) will be receptive to a voluntary retreat strategy. This is consistent with a recent study by the Union of Concerned Scientists and already observed in high risk areas such as parts of Florida. Chronically inundated areas will also increasingly represent a disproportionate percentage of the Town's General Budget costs and may be, in the long term, financially unsustainable. These long-term strategies would maintain the character of the Town, preserve natural resources, provide public access, maintain the tax base and maintain or reduce Town and homeowner costs.

The conceptual images on the page 34 present a "snapshot" of what this future would look like.

NEAR-TERM STRATEGIES

Based on the community outreach performed during this study, many of the long- term strategies presented above (including retreat from beach areas) are unlikely to be approved by Town residents and implemented in the near-term. So, different near-term strategies are needed. These near-term strategies should be in alignment with: 1) the feedback from Town residents; 2) the coastal flood risks identified by this study; and 3) the Town's planning goals as presented in the Plan of Conservation and Development. Based on the current and future risks identified by this study and feedback received from the community and Town and State professionals, the following near-term measures have been identified. The near-term measures are generally consistent with a strategy of Accommodate (allowing flood inundation to occur, but protecting infrastructure, property and natural resources from damage through permanent and interim measures that are implemented on an on-going basis). Many of these measures were identified during the study outreach workshops.

INGRESS AND EGRESS: ROADS

Develop a roadway improvement plan to identify specific projects, project costs and funding mechanisms. The technical complexity and cost of elevating all roads that are vulnerable to low probability floods, such as the 100-year and 500-year recurrence interval floods, are very high. A strategy of improving only the portions of key roads that are subject to chronic and high probability floods is a more reasonable in the near-terms (about 4 to 10 miles of road, excluding the causeway). A combination of raising roads, low bridges and perimeter flood protection could be implemented. **Attachment 4** provides a detailed vulnerability analysis of the Town roads, bridges and culverts and **Attachment 7** provides a detailed, comprehensive assessment of road improvement including recommended roadway candidates.

PUBLIC SAFETY

1. Assuming that all roads that are vulnerable to low probability floods are not flood-protected, develop alternative emergency response capabilities such as amphibious emergency vehicles for use during storms when roads are flooded. Train to FEMA level II status. **Attachment 2** and **Attachment 4** describe the flood conditions that should be anticipated along throughout the roadway system, under different probability floods. See example: https://www.dvidshub.net/news/252966/west-virginia-swift-water-rescue-team-attains-fema-level-2-status-prepares-future-disasters
2. Establish and communicate evacuation guidance and protocols. **Attachment 4** provides roadway flood details for evacuation planning and predicted shelter requirements.

3. Provide flood protection for at-risk Essential and Lifeline Facilities. **Attachment 4** and **Attachment 7** provide flood risk details and recommendations for the Essential and Lifeline Facilities. This is a readily achievable measure, except for the ambulance facility which should be relocated.

SANITARY WASTEWATER TREATMENT

The Old Saybrook Water Pollution Control Authority has developed and is implementing a wastewater management program that is proposing to use a centralized community system for treatment of wastewater from the most vulnerable communities. The treatment systems should be designed to accommodate coastal flood vulnerabilities and sea level rise for the through 2100 years or their design life. **Attachment 2** and **Attachment 4** provide flood risk details. A separate memorandum (included as **Attachment 4, Appendix A**) was provided the Authority.

NATIONAL FLOOD PROTECTION PROGRAM

1. Continue to proactively achieve compliance and evaluate the benefits of investing to improve the Town's Community Rating System score.
2. 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. The analyses performed in this study and presented in **Attachment 2** provide a start to developing these hazard planning maps.
3. Implement a survey and monitoring program to readily document pre- and post-storm conditions to make efficient and optimize opportunities for federal and State Public Assistance.

REGULATIONS

Review and update building codes and zoning regulations to promote resilient and adaptive behavior and decisions, possibly including broader use of set-backs, special development overlay zones and a Town-specific Design Flood Elevation (DFE) reflective of sea level rise. **Attachment 2** provides technical information to inform selection of DFEs.

PROTECTION OF PRIVATE PROPERTY

1. Protect homes, on an individual property basis, using methods available under the existing flood regulations and ordinances (such as elevating houses).
2. Provide guidance to homeowners on appropriate floor elevations considering sea level rise.
3. Evaluate the use of community-wide standards for elevating buildings to: 1) provide community aesthetic consistency; and 2) reduce the future challenges of elevating roads (i.e., multiple, differing entry elevations).

HISTORIC PROPERTIES

Provide flood protection for Historic properties. These properties are exempt from the federal flood regulations, allowing flexibility in the types of flood mitigation measures that can be used. **Attachment 7** recommends a flood mitigation approach for historic properties. The Town should provide flood mitigation guidance to property owners that is consistent with zoning regulations for historic districts.

SHORELINE PROTECTION

1. Employ Living Shoreline solutions for select areas including low wave energy environments such as tidal marsh borders and river mouths. GZA recently designed a Living Shoreline project in Fenwick that can serve as an example.
2. Maintain the structural condition of the existing groins.
3. Develop a Town-wide and regional beach nourishment plan.
4. Coordinate with the USACE relative to beach nourishment as part of a regional group.
5. Evaluate the technical feasibility of constructing dunes and berms along the beaches.

LAND USE

Achieve a balance of public and private land use in a manner that reduces the risks of coastal flooding:

1. Create a re-development plan for Saybrook Point that requires measures to achieve compliance with flood regulations and ordinances as well as addresses sea level rise. Development agreements and special overlay zones have been used for this purpose in Connecticut for large re-development projects.
2. Focus on promoting new development in non-vulnerable areas of Town.
3. Initiate an on-going discussion with residents regarding:
    - Long-term retreat from very high vulnerability areas, including the beaches;
    - Land acquisition for: a) future relocation; b) expansion of tidal marsh; c) conservation land, including beachfront property;
    - Process for developing perimeter flood protection berms, including easements or land acquisitions, and responsibility for maintenance and operation during flooding.
    - The possibility of using perimeter flood protection berms as public greenways.

Attachment 7 presents a detailed discussion on land acquisition.

MARSHES

Monitor the marsh performance relative to sea level rise. Should the rate of sea level rise be greater than the observed sedimentation rates, consider implementing a program of artificial thin layer deposition.

ADDITIONAL STUDY: STORMWATER

Analyze the existing stormwater infrastructure under "precipitation only" and "combined coastal flood-precipitation" events. This information is necessary to comprehensively characterize the Town's flood risk and to identify the need for:

- additional catch basins;
- pumps stations;
- applicable use of Green infrastructure for stormwater infiltration;
- Improved hydraulic capacity of culverts; and
- additional tide-gates on outfalls.

ECONOMIC CHALLENGES

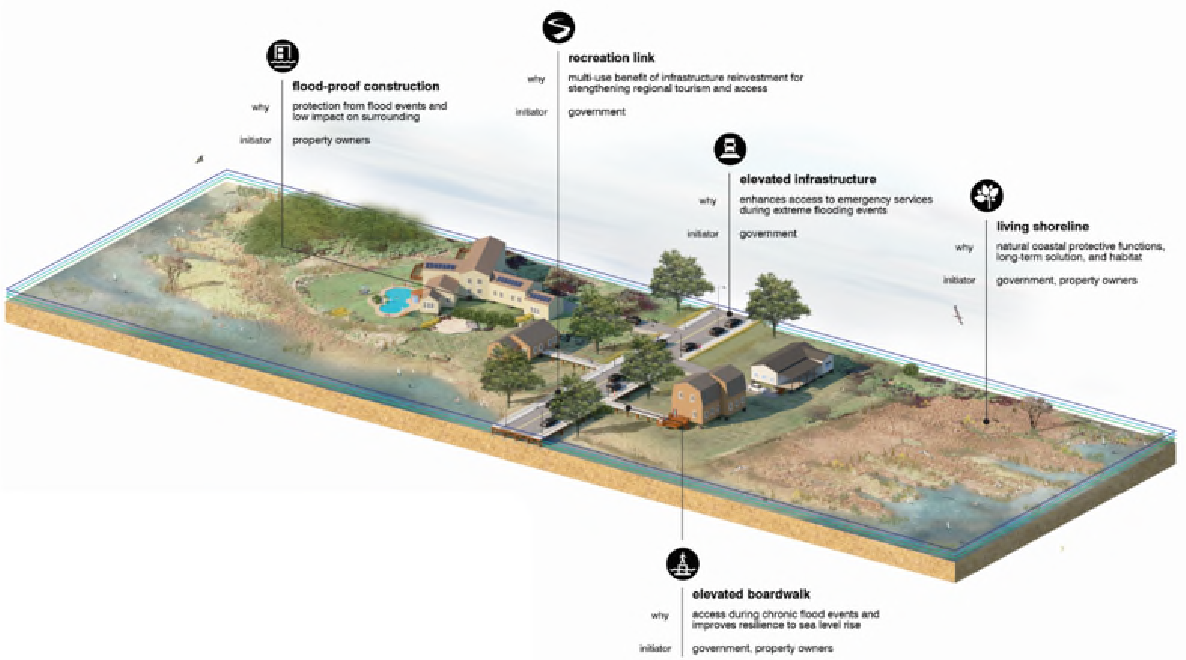
1. Perform a budget analysis to identify coastal flood risk cost liabilities associated with:
   - increased public works and public safety costs;
   - potential erosion of tax base;
   - effect on future Town tax rates; and
   - effect on Town municipal bond credit rating.
2. Identify project funding mechanisms for physical projects including municipal bonds, taxes and alternative bonds (e.g., resilience bonds).
3. Evaluate cost sharing and use fees for resilience and adaptation measures.

The information presented in this study, in particular **Attachment 4** and **Attachment 7** will be informative to these analyses.

ALIGNMENT WITH TOWN PLANNING GOALS

The long-term and near-term strategies and measures are consistent with goals defined in the plan for Conservation and Development including:

- Preservation, conservation, and development consistent with the Connecticut Coastal Management Act.
- Protection of water resources and groundwater quality.
- Prevention of destruction of valuable wetland systems and protection of native wetlands species and habitats.
- Conservation, restoration, and wise use of the shorefront to minimize erosion.
- Avoidance of flood problems.
- Consideration in the planning process of the potential impact of coastal flooding and erosion patterns on coastal development to minimize damage to and destruction of life and property and reduce the necessity of public expenditure to protect future development from such hazards.
- Maintenance and improvement of tidal and freshwater wetlands for their natural functions and social benefits.
- Preservation and enhancement of coastal resources in accordance with State policies concerning environmental protection, inland wetlands & watercourses, water resources, water pollution, parks and forest, and pollution, and flood control & beach erosion.
- Development of corridors of open space in "greenways", which protect natural resources, preserve scenic landscapes, and historical resources.
- Acquisition of land for municipal purposes, including recreation, habitat protection, economic development, historical and cultural preservation, and the public health, safety, and welfare.
- Implementation of an aggressive open space identification, acquisition and management program using outside funding sources to supplement town funds where feasible and appropriate.
- Protection of important natural resources, including the Connecticut River and Long Island Sound, tidal and inland wetlands, streams, ponds and lakes, forested ridges and hills, as well as open fields and farms, from degradation due to inappropriate development.
- Preserve unique historical and cultural resources of the community to focus on Old Saybrook's past.



Representation of a long-term resilience and adaptation strategy for Old Saybrook., above. Function shown below.

IMPLEMENTATION

Recommended implementation steps include the following:

RECOMMENDATION	STRATEGY	ACTION TYPE	RESPONSIBILITY	PRIORITY
Policies, Plans and Programs				
Action 1: Designate the Board of Selectmen (BOS) as the Town Resiliency Program Lead. Task the BOS with annually requesting Town Departments/Staff to report on policies, plans and projects to ensure integration of coastal resiliency and climate change for the future.	A	N-S	First Selectman State Representatives	H
Action 2: Establish the BOS as the Flood and Erosion Control Board (FECB) for the Town of Old Saybrook 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.	A	N-S	Board of Selectmen (BOS)	H
Action 3: FEMA Community Rating System (CRS). The Town has identified the programs, higher standards and resilience activities for inclusion as a part of a future CRS application for consideration by FEMA. The Town does not currently participate in the CRS program because of limited resources and support, and the costs required to maintain such a program. If in the future resources become available to support a CRS program, it is recommended the Town apply for a Level 9 status with FEMA.	A	N-S	BOS/FECB	H
Action 4: 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 repetitive loss properties.	A	N-S	LUD BOS/FECB PW	H
Action 5: Integrate findings of Old Saybrook Coastal Resilience and Adaptation Plan into the 2019 Natural Hazard Mitigation Plan Update.	A	N-S	Planning Commission (PC) BOS/FECB	H

RECOMMENDATION	STRATEGY	ACTION TYPE	RESPONSIBILITY	PRIORITY
Policies, Plans and Programs				
Action 6: Integrate findings and resilience strategies presented in the Old Saybrook Coastal Resilience Study into the Plan of Conservation and Development Update.	A	N-S	PC LUD Economic Development (ED)	H
Action 7: NATIONAL FLOOD INSURANCE PROGRAM. 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. The analyses performed in this study and presented in Attachment 2 provide a start in developing these planning maps.	A	N-S	Land Use Department (LUD)	H
Action 8: NATIONAL FLOOD INSURANCE PROGRAM. Implement a survey and monitoring program to readily document pre- and post-storm conditions to make efficient and optimize opportunities for federal and State Public Assistance.	A	N-S	EM PW	H
Action 9: INGRESS AND EGRESS: Roads. Develop 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 about 4 to 10 miles of road, excluding the causeway). Hold formal meetings with ConnDOT regarding improvement and resilience of State roads and bridges located within the Town limits.	A	N-S, S	Public Works (PW) Planning Commission (PC) BOS	H
Action 10: PUBLIC SAFETY: Emergency Response. Develop alternative emergency response capabilities such as amphibious emergency vehicles for use during storms when roads are flooded. See example: https://www.dvidshub.net/news/252966/west-virginiaswift- water-rescue-team-attains-fema-level-2-status-prepares-future-disasters	A	N-S	Fire Department (FD) Police Department (PD) Emergency Management (EM)	H
Action 11: PUBLIC SAFETY: Evacuation Planning. Establish and communicate evacuation guidance and protocols. Attachment 4 provides roadway flood details for evacuation planning and predicted shelter requirements.	A	N-S	FD/PD/EM	H

RECOMMENDATION	STRATEGY	ACTION TYPE	RESPONSIBILITY	PRIORITY
Policies, Plans and Programs				
Action 12: PUBLIC SAFETY: Flood Protection. Provide flood protection for at-risk Essential and Lifeline Facilities. Attachment 4 and Attachment 7 provide flood risk details and recommendations for the Essential and Lifeline Facilities.	A	N-S, S	PC BOS/FECB	H
Action 13: PROTECTION OF PRIVATE PROPERTY. Protect homes, on an individual property basis, using methods available under the existing flood regulations and ordinances (such as elevating houses).	A	N-S, S	Building Department (BD) Planning Commission (PC)	H
Action 14: PROTECTION OF PRIVATE PROPERTY. Provide guidance to homeowners on floor elevations considering sea level rise.	A	N-S	LUD	H
Action 15: SHORELINE PROTECTION. Employ Living Shoreline solutions for select areas including low wave energy environments such as tidal marsh borders and river mouths.	A	N-S	LUD	M
Action 16: SHORELINE PROTECTION. Program to maintain Existing Groins	A	S	Beach Communities PW	H
Action 17: SHORELINE PROTECTION. Develop a Town-wide and regional beach nourishment plan.	A	NNB	Beach Communities; Town; Regional Committee to be formed	H
Action 18: LAND USE. Create a re-development plan for Saybrook Point that requires measures to achieve compliance with flood regulations as well as addresses sea level rise.	A	N-S	BOS/PC Coastal Resilience Management Team (CRMT)	H
Action 19: LAND USE. Focus on promoting new development in non-vulnerable areas of Town.	A	N-S	BOS/PC/CRMT	H
Action 20: 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.	A	NNB	BOS/PC/CRMT	H
Action 21: STORMWATER. Analyze the existing stormwater infrastructure under precipitation only and combined coastal flood-precipitation events. This information is necessary to comprehensively characterize the Town's flood risk and to identify the need for additional catch basins, pump stations, additional tide gates, and green infrastructure.	A	N-S	BOS/PC/CRMT	H

RECOMMENDATION	STRATEGY	ACTION TYPE	RESPONSIBILITY	PRIORITY
Policies, Plans and Programs				
Action 22: LAND USE. Initiate an on-going discussion with residents regarding: 1) Long-term retreat from very high vulnerability areas, including the beaches; 2) Land acquisition for: a) future relocation; b) expansion of tidal marsh; c) conservation land, including beachfront property; 3) Process for developing perimeter flood protection berms, including easements or land acquisitions, and responsibility for maintenance and operation during flooding; 4) the possibility of using perimeter flood protection berms as public greenways. Attachment 7 presents a detailed discussion on land acquisition.	A	N-S	BOS/PC Coastal Resilience Management Team (CRMT)	H
Regulations and Permits				
Action 23: Every 10-years, adopt future coastal flood risk overlay maps and sea level rise projections.	A	N-S	BOS CRMT	H
Action 24: PROTECTION OF PRIVATE PROPERTY. Evaluate the use of community-wide standards for elevating buildings to: 1) provide community aesthetic consistency; and 2) reduce the challenges of elevating roads (i.e., multiple, differing entry elevations.) Review and modify the Town's Floodplain Management Ordinance to incorporate coastal resilience and adaptation, including adoption of a Town Design Flood Elevation (DFE).	A	N-S	LUD Building Department (BD)	H
Action 25: 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.	A	N-S	PW	M
Action 26: SHORELINE PROTECTION. Evaluate the technical feasibility of constructing dunes and berms.	A	NNB	PW	H
Action 27: HISTORIC PROPERTIES. The Town should provide flood mitigation guidance to property owners that is consistent with Historic District Regulations. Attachment 7 recommends a flood mitigation approach for historic properties.	A	N-S,	Historic District Commission (HDC)	H
Action 28: 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	A	N-S	PW	M

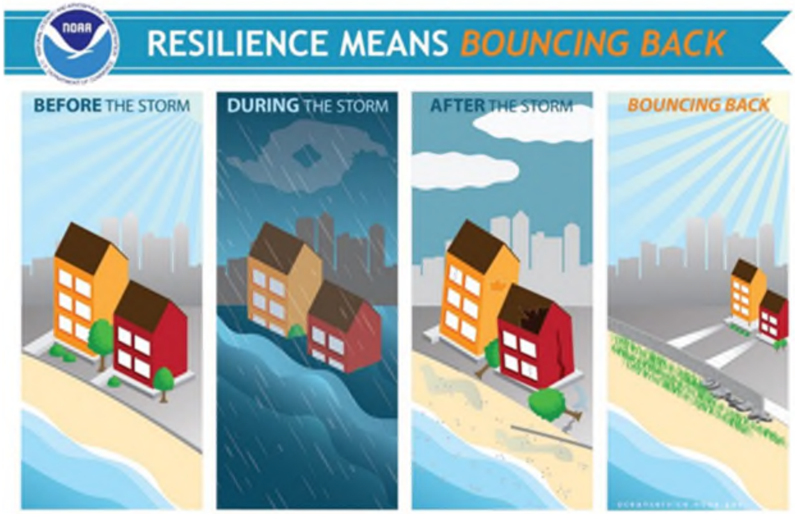
RECOMMENDATION	STRATEGY	ACTION TYPE	RESPONSIBILITY	PRIORITY
Project Funding				
Action 29: Identify and Prioritize Physical Improvement Projects	P	S, NNB	Board of Selectmen; Board of Finance	H
Action 30: Grant Application Plan. Prepare detailed application plan for grant opportunities, including FEMA Hazard Mitigation Grant, USACE, NOAA, HUD, CIRCA, DOT, DECD and EPA programs. Initiate grant applications.	A	N-S	TBD	H
Action 31: FEMA Pre-Disaster Mitigation and Post-Disaster Recovery Preparation Grants. Initiate grant application process for the three FEMA Hazard Mitigation Assistance (HMA) grant programs: Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM) and Flood Mitigation Assistance (FMA).	A	N-S	LUD PC BOS	M
Action 32: Request the USACE to perform a feasibility study under Section 103 Hurricane and Storm Damage Protection, to support future USACE grants	A	NNB	LUD PC Beach Communities	M
Action 33: Evaluate Coastal Flood and Climate Change Effects on Municipal Bond Rating	A	N-S	BOS Finance Director	L-M

Legend

- STRATEGY: Protection = P, Accommodate = A, Retreat = R
- ACTION TYPE: Structural = S, Non-Structural = N-S, Natural and Nature-Based = NNB
- RESPONSIBLITY: Board of Selectmen = BOS, Coastal Resilience Management Team (CRMT), Planning Commission (PC), Historic District Commission (HDT), Land Use Department = LUD, Public Works = PW, Flood and Erosion Control Board, and Economic Development (ED), Building Department (BD)
- PRIORITY: High=H, Moderate=M, Low=L

Attachment 1: Approach and Methodology

Resilience and Adaptation



"Resiliency is the ability of a community to "bounce back" after hazardous events such as hurricanes, coastal storms and flooding." (NOAA)

Coastal resiliency is the ability to recover quickly from coastal flood events such as nor'easters and hurricanes. It can be achieved through a combination of: 1) zoning and building codes that require buildings to be protected from flooding; 2) public outreach and education; 3) appropriate emergency response capabilities; 4) the fostering of strong social networks; and 5) physical shoreline protection and flood mitigations measures (such as structural and natural and nature-based features), that work together to reduce the short-term effects of flooding.

However, the frequency and intensity of coastal floods will increase in the future, primarily as a result of sea level rise. Over the last 100 years the, sea level within Long Island Sound has risen about 0.8 foot. Over the next 100 years sea levels are projected to rise, with a reasonable probability, another 4 to 6 feet and may increase as much as 15 feet. During the next 100 years, regardless of the actual amount of sea level rise, the rate of sea level rise will steadily increase. The on-going, incremental effects of rising sea levels will require that communities adapt. And the successful communities will those that proactively develop the social and economic capacity to adapt.

Study Approach

This Study is part of an on-going process that the Town has embarked on to proactively reduce coastal flood risk and prepare for the effects of sea level rise. The Study used:

- Industry-accepted "State-of-the-Science" sea level rise projections that are also consistent with current State of Connecticut guidance.
- A "risk-based" approach, including defining coastal flood hazards in terms of probability of occurrence, consistent with methods currently being used by state and federal agencies.
- High resolution, hydrodynamic computer flood modeling to supplement flood hazard analyses performed by FEMA and the US Army Corps of Engineers (USACE).
- ESRI ArcGIS geographic information system (GIS) software, also used by the Town.
- Resilience and adaptation strategies, actions and measures that are consistent with Old Saybrook's current vision and plans for development.

Study Methodology

The preparation of the Study included:

Step 1: Characterization of the Coastal Flood Hazards

Step 2: Assessment of the Vulnerability of Town Infrastructure, Neighborhoods, Buildings, and Natural Resources

Step 3: Identification of Coastal Resilience and Adaptation Strategies, Actions and Measures

Step 4: Public and Stakeholder Outreach

Step 5: Identification of steps to implement the Study

Terminology

The Study uses flood terminology consistent with that used by FEMA. Flood hazard areas identified on the FEMA Flood Insurance Rate Maps (FIRMs) are identified as a Special Flood Hazard Area (SFHA). SFHAs define the limits of flood inundation associated with floods that have: 1) a 100-year recurrence interval (aka 1% annual exceedance probability); and 2) a 500-year recurrence interval (aka 0.2% annual exceedance probability). The 100-year recurrence interval flood elevation is a flood elevation that has, in any given year, a 1 in 100 chance of being met or exceeded. The FEMA 100-year recurrence interval flood is also referred to as the base flood and the associated water level is the base flood elevation (BFE). Similarly, the 500-year recurrence interval flood elevation is a flood elevation that has, in any given year, a 1 in 500 chance of being met or exceeded.

Other FEMA terminology includes:

- Floodplain: FEMA defines any land area susceptible to being inundated by water from any source as the "floodplain".
- AE Zones: AE flood hazard zones are areas within the 1% percent annual chance (base) flood, with waves of 1.5 feet or less in height. Coastal AE zones are areas within the 1% percent annual chance (base) flood, with waves between 1.5 and 3 feet height. These are areas that will be exposed to both flood, moderate wave forces and other wave effects.
- VE Zones: VE flood hazard zones are areas within the 1% percent annual chance (base) flood, with waves greater than 3 feet in height. These areas are subject to storm-induced high velocity wave currents and significant wave forces.
- LiMWA: The Limit of Moderate Wave Action (LiMWA) is the demarcation between areas with waves greater and lower than 1.5 feet height.

Figure 1-1 graphically illustrates the FEMA SFHAs.

Step 1: Coastal Flood Hazards

Coastal flood hazards include tides, storm surge, waves, high winds and coincident precipitation (rain or snow). The coastal flood hazards at Old Saybrook were characterized using several methods and sources of information:

1. The effective (2013) FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) for Old Saybrook. The FEMA FIS and FIRMs present Old Saybrook's flood hazard as determined by FEMA for purposes of the National Flood Insurance Program (NFIP). The FEMA Base Flood shown on the FIRM is also referenced in State and local building codes.

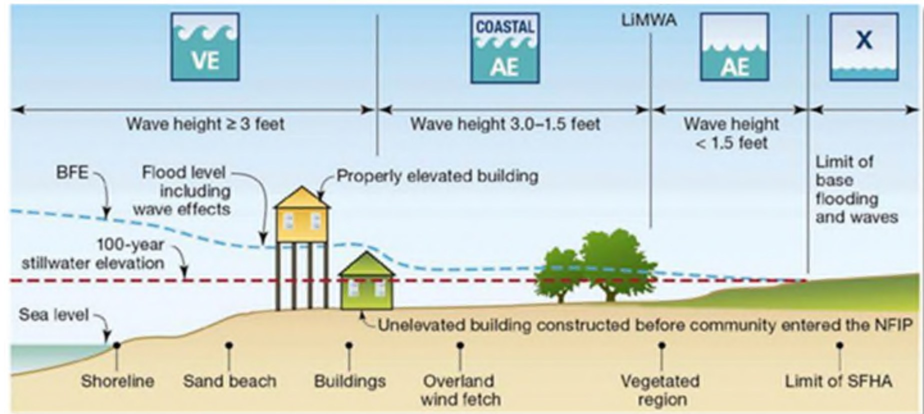


Figure 1-1: FEMA Coastal Flood Hazard Zones

2. Statistical analyses of the NOAA New London tide gage historical water level data. The New London tide gage monitors water level and has an approximately 79-year period of record. Statistical analysis of the tide gage data provides an estimate of flood elevation versus probability (i.e., likelihood of occurrence).
3. The North Atlantic Coast Comprehensive Study (NACCS). This study was performed by the USACE after Hurricane Sandy to characterize coastal flood hazards in areas impacted by Hurricane Sandy (from the Chesapeake Bay to New Hampshire) for use on federal projects. The study performed statistical analysis and computer modeling of storm surge and waves on a coarse resolution. The USACE has made the information available for public use. The NACCS presents nearshore flood hazard data at a number of locations along the Old Saybrook shoreline.
4. Sea level rise projections used by the USACE and the National Oceanic and Atmospheric Administration (NOAA) were used to predict the effect of sea level rise on coastal flooding in the future. The projections are available on-line for the NOAA tide gage station locations using the USACE "Sea Level Rise Calculator".
5. High resolution LiDAR topographic data and NOAA bathymetry were utilized to develop ground surface elevations nearshore and throughout the Town limits. Shoreline features (such as beaches, wetlands, man-made structures) were identified.
6. Flood inundation observed during Hurricane Irene and Superstorm Sandy. Available information about the effects of these storms at Old Saybrook includes photographs, anecdotal information and documented limits of flood inundation and elevation.

7. Computer modeling of storm surge and waves. GZA performed high resolution, numerical hydrodynamic modeling of tides, storm surge and waves to supplement analyses performed by FEMA and the USACE. GZA also performed non-hydrodynamic modeling of tides and storm surge.

GZA Coastal Flood and Wave Modeling

GZA modeled the tides, storm surge and waves at Old Saybrook using the ADvanced CIRCulation Model (ADCIRC) storm surge model and the Simulating Waves Nearshore (SWAN) wave model. ADCIRC is a two-dimensional, depth-integrated, barotropic, hydrodynamic circulation model. SWAN is a third-generation model developed at Delft University that computes wind-generated waves in coastal regions and inland waters. Both models are used by federal agencies such as FEMA and the USACE, including the NACCS.

GZA developed a high-resolution model mesh and local model domain to represent the detailed topographic and bathymetric features at Old Saybrook (Figure 1-2) in the flood models. The model mesh covers all coastal areas of the Town, Long Island Sound and tidal portions of the Connecticut River. The model extends about 3 miles offshore of the Old Saybrook coast into Long Island Sound. The resolution of the model in Old Saybrook is as fine as 10 meters.

The results of the NACCS (the flood-frequency curves) were used as input to GZA's high resolution model simulations. GZA also developed synthetic hydrographs, representative of typical Connecticut hurricanes and nor'easters to characterize storm duration in the model simulations. GZA's model simulations of Hurricane Sandy were compared to the observed conditions to check the model accuracy.

GZA's flood simulations were performed for both astronomical tidal conditions (Mean Sea Level and High Tide) and for storm surge (the 100-year and the 500-year recurrence intervals floods). To capture the effects of sea level rise, model simulations of tide and storm surge were also performed for several time horizons. In addition to the current time, flood model simulations were performed for the years 2041, 2066 and 2116.

GZA's model simulations are intended to supplement, not replace, the effective FEMA Flood Insurance Rate Maps. They are only intended to be used to support resilience and adaptation planning and are not intended to be used for establishing the flood hazard at any specific location and for any other purpose.

Step 2: Flood Vulnerability Assessment

The vulnerability of Old Saybrook to coastal flooding was evaluated by:

1. Inventoring all assets and organizing by category;

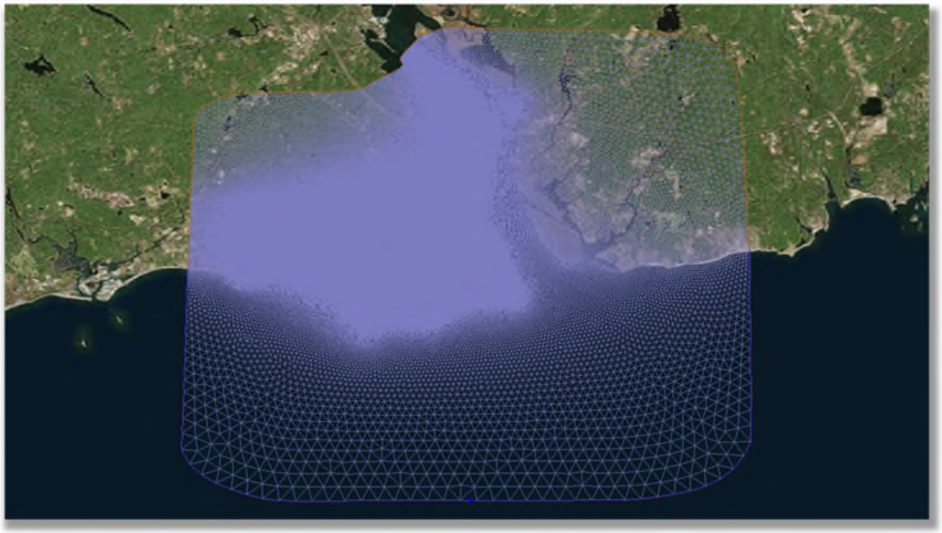


Figure 1-2: GZA High Resolution Computer Model Domain

2. Evaluating the flood vulnerability of each asset and asset category based on:
   a. Review of FEMA Flood Insurance Studies and Flood Insurance Rate Maps;
   b. Supplemental computer modeling to simulate flood inundation due to floods associated with different probabilities of occurrence, ranging from astronomical tide conditions to the 500-year recurrence interval flood. Flood depths were assessed by comparing flood elevations to ground surface elevations. Computer modeling of waves was also performed to identify areas vulnerable to large waves and wave-induced loads;
   c. Evaluation of economic loss using the FEMA Hazus software; and
   d. Area and asset-specific risk profiling.

Sea level rise was predicted base on both the USACE 2013 and the NOAA 2017 projections. The effects of sea level rise was determined based on additional flood simulations for different future time horizons.

Asset Inventory

The first step of the vulnerability assessment was to create a detailed inventory of Town assets. These assets were categorized consistent with criteria used by federal agencies for hazard management and the building code.

Categories	ASCE 7-10	ASCE 24-14	Other
Essential Facilities	Occupancy Category IV	Flood Design Class 4	
Lifeline Utility Systems	Occupancy Category IV	Flood Design Class 4	
Transportation Systems	-	-	AASHTO
High Potential Loss Facilities	-	-	FERC, USACE, NRC
Hazardous Material Facilities	Occupancy Category III & IV	Flood Design Class 3 and 4	
Support, High Occupancy and Vulnerable Population Facilities	Occupancy Category III	Flood Design Classes 2 to 3	
Neighborhoods	Residential	Flood Design Class 2	
Natural Resources			

Table 1-1: Old Saybrook Asset Inventory Categories

The definitions of the asset categories are:

- Essential Facilities are essential to public safety and welfare and include buildings and other structures that provide services (such as emergency response and recovery) that are intended to be available in the event of extreme environmental loading from flood, wind, snow, or earthquakes.
- Lifeline Systems are those public and private utility facilities that are vital to maintaining or restoring normal services to flooded areas before, during and after a flood.
- Transportation Systems generally refer to those key roadways, rail, etc. that are necessary for evacuation and emergency response.
- Hazardous Material Facilities are buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.
- High Potential Loss are those facilities, such as dams, whose failure can result in catastrophic loss of human life. Old Saybrook does not have any High Potential Loss facilities.
- Support, High Occupancy and Vulnerable Populations are those facilities that represent a substantial hazard to human life in the event of failure such as schools, assembly areas, jails and detention facilities and other areas where a large number of people congregate.
- High Density Development Areas and Neighborhoods are developed areas.
- Natural Resources, at Old Saybrook, include beaches, wetlands, salt marshes, tidal flats, etc.

Table 1-1 Notes: 1) ASCE 7-10 and ASCE 24-14 are American Society of Civil Engineers guidance documents that are incorporated by reference in the State Building Code. 2) FERC indicates Federal Energy Regulatory Commission. USACE indicates U.S. Army Corps of Engineers. NRC indicates Nuclear Regulatory Commission, AASHTO indicates American Association of State Highway and Transportation Officials, and EPA indicate Environmental Protection Agency.

Loss Estimation

The consequences from coastal flooding include damage to buildings and infrastructure, displacement of people, disruption of services and damages to natural resources. Economic loss and displacement of people were evaluated using the FEMA United States Multi-Hazards (HAZUS-MH) software. HAZUS-MH is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods and hurricanes.

Economic losses were characterized based on an "Average Annualized Loss" basis. The results of this analysis were used to predict potential current losses at a census block level.

Impacts to Natural Resources

The Town's coastal natural resources include extensive tidal marshes and a coastal shoreline fronting on both Long Island Sound and the Connecticut River. The effect of sea level rise on the tidal marshes was performed using the "Application of the Sea Level Affecting Marsh Model to Coastal Connecticut" simulation results. To evaluate the long-term shoreline change, GZA used the results of the University of Connecticut "Analysis of Shoreline Change in Connecticut" results in GIS. GZA also performed a statistical wind and wave analysis, including numerical wave modeling of prevailing conditions, to infer sediment transport/littoral drift. GZA also performed numerical wave modeling of the 100-year recurrence interval flood to qualitatively evaluate the potential for cross-shore beach erosion under storm events.

Risk Level

The Study uses a "risk-based" approach; specifically, the methodology "Risk-Informed Decision Making". "Risk-Informed Decision Making" is the process of making decisions that are informed by an understanding of risk, where risk is defined as:

Risk = Hazard Probability X Vulnerability

and:

- *Hazards* are events that have the potential to cause harm or loss. Coastal flood hazards principally include flood inundation, flood depth and waves, including the resulting hydrostatic and hydrodynamic loads from currents and wave action. Flood hazards can also include rain, intense winds and salt spray that often accompany coastal flooding.

- *Hazard Probability* is the likelihood (or chance) that the hazard will occur.

Asset vulnerability is characterized by Risk Level where:

High: indicates a high probability of occurrence and a significant consequence.

Low: indicates either a low probability of occurrence and/or a consequence of less significance.

Moderate: indicates either a high probability of occurrence and a consequence of minor significance, a moderate probability of occurrence and a moderate consequence, or a low probability of occurrence and a significant consequence.

Flood Probability

Just like flipping a coin, the probability of flooding is an expression of chance. Each time a coin is flipped, there is a 50% chance that it will be heads. If the coin is flipped multiple times in a row, the chance of getting a heads at least once increases (in ten consecutives flips, there will be nearly a 100% chance that at least one of the flips will be heads).

The probability of flooding is characterized in a similar manner. Flood probabilities are described in the Study (and by FEMA and other State and federal agencies) in terms of the "recurrence interval" or "annual exceedance probability". Each of these terms characterize the probability of experiencing a specific flood (i.e., flood elevation, inundation limits, waves) in any given year. As noted previously,

- the 100-year recurrence interval flood (1% annual exceedance probability) has, in any given year, a 1 in 100 chance of being equaled or exceeded.
- the 500-year recurrence interval flood (0.2% annual exceedance probability) has, in any given year, a 1 in 500 chance of being equaled or exceeded.

Other flood probabilities considered in the Study include:

- the 2-year recurrence interval flood (50% annual exceedance probability) has, in any given year, a 1 in 2 chance of being equaled or exceeded.
- the 10-year recurrence interval flood (10% annual exceedance probability) has, in any given year, a 1 in 10 chance of being equaled or exceeded.
- the 20-year recurrence interval flood (5% annual exceedance probability) has, in any given year, a 1 in 20 chance of being equaled or exceeded.

The chance of experiencing a given flood at least once increases over a time period of interest. For example, the 100-year recurrence interval flood has a 25% (1 in 4) chance of being equaled or exceeded at least once in any 30 year period.

The risk of coastal flooding will also increase due to climate change, in particular as a result of sea level rise. As the average water level of Long Island Sound (e.g., the mean sea level) increases over time due to sea level rise, the elevation of an equivalent storm surge will be higher in the future than it is today. For example, the 100-year recurrence interval flood today will occur with much greater frequency (say, a 10-year recurrence interval) in the future. The implication is that coastal flooding will become more frequent, and for a given probability of occurrence the effect of the flood (i.e., flood elevation, inundation limits, etc.) will become worse.

Step 3: Resilience and Adaption Strategies, Actions and Measures

A range of coastal resiliency strategies, actions and measures, appropriate for Old Saybrook, were evaluated. The strategies, actions and measures are consistent with those used in other State and federal coastal resilience plans and programs, and previously approved for State and Federal funding. They are also consistent with current regulatory codes. The USACE's September 2013 publication *Coastal Risk Reduction and Resilience: Using the Full Array of Measures* (CWTS 2013-3) provided valuable guidance for selection of the strategies, actions and measures.

The Study approach was also to select resiliency strategies, actions and measures that can support and be integrated into future updates of relevant Town plans such as the upcoming update of the Natural Hazards Mitigation Plan Update scheduled for 2019 and the current Local Plan of Conservation and Development.

Resilience and Adaptation Strategies

Resilience and adaptation strategies include:

Retreat: Managed withdrawal from coastal areas, most often accompanied by adaptive land use and managed relocation.

Protect: A range of interventions designed to hold back flooding from inundating developed areas and preventing erosion and loss of land.

Accommodate: Allowing inundation to occur, but protecting infrastructure, property and natural resources from damage through permanent and interim measures implemented on an on-going basis.

Resilience and Adaptation Actions and Measures

Resiliency actions and measures fall into three categories: 1) Non-Structural; 2) Structural; and 3) Natural and Nature-Based Features.

Nonstructural:

Non-structural measures reduce human exposure or vulnerability to a flood hazard without altering the nature or extent of the flooding. Plans, Policies and Regulations that regulate flooding are considered non-structural measures.

Structural:

Structural measures are designed to protect (i.e., prevent flooding) and are consistent with a resiliency strategy of Protection. Specifically, they decrease shoreline erosion and/or reduce coastal risks associated with wave damage and flooding.

Natural and Nature-Based Features:

Natural features are features that are created and evolve over time through the natural actions of physical, biological, geological and chemical processes. Nature-Based Features are features that "mimic" natural features but are created by human design, engineering and construction to provide specific services such as coastal risk reduction. Nature-based features are acted upon by the same physical, biological, geological and chemical process that effect natural features, and therefore will need maintenance to reliably perform.

Accreditation by FEMA

While each of the resilience and adaptation actions and measures presented above will reduce the Town's flood risk, most will not be recognized by FEMA for their classification of special flood hazard zones. The only flood mitigation measures accredited by FEMA for hazard mapping purposes are: 1) elevated structures; 2) dry and wet floodproofed structures; and 3) levees that are constructed and managed in accordance with 44CFR§65.10.

Levees are defined as "a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water in order to reduce risk from temporary flooding." The NFIP regulations define a levee system as "a flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices." Non-accredited levees may be provisionally considered by FEMA in concert with local authorities.

Natural primary sand dunes are considered by FEMA during flood mapping. Beach nourishment and engineered dunes may be considered by FEMA under specific circumstances. FEMA takes beach nourishment and dune projects into consideration only when the project is significant (i.e., has the dimensions necessary to affect 1-percent-annual-chance flood hazards) and with guarantees for maintenance and management.

Step 4: Public and Stakeholder Outreach

The Town organized and facilitated a series of resiliency team meetings and workshops, and two public meetings. The resiliency team meetings and workshops included presentations to inform the resiliency team and public of the interim Study findings and to receive feedback throughout the planning process. The study team gathered and documented input at each public meeting through an interactive discussion followed by questions and answers.

The study team conducted a survey during the 2nd resiliency team meeting to document the community's observations of vulnerable areas of Town impacted by Hurricanes Sandy and Irene as well as areas that will need resiliency improvements in the future.

The two public meetings were conducted upon completion of the following two project milestones.

- June 7, 2017 – Public Meeting on the Vulnerability and Risk Assessment
- November 15, 2017 – Public Meeting on the Draft Study

Several additional meetings were held with Town commissions and department heads to discuss the findings and recommendations and to receive Town input.

Neighborhood Studies

In addition to the Town-wide public meeting, a series of neighborhood workshops were performed to evaluate needs, concerns and options at the neighborhood level. Two neighborhoods were identified including: 1) Chalker Beach, which is representative of the Low Beach Communities; and 2) Route 154 and surrounding area between Saybrook Point and Town Center, which is representative of a common coastal flood condition throughout Old Saybrook – flooding of a major arterial, impacting resident ingress and egress, limiting the Town's capability to provide emergency services and disrupting business for commercial activities.

Step 5: Implementation

The Study recommends Action Items to implement the steps to create resilience and adapt to the effects of sea level rise. The existing Town plans were reviewed in the context of the proposed coastal resilience and adaptation strategies.

Attachment 2: Coastal Flood Hazards

Old Saybrook Coastal Resilience and Adaptation Study **GZA**

Coastal Flood Hazards

Flooding within the Chalker Beach Neighborhood during Hurricane Sandy in 2012 (from CT Mirror File Photo February 7, 2014)

Old Saybrook's coastal flood hazards include: tides, storm surge, waves, wind and precipitation. The risks associated with each of these hazards will increase due to climate change, in particular the effects of sea level rise.

This attachment presents information that provides the basis for: 1) understanding coastal flooding at Old Saybrook, including the probability, frequency and extent of coastal floods; and 2) evaluating the vulnerability of Town neighborhoods, assets and natural resources. The report attachment presents:

- Overview: An overview of Old Saybrook's coastal setting, topography and shoreline features. Evaluation of the coastal setting sets the stage for understanding Old Saybrook's vulnerability to coastal floods.
- Tides: Tides and tidal flooding details.
- Extreme Water Levels: Published flood studies as well as the results of GZA computer simulations of extreme flood events.
- Sea Level Rise: The effects of sea level rise on tides and extreme floods.
- Precipitation Data: NOAA Atlas 14 predicted precipitation rates by return period and duration.
- Additional Climate Change Considerations: Additional considerations including predicted changes to air and water temperature.

To evaluate the coastal flood hazards at Old Saybrook, GZA performed:

1. a metocean analysis of observed wind, wave and water level data.
2. review of published flood hazard data including.
    a. the Federal Emergency Management Agency (FEMA) effective Flood Insurance Rate Map (FIRM) and the FEMA Flood Insurance Study (FIS);
    b. the National Oceanic and Atmospheric Agency (NOAA) tide gage data; and
    c. the U.S. Army Corps of Engineers (USACE) North Atlantic Coast Comprehensive Study (NACCS).
3. review of USACE and National Oceanic and Atmospheric Agency (NOAA) sea level rise projections.
4. numerical hydrodynamic modeling of tides, storm surge and waves using the Advanced Circulation Model (ADCIRC) and the Simulating WAves Nearshore (SWAN) models.

Flooding due to local intense precipitation (LIP) and stormwater run-off are a source of flooding. LIP events often occur during storms that also include storm surge and waves. Flooding due to precipitation, including the capacity of the existing stormwater infrastructure to provide drainage, was not evaluated as part of this study.

Coastal Setting

Old Saybrook is located where the Connecticut River meets Long Island Sound. **Figure 2-1** identifies Old Saybrook's coastal features.

Location: Old Saybrook is located within Middlesex County in south-central Connecticut on a peninsula along the northern shore of Long Island Sound. Old Saybrook is bounded to the south by Long Island Sound, to the east by the Lower Connecticut River, to the west by the town of Westbrook and to the north by the town of Old Essex.

Characteristics: Old Saybrook 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. Old Saybrook has over 23 linear miles of shoreline abutting Long Island Sound (6 miles) and the Connecticut River (17 miles). The total area of Old Saybrook (excluding the North and South Cove coastal embayments) is about 15.2 square miles. The areas to the south of Interstate 95 are low-lying, consisting mostly of tidal marsh and coastal plain. The area to the north of Interstate 95 consists of rolling hills of bedrock and glacial till, with a network of valley streams and inland wetlands.

Beaches: Old Saybrook's southern shoreline consists of a series of beaches. Moving from west to east, are Chalker Beach, BelAire Manor Beach, Saybrook Manor Beach, Indiantown Beach, Great Hammock Beach, Harvey Beach, Town Beach (Plum Bank), Cornfield Point Beaches and Knollwood Beach.

Shoreline Structures: As shown on **Figure 2-2**, Old Saybrook's shoreline is extensively developed with hard coastal structures including piers, groins, revetments and bulkheads.

Harbors: There are several Town harbors and marinas, including Indiantown, a dredged channel and harbor with breakwaters; the Harbor One Marina located at the intersection of College Street and Bridge Street (Rt. 154); and five marinas located to the north of the Amtrak railway on the Connecticut River (Island Cove, Oak Leaf, Between the Bridges and Ragged Roak Marinas). A mooring field is also located in the North Cove.

Embayments: There are two large embayments (North and South Cove) along the Old Saybrook coastline with the Connecticut River. The embayments were natural coves that have been altered by the construction of a bridge (South Cove) and construction of shoreline structures (North Cove) along their mouths. These structures have affected the natural tidal flow, resulting in sedimentation.

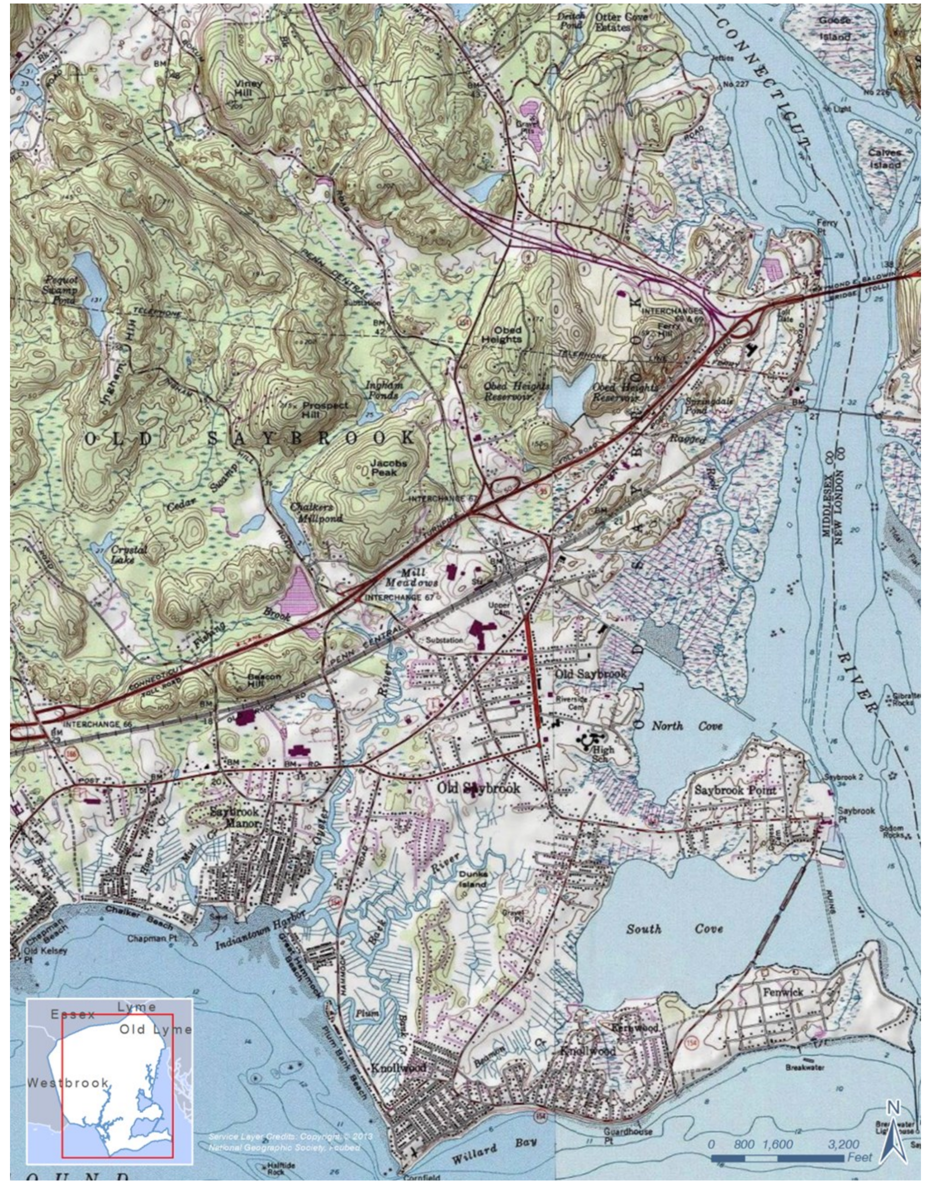


Figure 2-1: USGS Topographic Map Highlighting Coastal Features

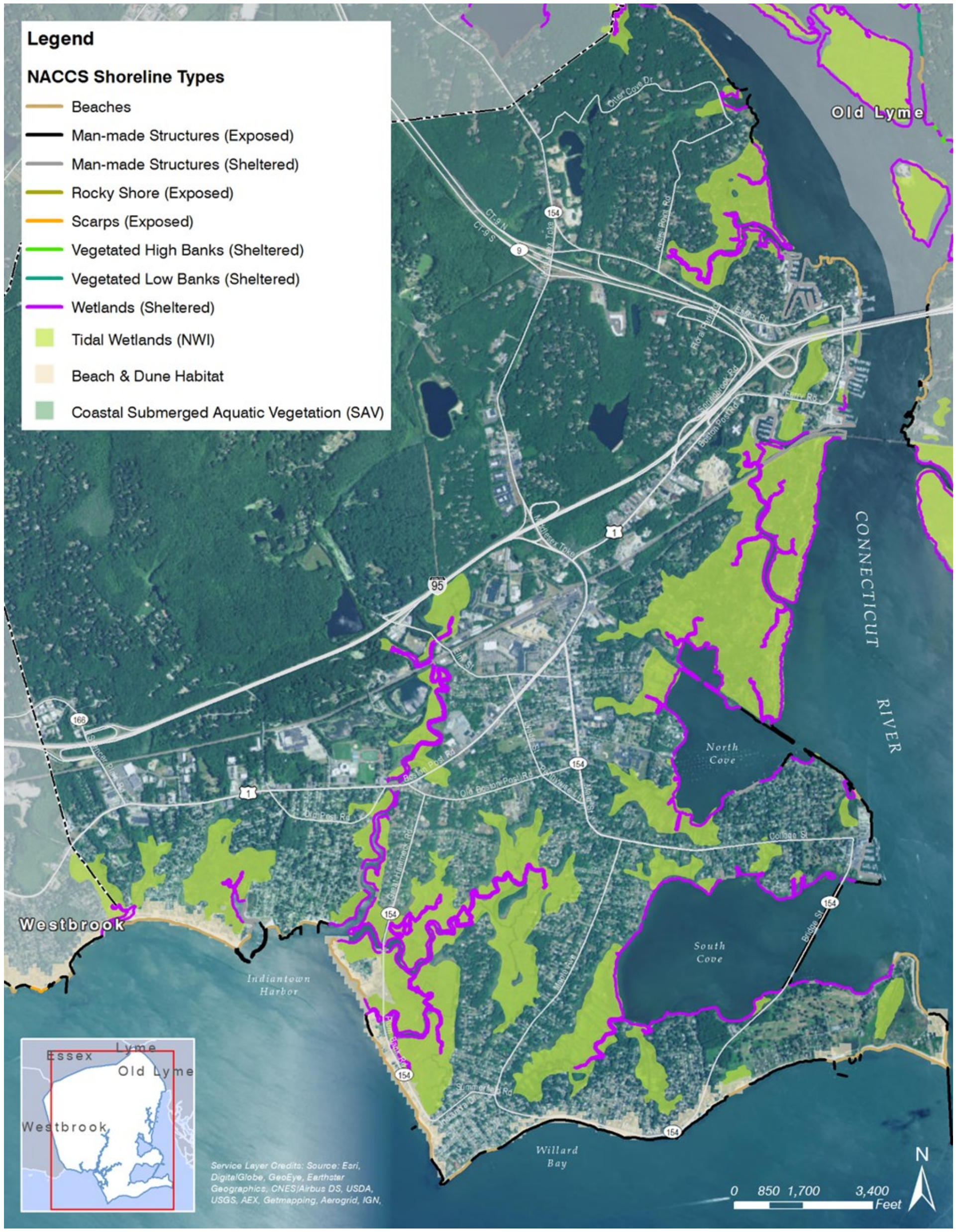


Figure 2-2: Old Saybrook Shoreline Features

Topography and Geology

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 Old Saybrook to flooding due to tides, coastal storm surge and sea level rise.

The most current Connecticut high resolution LiDAR (Light Detection and Ranging) topographic survey was utilized for this study. **Figure 2-3** presents color imagery reflecting the change in ground surface elevation within Old Saybrook based on the high-resolution LiDAR survey data. 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 Old Saybrook. All elevations presented in this plan reference NAVD88.

Figure 2-4 presents the surficial geology of Old Saybrook. The surficial geologic features and materials are the result of glacial and postglacial actions. About 20,700 years ago, Glacial Lake Connecticut covered the area that currently is Long Island Sound. The freshwater lake consisted of meltwater run-off from the retreating glacial Laurentide Ice Sheet, which (at that time) covered most of Connecticut. Sea level was about 300 feet lower than it is today and the Atlantic shoreline was about 7.5 miles to the south of current-day Long Island Sound. As shown on Figure 2-3, the geologic materials to the north of Interstate 95 (I-95) consist predominantly of glacial till - ice laid deposits of dense mixed sand, silt, gravel and cobbles. To the south of I-95, the surficial geologic materials consist of sand and gravel glacial lake meltwater deposits and glacial moraine deposits and postglacial beach and dune deposits, tidal marsh deposits and artificial fill.

The topographic elevation data presented in **Figure 2-3** clearly delineates the transition from the upland portions of Old Saybrook (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 areas located within the southern portion of Old Saybrook, characterized by blue, represent areas with thick deposits of sand and gravel glacial meltwater deposits and correspond to higher ground surface elevation (generally on the order of Elevation 10 to 15 feet NAVD88).

The tidal marsh and wetlands systems are developed around waterways (brooks, creeks and rivers), and are hydraulically connected to the Lower Connecticut 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. GZA computer simulations of flooding during a 100-year return period coastal flood, presented later in this attachment, demonstrate how these low-lying areas contribute to flooding of the inland areas of Old Saybrook during coastal storms.

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

Tides

Tides are the daily rise and fall of the Earth's waters by long period waves that move through the oceans in response to astronomical gravitational forces, predominantly exerted by the moon and sun. The tides in Long Island Sound, including Old Saybrook, are diurnal, which means that during each lunar day (24 hours and 50 minutes) there are two high tides and two low tides. The high and low tides elevations vary during a daily tide cycle and over a lunar cycle.

Tidal datums are used to define tide elevations and include:

- Mean High Water (MHW), which represents the average of the two high tides over the "National Tidal Datum Epoch" (the 19 years between 1983 and 2001);
- Mean Low Water (MLW), which is the average of the two low tides;
- Mean Higher High Water (MHHW), which is the average of the higher of the two high tides during each tidal day observed over the National Tidal Datum Epoch;
- Mean Lower Low Water (MLLW), which is the average of the lower of the two low tides over the same time period;
- Mean Sea Level, which is the arithmetic mean of all hourly heights over the National Tidal Datum Epoch;
- The mean range of tide (MN), which is the difference between the Mean High Water and the Mean Low Water; and

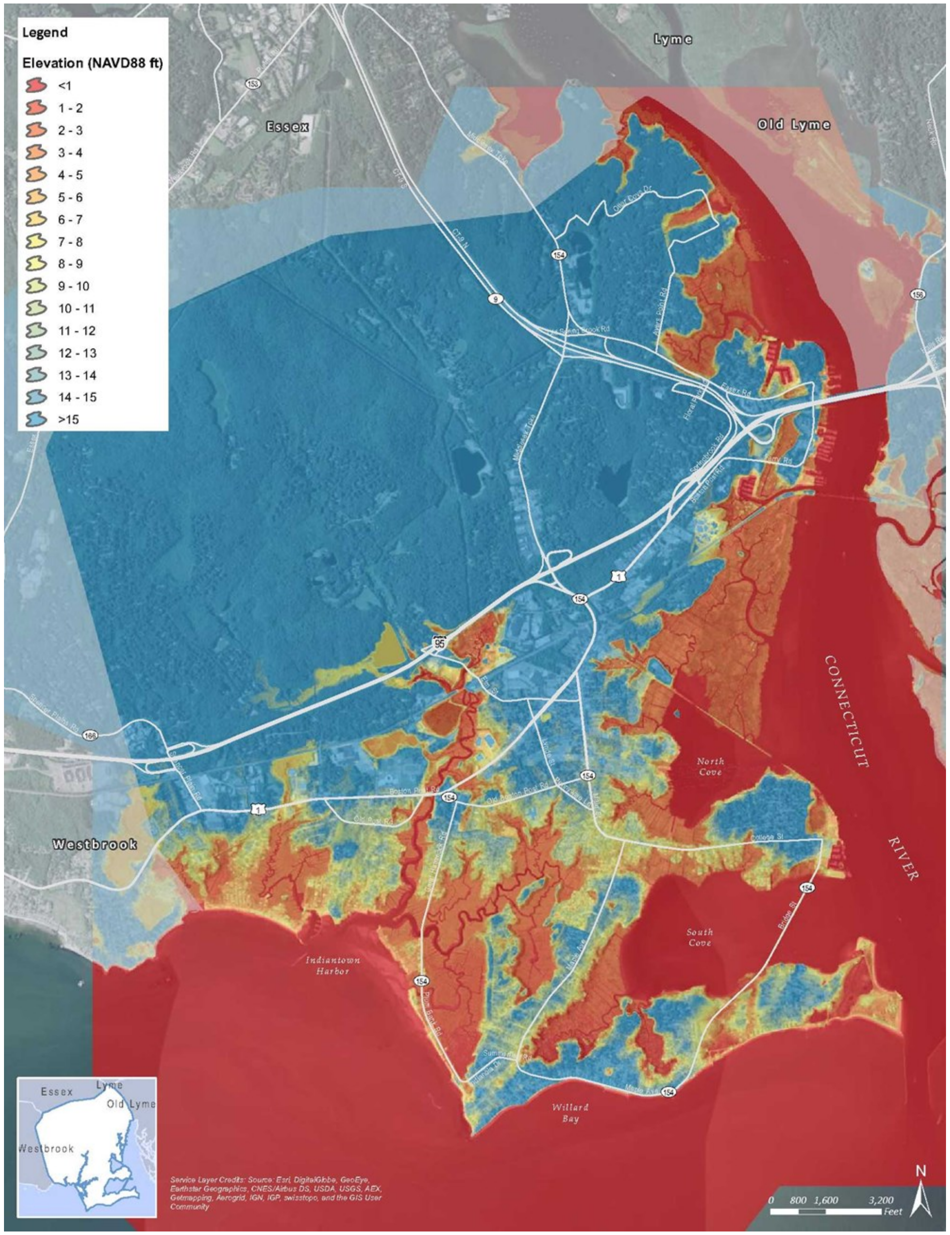


Figure 2-3: Digital Elevation Data based on Current Connecticut LiDAR

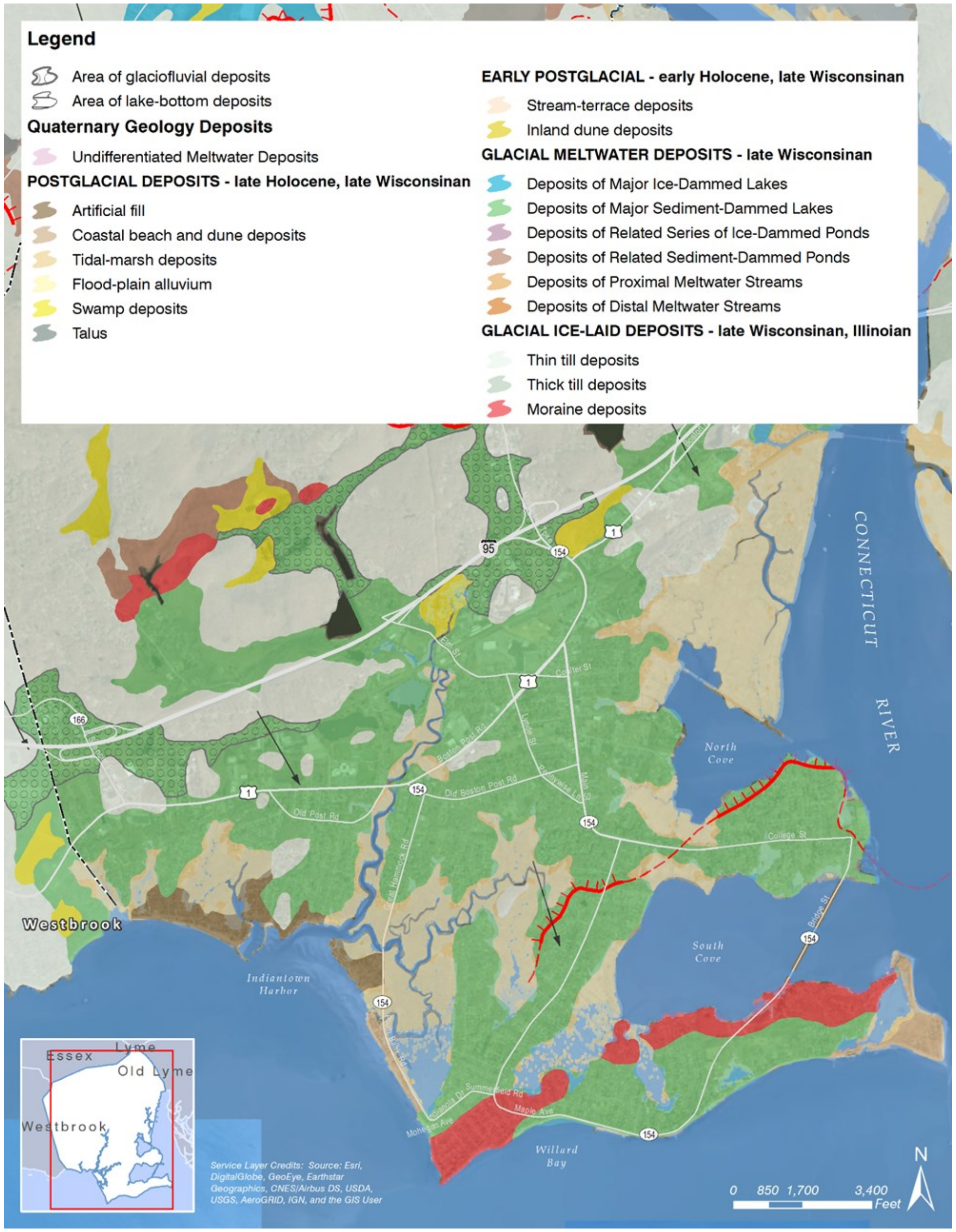


Figure 2-4: Old Saybrook Geologic Map

- Highest Astronomical Tide (HAT), which is the highest level predicted to occur under average meteorological conditions and any combination of astronomical conditions.

Tidal datums are developed based on observed water level data during the current National Tidal Datum Epoch at NOAA tide stations (the 19-year period between 1983 and 2001). NOAA tide stations are present at New London and Bridgeport, Connecticut. The NOAA tide gage at New London, CT (NOAA Station 8461490) provides a detailed record of water levels and tides applicable to Old Saybrook over the last, approximately, 80 years (1938 to 2016).

The mean range of tide (MN) at New London, the difference in height between the MHW and the MLW, is 2.57 feet. The current tide elevations, relative to the NAVD88 datum, at New London are indicated in Table 2-1. Tide corrections from the New London Tide Gage to Saybrook Point are 1.24 * New London (High Tide) and 1.25 * New London (Low Tide). Corrected values at Old Saybrook are indicated in parenthesis in **Table 2-1**.

Tide Condition	Elevation (ft); NAVD88
Highest Astronomical Tide (HAT)	2.04
Mean Higher-High Water (MHHW)	1.21 (1.5)
Mean High Water (MHW)	0.92 (1.14)
Mean Tide Level (MTL)	-0.36 (-0.33)
Mean Sea Level MSL)	-0.30 (-0.28)
Mean Diurnal Tide Level (MDTL)	-0.31(-0.22)
Mean Low Water (MLW)	-1.65 (-2.10)
Mean Lower-Low Water (MLLW)	-1.84 (-2.3)

Table 2-1: Tide Datum Elevations at New London (interpolated to Old Saybrook tides)

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 2-5**, the observed RSLC at the NOAA New London station, over the last approximately 80 years, indicates a mean sea level rise trend of 2.55 millimeters (mm) per year (with a 95% confidence interval of +/- 0.23 mm per year) (2.55 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.

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, used for the Study, 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 2-6,** 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 Bridgeport, CT and USACE 2013/NOAA2012 projections) are summarized in **Table 2-2** and Figure 2-5 below (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 2012 projections.

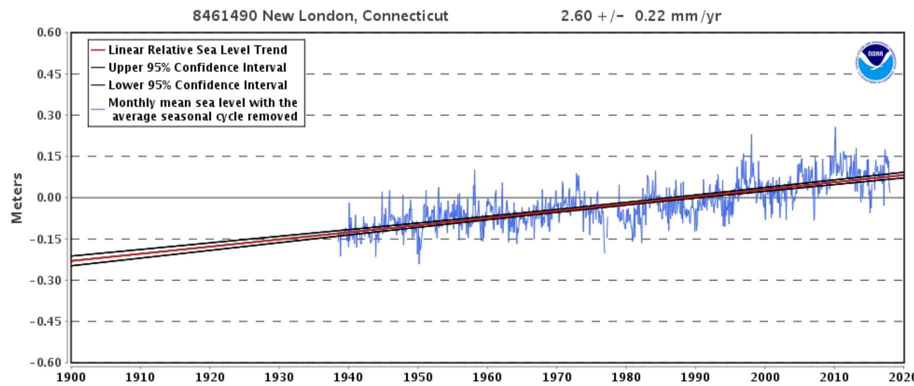


Figure 2-5: Observed Sea Level Rise at New London, Connecticut

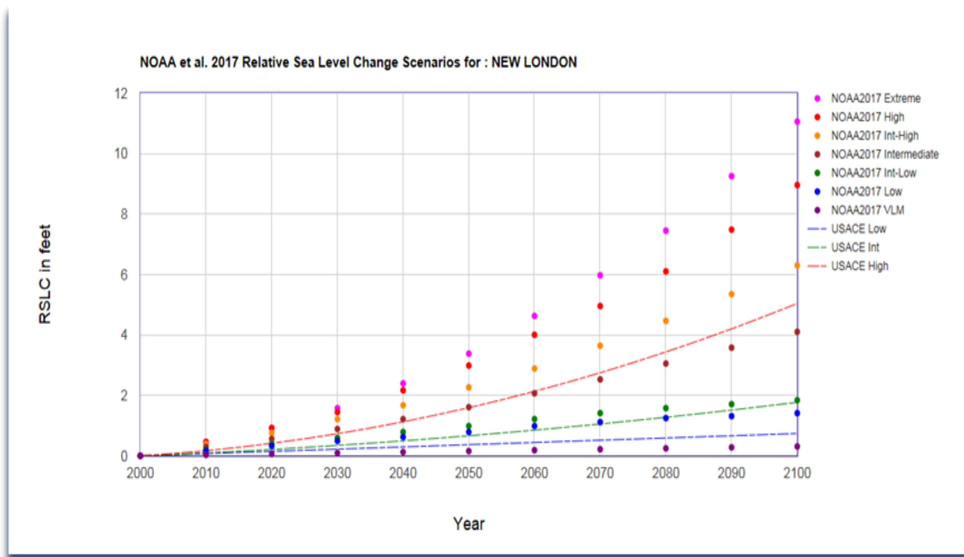


Figure 2-6: Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for USACE2013/NOAA 2012 projections)

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 2-2: Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for USACE 2013/NOAA 2012 projections; relative to the year 2017)

The NOAA sea level rise projections were revised subsequent to completion of GZA's analysis but prior to completion of the Study report. NOAA 2017 projections (mean values) are presented in **Figure 2-5** and **Table 2-3**. 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 2-3: Sea Level Rise Projections (using the USACE Relative Sea Level Change Calculator for NOAA et. al. 2017 projections; relative to the year 2017)

Table 2-3 presents the NOAA 2017 mean projections, interpolated from the year 2017. (These interpoltaions assume a RSLC of about 0.33 feet between the years 2000 and 2017.) **Table 2-4** 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 2-4: 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) liklihood 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 2013 USACE projections, the latest projections available at the time of GZA's analyses, were used to model flooding for the Study. The exceedance probabilities associated with the USACE projections can be approximated using Table 2-5 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. These recommended values are close to the NOAA 2017 Intermediate projections (see **Table 2-3**). They are also reasonably represented by the 2013 USACE High projections. See **Tables 2-2** and **2-3** 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, which was used for the Study, 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 2-5** presents the current and predicted changes to the tidal datums for Old Saybrook due to RSLC for the years 2040, 2070 and 2100, in feet NAVD88.

Figure 2-9 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

Except for areas along the beaches and near tidal wetlands, the effects of tidal flooding on the Town are currently minimal. The 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.

	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 2-5: Projected Old Saybrook Tidal Datums Based on 2013 USACE High RSLC Projections

The following images present the results of GZA's model simulations of MHW (mean high tide) during the years 2041, 2066 and 2116, assuming the USACE Intermediate sea level rise projection which is considered to have a high likelihood of occurrence.

Figure 2-7: Predicted MHW Flood Inundation by the year 2041 assuming USACE Intermediate Sea Level Rise Projection

Figure 2-8: Predicted MHW Flood Inundation by the year 2066 assuming USACE Intermediate Sea Level Rise Projection

Figure 2-8: Predicted MHW Flood Inundation by the year 2116 assuming USACE Intermediate Sea Level Rise Projection

Chronic Flood Inundation

Per the Union of Concerned Scientists report "When Rising Seas Hit Home", "chronic flood Inundation" occurs within a coastal community when more than 10% of its developed land is inundated 26 times per year (on average, about every other week). This was considered as a threshold that disrupts people's routines, likelihoods, homes and communities to the extent that the communities are unsustainable.

GZA analyzed 20 years of water level data collected from the NOAA New London tide gage (19917 to 2017). GZA's analysis ranked water level to determine the water elevation corresponding to a flood condition that occurs 26 times per year. The data was then corrected for RSLC between the years 1997 and 2017 and averaged; the average was then adjusted for projected RSLC using the 2013 USACE High projection, as follows:

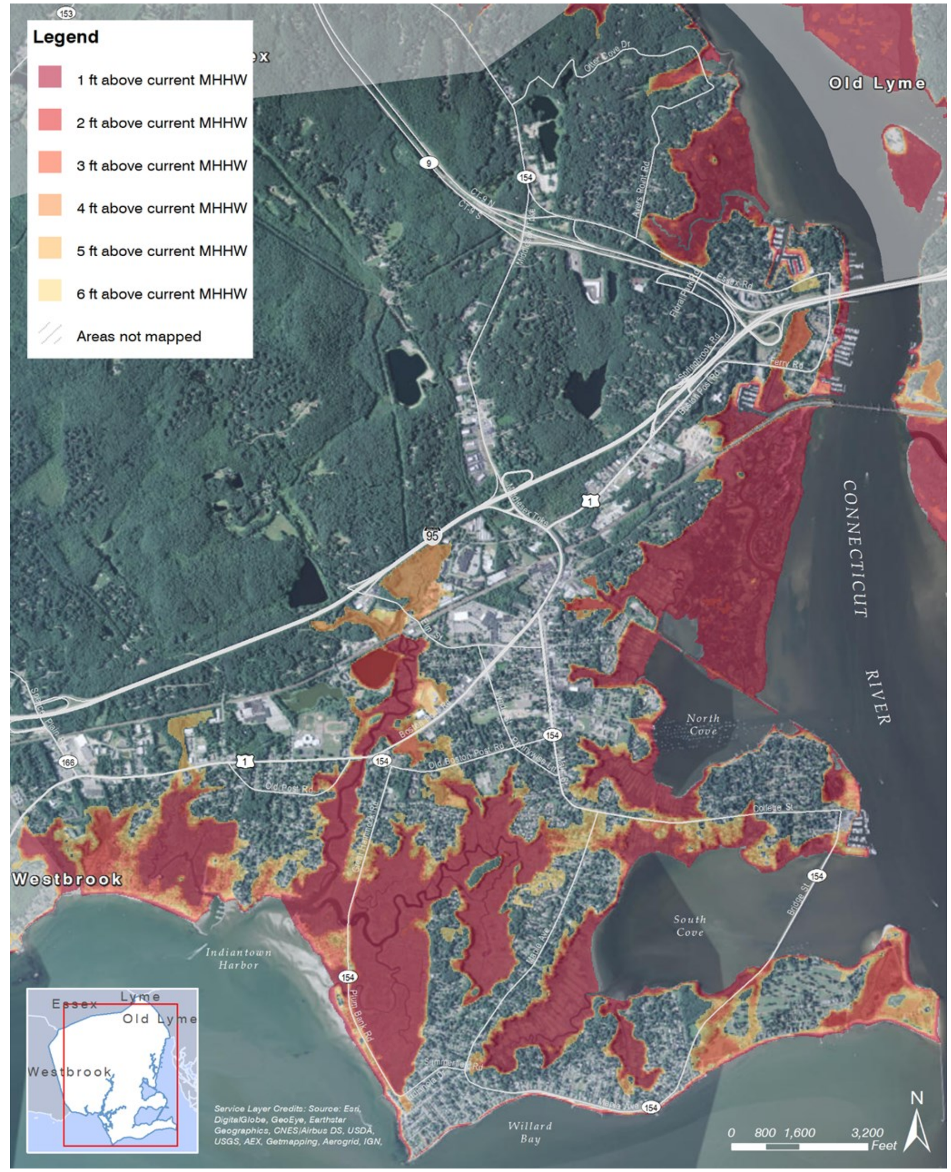


Figure 2-9: Limits of Flood Inundation due to Relative Sea Level Rise

Year 2017: Elevation 2.8 NAVD88 (1.3 feet above current MHHW)
Year 2040: Elevation 3.6 NAVD88 (2.1 feet above current MHHW)
Year 2050: Elevation 4.2 NAVD88 (2.7 feet above current MHHW)
Year 2070: Elevation 5.2 NAVD88 (3.7 feet above current MHHW)
Year 2100: Elevation 7.5 NAVD88 (6.0 feet above current MHHW)

The average 26th value adjusted for projected RSLC using the 2017 USACE Intermediate projection:

Year 2017: Elevation 2.8 NAVD88 (1.3 feet above current MHHW)
Year 2040: Elevation 3.7 NAVD88 (2.2 feet above current MHHW)
Year 2050: Elevation 4.1 NAVD88 (2.6 feet above current MHHW)
Year 2070: Elevation 5.0 NAVD88 (3.5 feet above current MHHW)
Year 2100: Elevation 6.6 NAVD88 (5.1 feet above current MHHW)

Extreme Flooding

Extreme flooding resulting from coastal storm surges at Old Saybrook result from two types of storms: Extra-tropical storms (Nor'easters) and tropical cyclones (Tropical Storms and Hurricanes).

Nor'easters are relatively common in New England during the spring, winter and fall. They are less intense than hurricanes but have a large wind field and are long in duration (sometimes lasting several days). These characteristics can result in significant storm surges. This is particularly true within Long Island Sound, where the long axis of the Sound trends northeast-southwest in line with the predominant wind direction during Nor'easters. Nor'easters often occur in conjunction with large snowfalls, which makes emergency response and recovery much more difficult.

Hurricanes occur relatively infrequently in New England. Hurricanes of high intensity with the tracks and landfalls necessary to cause large floods in New Haven are even rarer. However, as discussed below, hurricanes have historically resulted in the largest storm surge flooding effecting the Old Saybrook area. Tropical cyclones, including tropical storms and hurricanes, have also resulted in the most significant rainfalls.

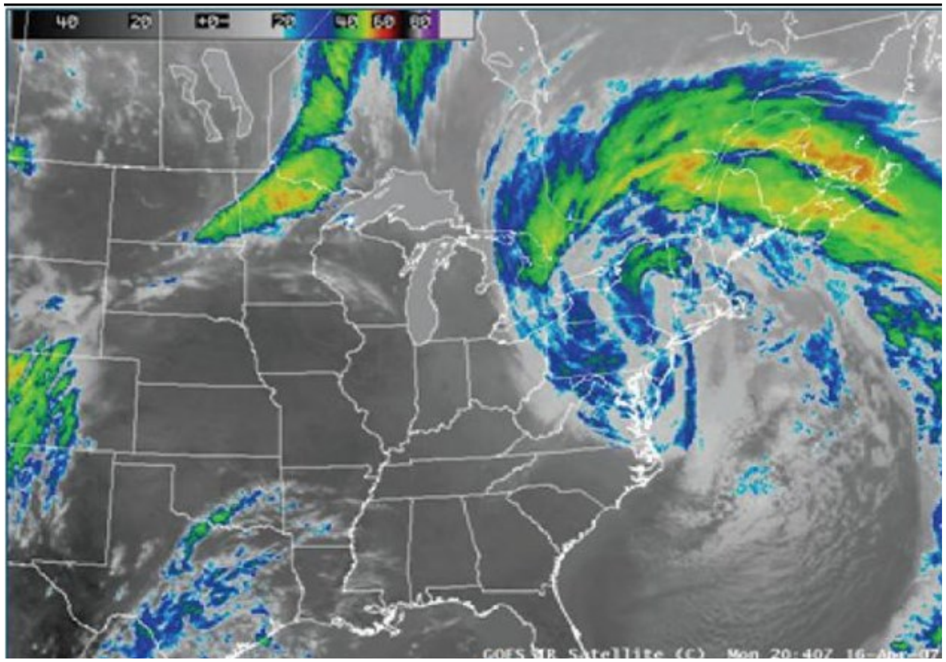


Figure 2-10: NOAA satellite image showing windfield and precipitation during a typical New England Nor'easter

According to the NOAA Office for Coastal Management, 40 tropical cyclones (including hurricanes and tropical storms) have tracked within a 50-nautical mile radius of Old Saybrook since the mid-1800s (see **Figure 2-11** for storm tracks). The most intense hurricane of record in the vicinity of Old Saybrook is the Hurricane of 1938 (track highlighted in **Figure 2-11**). 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 Sandy, although its landfall was over 200 nautical miles south of Old Saybrook, 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 Old Saybrook.

Based on NOAA's HURDAT2 database, **Figure 2-11** indicates the hurricanes that have tracked within a 50-mile radius of Old Saybrook. **Table 2-8** 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 Old Saybrook)
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	9/26 to 10/12/1894	H1 (Category 1)	West
Unnamed 1894	10/01 to 10/12/1894	H1 (Category 1)	West
Unnamed 1934	9/05 to 9/10/1934	H1 (Category 1)	West
Donna 1960	8/29 to 9/14/1960	H2 (Category 2)	Landfall at Old Saybrook
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

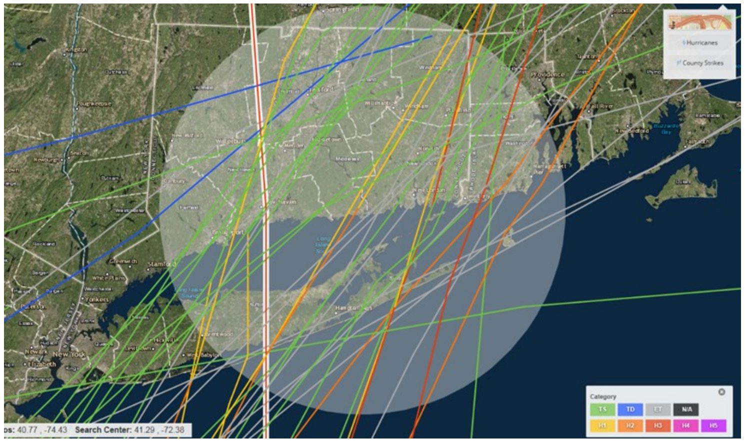
Table 2-7: NOAA Hurricanes within 50-mile Radius of Old Saybrook

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

Notes: 1. Station data since 1938. 2. Station data since 1964. 3. Water levels not corrected for sea level rise.

Table 2-8: NOAA Station Top Ten Water Levels (in feet above MHHW)

Figure 2-11: NOAA Storm Tracks for Tropical storms and



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 Old Saybrook. These include:

1. 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.

2. FEMA Flood Insurance Study and Rate Maps: FEMA has characterized the current flood hazard within Old Saybrook 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 B-11 presents the effective (i.e., currently applicable) FEMA Flood Insurance Rate Map (FIRM) flood limits and elevations, used to calculate flood insurance rates for Long Wharf.

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 Old Saybrook, 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 Old Saybrook.

Figure 2-12: Temporary USGS Tide Gage on South Cove Causeway, measuring water levels during Hurricanes Irene and Sandy

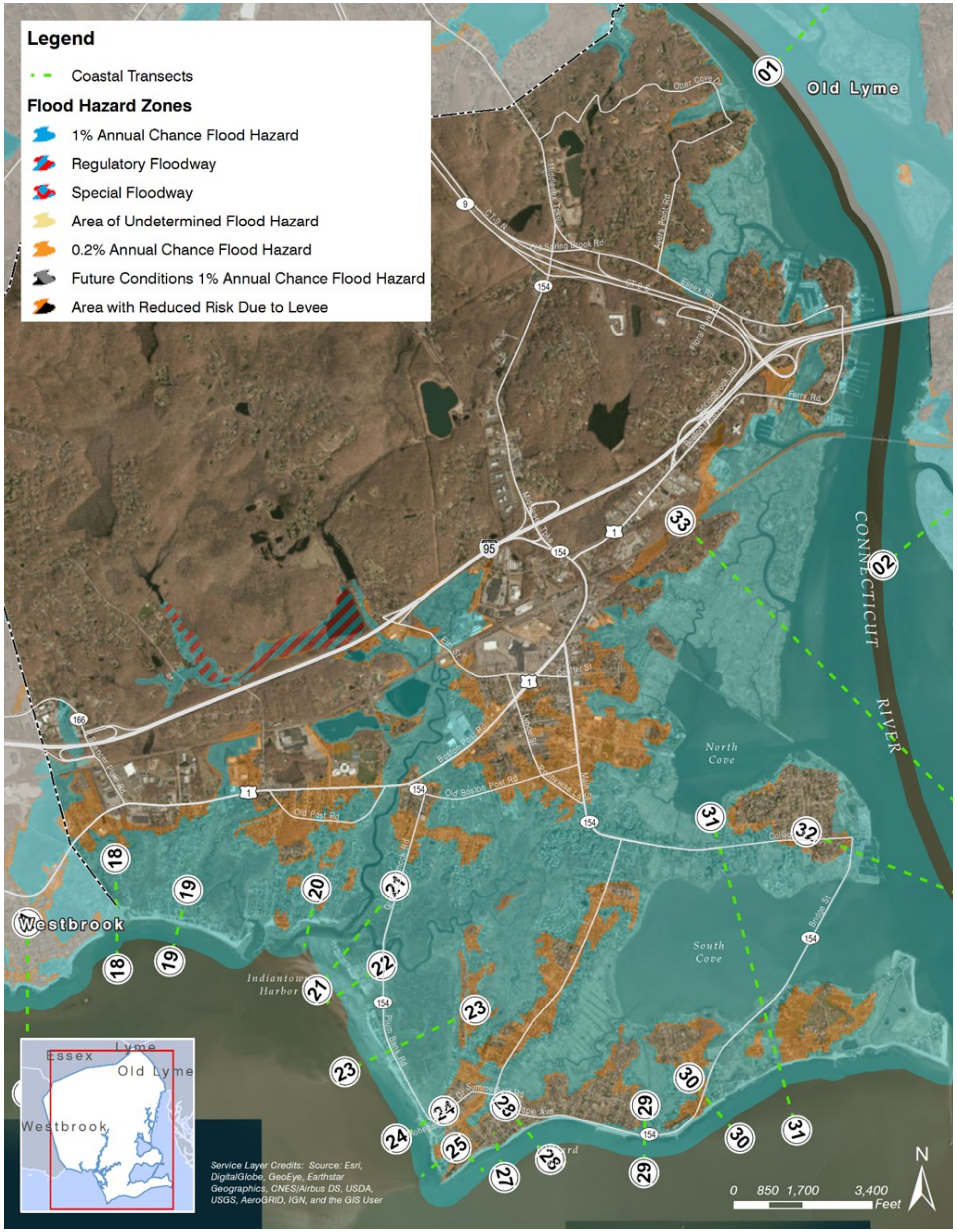
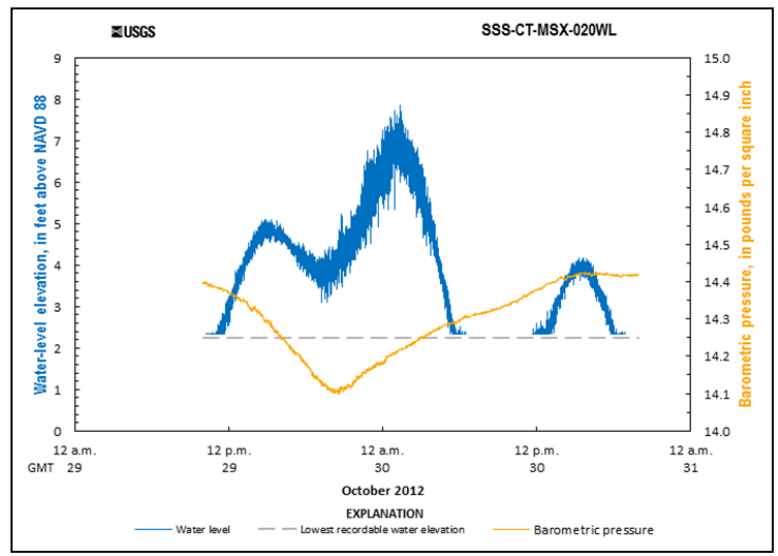


Figure 2-13: FEMA Flood Insurance Rate Map Flood Hazard Zones and Base Flood Elevations

South Cove Causeway during Irene showing wave overtopping bridge deck. The image above photo by Mara Lavitt won a first-place award in the Connecticut SPJ contest. "Thrill seekers on the causeway between Old Saybrook and Fenwick Point during Tropical Storm Irene, on Aug. 28, 2011." The tide gage data USGS gage data indicated a peak water level during Irene of about Elevation 6.5 feet NAVD (about or slightly higher than the bridge deck elevation). In comparison, the same tide gage (shown below) measured a peak water level of about Elevation 8 feet NAVD during Sandy. The gage data likely includes some wave effects and the actual stillwater flood elevation during Sandy was lower.



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 2-14** (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 Old Saybrook) is at about Elevation 7.5 feet NAVD88.

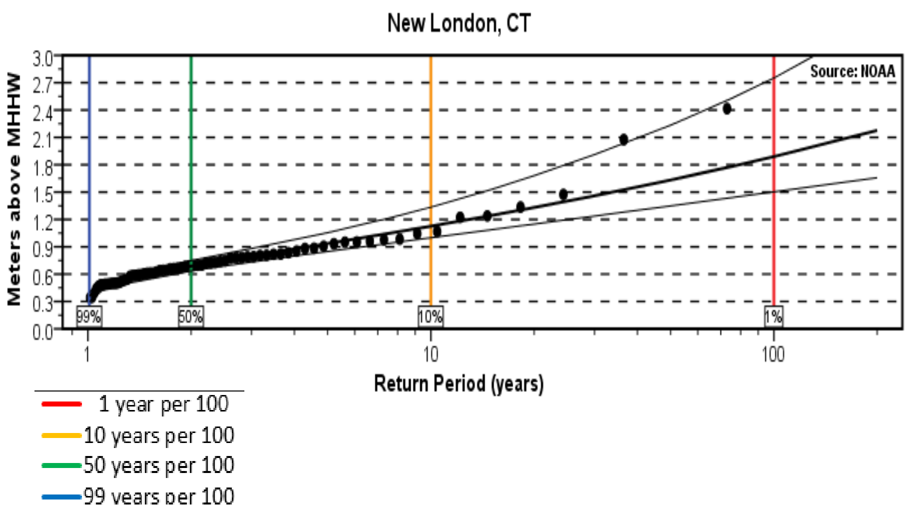


Figure 2-14: NOAA Annual Exceedance Probability Curve for the New London Station

USACE North Atlantic Coast Comprehensive Study

The results of the USACE NACCS are available at specific model "save point" locations. **Figure 2-15** shows the locations of "save points" along the Old Saybrook shoreline. 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 Old Saybrook.

Figure 2-15: USACE North Atlantic Coast Comprehensive Study Results Save Points

Summary of Predicted Summary of Predicted Flood Elevations and Probabilities

Table 2-9 summarizes the coastal, nearshore predicted flood stillwater elevations by annual exceedance probability (return period). The data presented in **Table 2.9** is relative to FEMA FIS Transect 29 and USACE NACCS Save Point 8244. Similar to tides, a reasonable estimation of the effects of RSLC on storm surge stillwater elevations can be developed by linear superposition of the predicted RSLR to the predicted stillwater elevation. **Figure 2-16** presents the flood-frequency curve (mean with uncertainty) for the USACE NACCS Save Point 8244.

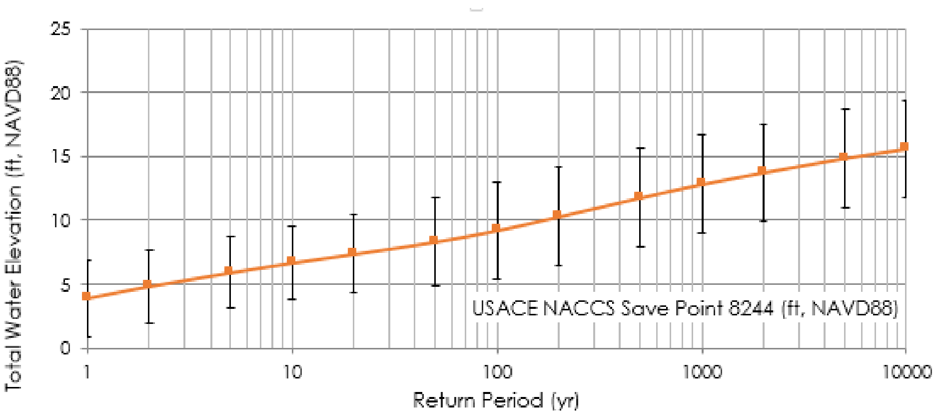


Figure 2-16: Flood Frequency Curve Base of USACE North Atlantic Coast Comprehensive Study along Old Saybrook Shoreline for the year 2017. Mean, upper and lower bounds shown.

Table 2-9: Summary of Predicted Flood Elevations and Probabilities for the Years 2017, 2041, 2066 and 2116; UB and LB indicate lower and upper bounds, respectively. In feet, NAVD88.

Recurrence Interval (years)	1	2	5	10	20	50	100	200	500	1,000
2017:										
NOAA MEAN	2.3	3.5	4.4	5.0	5.6	6.6	7.5	8.4		
NOAA UB	2.3	3.7	4.7	5.7	6.7	8.6	10.3	12.6		
NOAA LB	2.3	3.3	4.1	4.5	5.0	5.7	6.2	6.8		
FEMA				5.5		7.7	9.2		15.3	
USACE MEAN	3.9	4.8	5.9	6.7	7.4	8.3	9.2	10.3	11.8	12.8
USACE UB	6.9	7.7	8.7	9.6	10.4	11.8	12.9	14.1	15.6	16.6
USACE LB	0.9	2.0	3.1	3.7	4.3	4.9	5.5	6.4	7.9	9.0
2040:										
USACE MEAN (INT SLR)	4.2	5.1	6.2	7.0	7.7	8.6	9.5	10.6	12.1	13.1
USACE MEAN (HIGH SLR)	4.9	5.8	6.9	7.7	8.4	9.3	10.2	11.3	12.8	13.8
2070:										
USACE MEAN (INT SLR)	4.7	5.6	6.7	7.5	8.2	9.1	10.0	11.1	12.6	13.6
USACE MEAN (HIGH SLR)	6.2	7.1	8.2	9.0	9.7	10.6	11.5	12.6	14.1	15.1
2100:										
USACE MEAN (INT SLR)	5.9	6.8	7.9	8.7	9.4	10.3	11.2	12.3	13.8	14.8
USACE MEAN (HIGH SLR)	10.3	11.2	12.3	13.1	13.8	14.7	15.6	16.7	18.2	19.2

Seasonality of Coastal Flood Hazard

NOAA statistically analyzed water level data on a monthly basis showing the seasonal variability of coastal flood risk. The results are presented in Figure 2-15 for the NOAA Bridgeport tide gage (relative to meters above MHHW).

As shown on **Figure 2-17**, the greatest flood risk is during the late Summer, Fall and Winter which includes tropical storms, hurricanes and Nor'easters. The probability of extreme flooding during late Spring and Summer is low.

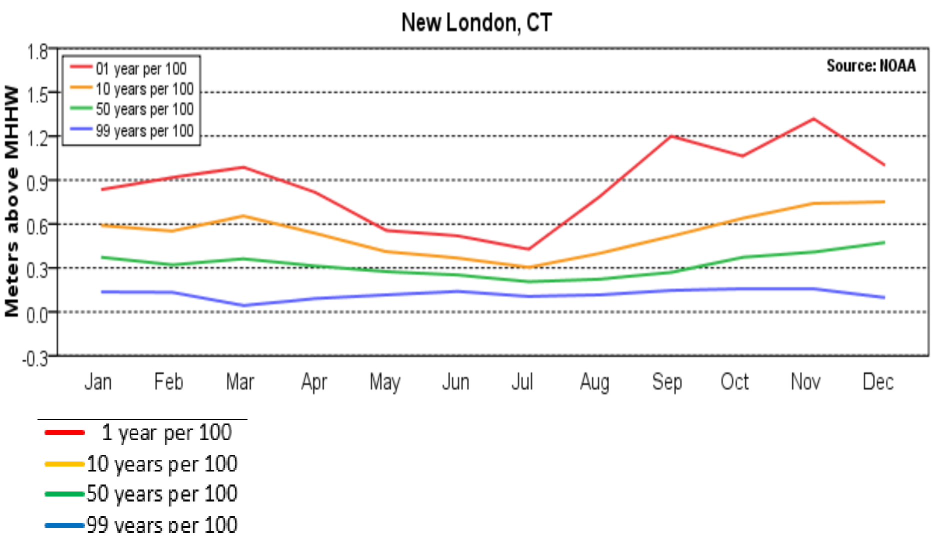


Figure 2-17: NOAA Seasonal Variation of Exceedance Probability Curve for the New London Station

Effect of Sea Level Rise of Flood Elevations

NOAA statistically analyzed monthly water level data to reflect the effect of past RSLC of flood elevations associated with different annual exceedance probability levels (see **Figure 2-18**). The monthly extreme probability levels include a MSL trend of 2.25 mm/year RSLR with a 95% confidence interval of +/-0.25 mm/yr based on the years 1938 to 2006 (0.74 foot per 100 years).

Table 2-9 shows the estimated effect of future RSLC on the USACE NACCS-predicted annual exceedance flood elevations for different projections of RSLC.

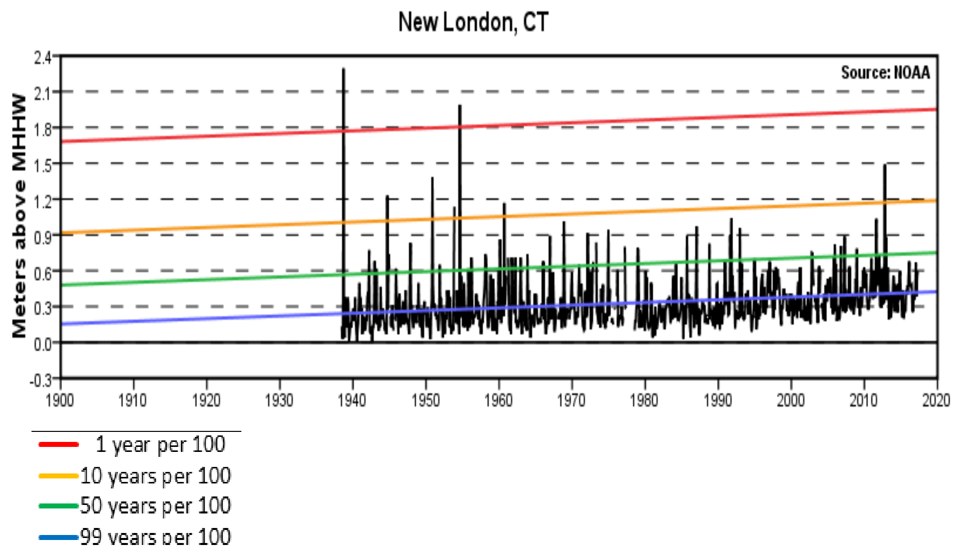


Figure 2-18: NOAA Water Levels with Exceedance Probability Curves for the New London Station

Prevailing Wind Analysis

The prevailing wind (and resulting wave) direction is a key factor in the direction of longshore sediment transport. "Prevailing" refers to the dominant, non-storm winds. GZA performed a statistical analysis of 1-minute sustained at 10-meter wind speed data collected by the anemometer at the New London airport for the period of record (1943 to 2017). The results of that analysis indicate the following:

- The prevailing, low velocity, winds are from the south to southwest and from the northwest to north. The south to west winds (in particular, the southerly winds) are prevailing during the summer months and the northerly winds during the Fall, Winter and Spring.

- About 49% of the 1-minute sustained wind speeds are less than 10 miles per hour (mph); about 45% of the sustained wind speeds are between 10 mph and 20 mph and about 6% are between 20 mph and 30 mph.

- Less than 1% of the winds are greater than 30 mph, with less than 0.05% (90 events between 1943 and mid-2017) equal to or greater than 50 mph. Of these 90 events with wind speeds equal to or greater than 50 mph (representing Nor'easters, tropical storm and hurricanes), about 80% were from the east-southeast to west-southwest (southerly direction) and about 14% were from the west-northwest to the east-northeast (northerly direction).

In general, the data indicate that the prevailing winds (and associated waves) are from the south to southwest. **Figure 2-19** presents seasonal wind roses at Old Saybrook. **Figure 2-20** presents a plot of annual wind direction distribution and **Figure 2-21** presents an annual wind rose.

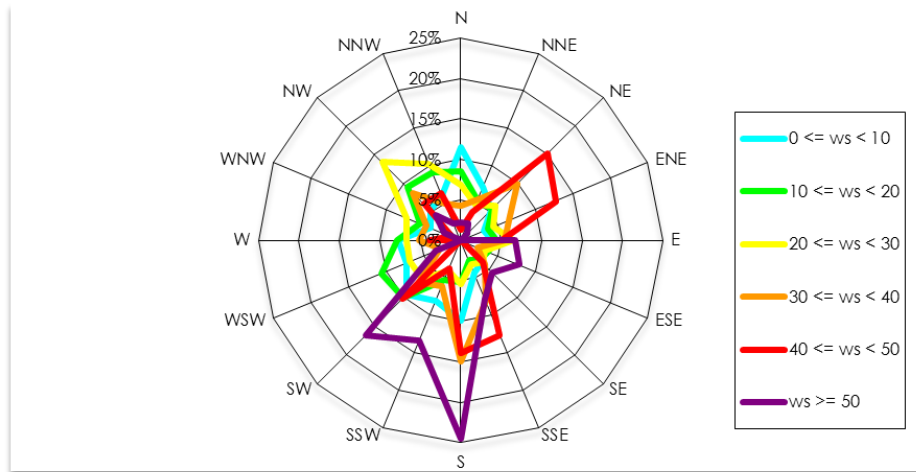


Figure 2-21: Wind Rose of Wind Speeds (miles per hour) and Direction at New London Airport

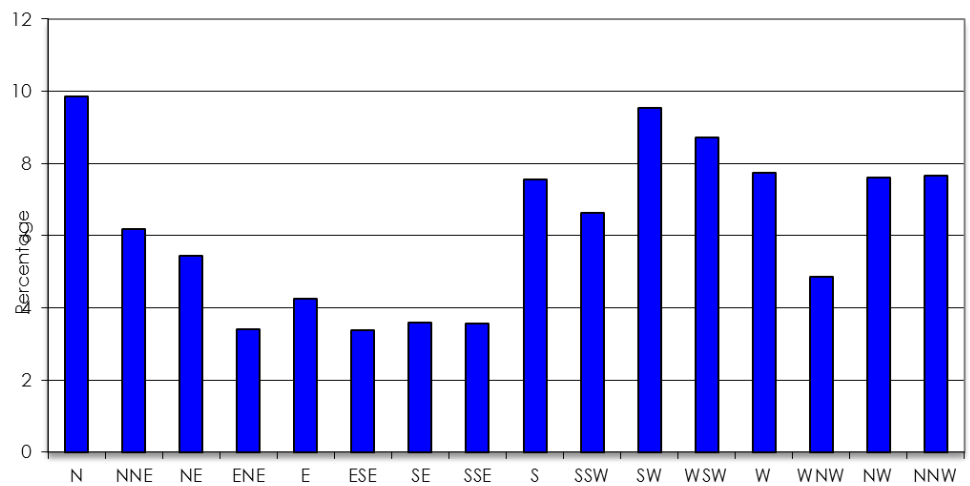


Figure 2-20: Distribution of Wind Directions at New London Airport

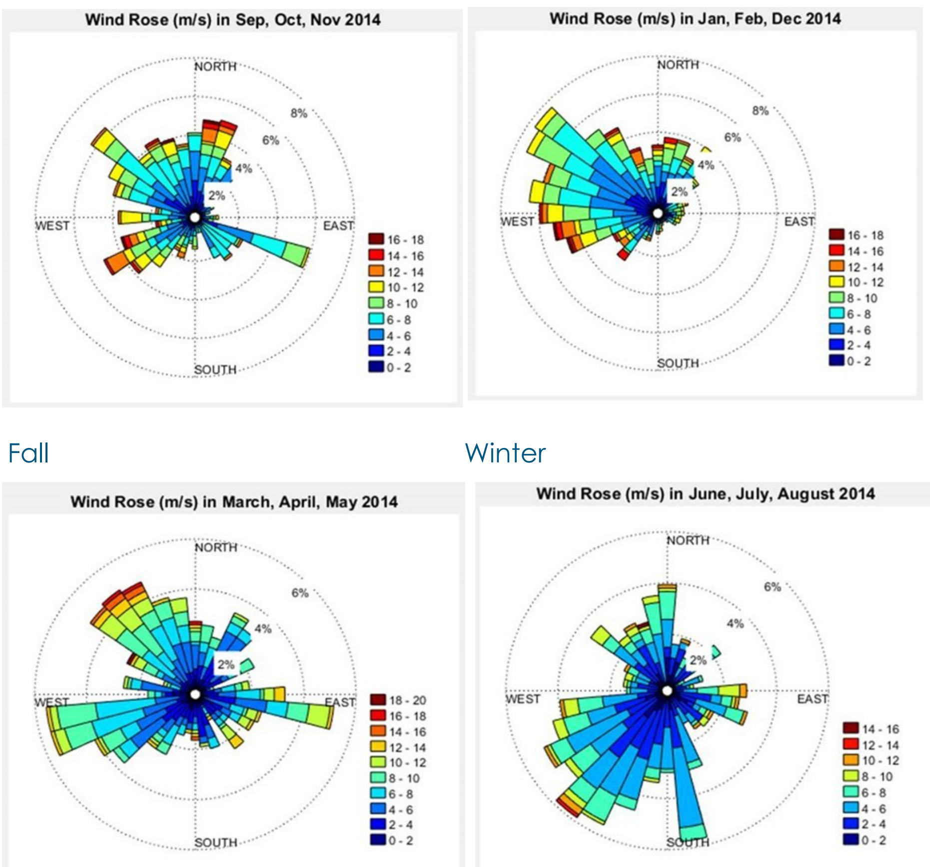


Figure 2-19: Distribution of Wind Directions and Intensities; Seasonally during 2014

Extreme Wind Analysis

Extreme sustained winds (greater than 40 mph and associated with storms) are also predominantly from: 1) the south to southwest; and 2) the east-northeast to northeast (Nor'easters). Sustained wind speeds 50 mph and greater are typically due to tropical cyclones (tropical storms and hurricanes). The following presents the results of GZA's statistical analysis of New London Airport wind data, representing the 1 and 2-minute sustained wind speed at 10 meters in mph.

Wind Direction	GEV Fit Wind Speed (mph)				Recommended Values (mph) for Modeling			
Return Period	10-year	50-year	100-year	500-year	10-year	50-year	100-year	500-year
All Direction	69	97	112	154	70	100	120	160
North	--	--	--	--	--	--	--	--
Northeast	43	53	57	68	45	55	60	70
East	49	71	82	117	50	75	90	120
Southeast	49	69	80	108	50	70	80	110
South	56	68	72	81	60	70	80	90
Southwest	48	66	75	99	50	70	80	100
West	43	59	69	98	45	60	70	100
Northwest	--	--	--	--	--	--	--	--

Table 2-10: Summary of Extreme Wind Speeds based on GZA Statistical Analysis of New London Airport

GZA Numerical Flood Model Simulations

GZA performed flood simulations using numerical hydrodynamic models of tides and storm surge and wave models. The coastal floods corresponding to tidal flow, the 100-year return period flood (1% annual chance) and the 500-year return period flood (0.2% annual chance) were modeled. The model simulations were performed using the two-dimensional, hydrodynamic computer model ADvanced CIRCulation model (ADCIRC). Waves were modeled using the Simulating WAves Nearshore (SWAN) model.

The purposes of GZA's model simulations were to: 1) evaluate flooding hydrodynamically and temporally; and 2) reflect the current topographic methodology. GZA also utilized GIS technology to evaluate flood inundation using "average" stillwater elevations for return periods ranging from 2-years to 50-years.

Model Flood Inundation Simulations

The ADCIRC storm surge flood simulation process utilized a robust, but simplified approach and included: 1) creation of a local area, high resolution model mesh; 2) development of synthetic hydrographs representative of storm types associated with the 100-year and 500-year return period floods (1% and 0.2% annual chance); 3) utilization of the USACE NACCS-predicted peak stillwater elevations at the model boundary to develop the peak hydrograph water level; and 5) stressing the model with the synthetic hydrograph and model domain wind field. This approach provides the benefits of numerical hydrodynamic models, approximating scenario-based simulations, but ties the overall flood hazard definition (model boundary water levels) to those developed by the USACE NACCS. Validation was performed by comparison of GZA model output to representative NACCS output for save points located within the model domain.

A high resolution ADCIRC mesh was developed to represent the detailed topographic features of Old Saybrook. The mesh covers Old Saybrook and extends approximately 4 miles off the coast into Long Island Sound (location of the open model boundary). The mesh consists of 190,968 finite elements, and the grid resolution across Old Saybrook land area is approximately 10 to 20 meters. The Digital Elevation Model utilized the following source topographic and bathymetric data based:

- Lidar provided by the Town (1 meter resolution); and
- 3 arc-second (approximately 30 meter) resolution Estuarine Bathymetric Digital Elevation Models in Long Island Sound, derived from NOAA source hydrographic survey data.

ADCIRC is a two-dimensional, depth integrated, barotropic time-dependent long wave, hydrodynamic circulation model, and can be applied to domains in deep oceans, the continental shelf, near-shore, and small-scale estuarine systems. The model input included synthetic hydrographs with peak water elevations corresponding to predicted USACE NACCS Save Point data at the model boundary.

2013 USACE Intermediate scenarios were simulated for the years 2040, 2070 and 2100 and 2013 USACE High scenarios for the years 2040 and 2070. RSLC was added to antecedent water levels and the synthetic hydrograph. The simulations were performed for tidal flow, the 100-year return period flood (1% annual chance) and the 500-year return period flood (0.2% annual chance). A time-stepped simulation of the 100-year return period flood was performed to evaluate flood progression.

Non-hydrodynamic simulations were also performed utilizing GIS to simulate the 2-year, 10-year, 20-year and 50-year return period flood inundation under current and future sea levels. The USACE NACCS flood levels from seventeen NACCS Save Points were utilized to estimate the mean water levels for these simulations.

Figures 2-19 through 2-23 present the simulated flood inundation limits for several different return period coastal floods.

Following Pages: Figures 2-22 through 2-25: GZA Flood Simulations corresponding to the 2-year, 10-year, 50-year, 100-year and 500-year Return Period floods. Return periods 2 through 50 years were developed using simple GIS technology of elevation overlay, with "average" stillwater flood elevations for that return period. These do not capture hydrodynamic effects which cause the peak stillwater flood elevation to vary in elevation throughout Old Saybrook – generally higher to the north). The 100-year and 500-yaer maps were made using hydrodynamic modeling. One limitation to the hydrodynamic models is that flooding within one location to the north of I-95 is not captured on these model simulations but is captured on the other maps as well as the FEMA FIRM.

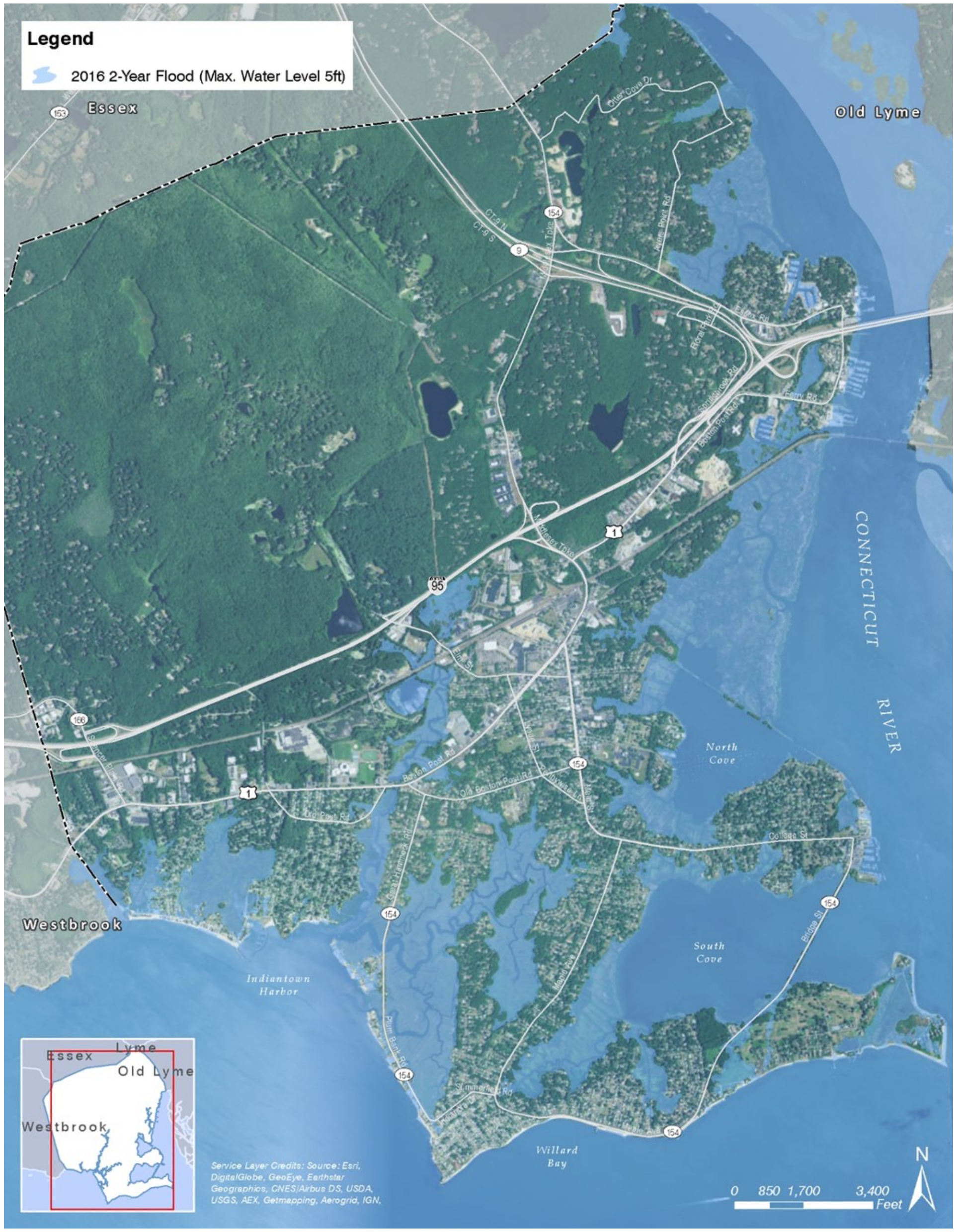


Figure 2-22: 2-year Recurrence Interval Flood Inundation

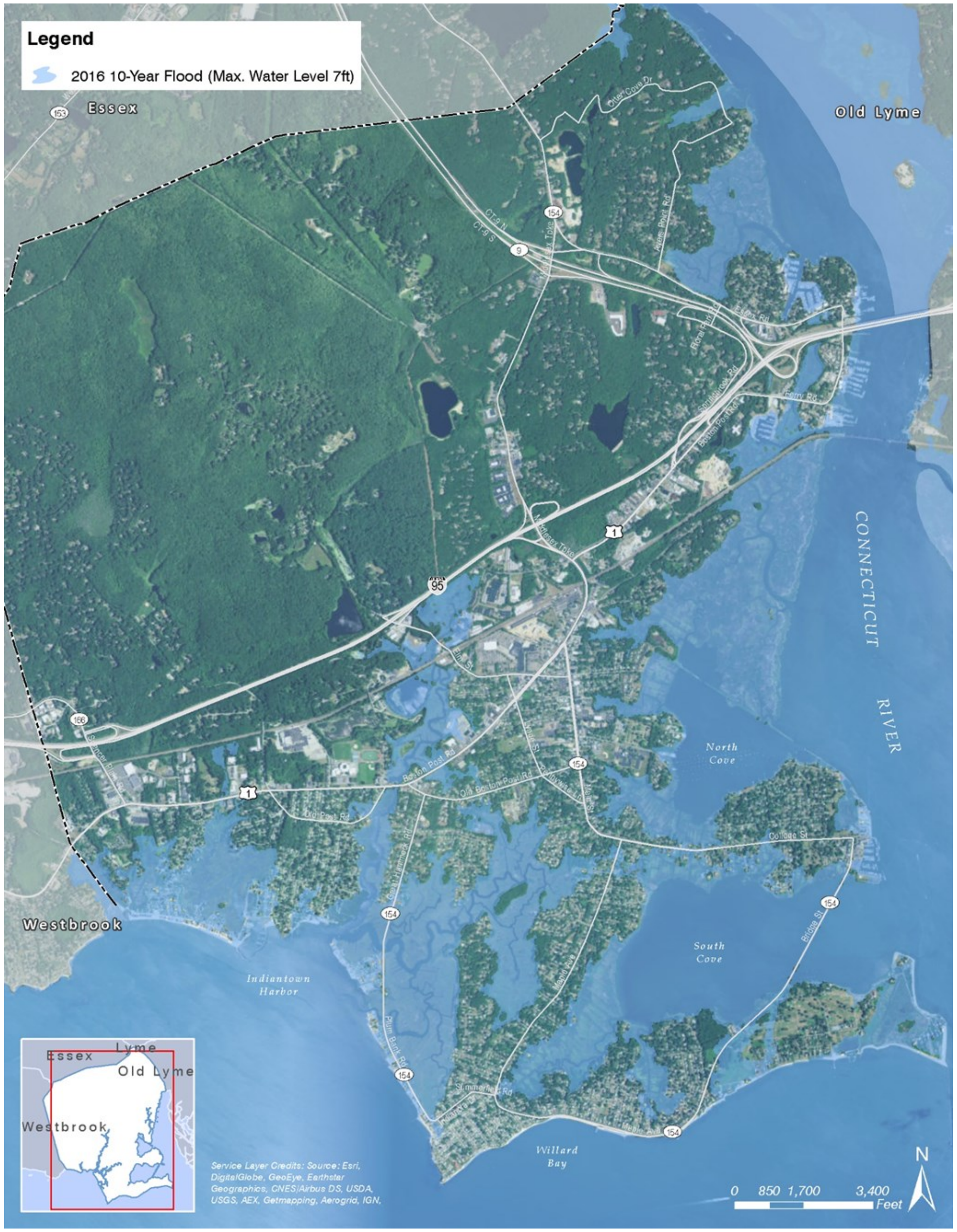


Figure 2-23: 10-year Recurrence Interval Flood Inundation

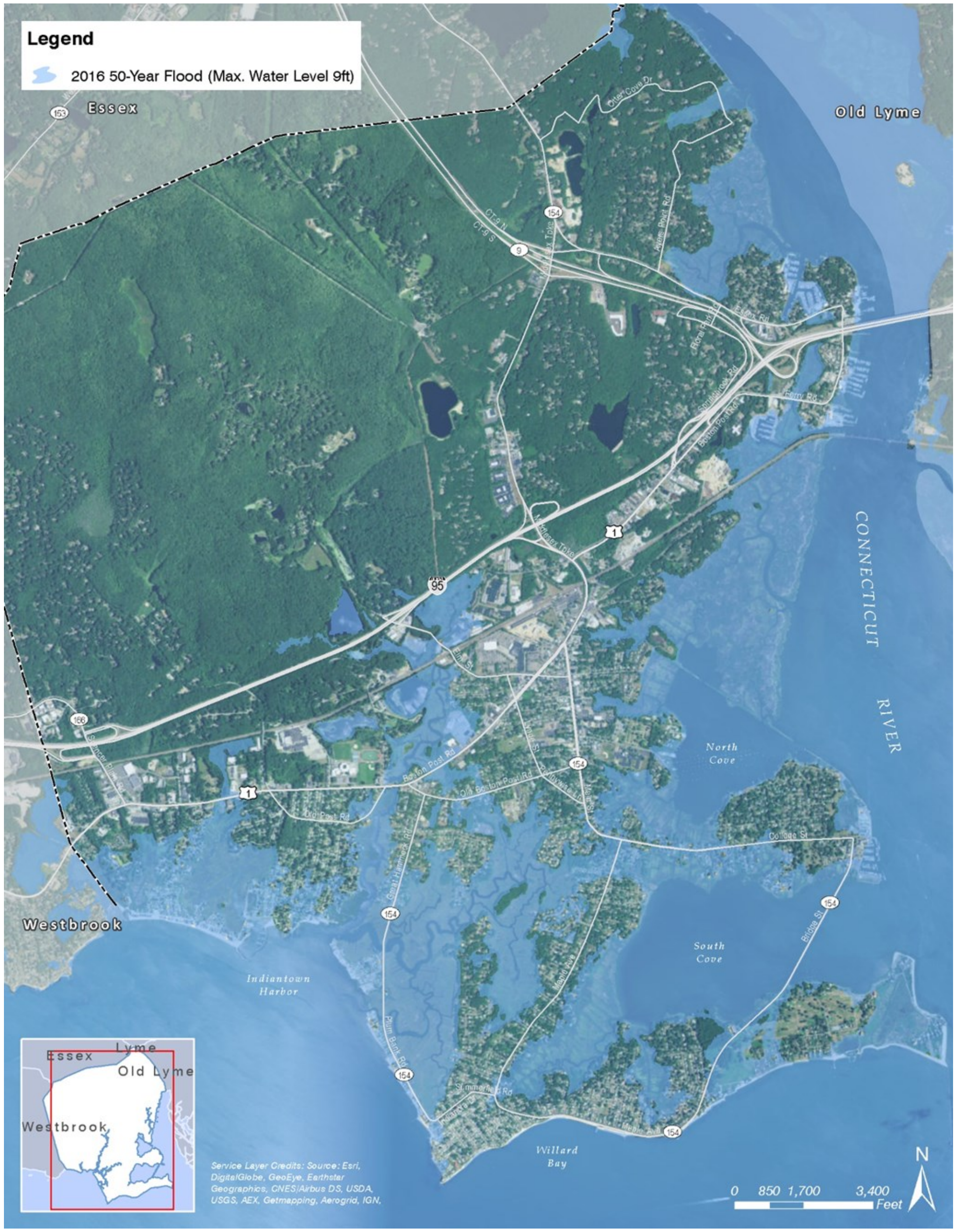


Figure 2-24: 50-year Recurrence Interval Flood Inundation

Figure 2-25: 100-year Recurrence Interval Flood Inundation

Figure 2-26: 500-year Recurrence Interval Flood Inundation

Model Wave Simulations

The Simulating WAves Nearshore (SWAN) model was used to model wave heights for the 100-year and 500-year return period floods.

The waves were modeled using the same model mesh and Digital Elevation Model as the ADCIRC storm surge simulations. Boundary condition waves were input at the Long Island Sound model boundary based on wave results for USACE NACCS Save Points located at the boundary. A local wind field was applied with wind intensities consistent with ASCE 7-10 3-second gusts converted to 1-minute sustained 10-meter winds.

Extreme Flood Wave Conditions:

ASCE 7-10 specified wind speed (3-second gust) for the project area is 107 miles per hour (mph) for the 100-year recurrence interval wind. This value is converted to a 1-minute sustained wind speed at 10 meters height of approximately 79 to 87 mph and a 10-minute sustained wind speed at 10 meters of approximately 71 mph to 77 mph, consistent with offshore winds to onshore winds at a coastline, respectively. Similarly, the 500-year recurrence interval wind is converted to a 1-minute sustained wind speed at 10 meters height of approximately 88 to 98 mph and a 10-minute sustained wind speed at 10 meters of approximately 79 mph to 87 mph, consistent with offshore winds to onshore winds at a coastline, respectively.

The waves were conservatively modeled coincident with the 100-year and 500-year return period flood water levels. **Figures 2-27** and **2-28** present the simulated significant wave heights for the 100-year and 500-year return period waves. Wave heights are also calculated by the USACE NACCS and predicted significant wave heights are available at NACCS save points. The results differ from GZA's wave model results at some locations. The differences may be due in part to the NACCS model capturing ocean swells from the southeast. The difference is less important as the waves encroach the shoreline and for overland waves.

Prevailing (Typical) Wind and Wave Conditions:

Typical wave conditions were modeled using the GZA-calculated prevailing wind speeds and directions (**Figures 2-29** and **2-30**). The wave vectors indicate a strong northerly direction of longshore transport from Cornfield Point to Plum Bank Creek (north of Town Beach). Between Plum Bank Creek and the mouth of Oyster River, the waves generally refract and attenuate due to the tidal flat. Along Chalker Beach, the shallow nearshore depths and cove shape of the shoreline attenuate wave heights somewhat. Longshore transport is expected to be variable and limited along this stretch of shoreline. The shoreline from Cornfield Point to Fenwick generally faces south and is exposed to larger waves. Longshore transport along this stretch of shoreline will generally be to the east, but locally variable due to the effects of shoreline structures and Cornfield Point.

USACE NACCS data offshore at representative locations are summarized below:

Recurrence Interval (yrs)	Mean Significant Wave Height (ft)				
	Plum Bank Road near Cornfield Point	Maple Avenue near Revetment	Within South Cove	Fenwick/ near Hepburn Beach	Off Saybrook Point (Dock Road)
1	3.4	5.0	2.6	3.9	3.1
2	4.6	6.7	3.1	4.8	4.0
5	5.8	7.8	3.6	5.4	4.8
10	6.6	8.5	3.9	5.8	5.4
20	7.3	9.2	4.2	6.2	5.9
50	8	9.9	4.5	6.6	6.6
100	8.6	10.4	4.7	6.9	7.1
200	9	10.9	4.9	7.2	7.5
500	9.5	11.5	5.2	7.4	8.1

Table 2-11: Summary of Predicted Flood Elevations and Probabilities for the Years 2017, 2041, 2066 and 2116; UB and LB indicate

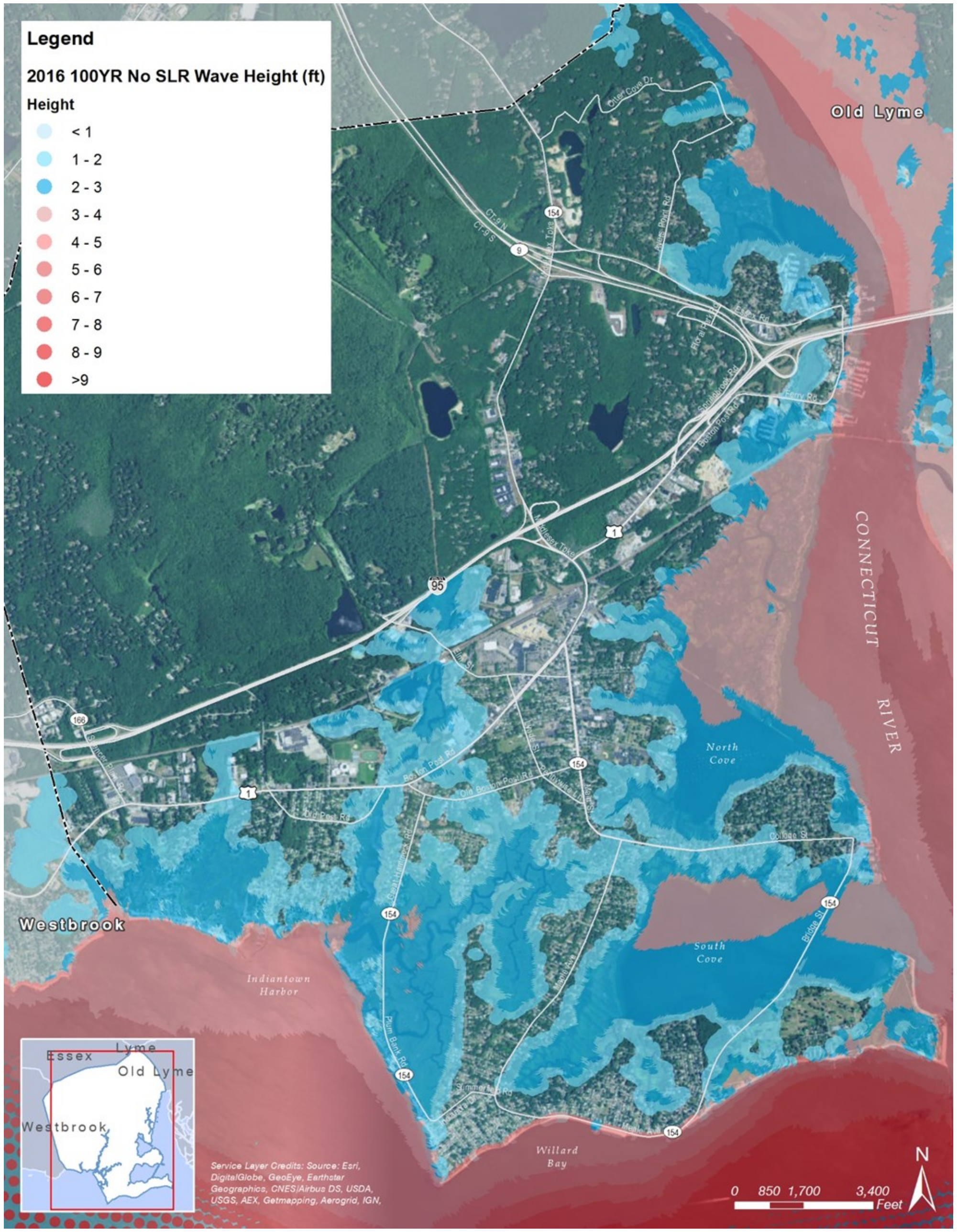


Figure 2-26: 100-year Recurrence Interval Wave Heights

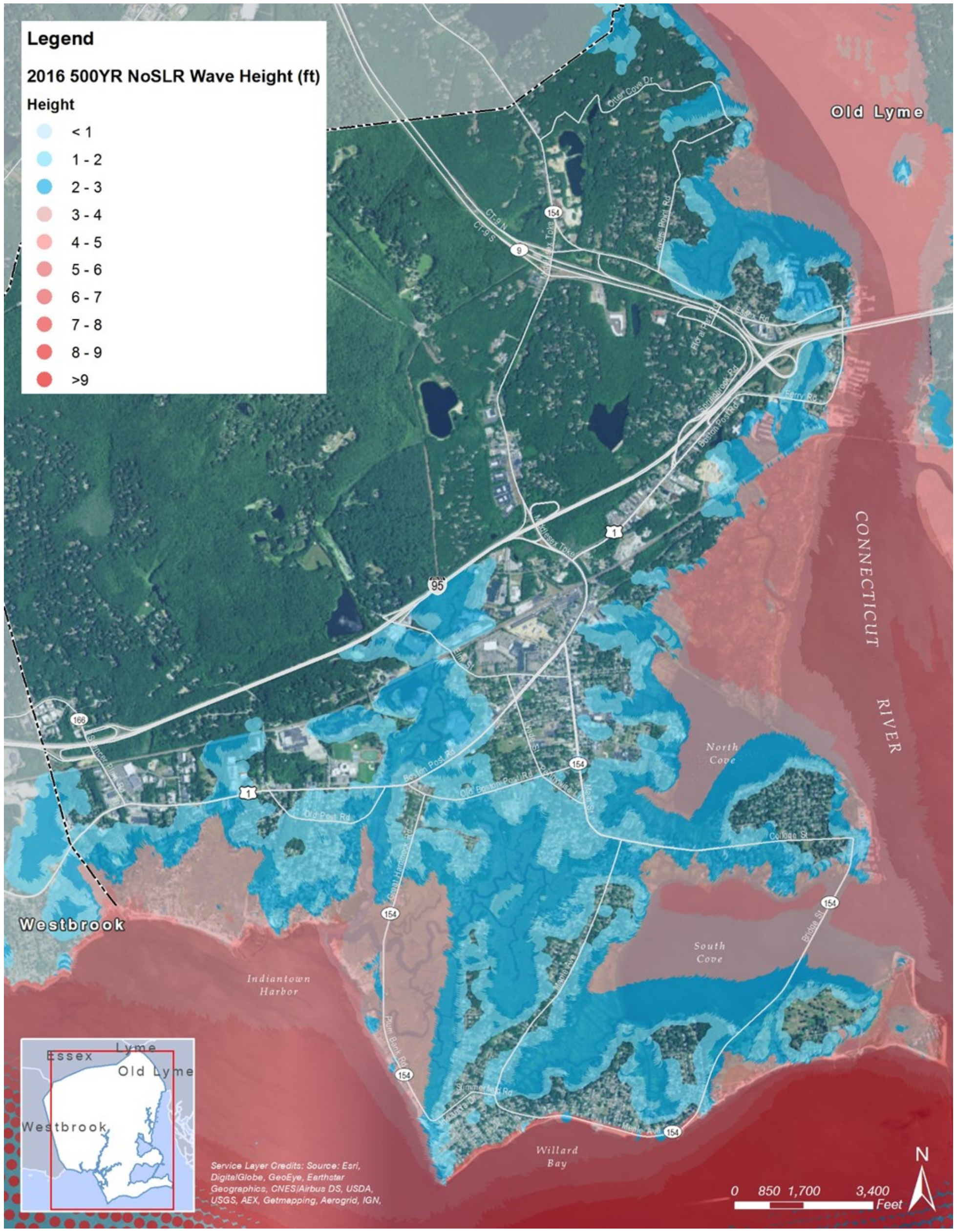


Figure 2-27: 500-year Recurrence Interval Wave Heights

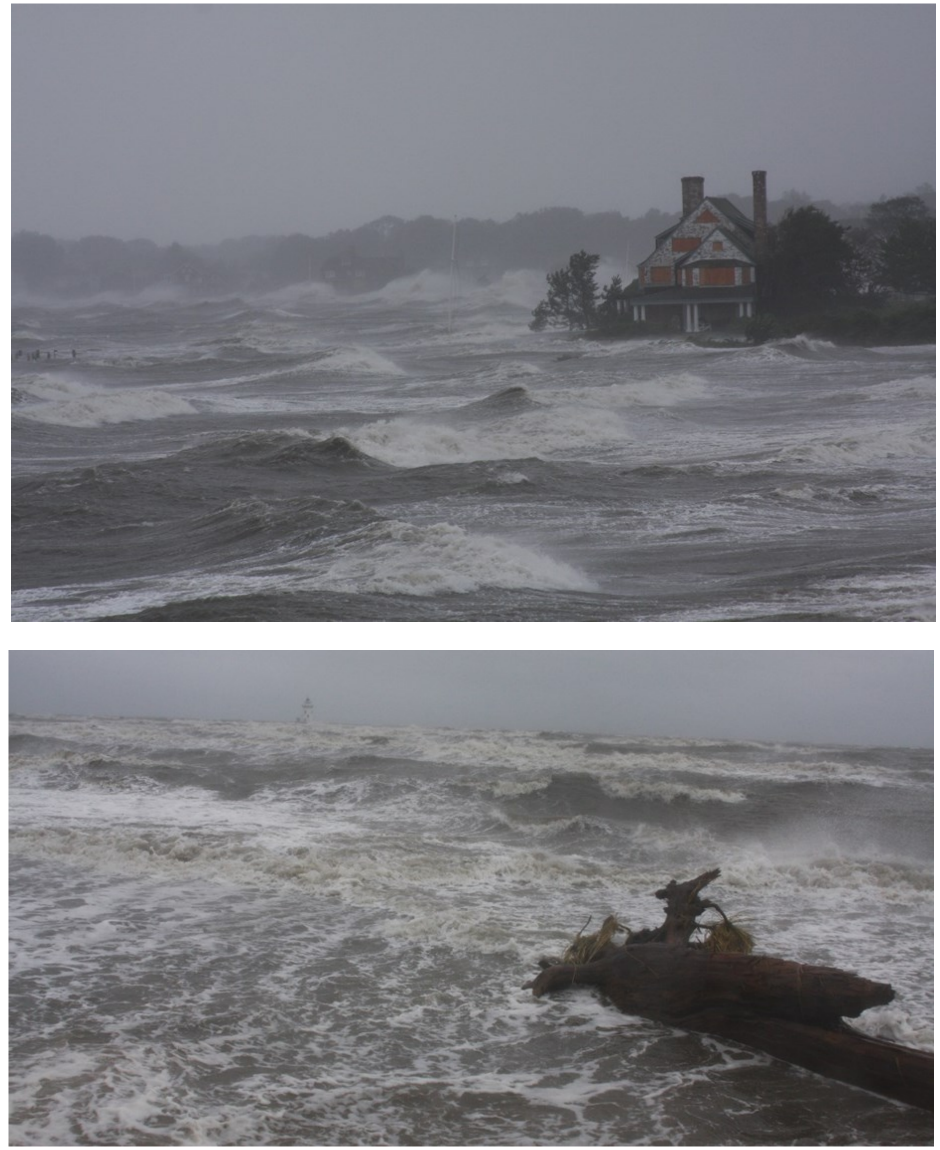


Figure 2-28: Photographs of Tropical Storm Irene (+/- 10-yr recurrence interval) at Fenwick. Wave heights about 3 to 4 feet.

Prevailing Wind-Generated Waves

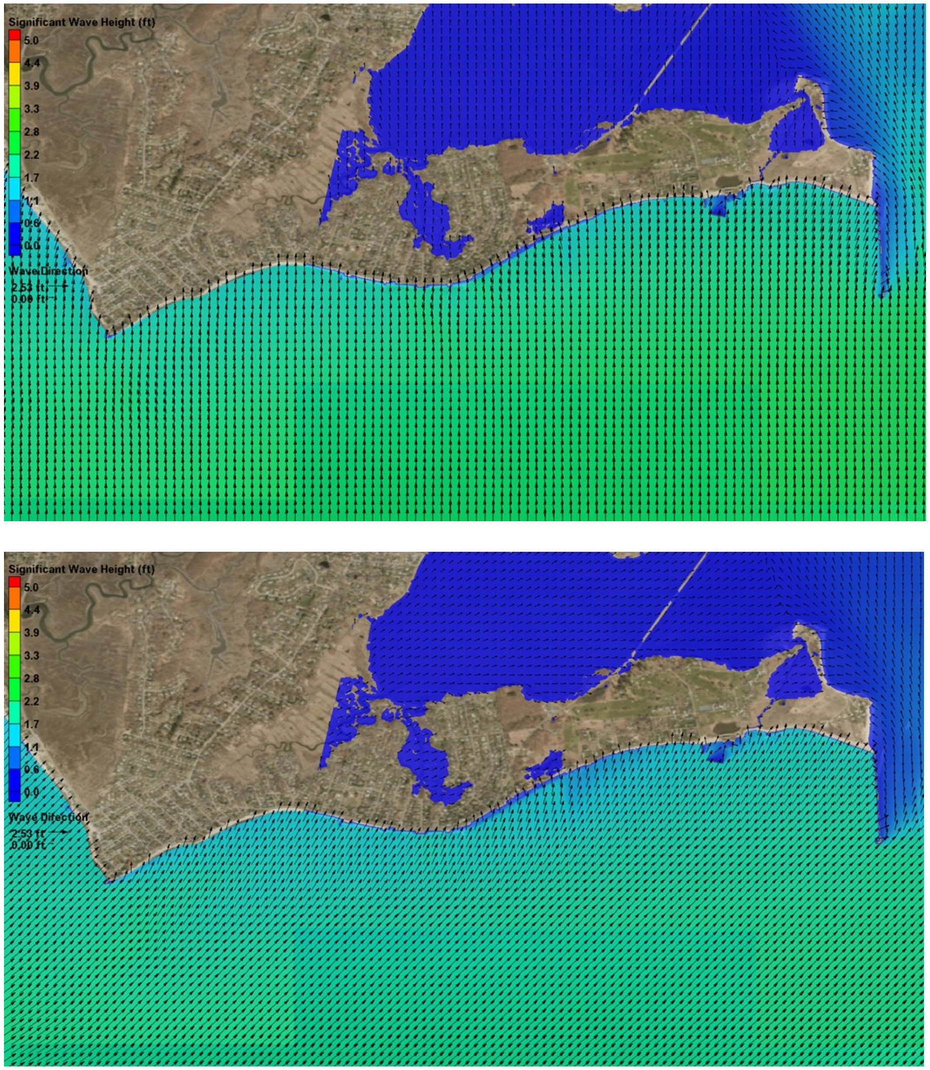


Figure 2-29: Prevailing Wave Vectors and Heights – South Wind (above) and Southwest Wind (below); South Facing Shore

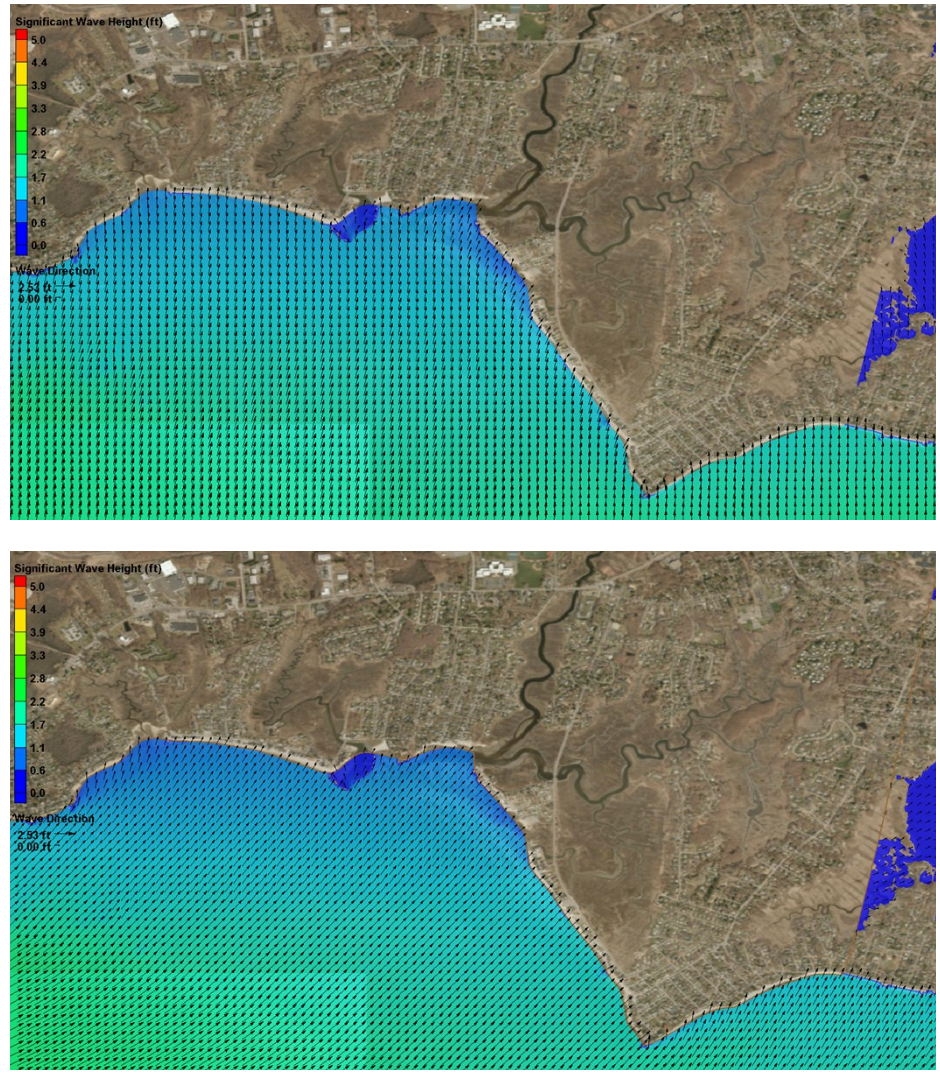


Figure 2-30: Prevailing Wave Vectors and Heights – South Wind (above) and Southwest Wind (below); Low Beach Communities

Precipitation

Precipitation probability point data is available from NOAA's National Weather Service Atlas 14. Data is presented in tabular and graphical form in **Table 2-10** and **Figure 2-26.**

The predicted trend for the Northeast US is for an increase in the frequency of intense precipitation events. Detailed climate-related precipitation change predictions have not been developed for Connecticut; however, increase in the frequency of intense rainfalls in Connecticut of 200% to 300% are likely by the end of the century. The predicted trend is also for wetter winters, springs and summers.

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	**0.341** (0.260-0.445)	**0.409** (0.311-0.535)	**0.521** (0.395-0.682)	**0.613** (0.462-0.806)	**0.740** (0.543-1.00)	**0.838** (0.604-1.16)	**0.936** (0.658-1.33)	**1.06** (0.709-1.52)	**1.22** (0.790-1.80)	**1.35** (0.852-2.01)
10-min	**0.483** (0.368-0.631)	**0.580** (0.441-0.758)	**0.738** (0.559-0.966)	**0.868** (0.655-1.14)	**1.05** (0.769-1.42)	**1.19** (0.856-1.64)	**1.33** (0.933-1.88)	**1.50** (1.00-2.15)	**1.73** (1.12-2.55)	**1.91** (1.21-2.85)
15-min	**0.568** (0.433-0.742)	**0.682** (0.519-0.891)	**0.868** (0.658-1.14)	**1.02** (0.771-1.34)	**1.23** (0.905-1.68)	**1.40** (1.01-1.93)	**1.56** (1.10-2.21)	**1.77** (1.18-2.53)	**2.04** (1.32-3.00)	**2.24** (1.42-3.35)
30-min	**0.792** (0.603-1.03)	**0.951** (0.723-1.24)	**1.21** (0.917-1.58)	**1.42** (1.07-1.87)	**1.72** (1.26-2.34)	**1.95** (1.40-2.69)	**2.18** (1.53-3.09)	**2.46** (1.65-3.53)	**2.84** (1.84-4.18)	**3.13** (1.98-4.66)
60-min	**1.02** (0.774-1.33)	**1.22** (0.927-1.59)	**1.55** (1.18-2.03)	**1.83** (1.38-2.40)	**2.21** (1.62-3.00)	**2.50** (1.80-3.45)	**2.79** (1.96-3.96)	**3.16** (2.11-4.53)	**3.64** (2.35-5.36)	**4.01** (2.54-5.98)
2-hr	**1.32** (1.01-1.72)	**1.59** (1.22-2.07)	**2.03** (1.55-2.64)	**2.39** (1.81-3.12)	**2.89** (2.13-3.91)	**3.28** (2.38-4.50)	**3.66** (2.60-5.18)	**4.18** (2.81-5.96)	**4.87** (3.16-7.11)	**5.39** (3.42-7.98)
3-hr	**1.54** (1.18-1.98)	**1.85** (1.41-2.39)	**2.35** (1.80-3.05)	**2.78** (2.11-3.61)	**3.36** (2.48-4.52)	**3.80** (2.77-5.21)	**4.25** (3.03-6.00)	**4.87** (3.27-6.91)	**5.69** (3.70-8.28)	**6.31** (4.01-9.31)
6-hr	**1.95** (1.51-2.51)	**2.35** (1.81-3.02)	**2.99** (2.30-3.85)	**3.53** (2.69-4.56)	**4.26** (3.17-5.70)	**4.83** (3.53-6.57)	**5.39** (3.86-7.57)	**6.19** (4.17-8.72)	**7.23** (4.71-10.4)	**8.03** (5.12-11.8)
12-hr	**2.43** (1.88-3.10)	**2.92** (2.26-3.72)	**3.72** (2.87-4.75)	**4.38** (3.36-5.62)	**5.29** (3.95-7.03)	**5.99** (4.40-8.09)	**6.70** (4.80-9.32)	**7.66** (5.19-10.7)	**8.94** (5.85-12.8)	**9.91** (6.34-14.4)
24-hr	**2.85** (2.22-3.61)	**3.45** (2.68-4.37)	**4.43** (3.43-5.63)	**5.24** (4.04-6.68)	**6.35** (4.77-8.40)	**7.21** (5.33-9.69)	**8.07** (5.83-11.2)	**9.30** (6.32-12.9)	**10.9** (7.16-15.5)	**12.1** (7.79-17.5)
2-day	**3.18** (2.49-4.00)	**3.90** (3.05-4.91)	**5.07** (3.95-6.39)	**6.04** (4.68-7.65)	**7.37** (5.58-9.70)	**8.40** (6.25-11.3)	**9.43** (6.88-13.1)	**11.0** (7.51-15.2)	**13.1** (8.61-18.5)	**14.7** (9.45-21.0)
3-day	**3.45** (2.71-4.32)	**4.22** (3.31-5.30)	**5.49** (4.29-6.90)	**6.53** (5.08-8.24)	**7.98** (6.05-10.5)	**9.09** (6.78-12.1)	**10.2** (7.46-14.1)	**11.9** (8.14-16.4)	**14.2** (9.34-19.9)	**15.9** (10.3-22.6)
4-day	**3.70** (2.92-4.63)	**4.51** (3.55-5.64)	**5.83** (4.57-7.31)	**6.93** (5.40-8.72)	**8.43** (6.41-11.0)	**9.60** (7.17-12.8)	**10.8** (7.87-14.8)	**12.5** (8.58-17.2)	**14.9** (9.82-20.8)	**16.6** (10.8-23.6)
7-day	**4.42** (3.50-5.50)	**5.29** (4.18-6.58)	**6.71** (5.28-8.36)	**7.88** (6.17-9.86)	**9.50** (7.24-12.3)	**10.7** (8.04-14.2)	**12.0** (8.77-16.3)	**13.8** (9.48-18.8)	**16.2** (10.7-22.5)	**18.0** (11.7-25.4)
10-day	**5.12** (4.06-6.35)	**6.03** (4.77-7.47)	**7.50** (5.92-9.32)	**8.72** (6.85-10.9)	**10.4** (7.94-13.4)	**11.7** (8.77-15.3)	**13.0** (9.49-17.5)	**14.8** (10.2-20.0)	**17.1** (11.4-23.8)	**18.9** (12.3-26.6)
20-day	**7.25** (5.78-8.93)	**8.23** (6.55-10.1)	**9.82** (7.79-12.1)	**11.1** (8.79-13.8)	**13.0** (9.91-16.5)	**14.4** (10.8-18.5)	**15.8** (11.5-20.9)	**17.4** (12.1-23.4)	**19.6** (13.1-27.0)	**21.3** (13.9-29.7)
30-day	**9.04** (7.23-11.1)	**10.1** (8.03-12.3)	**11.7** (9.34-14.4)	**13.1** (10.4-16.2)	**15.0** (11.5-19.0)	**16.5** (12.4-21.1)	**18.0** (13.0-23.5)	**19.5** (13.6-26.1)	**21.6** (14.4-29.5)	**23.1** (15.1-32.1)
45-day	**11.3** (9.04-13.8)	**12.3** (9.89-15.1)	**14.1** (11.3-17.3)	**15.6** (12.3-19.1)	**17.6** (13.5-22.0)	**19.1** (14.3-24.3)	**20.6** (14.9-26.7)	**22.1** (15.4-29.3)	**23.9** (16.0-32.5)	**25.3** (16.6-35.0)
60-day	**13.1** (10.6-16.0)	**14.3** (11.4-17.4)	**16.1** (12.9-19.6)	**17.6** (14.0-21.5)	**19.7** (15.1-24.6)	**21.3** (16.0-26.9)	**22.9** (16.5-29.4)	**24.2** (16.9-32.0)	**25.8** (17.4-35.1)	**27.1** (17.8-37.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Table 2-10: NOAA Atlas 14 Precipitation

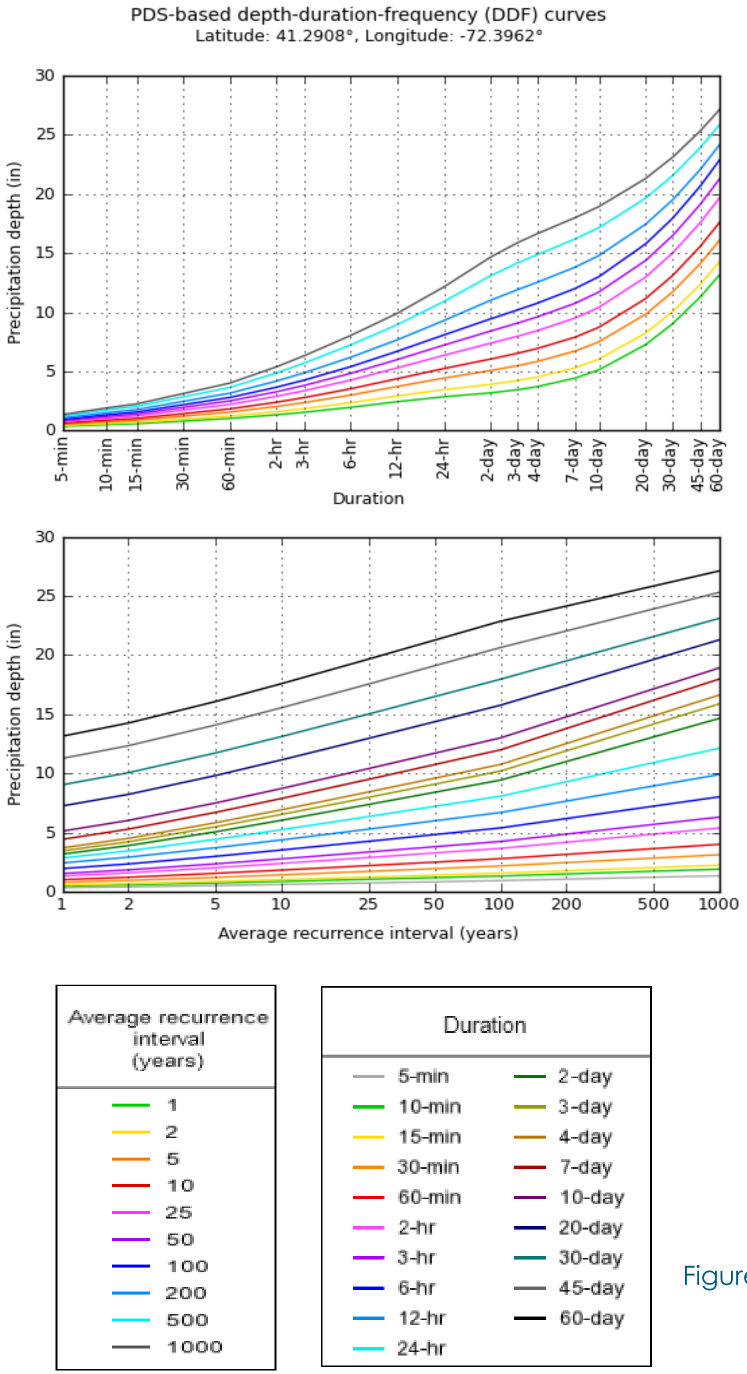


Figure 2-29: Precipitation Point Data

Additional Climate Considerations

Additional, relevant climate considerations include changes to temperature, precipitation and the water balance including snow water equivalent, runoff, soil water storage and evaporative deficit. Worldwide climate modeling centers participating in the 5th Climate Model Intercomparison Program (CMIP5) are providing climate information for the ongoing Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC).

Attachment 2 Appendix A presents a summary report for Middlesex County using the United States Geological Survey Climate Change Viewer (NCCV). The NCCV includes the historical and future climate projections from 30 of the downscaled models for two of the RCP emission scenarios, RCP4.5 and RCP8.5. RCP4.5 is one of the possible emissions scenarios in which atmospheric GHG concentrations are stabilized so as not to exceed a radiative equivalent of 4.5 Wm^{-2} after 2100, about 650 ppm CO_2 equivalent. RCP8.5 is the most aggressive emissions scenario in which GHGs continue to rise unchecked through the end of the century leading to an equivalent radiative forcing of 8.5 Wm^{-2}, about 1370 ppm CO_2 equivalent. The climate and water balance data are averaged into four climatology periods: 1981-2010, 2025-2049, 2050-2074, and 2075-2099.

United States Geological Survey Climate Change Viewer (NCCV). The NCCV includes the historical and future climate projections from 30 of the downscaled models for two of the RCP emission scenarios, RCP4.5 and RCP8.5. RCP4.5 is one of the possible emissions scenarios in which atmospheric GHG concentrations are stabilized so as not to exceed a radiative equivalent of 4.5 Wm^{-2} after 2100, about 650 ppm CO_2 equivalent. RCP8.5 is the most aggressive emissions scenario in which GHGs continue to rise unchecked through the end of the century leading to an equivalent radiative forcing of 8.5 Wm^{-2}, about 1370 ppm CO_2 equivalent. The climate and water balance data are averaged into four climatology periods: 1981-2010, 2025-2049, 2050-2074, and 2075-2099.

The output from the CMIP5 models is typically provided on grids of ~1 to 3 degrees in latitude and longitude (roughly 80 to 230 km at 45° latitude). To derive higher resolution data for regional climate change assessments, NASA applied a statistical technique to downscale maximum and minimum air temperature and precipitation from 33 of the CMIP5 climate models to a very fine, 800-m grid over the contiguous United States (CONUS). The full NEX-DCP30 dataset covers the historical period (1950-2005) and 21st century (2006-2099) under four Representative Concentration Pathways (RCP) emission scenarios developed for AR5.

The USGS used the air temperature and precipitation data from the 30 CMIP5 models as input to a simple water-balance model to simulate changes in the surface water balance over the historical and future time periods on the 800-m CONUS grid. Combining the climate data with the water balance data in the NCCV provides further insights into the potential for climate-driven change in water resources.

Air Temperature: The seasonal average Summer, 2-meter air temperature is predicted to increase (from historical averages of around 80^{o}F) to about 85^{o}F (RCP4.5) to about 92^{o}F by the year 2100. The seasonal average Winter, 2-meter air temperature is predicted to increase (from historical averages of around 40^{o}F) to about 45^{o}F (RCP4.5) to about 50^{o}F by the year 2100. The annual number of extreme heat days is predicted to increase significantly in Connecticut.

Water Temperature: In general, over the last 45 years there has been a steady, but slight increase in Long Island Sound water temperature, with average winter temperatures at around 41^{o}F (5^{o}C). Winter water temperatures appear to be increasing more rapidly than spring, summer or fall temperatures, and winter 2012 is the warmest since the inception of this record by a large margin. Increases in surface water temperatures have been linked to observed changes in the fish community. Cold-adapted fish have been observed less frequently in recent years, while warm-adapted fish have been observed more frequently. The combination of increasing water temperatures and changing fish community is believed to be indicative of climate change. The overall mean from 1976 through 2015 is 3.90°C (39.02 F) for winter, 11.22°C (52.20F) for spring, 20.07°C (68.13F) for summer, and 12.24°C (54.03F) for fall. (From Long Island Sound Study).

Spring Freshet: As temperatures rise in the spring, snow and ice that have accumulated throughout Long Island Sound's watershed begins to melt, which leads to high levels of runoff into small streams and rivers which, in turn, drain into the Connecticut River, which provides about 70% of the fresh water input into Long Island Sound, as well as other smaller rivers. This process is called the spring 'freshet'. Changes in the timing of the freshet may have implications for some aquatic species and human activities along the coast. Flooded fields and marshes along the river during the freshet provide critical feeding areas for migratory waterfowl. So if the freshet comes earlier, waterfowl could be impacted if they do not adjust the timing of their migration. Changes in the timing of flooding may also provide a competitive advantage to invasive plants (such as purple loosestrife and Phragmites) in the marshes since some of these species emerge earlier than the natives. In the past, these invasives were flooded in early spring and often rotted due to submergence for prolonged periods. So, if the flooding occurs earlier, the invasives (still emerging before the natives) will no longer rot in early spring and may gain a competitive advantage over natives.

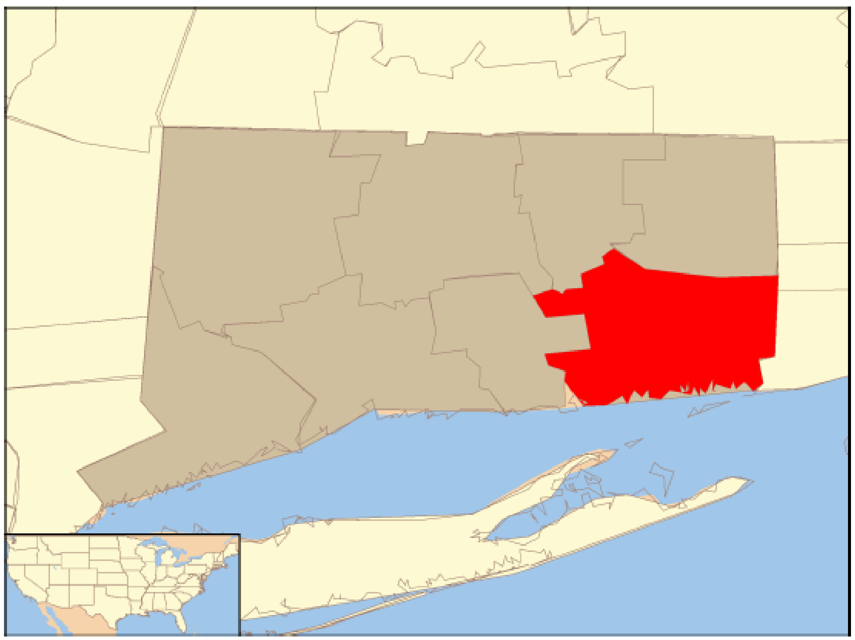
By looking at 80 years of river data, scientists at the US Geological Survey and UConn have determined that the spring freshet is occurring earlier in the spring. This indicator is derived from measurements of river flow at a gauge at Thompsonville, CT, near the Massachusetts border). The indicator is the date (we use Julian days, or # of days into the year, to account for leap years) that the total volume of water that has passed by the gauge exceeds half of the total for the year. The critical date is called the "winter-spring center of volume" or WSCV. While spring weather in New England is quite variable, the WSCV usually occurs in late March or early April. Despite large oscillations, the freshet is getting to Long Island Sound on average about 10 days earlier than it did a hundred years ago.

While the exact magnitude and timing of the freshet in any given year is highly dependent on local and regional weather patterns during the late winter/early spring period, the long-term shift towards an earlier center of volume is indicative of a general warming trend throughout the region. (From Long Island Sound Study)

Growing Season: The length of the growing season is the variation between the last frost of spring and the first frost of fall. This indicator uses air temperatures measured at Tweed-New Haven Airport in New Haven since 1973 and compares it to frost measurements from an 18th and 19th century datasets collected and published in 1866 by Yale College. The average length of the growing season over the past 40 years (1973-2015) is 26 percent higher than the average length of the growing season from 1788 to 1866, an increase from 126 days to 159 days. Over the past 11 years the length of the growing season has been equal to or exceeded the modern-era average every year, but two. (from Long Island Sound Study)

U.S. Geological Survey - National Climate Change Viewer

Summary of New London County, Connecticut



December 1, 2016

1 Maximum 2-m Air Temperature

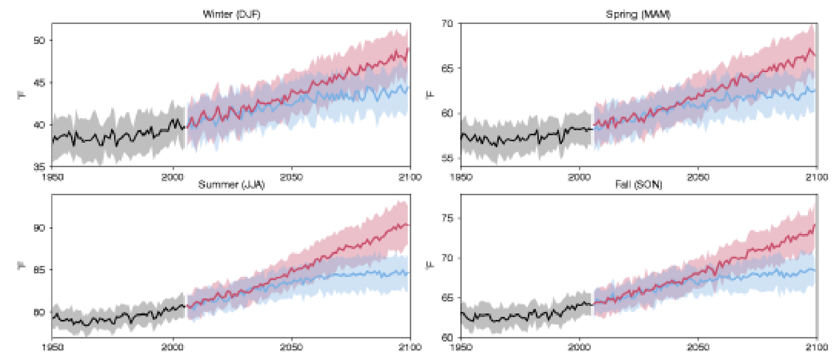


Figure 1: Seasonal average time series of maximum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

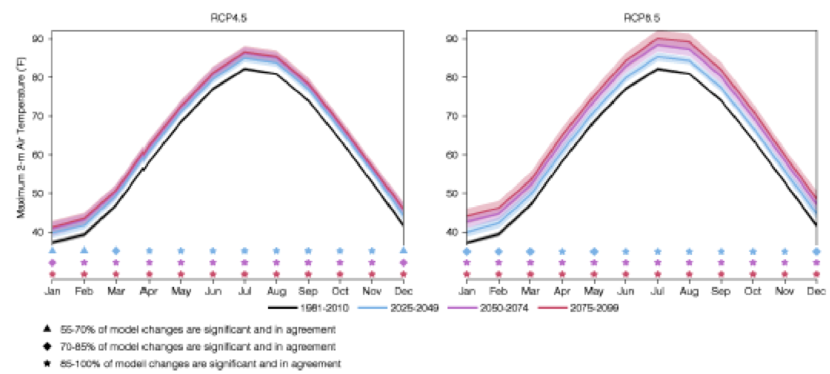


Figure 2: Monthly averages of maximum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

2 Minimum 2-m Air Temperature

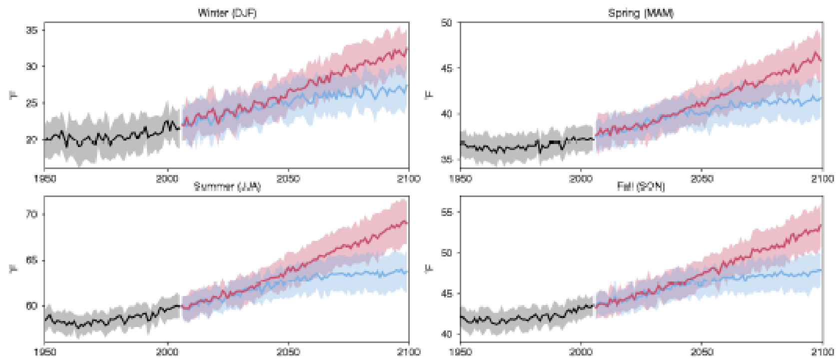


Figure 3: Seasonal average time series of minimum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

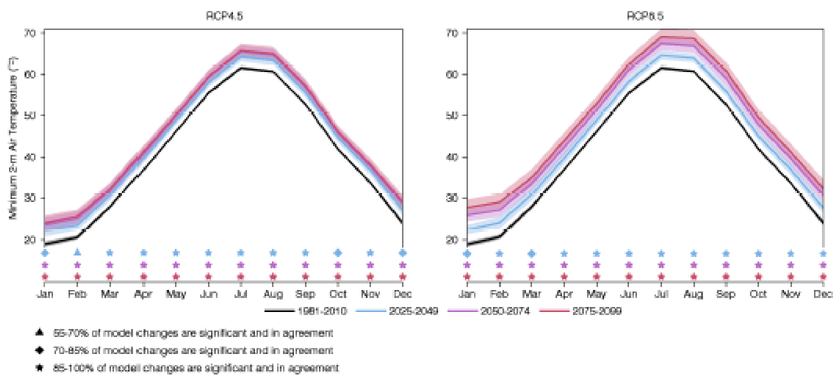


Figure 4: Monthly averages of minimum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

3 Precipitation

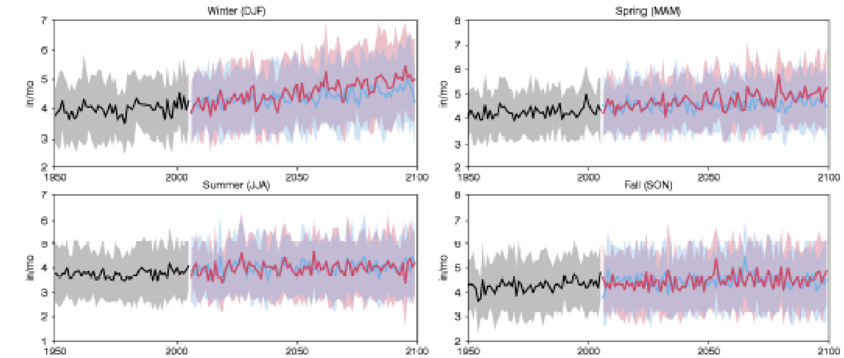


Figure 5: Seasonal average time series of precipitation for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

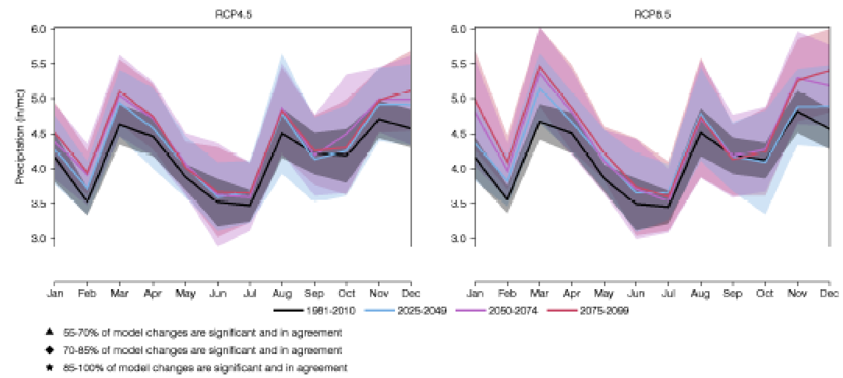


Figure 6: Monthly averages of precipitation for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

4 Snow Water Equivalent

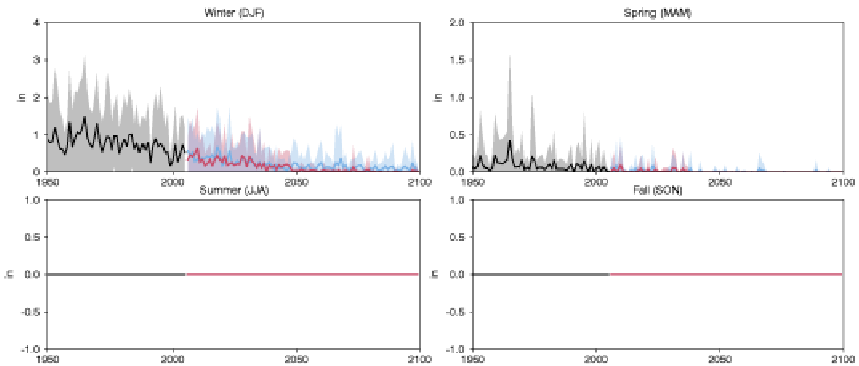


Figure 7: Seasonal average time series of snow water equivalent for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

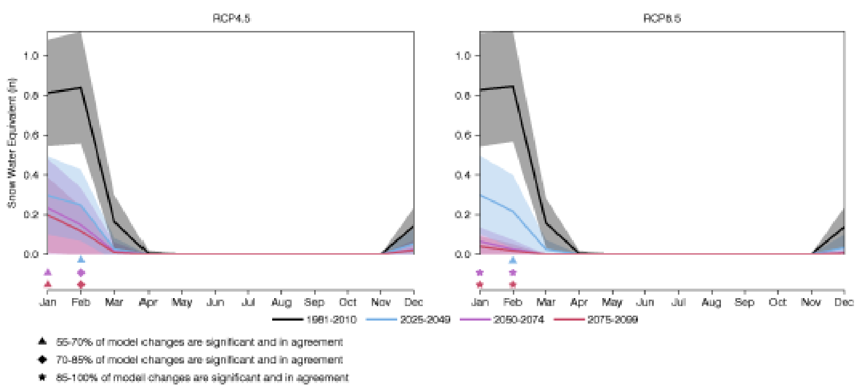


Figure 8: Monthly averages of snow water equivalent for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

5 Runoff

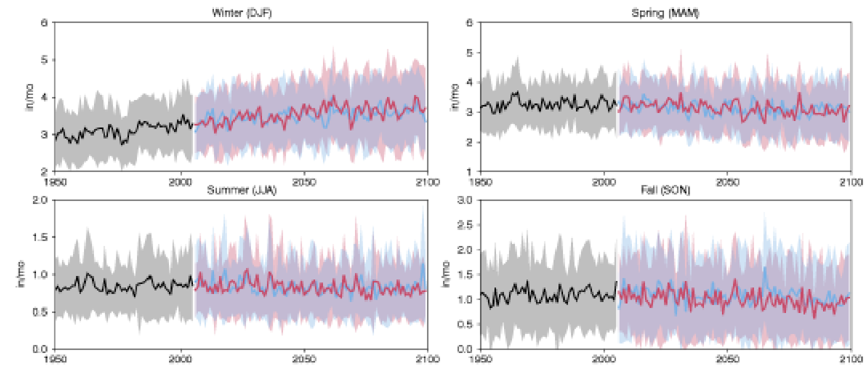


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

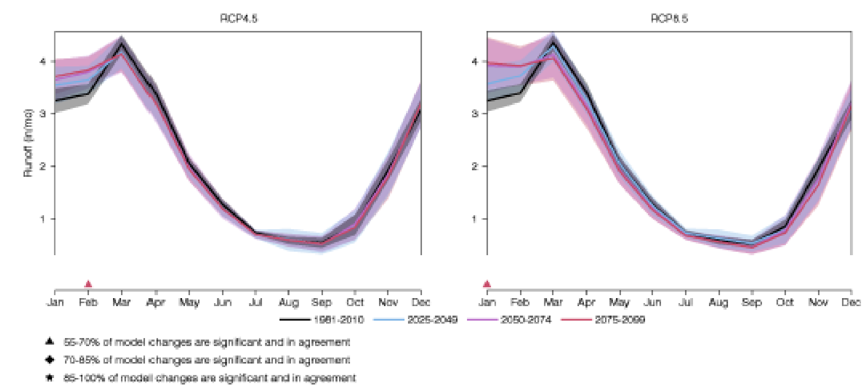


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

6 Soil Water Storage

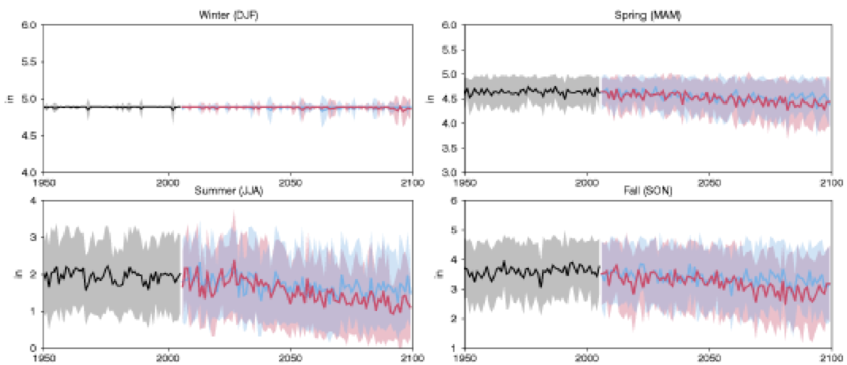


Figure 11: Seasonal average time series of soil water storage for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

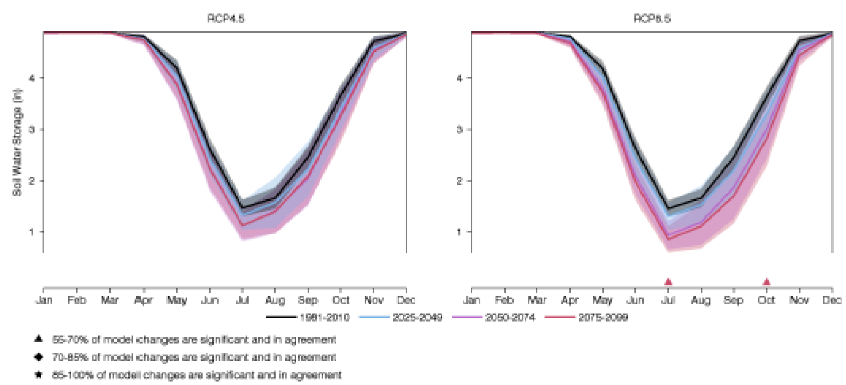


Figure 12: Monthly averages of soil water storage for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

7 Evaporative Deficit

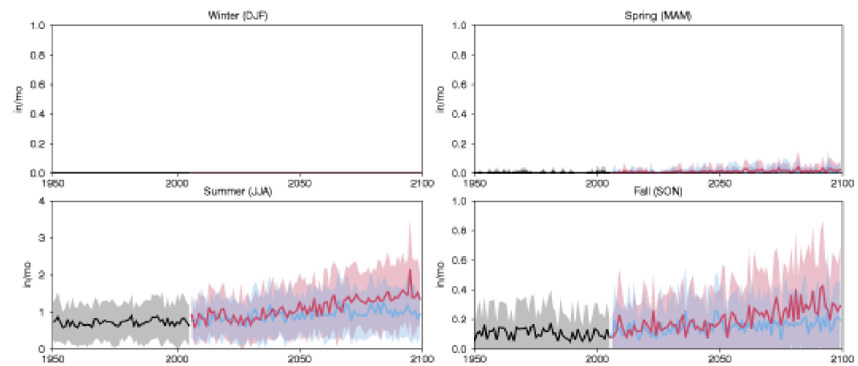


Figure 13: Seasonal average time series of evaporative deficit for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

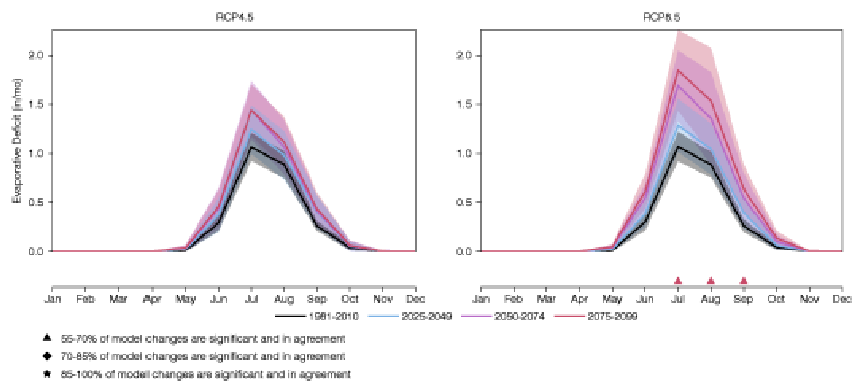


Figure 14: Monthly averages of evaporative deficit for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes. Triangle, diamond and square symbols indicate the percent of models that simulate future minus present changes that are of the same sign and significant. A two-sided Students t-test is used to establish significance ($\rho \leq 0.05$).

8 Data

The temperature and precipitation summaries are created by spatially averaging the NASA NEX-DCP30 data set (Thrasher et al., 2013). The water-balance variables snow water equivalent, runoff, soil water storage and evaporative deficit are simulated by using the NEX-DCP30 temperature and precipitation as input to a simple model (McCabe and Wolock, 2007). The water-balance model accounts for the partitioning of water through the various components of the hydrologic system, but does not account for groundwater, diversions or regulation by impoundments.

9 Models

ACCESS1-0	bcc-csm1-1	bcc-csm1-1-m	BNU-ESM	CanESM2	CCSM4
CESM1-BGC	CMCC-CM	CNRM-CM5	CSIRO-Mk3-6-0	FGOALS-g2	FIO-ESM
GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	GISS-E2-R	HadGEM2-AO	HadGEM2-CC
HadGEM2-ES	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	IPSL-CM5B-LR	MIROC5
MIROC-ESM	MIROC-ESM-CHEM	MPI-ESM-LR	MPI-ESM-MR	MRI-CGCM3	NorESM1-M

10 Citation Information

Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp doi:10.5066/F7W9575T.

Hostetler, S.W. and Alder, J.R., 2016. Implementation and evaluation of a monthly water balance model over the U.S. on an 800 m grid. Water Resources Research, 52, doi:10.1002/2016WR018665.

Thrasher, B., J. Xiong, W. Wang, F. Melton, A. Michaelis, and R. Nemani, 2013. New downscaled climate projections suitable for resource management in the U.S. Eos, Transactions American Geophysical Union 94, 321-323, doi:10.1002/2013EO370002.

11 Disclaimer

These freely available, derived data sets were produced by J. Alder and S. Hostetler, US Geological Survey (USGS). The original climate data are from the NEX-DCP30 dataset, which was prepared by the Climate Analytics Group and NASA Ames Research Center using the NASA Earth Exchange, and is distributed by the NASA Center for Climate Simulation. No warranty expressed or implied is made by the USGS regarding the display or utility of the derived data on any other system, or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. The USGS shall not be held liable for improper or incorrect use of the data described and/or contained herein.

Attachment 3: Town Facts, Plans Policies and Regulations

Town Facts

People

Population:	+/- 10,160 people
Population Change since 2000:	-1.2%
Percent female/male:	52.6%/47.4%
Land Area:	about 15.3 square miles
Population density:	about 681 people per square mile
Median age:	about 50 years (compared to the median age of 39 for the State)

Ethnicity (2011-2015 American Community Survey:

+/-9,600 of residents are White (+/- 92%),
+/-330 residents are of Hispanic descent (+/- 3%),
+/-100 residents are of African American descent (<1%),
+/- 240 residents are of Asian descent (+/- 2%)

People cont.

Age (2010 census):	+/- 2,500 Old Saybrook residents are elderly +/- 2,000 residents 18 years old and younger (2010 US Census)
Disability (2010 census):	age 5 to 15: 7 age 16 to 64: 296 age >65: 138
Households (2010 census):	4,247 households; just under 24% children under the age of 18 living in them average household size 2.21 people average family size was 2.71 people per household population density of about 682.8 people per square mile
Median household income:	$84,546 (compared to Connecticut average $73,433)
Estimated per capita income:	$49,015
Education:	High school or higher: +/-93% Bachelors or higher: +/-38% Graduate or professional: +/-15%
Unemployed:	+/-4 to 6% (2015)

Buildings

Residential: 5,730

Commercial/industrial: 466

Homes

Residential Buildings: 5,730

Building ownership (2011-2015 American Community Survey):

Owner-occupied: +/-81% (4,666 residences)
Renter: +/-16% (938; average rent $1,622/month)

New, single family building permits (2004 – 2014):

2004: 58; average cost $229,900
2005: 60; average costs $234,600
2006: 22; average cost $258,000
2007: 14; average cost $340,000
2008: 12; average cost $230,700
2009: 13; average cost $283,100
2010: 8; average cost $234,200
2011: 9; average cost $214,100
2012: 18; average cost $256,500
2013: 25; average cost $273,100
2014: 10; average cost $421,700

Median housing cost: $369,300

Cost of living index: 140.8 (US average 100)

Motor Vehicles: 12,925

Schools

School Enrollment: +/- 1,344 students (based on 2016 Old Saybrook Annual Report)

Schools: 3

Essential Facilities

Hospitals: None
Healthcare Facilities: 3
Emergency Shelter: 1 (School)
Fire Station: 1

Lifeline Facilities

Water:

- Provider: Connecticut Water Company
- Guilford Water System (wells and reservoirs)
- Water Supply Source: Holbrook Wellfield
- Old Saybrook Aquifer Protection Zones: Holbrook and Saybrook well fields
- Individual Wells

Electrical:

- Provider: Eversource
- Overhead transmission
- Two substations:
  - Bokum Road
  - Elm Street

Wastewater (Sanitary):

- Decentralized Wastewater Management District (DWMD) – Not Completed
- On-Site Septic

High Loss Potential Facilities

Dams 11

Transportation Infrastructure

State Roads: +/- 47 miles
Municipal Roads: +/- 88 miles
Bridges: 22
Culverts: 111
Amtrak Rail Line

Zoning

Residential: AAA, AA-1, AA-2, AA-3, A, B, C (Conservation District)

Commercial: Central Business B-1, Shopping Center Business B-2, Restricted Business B-3, Gateway Business B-4, Marine Industrial MI, Saybrook Point SP-1 through SP-3, Industrial District I-1

Overlay Zones: Flood Plain Zone FP, Planned Residential Development Zone PRD, Aquifer Protection Zone APA, Gateway Conservation Zone GC, Coastal Area Management Zone CAM, Incentive Housing Zone IH

Town Budget

Old Saybrook Budget (2018 Budget; 2016 mill rate; 2015 revenues):

2016 Grand List Mill Rate 19.66 mills (0.01966; $19.66 per $1,000 of taxable property assessed value)
2015 general revenues:
Property taxes +/-$40 million
Other +/-$2.5 million
2018 general expenses:
General government +/-$19.7 million, including:
Public safety +/-$5.7 million
Public works +/-$4.2 million
Bond Indebtedness: +/-$3.5 million
Education +/-$25.6 million

Moody's Bond Rating: AA2

Town Map Overview

Figure 3-1 presents the distribution of assessed property value. **Figure 3-2** presents the Town Zoning Map.

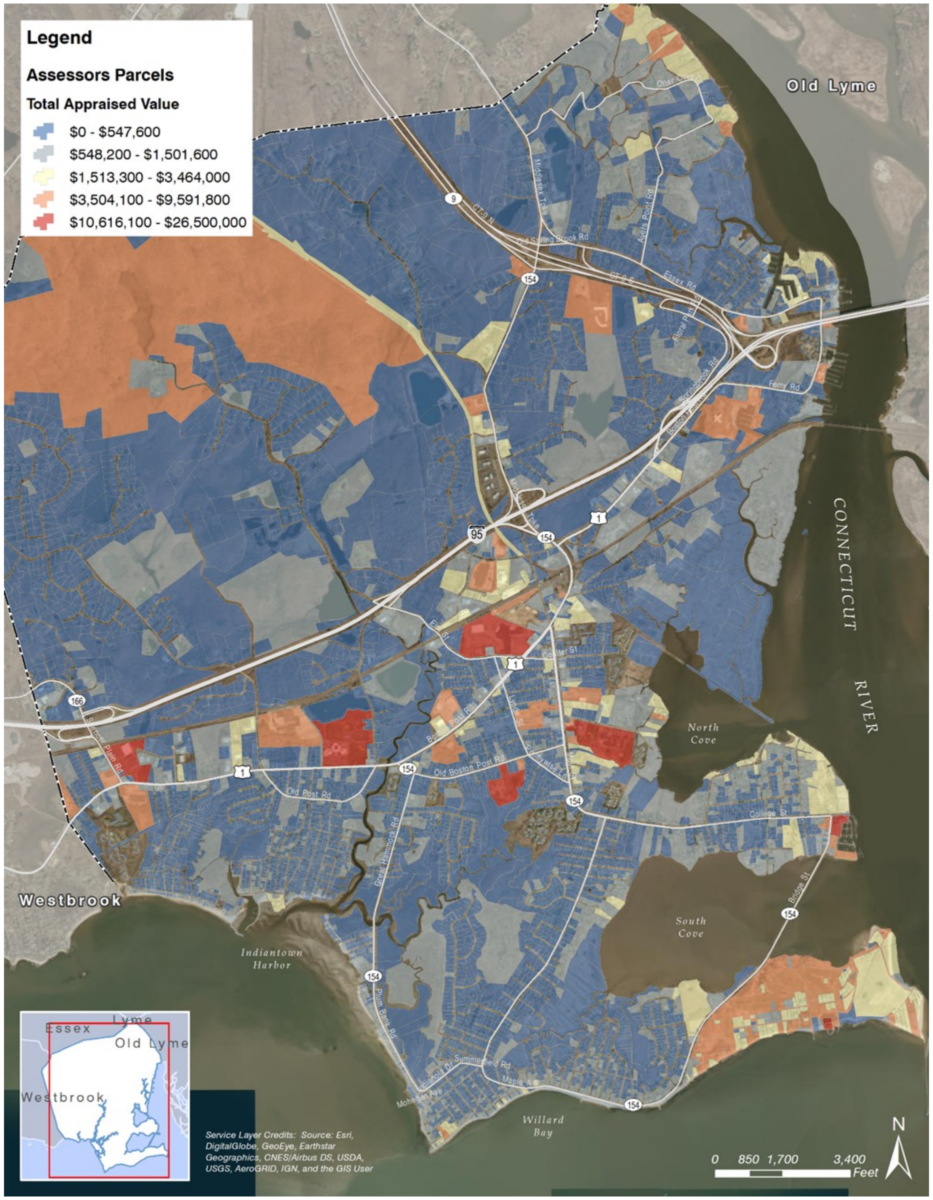


Figure 3-1 Property Appraisal Values throughout Old Saybrook

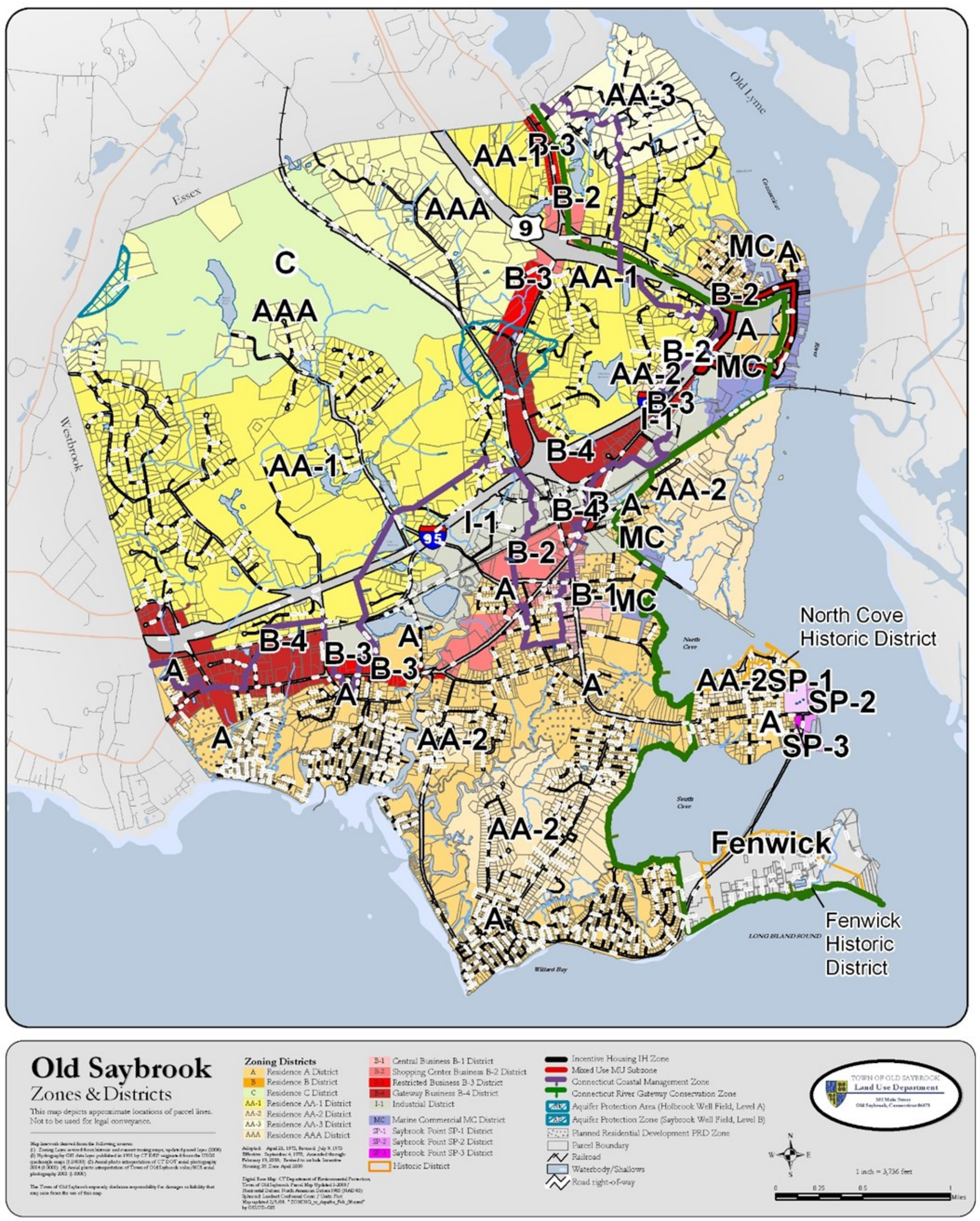
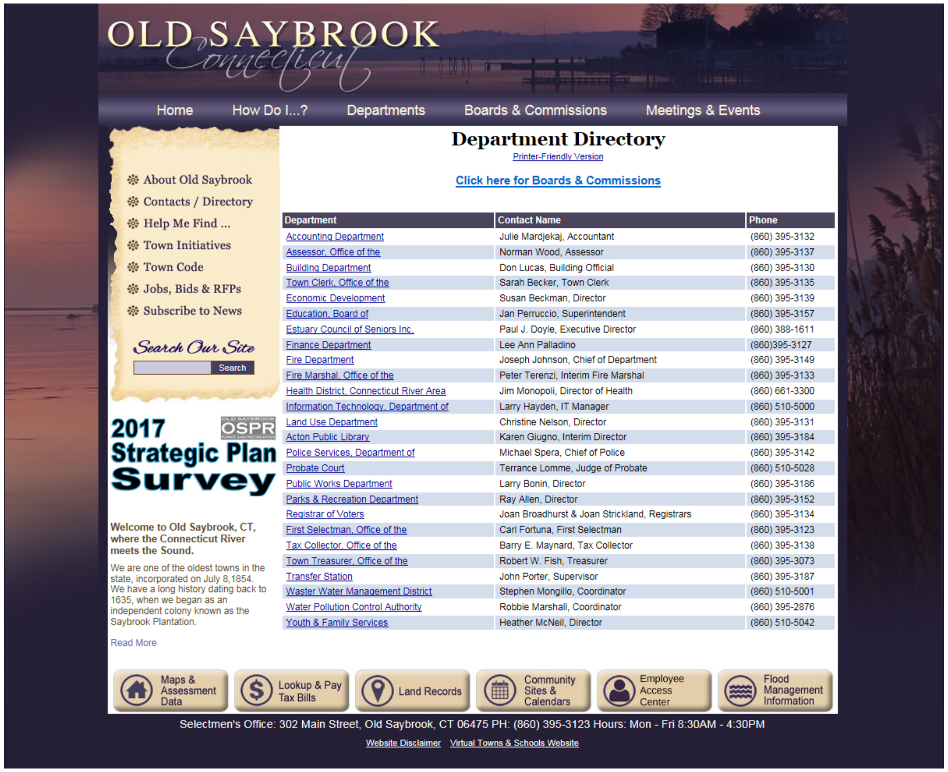


Figure 3-2 Town Zoning Map

Relevant Plans, Policies and Regulations



Old Saybrook Coastal Planning Overview

The State and the Town have an established planning process that provides a potential framework for resilience and adaptation planning at Old Saybrook. Plans include: 1) the State Natural Hazard Mitigation Plan; 2) the Old Saybrook and Borough of Fenwick Natural Hazards Mitigation Plan; 3) the State of Connecticut Conservation and Development Plan; and 4) the Old Saybrook Plan of Conservation and Development. Old Saybrook is also a participating community under the National Flood Insurance Program (NFIP). The Town Planning Commission is responsible for the Old Saybrook Plan of Conservation and Development. The Town also has numerous supplemental plans that address issues relevant to resilience and adaptation planning.

Natural Hazard Mitigation Plans

The purpose of the State and Old Saybrook Natural Hazard Mitigation Plans is to identify natural hazard risks and prepare for natural disasters before they occur. Adoption of a FEMA-approved plan is also required to be eligible for federal disaster relief grants per the Disaster Mitigation Act of 2000. The State's Natural Hazards Mitigation Plan was most recently updated in January 2014. The State Plan establishes the hazard mitigation strategy for the State, including climate change and acknowledges that extreme weather events have already become more frequent over the past 50 years and that this trend is expected to continue into the future.

The State Plan includes three resilience and climate change adaptation strategies:

- Support and enhance State policy and legislative efforts to mitigate the effects of natural hazards and adapt to climate change;
- Identify, develop, and prioritize hazard mitigation projects including climate change adaptation strategies and relocation for State-owned facilities considered at risk to natural hazards; and
- Investigate climate change adaptation strategies as they affect natural hazard mitigation and State investment policies, and link hazard mitigation activities with climate adaptation strategies when appropriate and possible.

The State Plan affirms three mitigation goals for Connecticut:

- Promote implementation of sound floodplain management and other natural hazard mitigation principles on a state and local level;
- Implementation of effective natural hazard mitigation projects on a state and local level; and
- Increase research and planning activities for the mitigation of natural hazards on a state and local level.

The Town's Natural Hazard Mitigation Plan identifies coastal flooding and sea level rise as major natural hazard risks. The next Old Saybrook Natural Hazard Mitigation Plan update is in 2019. The Town Plan identifies Town-owned vulnerabilities and assets with respect to coastal flooding, inland and riverine flooding, winter storms and wind. The Plan also includes mitigation strategies to address the future impacts from coastal flooding.

Plan of Conservation and Development

The State Conservation and Development Plan serves as the official policy for the State's Executive Branch in matters pertaining to land and water resources conservation and development. It is required by law and is revised every five years in consultation with regional councils of governments, municipalities, state agencies and the public. The current (December, 2017) plan covers the period of 2018 to 2023. Municipalities and regional planning organizations are also required by law to prepare and update their respective plans at least every 10 years, and must formally adopt their plan to be eligible for discretionary state funding. The date of the most recent plan adopted by Old Saybrook is July 2014, and that the Town is currently eligible for discretionary state funding.

The State plan has six Growth Management Principles:

1. Redevelop and Revitalize Regional Centers and Areas with Existing or Currently 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;
4. Conserve and Restore the Natural Environment, Cultural and Historical Resources, and Traditional Rural Lands;
5. Protect and Ensure the Integrity of Environmental Assets Critical to Public Health and Safety; and
6. Promote Integrated Planning Across all Levels of Government to Address Issues on a Statewide, Regional and Local Basis.

Connecticut Public Act 13-179 requires that the plan: 1) take into account risks associated with increased coastal erosion as anticipated by sea level rise projections published by the National Oceanic and Atmospheric Administration (NOAA) in Technical Report OAR CPO-1; 2) identify the impacts of such increased erosion on infrastructure and natural resources; and 3) make recommendations for the siting of future infrastructure and property development to minimize the use of areas prone to such erosion.

While all of the Old Saybrook Plan of Conservation and Development is relevant to coastal flooding and sea level rise resilience and adaptation, the chapter on Water Resources is particularly relevant, including sections on coastal management, protection of the undeveloped shorefront, beach erosion, use of developed shorefront and additional issues including wastewater management, water supply, surface and stormwater management and flood management. The Old Saybrook Plan includes the following relevant goals:

- Preservation, conservation, and development consistent with the Connecticut Coastal Management Act;
- Protection of water resources and groundwater quality;
- Prevention of destruction of valuable wetland systems and protection of native wetlands species and habitats;
- Conservation, restoration, and wise use of the shorefront to minimize erosion;
- Avoidance of flood problems;
- Consideration in the planning process of the potential impact of coastal flooding and erosion patterns on coastal development to minimize damage to and destruction of life and property and reduce the necessity of public expenditure to protect future development from such hazards;
- Maintenance and improvement of tidal and freshwater wetlands for their natural functions and social benefits;
- Preservation and enhancement of coastal resources in accordance with State policies concerning environmental protection, inland wetlands & watercourses, water resources, water pollution, parks and forest, and pollution, and flood control & beach erosion;
- Development of corridors of open space in "greenways", which protect natural resources, preserve scenic landscapes, and historical resources;
- Acquisition of land for municipal purposes, including recreation, habitat protection, economic development, historical and cultural preservation, and the public health, safety, and welfare;
- Implementation of an aggressive open space identification, acquisition and management program using outside funding sources to supplement town funds where feasible and appropriate;
- Protection of important natural resources, including the Connecticut River and Long Island Sound, tidal and inland wetlands, streams, ponds and lakes, forested ridges and hills, as well as open fields and farms, from degradation due to inappropriate development; and
- Preserve unique historical and cultural resources of the community to focus on Old Saybrook's past.

Connecticut Public Act 12-101 requires that future revisions to the State Plan of Conservation and Development (SPOCD) consider risks associated with coastal erosion caused by sea level rise, evaluate the impacts of such erosion on infrastructure and natural resources, and make recommendations for future development and infrastructure siting to minimize the use of erosion-prone areas.

Supplemental Plans and Reports

Supplemental plans and reports include: 1) the Conservation Plan; 2) the Harbor Management Plan; 3) the Municipal Coastal Program; 4) the Saybrook Point Enhancement Plan; 5) the Stormwater Management Plan; and 6) the "Sea Level Rise Climate Adaptation Report of Findings" (2015 SLRCC).

The resilience and adaptation goals identified in the 2015 SLRCC:

- Charge an existing Town agency or a new Committee to continue the work started by this committee and to monitor changes to sea level rise forecasts based on new data or improved scientific models.
- Engage a consulting firm that specializes in coastal resilience planning to study the impacts and risks of sea level rise and climate change to identify areas of increased flooding, coastal erosion and shoreline change. The study should recommend specific adaptation and mitigation actions for the Town and residents.
- Consider sea level rise and climate change in long-range and current planning, particularly updates to the Town's existing Natural Hazards Mitigation and Coastal Management Plans and to guide, where appropriate, future updates to the Town's Plan of Conservation and Development.
- Budget for design and construction of physical solutions, especially those for which matching funds garner government or non-profit grants.
- Continue to keep sea level rise and climate change on the front burner of community dialog.

The 1982 Municipal Coastal Program (MCP) addressed the Town's Coastal Boundary Area and resulted in the following:

- Identification and evaluation of local coastal resources;
- Consideration of local problems, needs and issues within the Coastal Boundary Area;
- Development of local goals and policies for the Coastal Boundary Area;
- Integration into the Town's Plan of Development for the Town of Old Saybrook; and
- Establishment of the Old Saybrook Planning Commission as responsible

The development of the program was funded in part by NOAA under the 1972 Coastal Zone Management Act and was prepared in compliance with state of Connecticut's Coastal Management Act as amended in 1979.

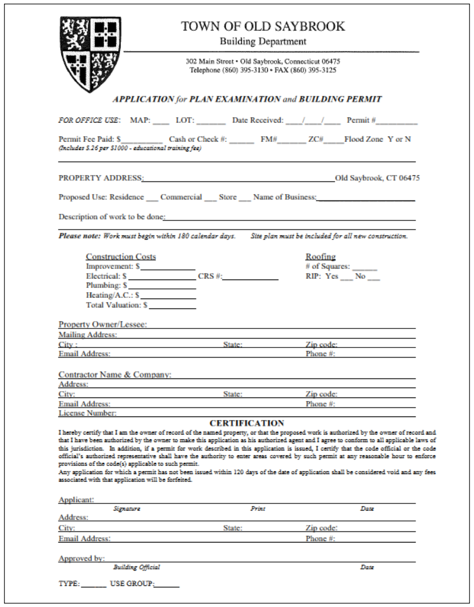
The MCP goals were:

- Coastal Hazards: in coastal hazard areas, to promote the public health, safety and general welfare and to minimize public and private losses due to flood conditions.
- Beach Erosion: to conserve, maintain, restore and wisely use the miles of beach available in Old Saybrook for recreation and for their natural resource advantages.
- Developed Shorefront (Limited): to continue the use and development of existing limited shorefront areas for marine-related uses, including recreational boating, recreational and commercial fishing and other uses which enable people to have contact with the resources of the shoreline.
- Wetlands: to maintain all existing viable wetlands and freshwater wetlands for their natural function and social benefits, providing for modification of tidal wetlands only to implement other established coastal goals and policies.
- Sewer Avoidance/Water Quality: to assure proper provision for sewage disposal and maintenance of water quality within the Coastal Boundary and in a manner, that meets established standards and supports coastal goals and policies.
- People to the Shore: to continue and increase opportunity for people to use and enjoy the amenities and resources of the shorefront in a variety of ways and in a manner, that conserves and replenishes coastal resources.
- Town Beach: to provide a suitable and sufficient beach and land support area for present and future Town of Old Saybrook residents.

While this program is no longer a part of the Town's local charter, it assisted the community in setting the foundation for better management of the Town's coastal resources. Many of the local problems and issues outlined in the MCP over 35 years ago continue to be at the forefront today, including beach erosion, sanitary sewer, wetlands, development along the coastal shoreline, and others. The legacy of the MCP continues to this day through the integration of many of its goals and policies into current plans and zoning regulations.

Old Saybrook Coastal Regulatory Overview

Connecticut is a Home Rule State. As such, Old Saybrook has primary responsibility for regulating land use (per the Zoning Enabling Act). However, when regulating land use, Old Saybrook still needs to comply with State and federal coastal management and flood regulations, in particular:



TOWN OF OLD SAYBROOK
Building Department
302 Main Street • Old Saybrook, Connecticut 06475
Telephone (860) 395-3130 • FAX (860) 395-3125

APPLICATION for PLAN EXAMINATION and BUILDING PERMIT

FOR OFFICE USE: MAP: ___ LOT: _____ Date Received: ___/___/___ Permit #________

Permit Fee Paid: $________ Cash or Check #: _____ FM#_____ ZC#____Flood Zone Y or N
(Includes $.26 per $1000 - educational training fee)

PROPERTY ADDRESS:______________________________Old Saybrook, CT 06475

Proposed Use: Residence __ Commercial __ Store __ Name of Business:________________

Description of work to be done:______________________________________

Please note: *Work must begin within 180 calendar days.* *Site plan must be included for all new construction.*

Construction Costs
Improvement: $__________
Electrical: $__________ CRS #:__________
Plumbing: $__________
Heating/A.C.: $__________
Total Valuation: $__________

Roofing
# of Squares: _____
RIP: Yes ___ No ___

Property Owner/Lessee:
Mailing Address:
City : State: Zip code:
Email Address: Phone #:

Contractor Name & Company:
Address:
City: State: Zip code:
Email Address: Phone #:
License Number:

CERTIFICATION

I hereby certify that I am the owner of record of the named property, or that the proposed work is authorized by the owner of record and that I have been authorized by the owner to make this application as his authorized agent and I agree to conform to all applicable laws of this jurisdiction. In addition, if a permit for work described in this application is issued, I certify that the code official or the code official's authorized representative shall have the authority to enter areas covered by such permit at any reasonable hour to enforce provisions of the code(s) applicable to such permit.
Any application for which a permit has not been issued within 120 days of the date of application shall be considered void and any fees associated with that application will be forfeited.

Applicant:
Signature *Print* *Date*
Address:
City: State: Zip code:
Email Address: Phone #:

Approved by:
Building Official *Date*

TYPE:______ USE GROUP:______

State Regulations:

1. the Connecticut Coastal Management Act (CCMA; CGS Sec. 22a-90 through 22a-112);
2. the Tidal Wetlands Acts (CGS Sec. 22a-28 through 22a-35); and 3) the Structures, Dredging and Fill Act (CGS Sec. 22a-359 through 22a-363f); and
3. the Connecticut State Building Code.

Federal Regulations:

1. Section 10 All Structures and Work within Navigable Waters (USACE);
2. Section 104 Discharge of Dredged or Fill Material (USACE);
3. Section 103 Ocean Disposal of Dredged Materials (USACE);
4. National Flood Insurance Program regulations (Code of Federal Register 44 CFR 59 through 80; and
5. Floodplain Management and Protection of Wetlands (44 CFR 9)

Regulatory Jurisdiction

The Town's regulates activities inland of the Coastal Jurisdiction Line (CJL). The coastal jurisdiction line for the Town includes: 1) Long Island Sound at Elevation 2.9 feet NAVD88; and 2) the Connecticut River at Elevation 2.9 feet NAVD88. The Connecticut Department of Energy and Environmental Protection (DEEP) has the primary authority to regulate tidelands seaward of the CJL (pursuant to the Tidal Wetlands Act and the Structures, Dredging and Fill Act). The Mean High Water (MHW) is the average shoreward extent of all high tides. The area between MHW and the CJL is co-regulated by both DEEP and Old Saybrook.

The US Army Corps of Engineers (USACE) has regulatory jurisdiction within "Navigable Waters" which are tidal waters located waterward of MHW and all waters that are, have been or may be used for the transport of interstate commerce. USACE regulatory jurisdiction extends 3 miles seaward for coastal waters and the area between 3 and 14 miles seaward for open ocean waters.

Under the Connecticut Coastal Management Act (CCMA), Coastal Site Plan review by the Town is required for all activities located within the Coastal Boundary, which is defined as: 1) a continuous line delineated on the landward side by the interior contour elevation of the FEMA FIRM 100-year recurrence interval flood; 2) a 1,000 linear foot setback from the Mean High Water Mark; or 3) a 1,000 linear foot setback from the inland boundary of tidal wetlands, whichever is farthest inland.

The Old Saybrook Zoning Commission regulates land use and is responsible for enforcement of the zoning regulations. The Old Saybrook Conservation Commission is responsible for the development, conservation, supervision and regulation of natural resources. The Town Inland Wetlands & Watercourses Commission is responsible for review of all regulated activities within 100 feet of a regulated area. The Town Building Department and Town Engineer are responsible for enforcement of the building codes. The Old Saybrook Planning Commission is responsible for Coastal Site Plan Review.

Coastal Zone Management Act (CZMA)

The federal Coastal Zone Management Act (CZMA) is administered by NOAA and provides for the management of the nation's coastal resources through three national programs:

the National Coastal Zone Management Program;
the National Estuarine Research Reserve System; and
the Coastal and Estuarine Land Conservation program.

As part of the federal program, Connecticut's Coastal Management Program is administered by the Department of Energy and Environmental Protection's (DEEP) Bureau of Water Protection and Land Reuse's Office of Long Island Sound Programs (OLISP) and is approved by NOAA under the federal Coastal Zone Management Act.

The Connecticut Coastal Management Act (CCMA) is intended to: 1) ensure balanced growth along the coast; 2) restore coastal habitat; 3) improve public access; 4) protect water-dependent uses, public trust waters and submerged lands; 5) promote harbor management; and 6) facilitate research. CCMA regulates work in tidal, coastal and navigable waters and tidal wetlands under: 1) Sections 22a-90 through 22a-112 of the Connecticut General Statutes (CGS); 2) the Structures Dredging and Fill statutes (Sections 22a-359 through 22a-363f); and 3) the Tidal Wetlands Act (Section 22a-28 through 22a-35). The Connecticut statutes include:

1. Conn. Gen. Stat §22a-90 to 22a-112 include:
    - Coastal Hazard Areas (Conn. Gen. Stat §22a-92(b)(2)(F): Development to minimize hazards to life and property and promote nonstructural solutions to flood and erosion except where structural alternatives are necessary to protect existing inhabited structures, infrastructure and water-dependent uses.
    - Coastal Hazard Areas (Conn. Gen. Stat §22a-92(b)(2)(J)): Maintain natural relationship between eroding and depositional coastal landforms; minimize adverse impacts of erosion and sedimentation on coastal land uses through nonstructural mitigation; structural solutions are permissible when necessary and unavoidable for protection of infrastructure, water-dependent uses, existing inhabited structures, and where not feasible, less environmentally damaging alternative and where all reasonable mitigation measures and techniques minimize adverse environmental impacts.
    - Tidal Wetlands (Conn. Gen. Stat §22a-92(c)(1)(B)): Disallows any filling of tidal wetlands and nearshore, offshore and intertidal waters for the purposes of creating new lands from existing wetlands or coastal waters unless adverse impacts on coastal resources are minimal.
    - Coastal Structures and Filling (Conn. Gen. Stat §22a-92 (b)(1)(D), 22a-92 (c)(1)(D), 22a-359(a) as referenced by 22a- 92(a)(2)): requires that all structures in tidal wetlands and coastal waters are designed, constructed and maintained to minimize adverse impacts on coastal resources, circulation and sediment patterns, flooding and erosion, and to reduce to the maximum extent practicable the use of fill; filling of tidal wetlands and nearshore for the purpose of creating new land is disallowed; and, the commissioner of environmental protection shall regulate dredging and the placement of fill.
    - Beaches and Dunes (Conn. Gen. Stat §22a-92(b)(2)(C)): Encourage the restoration and enhancement of disturbed or modified beach systems. Dune reshaping and beach scraping is generally allowed as part of beach/dune nourishment/filling.

2. Structures, Dredging and Filling (Conn. Gen. Stat §22a-359 to 22a-363f): regulates dredging and erection of structures and the placement of fill in the tidal and coastal waters to prevent or alleviate shore erosion, preserve wildlife habitat, development of adjoining uplands, etc.

3.Tidal Wetlands (Conn. Gen. Stat §22a-28 to 22a-35): regulates draining, dredging, excavation, or removal of soil, mud, sand, gravel, aggregate of any kind or rubbish from any wetland or the dumping, filling or depositing thereon of any soil, stones, sand, gravel, mud, aggregate of any kind, rubbish or similar material, either directly or otherwise, and the erection of structures, driving of pilings, or placing of obstructions, whether or not changing the tidal ebb and flow.

Changes to the CCMA during 2012 (through Public Act 12-101) launched new initiatives that are focused on sea level rise (SLR) and revisions to shoreline protection and shoreline protection regulatory procedures. SLR is now part of the CCMA's general goals and policies for coastal planning; in particular, consideration of the potential impacts from SLR, coastal flooding and erosion patterns on coastal development. The CCMA defines SLR based on published NOAA historic data (i.e., the trend observed in the historical period of record) to establish future sea levels [PA 12-101, section 2], but encourages the use of more conservative SLR projections. The State updates sea level rise projections every ten years, most recently during 2018.

The CCMA also revised policies related to shoreline flood and erosion control structures that encourage the protection of natural and nature-based shoreline protection and discourages the use of structural measures (e.g. seawalls, bulkheads and revetments) except in certain specified conditions. Under the CCMA, prior to approving projects the Town will need to consider two additional requirements:

Feasible, Less Environmentally Damaging Alternatives:

- Move the house landward away from floodwaters and wave action;
- Elevate the house vertically, preferably to the highest practical freeboard, at least as high as FEMA standards require;
- Restore or create a dune or vegetated slope between the house and the water to absorb storm waves and protect against erosion; and
- Create a Living Shoreline. "Living shorelines" involve restoration of waterfront habitats, often using fill to support tidal wetland vegetation.

Reasonable Mitigation Measures and Techniques:

- Upland migration of tidal wetlands can be provided by establishing a structure set-back or a rolling easement to ensure that wetlands can colonize upland areas as sea level rises;
- Beach re-nourishment to replace the sand supply that may be adversely affected by a seawall or groin; and
- 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 applicant's site or from another site. This approach can be conceptualized as "No-Net-Increase in Shoreline Armoring". PA 12-101, to encourage natural and nature-based features for shoreline protection, provides the Town with the ability to exempt "living shoreline" projects from the definition of shoreline flood and erosion control structures as long as the sole purpose or effect of the proposed project is the restoration or enhancement of tidal wetlands, beaches, dunes or intertidal flats. This gives the Town latitude to exempt such projects from the mandatory coastal site plan review process.

US Army Corps of Engineers

The following laws define the regulatory authorities and responsibilities of the Corps of Engineers:

- Section 10 of the Rivers and Harbors Act of 1899 (33U.S.C. 403) authorizes the Corps to regulate certain structures or work in or affecting navigable waters of the United States.
- Section 404 of the Clean Water Act (33 U.S.C 1344) authorizes the Corps to regulate the discharge of dredged or fill material into waters of the United States.
- Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended (33 U.S.C. 1413) authorizes the Corps of Engineers to regulate the transportation of dredged material for the purpose of disposal in the ocean.

The Corps also coordinates compliance with related federal laws. These include the National Environmental Policy Act, the Fish and Wildlife Coordination Act, the Endangered Species Act, the National Historic Preservation Act, the Deepwater Port Act, the Federal Power Act, the Marine Mammal Protection Act, the Wild and Scenic Rivers Act, the National Fishing Enhancement Act, the Magnuson-Stevens Fishery Conservation and Management Act, the National Flood Insurance Act of 1968 (as amended), and Executive Order 11988 on Flood Management.

Local Zoning Regulations

Old Saybrook has local zoning regulations and is authorized by Connecticut General Statutes to protect Old Saybrook against floods as well as consider future conditions (e.g., sea level rise) when enacting land use regulations, and to use specific ordinances to do so including size and height limitations, development density, use restrictions, setbacks, overlay zones and special use zones. Review of development within the Coastal Boundary at Old Saybrook is the responsibility of the Old Saybrook Planning Commission. While Old Saybrook has authority inland of the CJL, the CCMA requires that Old Saybrook refer all Flood and Erosion Control Structure (FECS) to DEEP for review and comment (including structures located inland of the CJL, if they are contrary to the intent of the CCMA). Implementation of the CCMA at Old Saybrook is through the Coastal Site Plan review process.

- Section 59 Coastal Area Management (CAM): In accordance with the provisions of C.G.S. §22a-105 through 22a-109, any application pertaining to a proposed *building*, other *structure*, *use*, site development, excavation or grading that is subject to these regulations and located fully or partially within the "Coastal Boundary" as defined by C.G.S. §22a-94 and as delineated on the Coastal Boundary map for the Town of Old Saybrook, will be accompanied by a Coastal Site Plan. 2012 changes to the Connecticut Coastal Area Management Act (CCMA) require that, at a minimum, SLR consistent with that observed over the historical record be addressed in design of shoreline flood and erosion control structures. More conservative assumptions of SLR are encouraged in the CCMA. The rate of SLR is increasing significantly in recent decades (relative to the mean during the entire record of data); therefore, it is recommended that the zoning recommendations define a more conservative SLR projection.
- Section 67 Soil Erosion and Sediment Control: When any use, building or structure or site development that is subject to these regulations involves a disturbed area of one-half (1⁄2) acre or more, or otherwise when provision for soil erosion and sediment control is required by these regulations, a certified Soil Erosion & Sediment Control Plan ("control plan") in connection therewith will be in effect prior to, during and upon completion of construction. A control plan certified by the Planning Commission in connection with approval of a subdivision under the Subdivision Regulations and in effect for the lot where the disturbed area is located, may constitute the control plan required by these regulations. Based on recent changes to the CCMA, the Town now has the latitude to exempt "living shoreline" and natural resource restoration (e.g. tidal wetlands, beaches, dunes or intertidal flats) from the coastal site plan review process as outlined in more detail in discussion presented below. Section 67 can be modified to encourage the use of natural and nature-based features.

Federal Coastal Resources Barrier Act

Congress passed the Coastal Barrier Resources Act (CBRA) in 1982 and the Coastal Barrier Improvement Act (CBIA) in 1990, with the goal of discouraging future development in coastal barrier areas by not allowing the use of federal funds for development or reconstruction projects after a coastal storm or flooding event. Congress designed the program to minimize the loss of human life and adverse impacts to fish, wildlife and other natural resources. The U.S. Fish and Wildlife Service administers this program, which includes over 3 million acres of coastal land (including, in Old Saybrook, portions of South Cove and Cold Spring Brook). The CBRA limits, but does not completely prohibit, development within the CBRS.

National Flood Insurance Program

The Town is a participating community in the National Flood Insurance Program (NFIP), which means that the Town has adopted and submitted a floodplain ordinance that meets or exceeds NFIP criteria, including adoption of the FEMA Flood Insurance Rate Maps (FIRMs) and is eligible for flood insurance through the NFIP and Emergency Public Assistance (PA) Funding.

Without participation in the NFIP:

- No resident would be able to purchase a NFIP flood insurance policy.
- Existing flood insurance policies would not be renewed.
- The Town and residents would not be eligible for Federal grants or loans for development made in identified flood hazard areas under programs administered by Federal agencies such as Department of Housing and Urban Development (HUD), Environmental Protection Agency (EPA), and Small Business Administration (SBA).
- No Federal disaster assistance would be available to repair insurable buildings located in identified flood hazard areas for damage caused by a flood.

No Federal mortgage insurance or loan guarantees would be available for identified flood hazard areas, including policies written by Federal agencies such as the Federal Housing Authority (FHA), Veteran's Administration (VA), and others.

As part of the NFIP, Town floodplain areas are classified on FEMA FIRMS as Special Flood Hazard Areas (SFHAs) ranging from VE (wave heights equal to or greater than three feet) to Coastal AE (wave heights of 1.5 feet to 3 feet) to AE (wave heights less than 1.5 feet). The FIRMs identify the level of flood risk and establish the basis for the cost of the flood insurance premiums as well as regulating construction in flood hazard areas (floodplains). Under the NFIP, buildings that pre-date the FIRM are treated dif-

The FIRMS are periodically updated by FEMA; however, they are based on the level of risk that is exists at that time of FIRM development and do not include future changes to the flood risk (for example, due to climate change and sea level rise). Climate change will have a significant impact on the Town's future flood risk and the flood limits and of the Town's SFHAs will increase in the future.

Local Building Regulations

Construction within the Town are subject to the requirements of the federal, State and local building codes. In general, the existing Town building code. The Office of the Building Official is responsible for the enforcement of all construction and building codes in the Town.

The State code is the 2016 Connecticut State Building Code, including:

- 2012 International Building Code (IBC)
- 2012 International Existing Building Code
- 2012 International Residential Code (IRC)
- 2012 International Mechanical, Plumbing, and Energy Conservation Codes; and
- 2014 National Electric Code (NFPA 70)

Chapter 128 of the Old Saybrook Town Code serves as the local floodplain ordinance. The purpose of Chapter 128 is to promote the public health, safety and general welfare and to minimize public and private losses due to flood conditions in specific areas by provisions designed to:

- Restrict or prohibit uses that are dangerous to health, safety and property due to water or erosion hazards, or that result in damaging increases in erosion or in flood heights or velocities;
- Require that uses vulnerable to floods, including facilities that serve such uses, be protected against flood damage at the time of initial construction;
- Control the alteration of natural floodplains, stream channels and natural protective barriers that are involved in the accommodation of flood waters;
- Control filling, grading, dredging and other development that may increase erosion or flood damage; and
- Prevent or regulate the construction of flood barriers that will unnaturally divert floodwaters or that may increase flood hazards to other lands.

The State Building Code also allows the Town to establish a Design Flood Elevation (DFE) that is higher than the BFE as the regulatory standard (which the Town has not done).

Town standards for FEMA AE Special Flood Hazard Zones:

New construction or substantial improvement of any commercial, industrial or other nonresidential structure located in Zone A or AE shall have the lowest floor, including basement, elevated at least one foot above the effective FEMA base flood elevation (BFE). Nonresidential structures located in all A and AE Zones may be dry floodproofed (to at least one foot above the BFE) in lieu of being elevated, provided that (together with all attendant utility and sanitary facilities) the areas of the structure below the required elevation shall be:

- Watertight with walls substantially impermeable to the passage of water.
- Use structural components capable of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy.
- Be certified by a registered professional engineer or architect that the design and methods of construction are in accordance with acceptable standards of this subsection; such certifications shall be provided to the Old Saybrook Town Engineer.

Town Standards for FEMA Coastal High-Hazard (VE and Coastal AE Zones):

- All buildings and structures shall be located landward of the reach of the Connecticut Coastal Jurisdiction Line as defined in C.G.S. § 22a-359, as amended by Public Act 12-101;
- All buildings or structures shall be elevated so that the lowest supporting horizontal member is located no lower than one foot above the base flood elevation and with all space below the lowest supporting horizontal member open so as not to impede the flow of water, except for breakaway walls as defined in § 128-6 and provided for in § 128-20D (5);
- All buildings and structures shall be securely anchored on pilings or columns. Pilings and columns and the attached structures shall be anchored to resist flotation, collapse, and lateral movement due to the effect of wind and water loads acting simultaneously on all building components. The anchoring and support system shall be designed with wind and water loading values which equal or exceed the one-hundred-year mean recurrence interval (one-percent annual chance floods and wind). There shall be no fill used for structural support;

Town standards for Critical Facilities:

New construction of critical facilities shall be elevated or dry floodproofed to the BFE for the five-hundred-year flood zone. The five-hundred-year flood is calculated by multiplying the elevation of the one-hundred-year BFE by 1.25.

Laws Related to the Taking of Private Property

Connecticut Constitutional Taking Law is complex and a simple summary is not possible here. Regardless, it is particularly relevant to coastal resilience and adaptation. A Managed Retreat adaptation strategy will, almost always, involve the voluntary or involuntary taking of private property. In addition, land use regulations (State or Old Saybrook) have the potential significantly impact property values and need to be considered with regard to constitutional prohibitions against regulations that take property. Further, discontinuing public services (e.g., maintaining public roads, sewer, electrical, water, emergency response, etc.) should also be considered with regard to constitutional prohibitions against regulations that take property. Connecticut and federal constitutions prohibit property taking without just compensation[1].

Public Access to Intertidal Lands and Waters

MHW denotes the seaward limit of private property in Connecticut and (per the Public Trust Doctrine) the lands and waters below MHW belong to all citizens of the State. The DEEP is tasked with preserving these rights by regulating the encroachment of private structures into the public trust area and by promoting public access opportunities.

Note:

1. A good overview of this issue is provided in "Coastal Management in the Face of Rising Seas: Legal Strategies for Connecticut", Grannis et al; Sea Grant Law and Policy Journal Vol. 5, No. 1; 2012.

Presidential Executive Orders 11988, 13690 and 13653

Although not applicable to most projects within Old Saybrook, Presidential Executive Orders (EO) mandate resilience, flood mitigation and climate change for agencies, programs and projects that receive federal investment (such as a state highway project). There are also several other executive orders that address sustainability and greenhouse gas emissions.

- EO 11988 (1977; 2015 Amendments), Floodplain Management, addresses long and short term adverse impacts associated with the occupancy and modification of floodplains, requiring avoidance of direct or indirect support of floodplain development wherever there is a practical alternative. This EO led to federal regulation of floodplains.
- EO 13653 (2013), Preparing the United States for the Impacts of Climate Change, directs federal agencies to take a series of steps to make it easier for communities to strengthen their resilience to climate change. This EO is comprehensive and broad in scope, affecting essentially all federal, state and local agencies as well as the private sector, and directing all agencies to identify climate change risk and put in place adaptation plans including design guidelines and standards for federal projects.
- EO 13690 (2015, 2017 EO Repealed), Establishing a Federal Flood Risk Management Standard (FFRM) and a Process for Further Soliciting and Considering Stakeholder Input, was issued in January 30, 2015. This order was established to reduce the risk and cost of future flood disasters by requiring all federal investments in and affecting floodplains to meet higher flood risk standards. Executive Order 13690 was repealed on August 15, 2017 by the current administration. The overarching purpose of the EC 13690 was to provide new standards that give federal agencies incorporate risk reduction and have flexibility. The order required selection of one of three approaches to establish design flood elevations and flood hazard areas for use in siting, design, and construction and implementation of amended Executive Order 11988:
    a. Use data and methods informed by best-available, actionable climate science;
    b. Build two feet above the 100-year (1%-annual-chance) flood elevation for standard projects, and three feet above for critical buildings like hospitals and evacuation centers; or
    c. Build to the 500-year (0.2%-annual-chance) flood elevation.

State and Federal Permits Related to Coastal Resilience and Adaptation

Compliance with the above-regulations requires that projects go through a permitting process. The following summarizes permits that are typically required for typical coastal resilience and adaptation projects in Connecticut:

1. DEEP Office of Long Island Sound Programs (OLISP) Coastal Permits:
    a. Structures, Dredging and Fill and Tidal Wetlands;
    b. Certificate of Permission (COP) (DEEP); and
    c. Emergency Authorizations.
    d. DEEP Section 401 Water Quality Certification;
    e. USACE Section 404 Permit; and
    f. USACE Section 10 Permit.

Dredging of Town coastal waterbodies such as the Connecticut, Oyster and Back Rivers, and Beamon, Hagar, Mud, Plum Bank and Ragged Rock Creeks and Long Island Sound requires the federal and State permits listed above. Dredge material can be used to restore or enhance marshes, beaches and dunes which can provide coastal resiliency for vulnerable waterfront areas. Such projects can be permitted as “ecological restoration” projects under the USACE and DEEP OLISP permit programs.

DEEP Permits

Coastal development activities are permitted through Connecticut’s Coastal Permit Program which includes DEEP Individual Permits, General Permits, Certificates of Permission and Emergency Authorizations. Individual Permits are typically required for activities which include new construction and other work for which a detailed review of potential environmental impacts is needed. The review process for an individual permit provides an opportunity for public comment.

DEEP OLISP regulates a variety of activities in tidal wetlands and in tidal, coastal or navigable waters of the state through two different permit programs: Structures, Dredging and Fill; and Tidal Wetlands. The authorizing statutes (discussed previously) include: Sections 22a-359 through 22a-363f of the CGS (Structures, Dredging and Fill); CGS Sections 22a-28 through 22a-35 (Tidal Wetlands); CGS Sections 22a-90 through 22a-112 (Connecticut Coastal Management Act); Section 401 of the Federal Clean Water Act (33 U.S.C., Sec. 1314). The regulations include Sections 22a-30-1 through 22a-30-17 of the Regulations of Connecticut State Agencies.

A DEEP OLISP permit is required for any regulated activity in the tidal wetlands, or in tidal, coastal, or navigable waters of the state, including, but not limited to:

- the erection of structures including, but not limited to: breakwaters, docks, pilings, booms, marine railways, culverts, floats, jetties, ramps, utility lines/cables, roadways, walkways, buildings, decks, etc.;
- dredging for the purposes of maintaining existing channels, turning basins, vessel berths, mooring areas and other waterfront facilities;
- the erection of shoreline flood and erosion control or stabilization structures such as riprap, seawalls, bulkheads, and tide gates;
- the placement of any obstacle, obstruction or encroachment;
- maintenance or repair of certain existing structures, fill, obstructions, or encroachments;
- all work occurring within tidal wetlands or waterward of the Coastal Jurisdiction Line incidental to any of the above activities including: any structure, activity, construction, staging of equipment, or site preparation; grading, excavating, dredging, disposing of dredged materials, filling, etc.; the removal of vegetation or other material, or other modification of a site;
- draining, dredging, excavating, or removing of soil, mud, sand, gravel, aggregate of any kind or rubbish from any tidal wetland;
- dumping, filling or depositing upon tidal wetlands any soil, stones, sand, gravel, mud, aggregate of any kind, rubbish or similar material, either directly or otherwise; and
- erecting structures, driving piling, or placing obstructions in tidal wetlands.
- Requires state permit for placement of structures, fill or dredging below High Tide Line (HTL) consistent with CCMA policies. Incorporates regulation of commercial excavation of in-water sand and gravel, which requires $2.00/cubic yard royalty payment. Activities that may be consistent include: a) filling along beach/dune for beach nourishment depending on quality of sand, minimizing water quality impacts, fill beach slope to maintain same natural beach slope, and limit destruction to dune vegetation/shore bird nesting/breeding habitat; and b) disposal of appropriate dredged material for beach nourishment or dune management.

Coastal general permits include:

- DEEP-OLISP-GP-2015-01 (Minor Coastal Structures): This general permit applies to the construction, installation, maintenance, removal and seasonal replacement of various minor structures within the tidal, coastal, and navigable waters of the state below the elevation of the coastal jurisdiction line and, where specifically allowed, in tidal wetlands.
- DEEP-OLISP-GP-2015-02 (Coastal Maintenance): This general permit applies to the maintenance of various coastal structures and activities within the tidal, coastal, and navigable waters of the state below the elevation of the coastal jurisdiction line and, where specifically allowed, in tidal wetlands.
- DEEP-OLISP-GP-2015-03 (Coastal Storm Response): This general permit applies to storm preparation and response activities within the tidal, coastal, and navigable waters of the state below the elevation of the coastal jurisdiction line and, where specifically allowed, in tidal wetlands.

DEEP also uses a short permit process for specific conditions:

- Certificates of Permission (COPs). COP's are certificates issued for certain minor activities involving dredging, erection of structures, or fill in any tidal, coastal or navigable waters of the state in accordance with sections 22a-361 through 22a-363c of the Connecticut General Statutes (CGS). The specific activities eligible under this program are listed in CGS section 22a-363b and include: substantial maintenance and minor alterations or amendments of authorized or pre-jurisdiction structures, fill, obstructions and encroachments; maintenance dredging of maintained permitted dredged areas; removal of derelict structures and vessels; and other enumerated minor activities. “Living Shorelines” can be permitted under a COP.

- Emergency and Temporary Authorizations. CGS section 22a-6k authorizes DEEP to issue emergency and temporary authorizations for certain activities. Additionally, CGS section 22a-363d authorizes DEEP to issue emergency authorizations for activities subject to the Structures, Dredging and Fill Regulatory Program. Emergency authorizations are limited to situations that pose an imminent threat to human health or the environment.

US Army Corps of Engineers

The U.S. Army Corps of Engineers' (USACE) Regulatory Program involves the regulating of discharges of dredged or fill material into waters of the United States and structures or work in navigable waters of the United States, under section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act of 1899. A proposed project's impacts to these areas will determine what permit type is required.

An individual, or standard permit, is issued when projects have more than minimal individual or cumulative impacts, are evaluated using additional environmental criteria, and involve a more comprehensive public interest review. A general permit is issued for structures, work or discharges that will result in only minimal adverse effects. General permits are issued on a nationwide, regional, or state basis for particular categories of activities. There are three types of general permits – Nationwide Permits, Regional General Permits, and Programmatic General Permits. The USACE does not use Regional General or Programmatic General Permits in Connecticut.

Nationwide permits are issued by USACE on a national basis and are designed to streamline Department of the Army authorization of projects such as commercial developments, utility lines, or road improvements that produce minimal impact the nation's aquatic environment.

Section 401 of the Clean Water Act requires applicants to obtain a certification or waiver from the state water pollution control agency to discharge dredged or fill materials. This agency reviews the effect of the discharge on water quality standards. Section 307(c) of the Coastal Zone Management Act of 1972, as amended, requires applicants to obtain a certification or waiver that the activity complies with the state's coastal zone management program for activities affecting a state's coastal zone.

CEPA

The Connecticut Environmental Policy Act (CEPA) requires that an Environmental Impact Evaluation (EIE) be performed for certain State-funded projects. Each State department, institution or agency responsible for the project (proposed State action) is responsible for conducting and environmental assessment of project. The process involves public review and comment. State agencies sponsoring the project determine whether an EIE is required based on the results of an early public scoping process.

Several State and Federal permits regulate future coastal resilience projects as well as how the Town implements maintenance of key utilities, such as tide gates, required for flood mitigation and response. The US Army Corps of Engineers (USACE) regulates activities below mean high water (MHW) and the Connecticut Department of Energy and the Environment (DEEP) regulates activities below the Coastal Jurisdiction Line (CJL) - which is elevation 2.9 feet NAVD88 for Old Saybrook. Tidal wetlands are regulated by DEEP and the USACE and are not subject to local jurisdiction.

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Attachment 4: Vulnerability and Risk

Attachment 4: Vulnerability and Risk

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

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

- Economic Risk
- Commercial and Industrial Districts
- Essential Facilities
- Lifeline Facilities
- High Potential Loss Facilities
- Shelter and Evacuation Requirements
- Historic Districts
- Hazardous Waste Facilities
- High Occupancy and Vulnerable Population Facilities
- Transportation Infrastructure
- Natural Resources: Marshes
- Natural Resources: Beaches

Coastal flooding is characterized in terms similar to those used by FEMA. Structures, businesses, property-owners, tenants and residents located:

- Within the limits of the 100-year recurrence interval flood are considered to be in a high flood hazard zone;
- Within the limits between the 100 and 500-year recurrence interval floods are located in a low to moderate flood hazard zone;
- Outside the limits of the 500-year recurrence interval flood are located in a low flood hazard zone.

The evaluation of the coastal flood risk also considers the type of asset and its relative importance to resilience, adaptation and public safety based on use and occupancy. ASCE/SEI 24-14 "Flood Resistant Design and Construction" categorizes buildings and structures into one of four Flood Design Classes based on use and occupancy. The Flood Design Class dictates the acceptable risk and appropriate level of flood protection.

Although not evaluated by FEMA for the National Flood Insurance program (NFIP), structures, businesses, property-owners, tenants and residents located within flood inundation areas with recurrence intervals less than 100-years (i.e., more frequent flooding) are considered to be in very high flood hazard zones. These include areas predicted to experience "chronic flood inundation" in the future.

The presence of waves, along with flood inundation, can significantly increase the 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. Areas exposed to waves greater than 1.5 feet but less than 3 feet (Limit of Moderate Wave Action) can also experience building damage, in particular to timber-framed structures such as typical houses.

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).

Economic Risk

Attachment 4: Vulnerability and Risk

Predicted Building Damage Loss

GZA performed an updated HAZUS-MH (Hazus) analysis to estimate of coastal flood-related economic loss (Hazus Flood Event Report). Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery. Hazus analyzes the risk on a census block scale. Old Saybrook contains 311 census blocks.

The analyses were performed for coastal flooding (per FEMA hazard characterization as represented on effective FEMA Firms for 100-year recurrence interval and interpolated other intervals) for the following recurrence interval flood: 10-year; 25-year; 50-year; 100-year and 500-year. A combined analysis was performed to estimate the Average Annualized Loss (AAL). The "Averaged Annualized Loss" (AAL) is the expected loss per year if averaged over many years.

The estimated values for Old Saybrook were compared to Middlesex County values using the FEMA's HAZUS Average Annualized Loss Viewer, 2016.

Current Asset Value

There are an estimated 5,874 buildings in the region with a total building replacement value (excluding contents) of 2,050 million dollars (2010 dollars). Approximately 89.33% of the buildings (and 72.45% of the building value) are associated with residential housing. See **Table 4-1** for total Old Saybrook asset value based on 2010 census data. As indicated in the Town of Old Saybrook & Borough of Fenwick Natural Hazards Mitigation Plan Update, 2014 (NHMP, 2014), 2011 Town assessment data indicates lightly different valuations (shown in parenthesis in Table 3-1). The 2011 assessment also carries additional categories. Of particular interest, public utilities ($3,770,600) and vacant land ($52,244,500). The 2011 assessment also distinguishes between residential (shown below) and apartments ($1,689,200).

Table 4-1 Old Saybrook Building Exposure and Occupancy Type

Occupancy	Exposure ($1000)	Percent of Total
Residential	1,485,236 (2,020,973)	72.4% (86%)
Commercial	404,804 (244,953)	19.7% (10%)
Industrial	92,785 (20,974)	4.5% (1%)
Agricultural	4,762	0.2%
Religion	28,859	1.4%
Government	19,222	.9%
Education	14,444	.7%
Total	2,050,112 (2,344,698)	100%

The 2011 assessment grand list also categorizes assets as:

Real Estate:	$2,332,996,248	94%
Personal Property:	$54,298,520	2%
Motor Vehicles:	$94,404,640	4%

Predicted Scenario Impacts

FEMA 10-year Flood:

The following presents the predicted building damage by occupancy type, number of structures and percent damage. The Hazus flood scenario analysis indicates that during the predicted FEMA 10-year recurrence interval it is estimated that about 296 buildings will be at least moderately damaged, all residential.

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	1	0.34	56	18.86	181	60.94	18	6.06	41	13.80	0	0.00
Total	**1**		**56**		**181**		**18**		**41**		**0**	

Table 4-2 Old Saybrook Estimated Building Damage during 10-year Recurrence Interval Flood

FEMA 25-year Flood:

The following presents the predicted building damage by occupancy type, number of structures and percent damage. The Hazus flood scenario analysis indicates that during the predicted FEMA 25-year recurrence interval it is estimated that about 380 buildings will be at least moderately damaged, all residential.

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	1	0.26	62	16.27	166	43.57	86	22.57	66	17.32	0	0.00
Total	**1**		**62**		**166**		**86**		**66**		**0**	

Table 4-3 Old Saybrook Estimated Building Damage during 25-year Recurrence Interval Flood

FEMA 50-year Flood:

The following presents the predicted building damage by occupancy type, number of structures and percent damage. The Hazus flood scenario analysis indicates that during the predicted FEMA 50-year recurrence interval it is estimated that about 542 buildings will be at least moderately damaged, all residential.

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	2	0.37	93	17.10	165	30.33	150	27.57	131	24.08	3	0.55
Total	**2**		**93**		**165**		**150**		**131**		**3**	

Table 4-4 Old Saybrook Estimated Building Damage during 50-year Recurrence Interval Flood

FEMA 100-year Base Flood:

The following presents the predicted building damage by occupancy type, number of structures and percent damage. The Hazus flood scenario analysis indicates that during the predicted FEMA 100-year recurrence interval Base Flood it is estimated that about 910 buildings will be at least moderately damaged, mostly residential with 3 commercial. Nine building are predicted to be destroyed (damages exceed substantially damaged criterion).

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	3	100.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	5	0.55	263	28.74	236	25.79	118	12.90	284	31.04	9	0.98
Total	**8**		**263**		**236**		**118**		**284**		**9**	

Table 4-5 Old Saybrook Estimated Building Damage during 100-year FEMA Base Flood

FEMA 500-year Flood:

The following presents the predicted building damage by occupancy type, number of structures and percent damage. The Hazus flood scenario analysis indicates that during the predicted FEMA 500-year recurrence interval Base Flood it is estimated that about 2,624 buildings will be at least moderately damaged, mostly residential with 8 commercial. Five hundred and twenty-eight (528) buildings are predicted to be destroyed (damages exceed substantially damaged criterion).

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	6	75.00	1	12.50	1	12.50	0	0.00	0	0.00
Education	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	100.00
Religion	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	1	0.04	31	1.19	295	11.29	765	29.27	995	38.06	527	20.16
Total	**1**		**39**		**296**		**766**		**995**		**528**	

Table 4-6 Old Saybrook Estimated Building Damage during 500-year Recurrence Interval Flood

Predicted Average Annualized Loss

Table 4-7 presents the Hazus-predicted Average Annualized Loss (AAL) for Old Saybrook. The predicted AAL is $16 million. Assuming a Town population of about 10,199 people (based on 2010 Census data), this translates to a per capita AAL of about $1,569. For comparison, FEMA (FEMA's HAZUS Average Annualized Loss Viewer, 2016) has estimated the total AAL for Fairfield County to be $77.4M, which represents a per capita average AAL within Middlesex County of $467 related to predicted flood losses. Damage to residential buildings accounts for a majority of the total loss, with privately-owned commercial and industrial buildings accounting for the 35 percent (%) of the loss. **Figure 4-1** shows the geographic distribution (by census block) of the estimated AAL.

Category:	10 yr	25 yr	50 yr	100 yr	500 yr	AAL
Residential	$51M	$67M	$99M	$156M	$580M	
Commercial	$20M	$25M	$33M	$54M	$192M	
Industrial	$6M	$7M	$10M	$15M	$59M	
Others	$6M	$8M	$10M	$15M	$51M	
Total	$83M	$107M	$153M	$240M	$882M	$16M

*Note: Dollars indicated are in Millions.

Table 4-7 Old Saybrook Estimated Average Annualized Loss (AAL)

These costs include building, content, inventory and business interruption losses, as indicated below.

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	6.25	1.04	0.27	0.19	7.74
	Content	4.33	2.57	0.74	0.87	8.51
	Inventory	0.00	0.05	0.07	0.00	0.12
	Subtotal	**10.57**	**3.66**	**1.07**	**1.06**	**16.36**
Business Interruption						
	Income	0.00	0.01	0.00	0.00	0.01
	Relocation	0.01	0.00	0.00	0.00	0.01
	Rental Income	0.00	0.00	0.00	0.00	0.00
	Wage	0.00	0.01	0.00	0.03	0.03
	Subtotal	**0.01**	**0.02**	**0.00**	**0.03**	**0.05**
ALL	**Total**	**10.58**	**3.67**	**1.07**	**1.09**	**16.41**

Table 4-8 Old Saybrook Estimated AAL Building Related Economic Loss

Distribution of Average Annualized Loss

The predicted distribution of economic loss, based on Hazus simulations, is presented on **Figure 4-1** in terms of estimated Average Annualized Loss (AAL). The predicted high loss area around North Cove (in red) is due to the presence of high values assets (both private and municipal, such as the school) and the exposure to coastal flooding.

Uncertainty

Loss estimations using HAZUS-MH 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 AAL 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). 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.

An estimate of observed losses during Tropical Storm Irene and Hurricane Sandy are presented in NHMP, 2014. Based on the observed peak water levels, these storms are generally on the order of 10 to 20 - year return periods as predicted by FEMA. As shown in NHMP, 2014:

Tropical Storm Irene:

FEMA Damage Class	# Residences	Estimated Cost
Affected	195	$192,000
Minor	15	$225,000
Major	8	$400,000
Destroyed	0	$0

Hurricane Sandy:

FEMA Damage Class	# Residences	Estimated Cost
Affected	274	$274,000
Minor	61	$915,000
Major	8	$400,000
Destroyed	4	$600,000

The numbers of building affected ranged from 218 to 347, which are generally consistent with the Hazus simulations. The estimated building damages due to these storms ranged from $817,000 (average $3,750 per building) to $2,189,000 (average $6,310 per building), were significantly less than that predicted by Hazus (+/-$29,000,000 for the 10-year recurrence interval flood, which corresponds to an average of about $98,000 per building). However, this comparison (which is based on relatively minor, high probability storms) may not be representative of more intense storms (i.e., > 50-year recurrence interval) which will have larger waves, deeper water and more intense winds, and Hazus may reasonably estimate losses during these types of coastal floods.

Additional costs incurred by the Town from these two storms (and reimbursed by FEMA) ranged from about $375,000 to $567,000.

NFIP Insurance Policies

As of November 30, 2016, there are 1,492 NFIP flood policies in the Town. Of these NFIP-insured properties, 61 are in the VE Zone and 852 are in AE Zones. Based on the Town's 2014 Natural Hazards Mitigation Plan (2014 NHMP) there are approximately 2,100 structures located within the A, AE, and VE zones. Nine hundred and thirteen (913) of the approximately 2,100 structures located in the SFHA are insured under the NFIP.

There has been a total of 628 paid claims since 1978 totaling $14.2 Million in paid losses (average of about $364,000 per year). The average premium for properties located within a FEMA SFHA is $1,867 (with total premium costs of $1,742,537). Three properties, making multiple claims, accounted for about 4% of the $14.2M in paid losses.

Structures on 14 repetitive loss properties were demolished and rebuilt over the last 10 years. Five repetitive loss structures are in the process of being rebuilt. An additional 75 homes located within FEMA special flood hazard zones have been made compliant with local, State and federal flood regulations.

The number of total NFIP policies in the Town is less than half of the number of buildings located within FEMA SFHAs. The number of NFIP policies in the Town corresponding to VE zones is less than half of the number of buildings located within the VE zone.

Thirty-seven percent (37%) of the NFIP-insured structures are located outside of the SFHA and have accounted for just under eight percent (8%) in paid losses through the NFIP.

The Biggert-Waters Flood Insurance Reform Act of 2012, which was temporally rescinded, will (if implemented) significantly increase the cost of premiums in the Town. The effect of climate change, which will result in more properties being included within future SFHAs (and to greater flood depths) and will further increase future insurance costs.

Attachment 4: Vulnerability and Risk

Potential Risk to the Town Budget

The Town's vulnerability to coastal flood risk will likely impact the Town Budget, including:

- Increase in public works costs;
- Increase in public safety costs;
- Decrease in property tax revenue; and
- Increase in interest rates for municipal bonds.

The increase in public works costs are related to: 1) roadway repair and improvements due to an increase in the extent and frequency of coastal flooding; 2) stormwater management; 3) implementation of flood mitigation measures; and 4) sanitary wastewater treatment. The magnitude of certain mitigation measures, such as roadway improvements, could require municipal bonds to finance.

The increase in public safety costs are related to: 1) developing capabilities for providing emergency response services during floods; 2) expanding shelter requirements; and 3) the increased frequency of flood-related emergency response events.

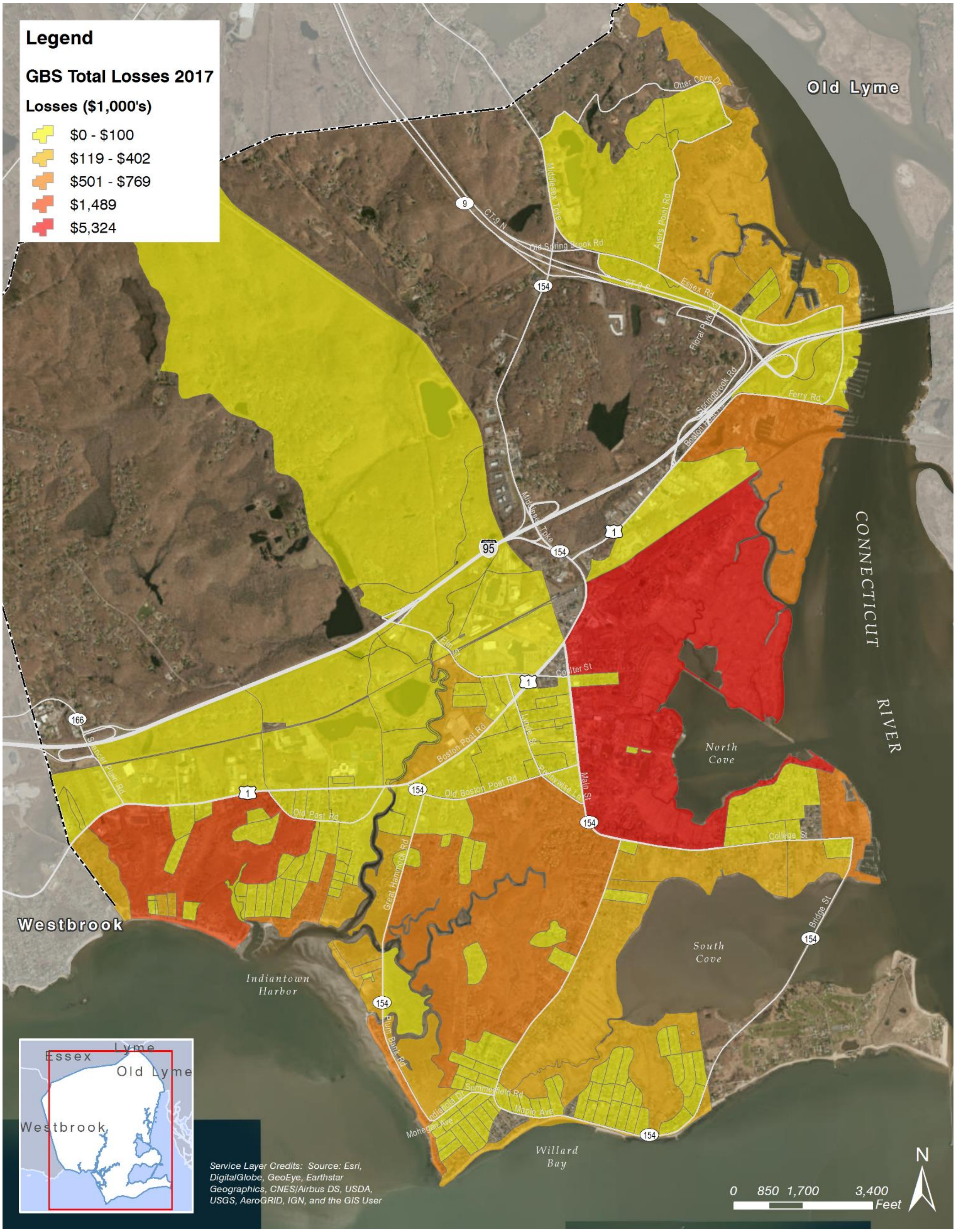
The decrease in property tax revenue is related to: 1) loss of taxable structures due to periodic, flood-induced damage and abandonment; 2) loss of commercial activity (e.g., restaurants) due to periodic, flood-induced damage, disruption of service and inconvenience; and 3) the weighted loss of waterfront properties, which typically have higher appraised values.

Effects on Municipal Bond Rating

The Town's vulnerability to coastal flood risk may impact the Town's municipal credit score. According to Moody's, municipalities and states will face higher interest rates that are directly related to flood vulnerability, representing a future hidden cost to taxpayers.

Attachment 4: Vulnerability and Risk

Figure 4-1 Geographic Distribution of Hazus Average Annualized Loss



Commercial and Industrial Districts

Commercial and Industrial Districts

The vulnerability of Commercial Districts is evaluated relative to coastal flooding, up to the 100-year recurrence interval flood (FEMA BFE). The coastal flood risk of Old Saybrook's commercial and industrial districts renges from Low to High. 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).

Due to their coastal setting, Saybrook Point SP-1 through SP-3 Disticts and the Marine Commercial Districts have the highest coastal flood risk.

Saybrook Point SP-1 through SP-3 Districts

Saybrook Point SP-1 through SP-3 Districts are coastally located along the shoreline of the Connecticut River and are highly vulnerable to coastal flooding. These areas experienced extensive flooding during recent storms (Sandy and Irene) and building and infrastructure damage.

As shown in **Figures 4-2** through **4-5**, the coastal flood risk of the SP-1 through SP-3 districts is High, with the area flooding during high frequency flood events. Further, road access to these areas becomes impossible during even high probability floods resulting in loss of business. The High flood risk makes this area the commercial district within Old Saybrook with the greatest flood vulnerability and potential for loss, including property damage, loss of income and disruption of service. This area is also vulnerable to significant wave effects. As shown in **Figure 4-2**, much of the area is located within a FEMA VE special flood hazard zone due to its exposure to waves greater than 3 feet in height.

Central Business B-1District

The Central Business District B-1 is located (almost entirely) outside the FEMA BFE. The exception are the eastern portions of the district located near the North Cove. See **Figure 4-6**. This vulnerability is expected to increase significantly in the future with sea level rise.

Shopping Center Business B-2 District

The Shopping Center Business B-2 District is located approximately 40% within the limits of the FEMA AE special flood hazard zone. See **Figure 4-7**. This area is vulnerable to coastal flooding propagating up the Oyster River and surrounding marsh. This area will also be flooded during higher probability flood events (about 10-year recurrence interval flood). This vulnerability is expected to increase significantly in the future with sea level rise.

Restricted Business B-3 District

The Restricted Business B-3 District is located within three separate areas. Two of these are located outside the FEMA AE special flood hazard zone. The third (see **Figure 4-7**) is located partially within the FEMA AE special flood hazard zone. This area will also be flooded during higher probability flood events (about 50-year recurrence interval flood). This vulnerability is expected to increase significantly in the future with sea level rise.

Gateway Business B-4 District

The Restricted Business B-4 District developable areas are located outside the FEMA AE special flood hazard zone.

Industrial I-1 District

The Industrial I-1 District located outside the FEMA AE special flood hazard zone, with a few localized areas within – see **Figure 4-8**. This vulnerability is expected to increase significantly in the future with sea level rise.

Marine Commercial District

The Marine Commercial District is coastally located along the shoreline of the Connecticut River and vulnerable to coastal flooding. As shown on **Figures 3-11 and 3-12**, areas within this district are located within the FEMA AE special flood hazard zone. This vulnerability is expected to increase significantly in the future with sea level rise.

Note: 1. The eastern portions of the district, near the North Cove, are located within FEMA AE Zone.

COMMERCIAL AND INDUSTRIAL DISTRICTS

	Current	2041	2066	2116
LOCATION				
Saybrook Point SP-1 through SP-3	High	High	High	High
Central Business B-1[1]	Low	Moderate	Moderate	Moderate
Shopping Center B-2	High	High	High	High
Restricted Business B-3	High	High	High	High
Gateway Business B-4	Low	Moderate	High	High
Industrial I-1	Low	Moderate	High	High
Marine Commercial District	Low	Moderate	High	High

Table 4-9 Commercial and Industrial Districts Risk Profile

Attachment 4: Vulnerability and Risk

Figure 4-2 Saybrook Point SP-1 through SP-3 Districts relative to FEMA FIRM

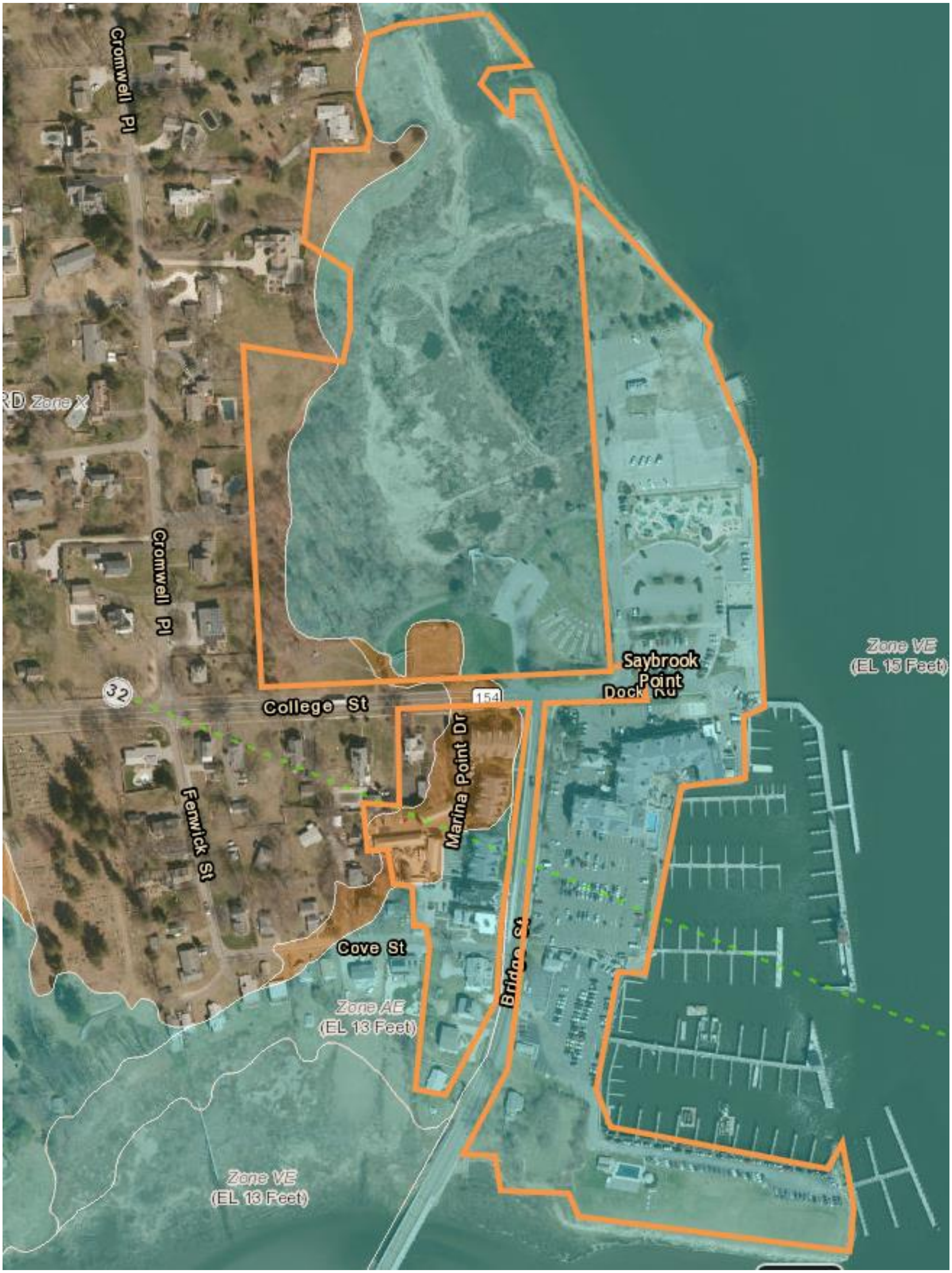


Figure 4-3 Saybrook Point SP-1 through SP-3 Districts relative to 2 year recurrence interval flood A FIRM

Attachment 4: Vulnerability and Risk

Figure 4-4 Saybrook Point SP-1 through SP-3 Districts relative to 10 year recurrence interval flood A FIRM

Figure 4-5 Saybrook Point SP-1 through SP-3 Districts relative to 50 year recurrence interval flood A FIRM

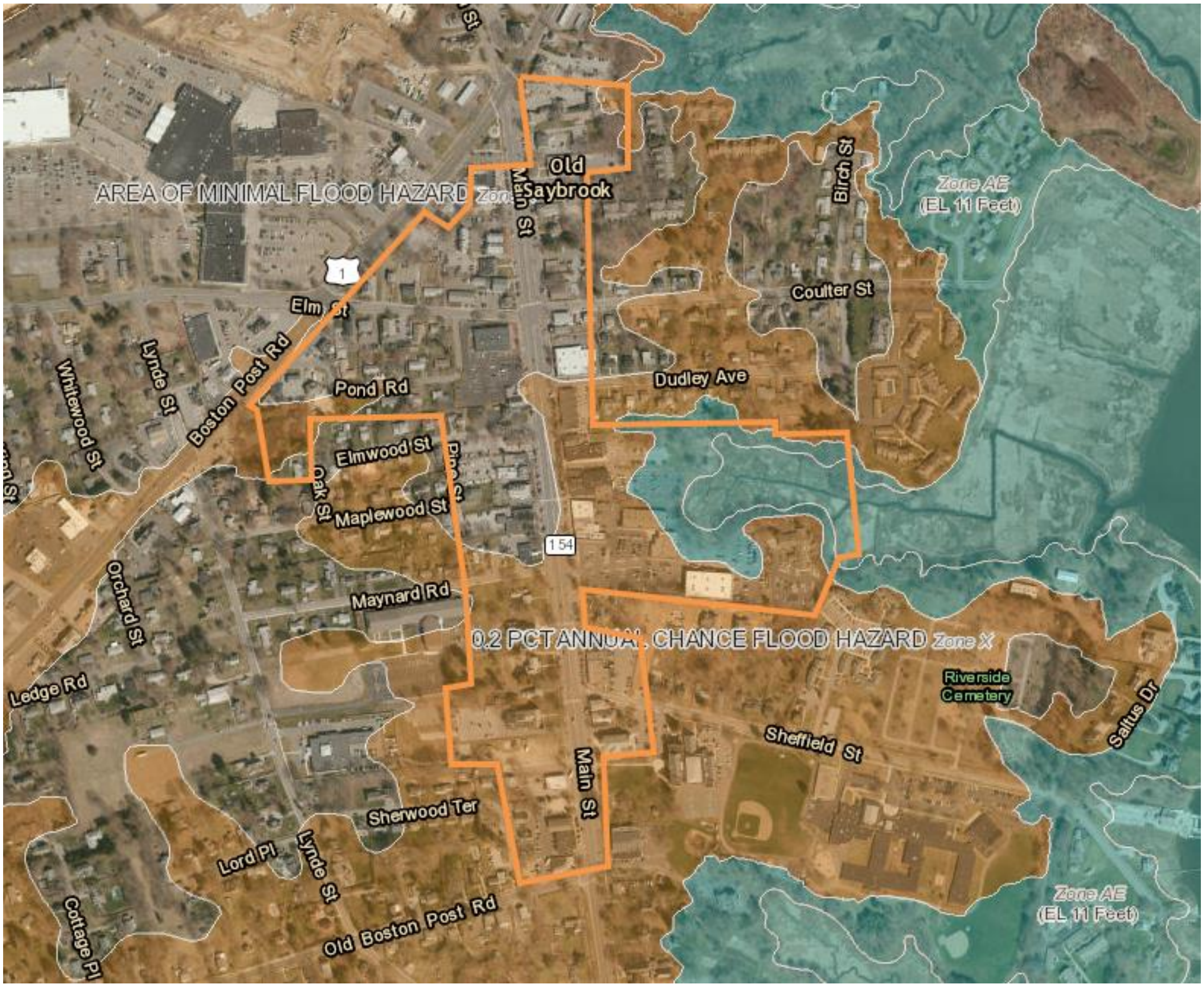


Figure 4-6 Central Business Districts B-1 relative to FEMA FIRM

Figure 4-7 Shopping Center B-2 Business District relative to FEMA FIRM

Figure 4-8 Restricted Business B-3 District relative to FEMA FIRM

Figure 4-9 Industrial I-1 District relative to FEMA FIRM

Figure 4-10 Marine Commercial District relative to FEMA FIRM

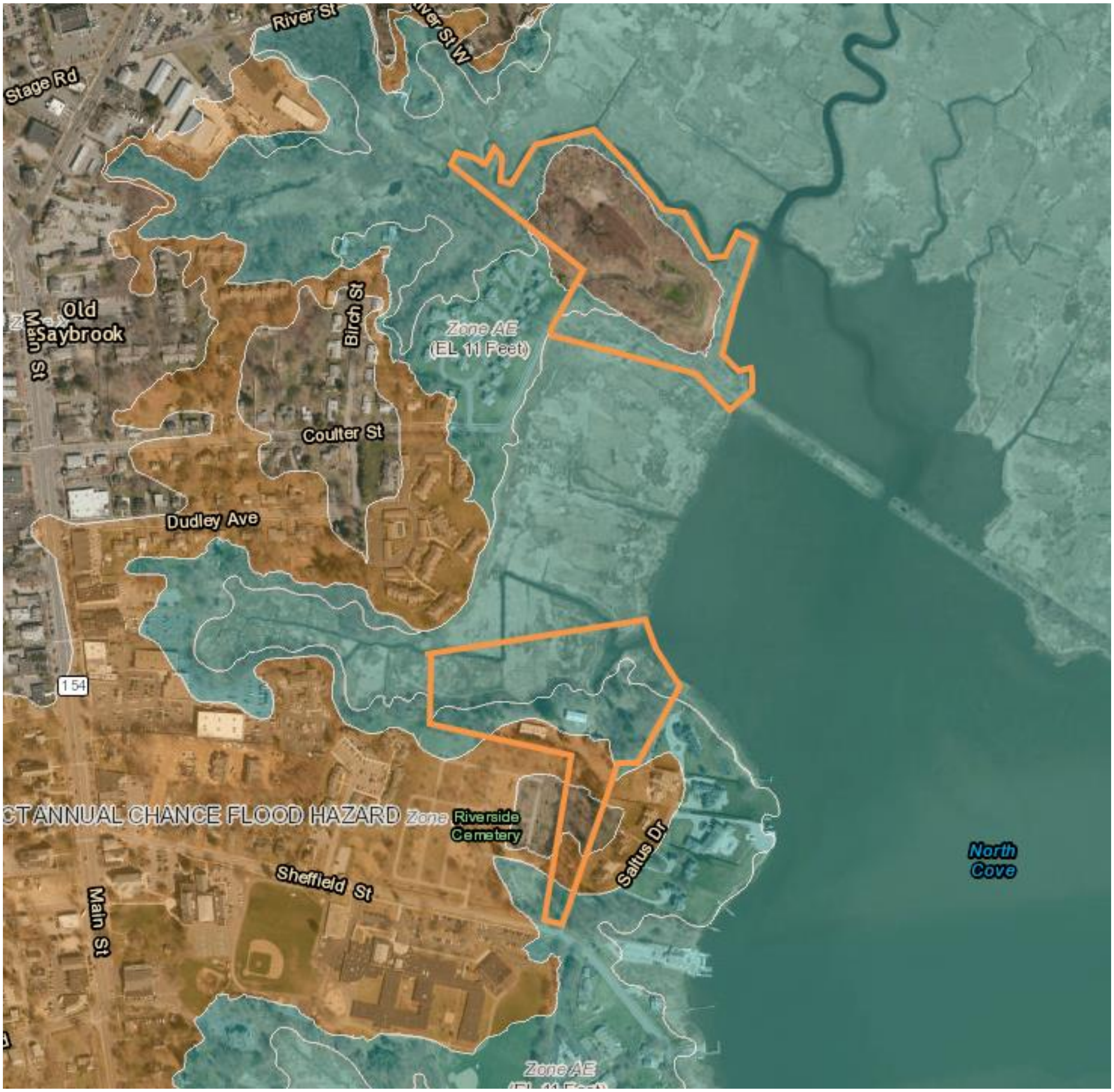


Figure 4-11 Marine Commercial Districts relative to FEMA FIRM

Communities

Attachment 4: Vulnerability and Risk

COMMUNITIES

LOCATION	Current	2041	2066	2116
Low Beach Communities	High	High	High	High
Cornfield Point to Fenwood	Moderate	Moderate to High	High	High
Saybrook Point and Town Center	High	High	High	High

Communities

The following provides an overview of the vulnerability of the Town's communities. The communities primarily consist of residential and commercial structures, 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).

Low Beach Communities

With frontage on Long Island Sound and surrounded by tidal marsh, the Low Beach Communities (including Chalker Beach; Indiantown; Meadowood; Saybrook Manor; Great Hammock Beach and Plum Bank) are very vulnerable to coastal flooding and have a High Risk. As shown of **Figure 4-12,** these communities are located entirely within the FEMA AE zone and developed beaches fronting on the Sound are exposed to high waves and located within a FEMA VE zone. As shown in **Figure 4-13**, these communities are also vulnerable to frequent flooding. **Figure 4-13** shows the limits of the 2-year recurrence interval flood. By the years 2040 to 2050, the inundated areas shown in **Figure 4-13** will be chronically flooded (i.e., flooding on average 26 times per year). **Figure 4-14** shows the limits of the 10-year recurrence interval flood. **Figure 4-15** shows the predicted wave heights during 100-year recurrence interval flood, with 3 to 5 foot high waves (significant wave height) breaking in the vicinity of the houses south of Beach and Bel Aire Manor Roads and west of Plum Bank Road.

Cornfield Point to Fenwood

The topography is variable within these communities, with much of the area located at higher elevation outside the limits of the FEMA AE special flood hazard zone. About 10% to 20% of the parcels within this area are located within the FEMA AE zone. Except for parcels located along the Sound at Cornfield Point, coastal flooding occurs primarily from overtopping of the banks of the tidal marsh.

As shown on **Figure 4-16**, during coastal floods, higher areas become isolated with flooded roads and limited egress and ingress. These areas abutting the tidal marsh begin to be flooded during high probability flooding (e.g., the 2-year recurrence interval flood). The effect of sea level rise will be to increases the frequency of coastal flood inundation within these areas.

Saybrook Point and Town Center

Route 154 and Saybrook point are very vulnerable to coastal flooding. Figure 4-17 shows the limits of the FEMA special flood hazard zones in this area. These areas begin to be flooded during high probability flooding (e.g., the 2-year recurrence interval flood).

Figure 4-12 Low Beach Communities relative to FEMA FIRM

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Figure 4-13 Low Beach Communities relative to 2-year recurrence interval flood

Figure 4-14 Low Beach Communities relative to 10-year recurrence interval flood

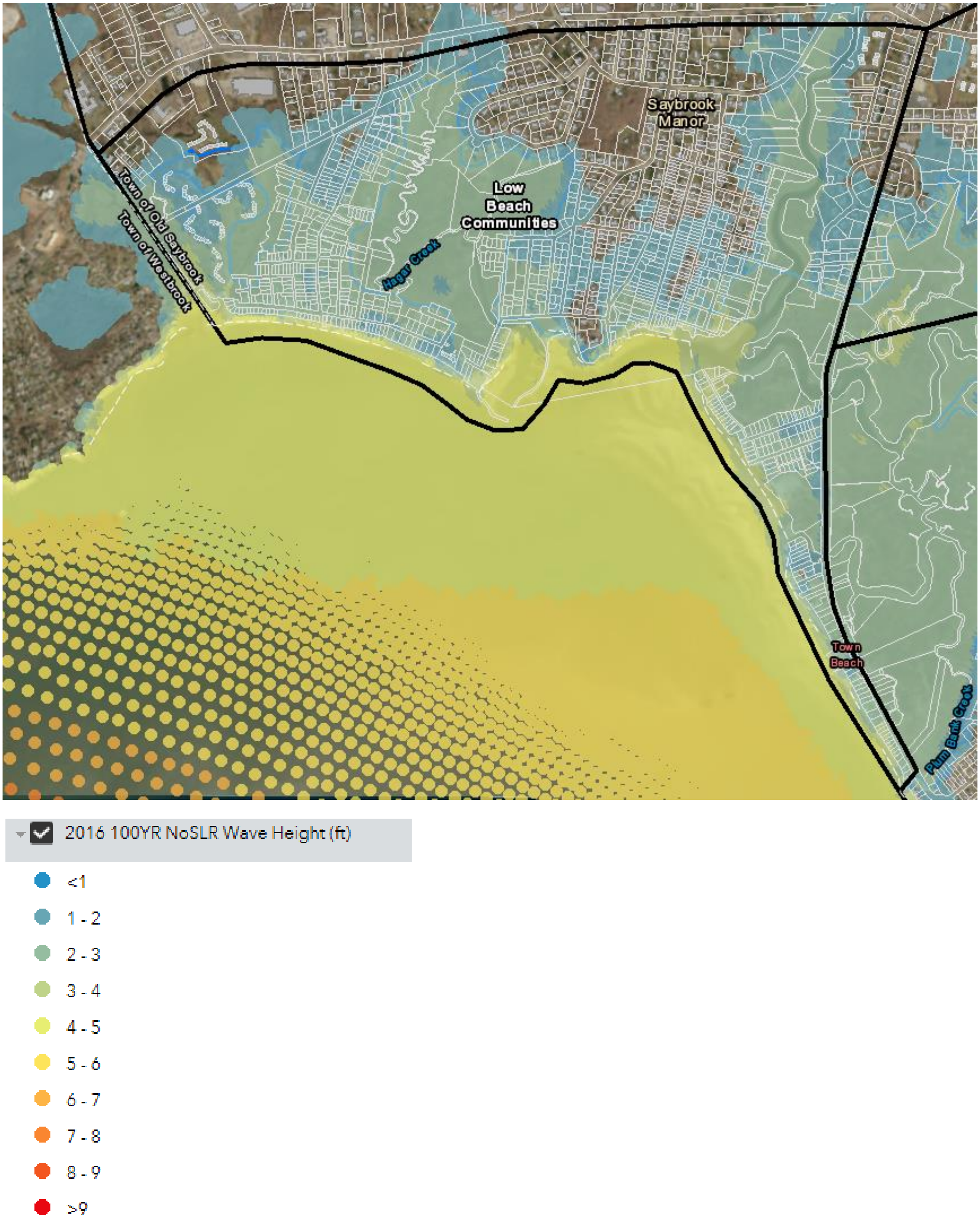


Figure 4-15 Low Beach Communities relative to 100-year recurrence Wave Heights

Figure 4-16 Cornfield Point to Fenwood relative to the FEMA FIRM

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

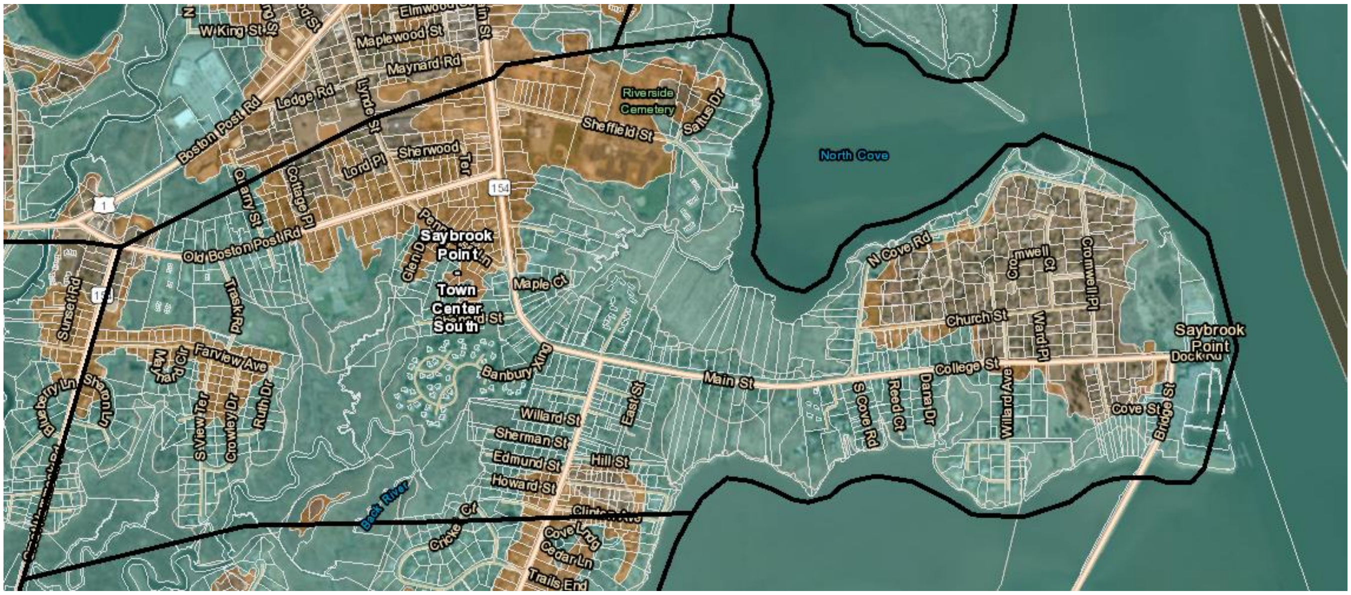


Figure 4-17 Saybrook Point to Town Center relative to the FEMA FIRM

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Essential Facilities

Essential Facilities

Essential facilties are those facilities that are necessary for emergency response and recovery and pose a substantial, risk to the community at large in the event of failure, disruption of function, or damage by flooding. 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 Town's Essential Facilities include:

- 2 Police Facilities
- 5 Fire and Rescue Facilities
- 3 Healthcare Facilities
- 1 Emergency Shelters (including 1 school)
- 1 Public Works Garage

There are two police facilities including:

- the Old Saybrook Police Station located at 36 Lynde Street
- the police boat located at a marina just north of I-95

There are five fire and rescue facilities including:

- Old Saybrook Fire Department at 310 Main Street;
- Emergency Management Public Safety Office at 302 Main Street;
- Emergency Management Services Unit 6 Custom Drive;
- Fire Boat located at a marina just north of I-95; and
- Old Saybrook Ambulance Association at 316 Main Street.

The three healthcare facilities include:

- the Middlesex Hospital Urgent Care at 1687 Boston Post Road;
- Middlesex Hospital Primary Care at 154 Main Street; and
- the Connecticut Area River Health District (CRAHD) at 455 Boston Post Road.

The two Middlesex healthcare facilities include walk-in care for non-emergency medical service, laboratory services and X-rays (at the Urgent Care Facility). The Shoreline Medical Center in neighboring Westbrook provides 24/7 emergency care and outpatient diagnostic services.

Public Emergency Shelter:

- The Old Saybrook High School serves as the primary emergency shelter for the Town and is located at 1111 Boston Post Road.

Figure 4-18 indicates the locations of the Essential Facilities relative to FEMA special flood hazard zones.

Police Station

The easternmost edge of the Police Station at 36 Lynde Street appears to be located within the FEMA 500-year recurrence interval flood limits. The ground elevation (based on available LiDAR) in the immediate area around the Police Station is about Elevation 15 feet to 16 feet NAVD88. The FEMA 500-year recurrence stillwater elevation (see **Attachment 2**) is Elevation 15.4 feet NAVD88. (As noted in **Attachment 2**, the FEMA 500-year recurrence interval stillwater elevation appears to be high relative to other data sources. GZA's flood simulations, which were bounded to the USACE NACCS study, indicate 500-year recurrence interval stillwater flood elevation of about 13.6 feet NAVD88 around the buildings.) Additional site survey may indicate that the FEMA map is incorrect based on elevation. The current coastal flood risk for the police station is considered Low due to the building elevation relative to the FEMA 500-year flood elevation. The ground surface elevation around the building should be confirmed.

Fire Department and Emergency Management Facility

The ground elevation (based on available LiDAR) in the immediate area around the Fire Station and the Emergency Management (Town Hall) is at elevation +/-13 feet NAVD. The FEMA 500-year recurrence stillwater elevation (see **Attachment 2**) is Elevation 15.4 feet NAVD88. (As noted in **Attachment 2**, the FEMA 500-year recurrence interval stillwater elevation appears to be high relative to other data sources. GZA's flood simulations, which were bounded to the USACE NACCS study, indicate 500-year recurrence interval stillwater flood elevation of about 13.6 feet NAVD88 around the buildings.) The current coastal flood risk for the fire department and emergency management facility are considered High due to the building elevations relative to the FEMA 500-year flood elevation.

Figure 4-19 indicates the locations of the Fire Department and Emergency Management Facility relative to the 500-year recurrence interval flood limits. **Figure 4-20** shows the vicinity of the Fire Department. **Figure 4-21** shows the vicinity of the Town Hall.

ESSENTIAL FACILITIES COASTAL FLOOD RISK PROFILE

LOCATION	Current	2041	2066	2116
Police Station at 36 Lynde Street	Low	Moderate	Moderate	Moderate
Fire Department at 310 Main Street	High	High	High	High
Emergency Management at 302 Main Street (Town Hall)	High	High	High	High
Ambulance Association at 316 Main Street	High	High	High	High
Emergency Shelter at 1111 Boston Post Road (Old Saybrook Senior High School)	Low	Moderate	High	High

Table 4-11 Essential Facilities Risk Profile

Figure 4-18 Location of Essential Facilities relative to Predicted Coastal Flood Limits FEMA FIRM

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Figure 4-19 Fire Department at 310 Main Street; Emergency Management at 302 Main Street (Town Hall); and Old Saybrook Ambulance Association at 316 Main Street relative to the FEMA FIRM

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Figure 4-20 Vicinity of Fire Department at 310 Main Street; Ground Surface +/- Elevation 13 feet NAVD88; FEMA 500-year flood +/-15.4 feet NAVD88 Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Figure 4-21 Vicinity of Town Hall; Ground Surface +/- Elevation 13 feet NAVD88;

Old Saybrook Ambulance Association

The Ambulance Association building, with ground surface at the rear of the building at about Elevation 8 feet NAVD88, is located within the FEMA 100-year recurrence interval AE Zone which has a Base Flood Elevation of 11 feet NAVD88 and is near the boundary with the FEMA VE Zone which has a Base Flood Elevation of 15 feet NAVD88. The upland marsh of the North Cove extends to close to the building. The current coastal flood risk for the ambulance facility is considered High due to the building elevations relative to the FEMA 100 year and 500-year flood elevations. **Figure 4-22** shows the roadway leading to the ambulance facility.

Figure 4-22 Vicinity of Fire Department at 310 Main Street; Roadway Leading to Ambulance Facility at 316 Main Street Ground Surface +/- Elevation 10 to 13 feet NAVD88

Public Emergency Shelter

The Old Saybrook High School serves as the primary emergency shelter for the Town and is located at 1111 Boston Post Road. The school building (ground surface at about Elevation 16 feet NAVD88) is outside the limits of the FEMA 500-year recurrence interval flood zone; however, the parking garage is within the 500-year flood limits. The Boston Post Road in the vicinity of the school is flooded during the 100-year and 500-year recurrence interval floods. **Figure 4-23** indicates the locations of the Fire Department and Emergency Management Facility relative to the 500-year recurrence interval flood limits.

Figure 4-23 The Public Emergency Shelter (Old Saybrook High School) with FEMA Flood Hazard Zones

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Figure 4-24 Vicinity of Emergency Shelter (Old Saybrook High School); Ground Surface +/- Elevation 14 to 16 feet NAVD88

Fire Department and Emergency Management Facility Flood Profile

The Fire Department and Emergency Management Facility are Essential Facilities and are located within the FEMA 500-year recurrence interval (0.2% annual exceedance probability) flood, which is the minimum design basis for Essential Facilities.

Design Basis Flood: Effective FEMA FIRM 500-year Recurrence Interval Flood

Flood Mitigation Goal: Essential facilities (not located within VE or Coastal AE Zones) should be designed with a minimum elevation of the lowest floor at or above the Effective FEMA Base Flood Elevation (BFE) plus 2 feet or the 500-year flood, whichever is higher. Essential facilities not constructed to these criteria should be either: 1) dry floodproofed; or 2) flood protected to above these criteria.

Storm Type: The 500-year coastal flood is expected to be a high intensity hurricane.

FEMA 500-year stillwater elevation: Elevation 15.4 feet

FEMA 500-year Coastal Flood Water Depths: The water depths around the building exterior during the 500-year recurrence interval flood are predicted to be (based on FEMA) about 2 to 3 feet. All of Main Street, in the vicinity of the Fire Station is similarly flooded during this event.

500-year Coastal Flood Waves: The ground elevation (based on available LiDAR) in the immediate area around the Fire Station and the Emergency Management (Town Hall) is at elevation +/-12 to +/- 13 feet NAVD. Wind-generated, depth limited waves will occur during the coastal flood event. Waves are predicted to be less than between 1.5 and 2 feet.

500-year Wind: High winds will occur coincident with coastal flooding during the 500-year recurrence interval flood. The predicted 500-year recurrence interval sustained wind is about 154 miles per hour.

Precipitation: Extreme precipitation, including areas of localized intense precipitation, may occur during this coastal flood event.

Non-Design Basis Floods: The Fire Department and Emergency Management Facilities are located outside the limits of the 100-year recurrence interval and higher probability coastal floods.

Future Risk Due to Sea Level Rise

Permanent modifications to these facilities should consider changes to the future coastal flood hazard due to sea level rise. Sea level rise will increase the flood risk. Based on NOAA 2017 relative sea level rise projections, tidal datum elevations are expected to increase by about 2 feet by the year 2050. Flood stillwater elevations will in the vicinity of the increase Fire Department and Town Hall at approximately the same amount. It should be anticipated that future revisions to the FEMA FIRMs will show an increase in flood risk relative to the FEMA FIRMS effective today.

Old Saybrook Ambulance Facility Flood Profile

The Ambulance Facility is an Essential Facility and is located within the FEMA 100-year recurrence interval (1% annual exceedance probability) AE Flood Zone and may be located within a Coastal AE Zone due to its proximity to the tidal marsh.

Design Basis Flood: Effective FEMA FIRM 500-year Recurrence Interval (0.2% annual exceeedance probability) Flood

Flood Mitigation Goal: Essential facilities (located within VE or Coastal AE Zones) should be designed with a minimum elevation of the bottom of the lowest horizontal structural member at or above the Effective FEMA Base Flood Elevation (BFE) plus 2 feet or the 500-year flood, whichever is higher. Essential facilities not constructed to these criteria should be either: 1) dry floodproofed; or 2) flood protected to above these criteria.

Storm Type: The 500-year coastal flood is expected to be a high intensity hurricane.

FEMA 500-year stillwater elevation: Elevation 15.4 feet

FEMA 500-year Coastal Flood Water Depths: The water depths around the building exterior during the 500-year recurrence interval flood are predicted to be (based on FEMA) about 5 to 7 feet. All of Main Street, in the vicinity of the Fire Station is similarly flooded during this event.

500-year Coastal Flood Waves: The ground elevation (based on available LiDAR) in the immediate area around the Ambulance Facility building is at elevation +/-8 to +/- 10 feet NAVD88. Wind-generated, depth limited waves will occur during the coastal flood event. Waves are predicted to be greater than 3 feet.

Attachment 4: Vulnerability and Risk

500-year Wind: High winds will occur coincident with coastal flooding during the 500-year recurrence interval flood. The predicted 500-year recurrence interval sustained wind is about 154 miles per hour.

Precipitation: Extreme precipitation, including areas of localized intense precipitation, may occur during this coastal flood event.

Non-Design Basis Floods: The Fire Department and Emergency Management Facilities are located within the limits of the 100-year recurrence interval and higher probability coastal floods.

Future Risk Due to Sea Level Rise

Permanent modifications to this facility should consider changes to the future coastal flood hazard due to sea level rise. Sea level rise will increase the flood risk. Based on NOAA 2017 relative sea level rise projections, tidal datum elevations are expected to increase by about 2 feet by the year 2050. Flood stillwater elevations will increase in the vicinity of the ambulance facility at approximately the same amount; however, due to the proximity to the marsh, wave effects will be greater than currently exists. It should be anticipated that future revisions to the FEMA FIRMs will show an increase in flood risk relative to the FEMA FIRMS effective today.

Lifeline Facilities

Lifeline Facilities

Lifeline Facilties include distributive systems and related facilities to provide electric power, oil and natural gas, water and wastewater and communications. The flood vulnerability of Lifeline Facilities should be evaluated relative to the 500-year recurrence interval flood. **Figure 4-25** shows the location of the Lifeline Facilities relative to the effective FEMA special flood hazard zones. Lifeline 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 Town's Lifeline Facilities include:

- Electricity (Eversource)
- Water (Connecticut Water Company)
- Natural Gas (Southern Connecticut Gas)
- Sewer (on-site subsurface disposal; Water Pollution Control Authority)
- Communication (AT&T Connecticut; Fiber Technologies Networks, LLC; Cellular Services)

LIFELINE FACILITIES COASTAL FLOOD RISK PROFILE

	Current	2041	2066	2116
LOCATION				
Electricity (Elm Street Substation only)	Moderate	Moderate	Moderate	Moderate
Natural Gas	Low	Low	Low	Low
Water	Low	Low	Low	Low
Sewer	High	High	High	High
Communication	Low	Moderate	High	High

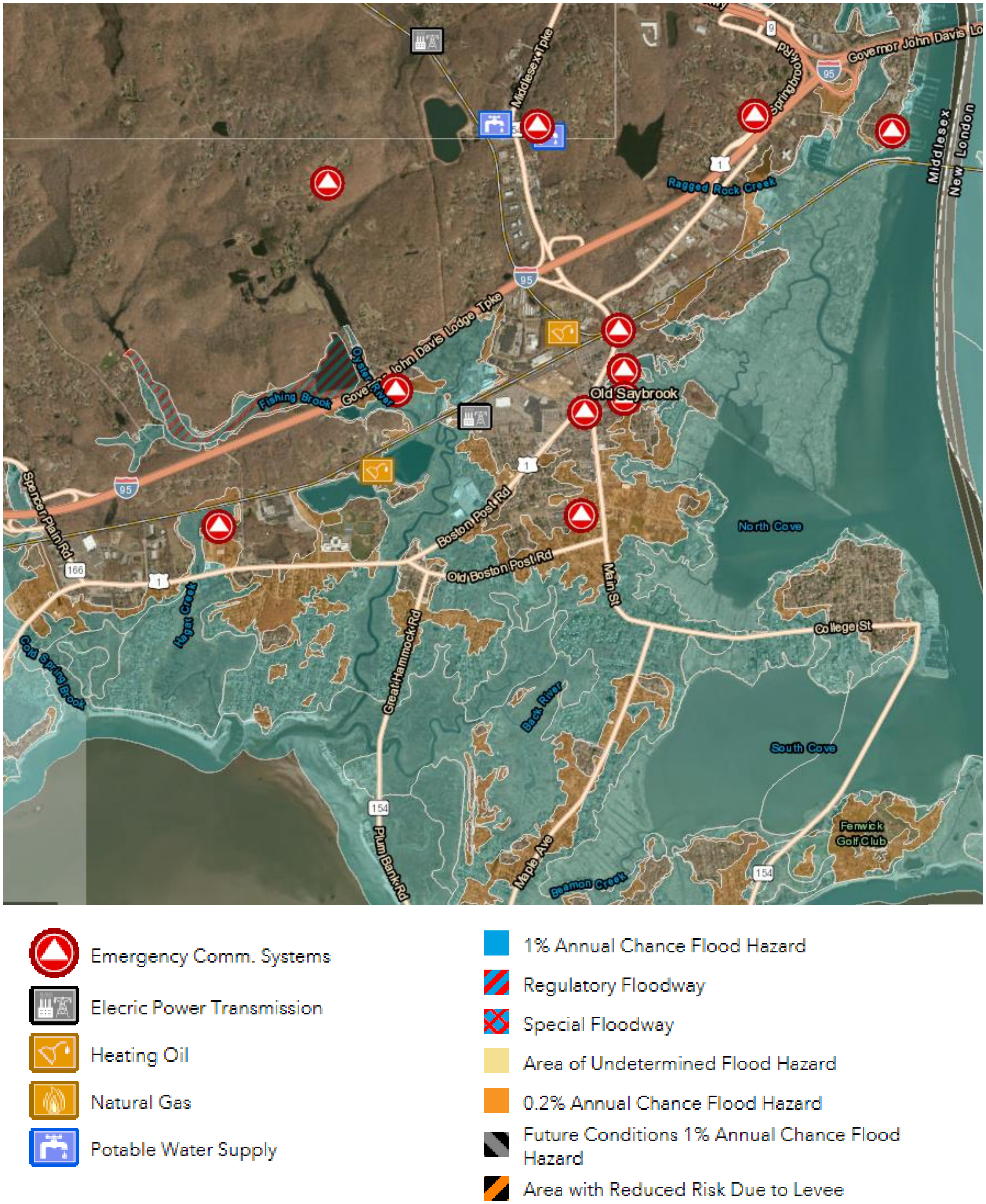
Table 4-12 Lifeline Facilities Risk Profile

Electricity

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 at: 1) Bokum Road; and 2) Elm Street. **Figure 4-26** shows the location of the electrical substations relative to the effective FEMA special flood hazard zones.

No public power generation occurs within the limits of Old Saybrook and power generation facilities are located outside of the Town limits. The coastal flood vulnerability to the electrical service is primarily due to: damage to overhead power lines due to wind-related damage (e.g., tree limbs); damage to poles due to high wind; and potential flooding of electrical substations.

Figure 4-25 Location of Old Saybrook Lifeline Facilities relative to effective FEMA FIRM Flood Hazard Zones Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.



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.

The vulnerability of the Old Saybrook Eversource electrical substations was evaluated relative to the current FEMA 500-year recurrence interval coastal flood. The Bokum Substation, located north of I-95 has a Low Risk to coastal flooding. The Elm Street electrical substation Moderate Risk to coastal flooding due to its location within the effective FEMA FIRM 500-year recurrence interval flood zone.

The ground elevation (based on available LiDAR) in the immediate area around the Eversource Elm Street substation is about Elevation 14 feet NAVD88. The FEMA 500-year recurrence stillwater elevation (see **Attachment 2**) is Elevation 15.4 feet NAVD88. (As noted in **Attachment 2**, the FEMA 500-year recurrence interval stillwater elevation appears to be high relative to other data sources). GZA's flood simulations, which were bounded to the USACE NACCS study, indicate 500-year recurrence interval stillwater flood elevation of about 13.6 feet NAVD88 around the buildings.)

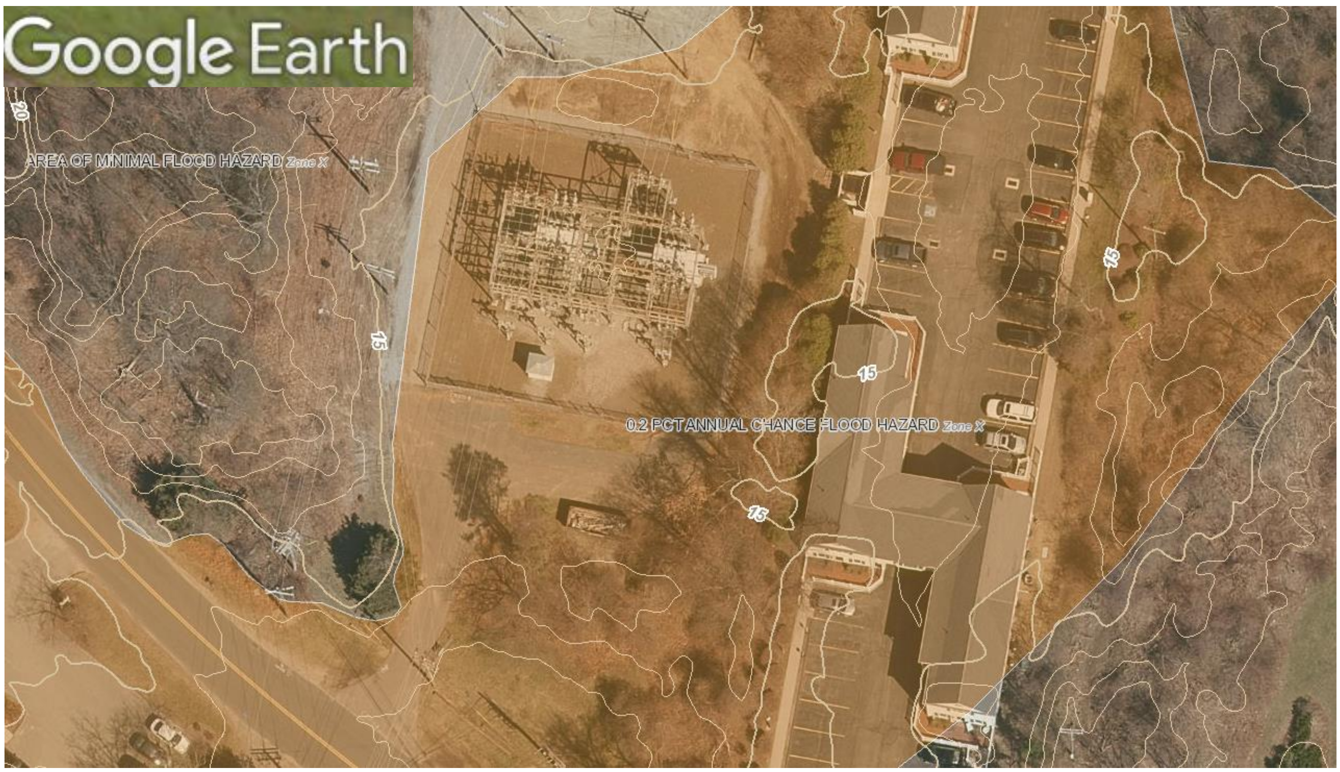


Figure 4-26 Location of Eversource Elm Street Substation relative to effective FEMA FIRM Flood Hazard Zones

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Figure 4-27 Vicinity of Eversource Elm Street Substation; Ground Surface Elevation +/- 14 feet NAVD88

Water

The Connecticut Water Company supplies drinking water in Old Saybrook via a central public water supply system. The CWC Guilford-Chester Division, a State-regulated public utility, provides service to the portion of the Town located to the south of I-95 and the railroad, but also extends north to include Floral Park, Middlesex Turnpike to the area just south of Route 9, and the Spencer Plain Road area. Houses and buildings in the remainder of town rely on private, on-site wells. The water system consists of the Obed Heights 1.09-million-gallon reserve storage tank, transmission water mains and distribution lines. The drinking water originates at a surface water supply reservoir in Killingworth and is supplemented by water wells. The Town created two Aquifer Protection Zones to protect groundwater supply sources.

The locations of the water tank and Aquifer Protection Zones are outside of the limits of the FEMA special flood hazard zones and areas of predicted future coastal flooding.

Wastewater

Town residents and businesses currently utilize, exclusively, individual on-site septic systems. Many of these systems are vulnerable due to shallow groundwater and the effects of coastal flooding and sea level rise. The Town established a Decentralized Wastewater Management District (WWMD) in August 2009 for the purpose of protecting the public health and the environment through improvements to the treatment of wastewater (per Article II of Chapter 173). Decentralized wastewater management approaches seek to deal with wastewater needs closer to the source of wastewater generation using smaller, dispersed (decentralized) treatment and disposal/recharge methods. Enhancing the existing on-site wastewater systems through the use of a Decentralized Wastewater Management Program (DWMP) proactively upgrades certain on-site systems and increases the extent of management of these systems.

The Town adopted WWMD boundaries that include: 1) approximately 1900 lots located within 15 neighborhood focus areas; and 2) Upgrade Program Standards for improvements. The areas were selected primarily based on physical characteristics such as density of houses, proximity to water bodies and marshes and shallow depth to groundwater. Upgrade Program Standards apply to on-site septic systems in 10 of the 15 focus areas (Ref. https://www.oswpca.org/). As of 2016, the Upgrade Program is in the 2nd Phase with over 500 on-site septic systems installed and over 800 designated "Upgrade Compliant" that include on-site septic systems in 10 of the 15 focus areas.

The Old Saybrook Water Pollution Control Authority (WPCA) recently completed a second study, "Old Saybrook Wastewater Pollution Control Authority [WPCA]) Draft Study" (2016-17) to evaluate the use of a Community System to improve the remaining 800 systems. The WPCA Draft Study included a cost and feasibility evaluation of following three options:

1. On-site Repairs
2. Community System(s) with dispersal of wastewater into the ground
3. Community System(s) with dispersal of wastewater into the Connecticut River

During the development of the WPCA Draft Study, GZA discussed and provided the WPCA's engineering consultant, Wright-Pierce, with a memorandum on July 3, 2017 presenting relevant coastal flooding data in relation to the WWMD. **Attachment 4, Appendix A** includes this memorandum that presents coastal flood information relevant to the Old Saybrook WWMD, including tides, sea level rise and storm surge and waves.

High Potential Loss Facilities

High Potential Loss

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 2017, there were eleven such dams in Old Saybrook:

Class C High Hazard Dam:	Obed Heights Reservoir Dam
Class B Significant Hazard Dams:	Chalkers Millpond Dam; Turnpike Pond Dam
Class BB Moderate Hazard Dam:	None
Class A Low Hazard Dams:	Old Rock Pond Dam, Ingham Hill Pond Dam, Crystal Lake Dam, Ayers Pond Dam, Otter Pond Dam, and Deitch Pond Dam
Class AA Negligible Hazard Dams:	None
Unclassified:	Pequot Swamp Pond Dam, Ingham 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.

High potential loss facilities are not classified or regulated using ASCE/SEI 24-14. At a minimum, Class C and B dams should be evaluated for risk relative to the 500-year recurrence interval flood.

A detailed assessment of dam failure risk is beyond the scope of this study. 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.

A preliminary determination of the location of the dam locations relative to the limits of coastal flood inundation was performed. **Figure 4-28** shows the location of the eleven dams relative to the effective FEMA FIRM. The following describes the coastal flood conditions in the vicinity of the Old Saybrook Class C and B dams.

- Obed Heights Reservoir Dam: the Obed Heights Reservoir and Dam are located at a high ground elevation, approximately 60 feet NAVD88 and outside the limits of current and future coastal flooding.
- Chalkers Millpond Dam: The Chalkers Millpond Dam is a low earthen dam located at the southern extent of the Chalkers Millpond. The spillway is located at the east end of the dam. Based on recent Lidar data, the crest elevation of the dam appears to be about Elevation 20 to 22 feet NAVD88. The spillway discharges to a drainage swale that appears to be hydraulically connected to the Oyster River via several roadway drainage culverts. The area immediately downgradient from the dam is classified as a FEMA A zone. Although the risk to the dam due to coastal flooding appears low, further investigation is required to evaluate the potential effect of coastal flooding at the spillway.
- Turnpike Pond Dam: The Turnpike Dam is located at a high ground elevation, approximately 56 feet NAVD88 and outside the limits of current and future coastal flooding.

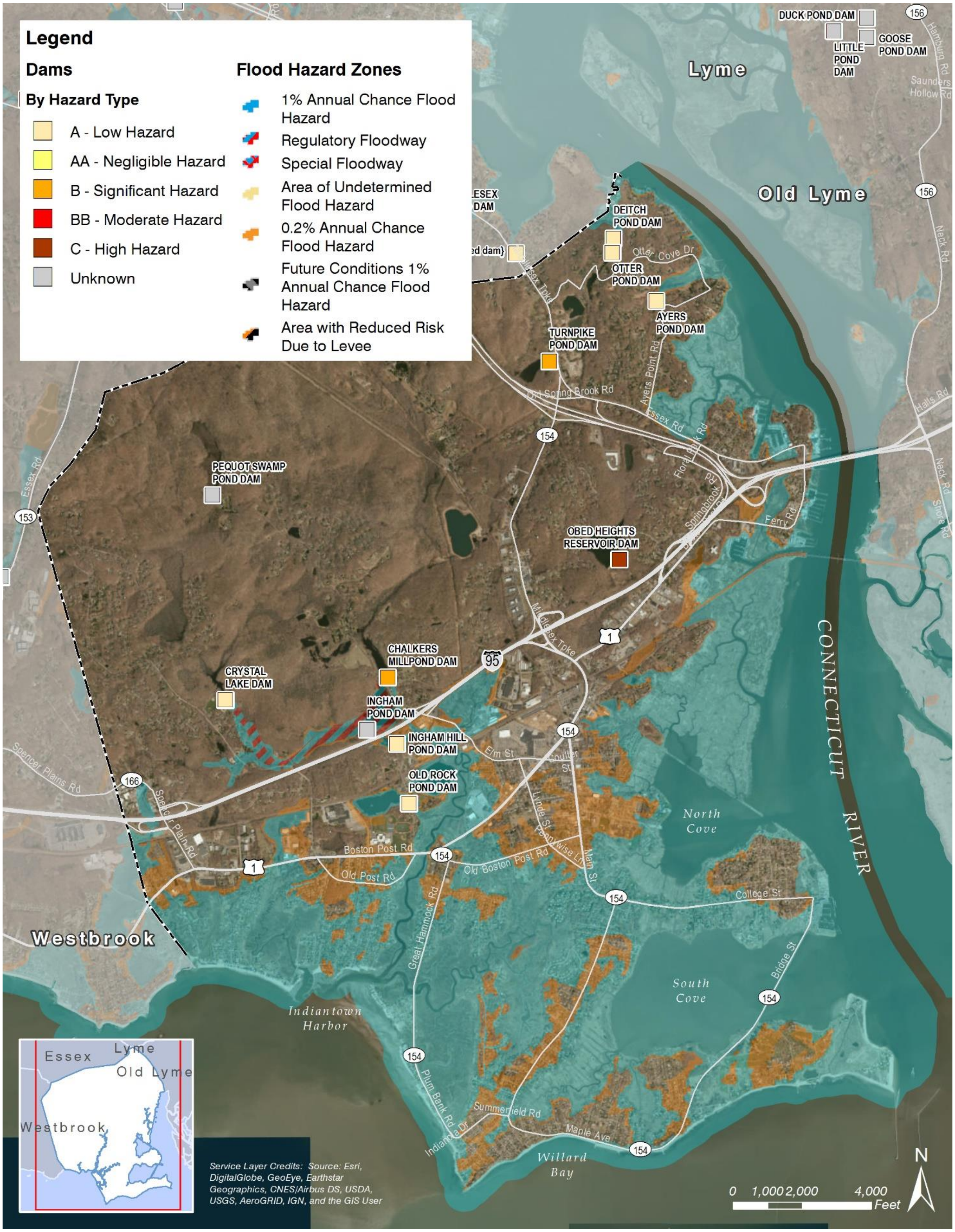


Figure 4-28 Location of Old Saybrook Dams relative to FEMA Special Flood Hazard Zones

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

Sheltering and Evacuation

Sheltering and Evacuation

Storm evacuation and sheltering capacity are key considerations relative to resilience to coastal flooding.

A detailed analysis of New England hurricane evacuation needs and capabilities is presented in "New England Hurricane Evacuation Study, Technical Data Report", June 2016, prepared by the USACE and FEMA. The study was developed to "… evaluate the major factors that must be considered in hurricane preparedness and to provide emergency management officials in Connecticut, Rhode Island and Massachusetts timely, state-of-the-art information needed for sound hurricane evacuation decision-making. State, county and town agencies can use the technical data presented in this report to supplement and/or revise their hurricane evacuation plans and operational procedures, enabling them to more effectively respond to future hurricane threats." This study provides estimates of Old Saybrook evacuation requirements related to coastal flood events.

Per this study, evacuation statistics were developed for three evacuation zones within Old Saybrook:

- Zone 1 (Category 1 and 2 hurricanes flood inundation): about 8,200 to 10,750 people are vulnerable, will be impacted and may require evacuation;
- Zone 2 (Category 3 and 4 hurricanes flood inundation): about an additional 90 to 260 people may require evacuation; and
- Zone 3 (areas located outside of coastal flood inundation): about an additional 440 to 800 people may require evacuation.

For comparison to the USACE/FEMA study referenced above, GZA completed a Hazus analysis to evaluate flood-related losses resulting in the following predictions for shelter requirements. This analysis relates displacement and shelter needs to building damage. The following presents predicted displaced people and shelter needs for different recurrence interval floods:

- 10-year return period flood: 256 households displaced, 648 people seeking temporary shelter
- 25-year return period flood: 305 households displaced, 801 people seeking temporary shelter
- 50-year return period flood: 431 households displaced, 1,161 people seeking temporary shelter
- 100-year return period flood: 1,166 households displaced, 3,096 people seeking temporary shelter
- 500-year return period flood: 1,811 households displaced, 4,709 people seeking temporary shelter

For the above comparison, 10 through 50-year recurrence interval floods can be considered to be analogous to Zone 1, and 100 to 500-year recurrence interval floods can be considered to be analogous to Zone 2.

Behavioral analyses indicate that: 1) during a Category 2 hurricane, about 65% to 70% of the people will evacuate; 2) during a Category 3 hurricane about 71% to 76% of the people will evacuate; and 3) during a Category 4 hurricane, about 82% to 85% of the people will evacuate. The evacuation response time (near full evacuation) ranges from about 3 hours (rapid response, a time when most families are together and can be motivated to respond quickly) to about 6 hours (medium response, weekend days and any evening hours when most families have been rejoined at their residences and can be mobilized in relatively short order) to about 9 hours (long response, nighttime hours, during the middle of a normal weekday when most families are scattered). The mean number of vehicles available to evacuate are based on about 1.8 people per vehicle.

A portion of evacuating people will require shelter within Old Saybrook and the remainder of evacuating people will shelter out of town. Old Saybrook's current public shelter capacity is about 450 to 500 people. "Sheltering at home" is also an alternative, in particular for smaller, higher frequency flood events. This assumes that emergency response services can be provided by the Town during and after the storm. Larger storms will significantly impact "sheltering at home" capabilities due to: 1) flooding of the residence; 2) wind-damage to the residence; 3) the increased likelihood of secondary effects including fire, loss of power, loss of water and loss of sanitary systems); and 4) the diminished capacity of the Town to provide emergency response services.

Historic Properties

Historic Properties

There are three historic districts and 335 historic properties located within Old Saybrook. The Historic Districts include: 1) the North Cove Historic District; 2) the South Green Historic District; and 3) the Fenwick Historic District. The first two historic districts are included in this study.

North Cove Historic District:

The North Cove Historic District is 37-acres in extent and is located on Saybrook Point. The District was listed on the National Register of Historic Places in 1994. The District extends to the north and east along North Cove Road from just north of Church Street on the west to past Cromwell Place to the east. The District also includes a small area along Cromwell Place that extends south from the intersection with North Cove Road for approximately 330 feet. The District is of historical significance because it was the site of the first settlement of the Saybrook Colony (1645) and is an example of a small maritime development between 1645 and 1927. Most housing stock was built between 1700 and 1855. The District includes the Black Horse Tavern and the William Tully House, both separately listed on the National Register. **Figure 4-29** shows the limits of the District relative to the FEMA special flood hazard zones.

The northern shoreline of the District is vulnerable to high waves (characterized as a FEMA VE zone); one historic building is located within the FEMA VE zone (175 North Cove Road). The District starts to be flooded during the 20-year recurrence interval flood.

Figure 4-29 The North Cove Historic District relative to FEMA Special Flood Hazard Zones
Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

South Green Historic District:

The South Green Historic District is 20-acres historic district located around the intersection of Main Street and Old Boston Post Road. The District was listed on the National Register of Historic Places in 1976. The district encompasses the historic town green of Old Saybrook, which was founded in the 1630s. Most of the buildings located around the green were built between 1760 and 1900. Among the buildings in the district are the c. 1767 Gen. William Hart House and the c. 1785 Humphrey Pratt Tavern, which are individually listed on the National Register. **Figure 4-30** shows the limits of the District relative to the

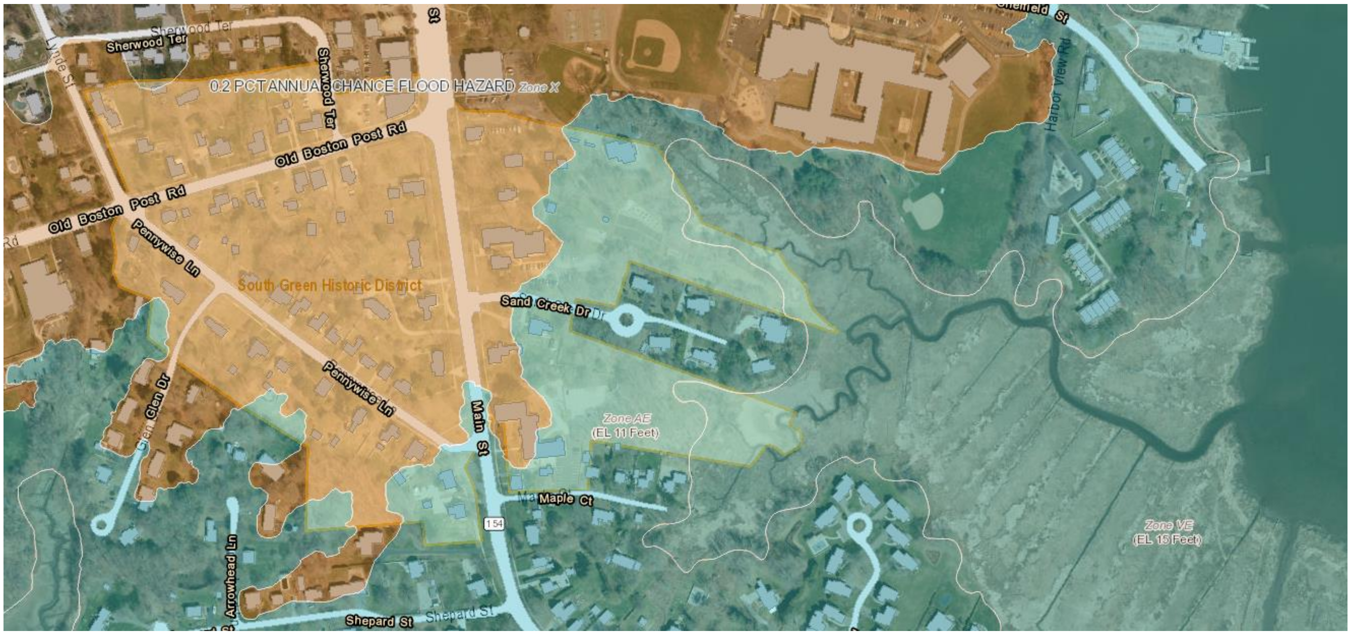


Figure 4-30 The South Green Historic District relative to FEMA Special Flood Hazard Zones

Note: Areas shaded in green represents the FEMA AE zone and areas in brown are located within the limits of the 500-year recurrence interval flood.

FEMA special flood hazard zones. Several properties are located within the FEMA AE zone. Sea level rise will extend the limits of flooding within the District.

The 335 historic properties located within Old Saybrook include:

- 17 National Register Federal Historic Properties;
- 76 State Register Federal Historic Properties;
- 236 Locally Significant Historic Properties; and
- 6 Historic Properties with Other Significance.

Historic properties are classified as Flood Design Class 2 per ASCE/SEI 24-14 and are evaluated for risk relative to the 100-year recurrence interval flood (i.e., FEMA Base Flood). As summarized below, 64 of Old Saybrook's historic properties are located within FEMA special flood hazard zones. **Figure 4-31** show the locations of the historic properties relative to the FEMA special flood hazard zones.

Table 4-13 Historic Properties Risk Profile

Type of Historic Property	Total Number	Total Number in VE/V Zone	Total Number in AE/A Zone
National Register Federal Historic Properties	17	3	3
State Register Historic Properties	76	1	17
Locally Significant Historic Properties	236	2	38
Other Significance	6	None	None
Total	335	6	58

National Register Historic Property

State Register Historic Property

Locally Significant Property

Other Significance

Figure 4-31 Old Saybrook Historic Properties relative to FEMA Special Flood Hazard Zones

Notes: Historic properties at Cornfield Point and within Fenwick are not indicated. FEMA AE zone limits shown in green and FEMA 500-year recurrence interval flood limits shown in brown.

Hazardous Materials Facilities

Hazardous Materials Facilities

There are 27 HazMat Category IV Facilities identified by the Environmental Protection Agency (EPA) within Old Saybrook, including the following:

- Old Saybrook Transfer Station
- Saybrook Veterinary Hospital
- M&J Bus Company
- Guardian Manufacturing
- Lighthouse Printing
- Fortune Plastics
- Paragon Products
- CT Valley Industries
- SSHC Inc.
- Vijon Studio
- Design X
- Stencil Ease
- Essex Cabinets
- Hanford Cabinets
- Saybrook Strip Shop
- Ryther Purdy
- Kiwi Engineering
- Opcon
- Documotion
- SNET
- Target Custom Manufacturing
- Tilcon
- C & M Technology
- Asterick, Inc.
- Fluopolymer
- Infiltrator

Animal shelters are included because these facilities are often repositories for hazardous waste.

Figure 4-32 shows the locations of the facilities relative to FEMA special flood hazard zones. Dependent upon the quantity of highly toxic substances, these facilities are classified as either Flood Design Class 3 or Class 4 per ASCE/SEI 24-14. Flood Design Class 3 structures are evaluated relative to the 100-year recurrence interval flood (i.e., FEMA Base Flood) and 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.

Of the 27 waste facilities, 9 are located within FEMA special flood hazard zones. These include:

- Opcon at 167 Elm Street (Research Parkway)
- Paragon Products at 175 Elm Street (Research Parkway)
- Ryther Purdy at 174 Elm Street (Research Parkway)
- M&J Bus Company at 130 Ingham Hill Road
- Essex Cabinets at 91 School House Road
- Target Custom Manufacturing at 164 Old Boston Post Road
- Design X at 83 Spencer Plain Road
- Vijon Studios at 97 Spencer Plain Road
- SSHC Inc. at 4 Custom Drive

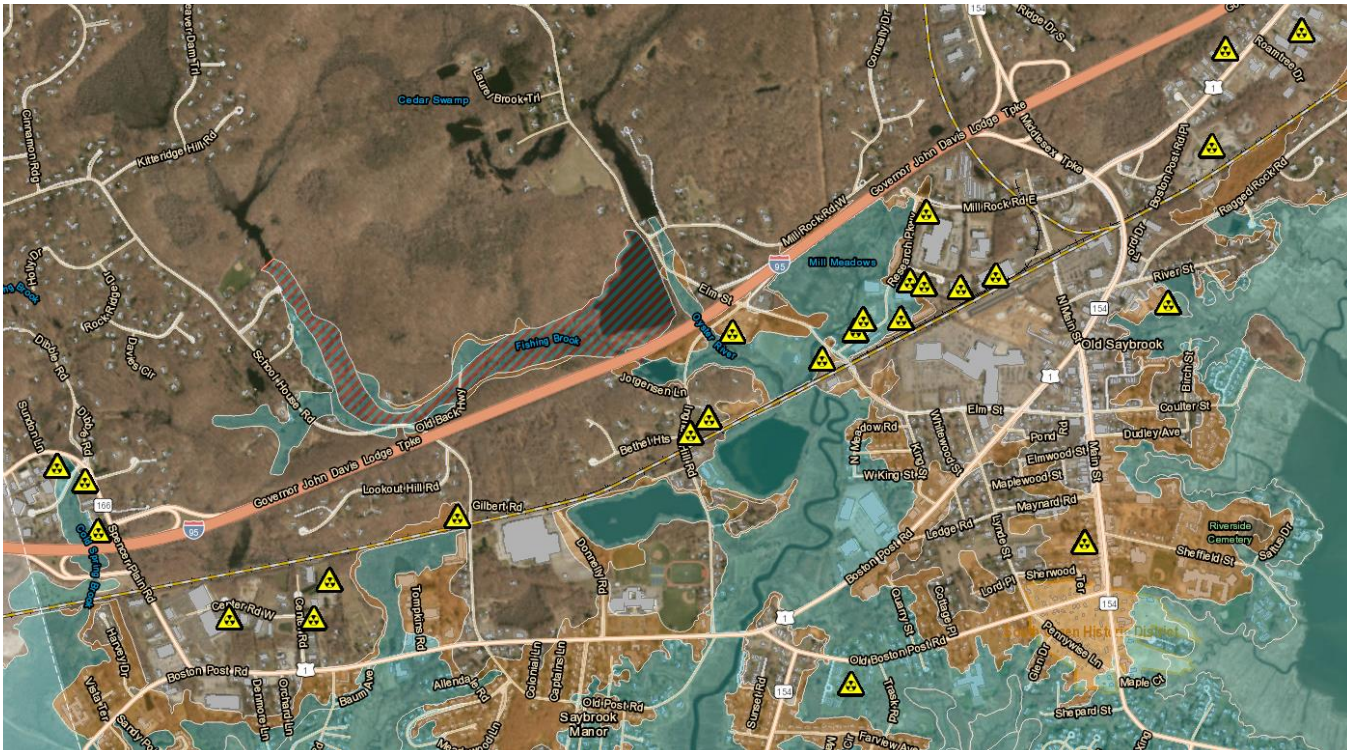


Figure 4-32 Old Saybrook Hazardous Materials Facilities relative to FEMA Special Flood Hazard Zones

Note: FEMA AE zone limits shown in green and FEMA 500-year recurrence interval flood limits shown in brown.

Support, High Occupancy and Vulnerable Populations Facilities

Support, High Occupancy, and Vulnerable Populations Facilities

Support, High Occupancy and Vulnerable Population Facilities (SHOVPFs) are facilities that represent a substantial risk to human life in the event of flood hazards. In Old Saybrook, these areas include:

- Town Administration Buildings
- Grocery & Supply Stores
- Theaters
- Elementary and Secondary Schools, & Buildings with College or Adult Education Classrooms
- Religious Institutions
- Museums and Galleries
- Community Centers & Other Recreational Facilities
- Athletic Facilities
- Care Facilities (including Nursing Homes)
- Pre-School and Child Care Facilities
- Hotels and Inns

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 4-33 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):

- Hotels: Pier Blue Guesthouse
- Schools: Kathleen E. Goodwin Elementary School; Community Nursery School
- Museum and galleries: The general William Hart House and Hart House Gardens,
- Religious Institutions: First Church of Christ, Full Gospel Tabernacle Church, St. Paul Lutheran Church, Valley Shore Assembly of God
- Grocery & Supply: Town Beach Store

The following are located within a FEMA VE special flood hazard zone:

- Town Administration: Vicki G. Duffy Pavilion
- Hotels: Saybrook Point Inn and Spa

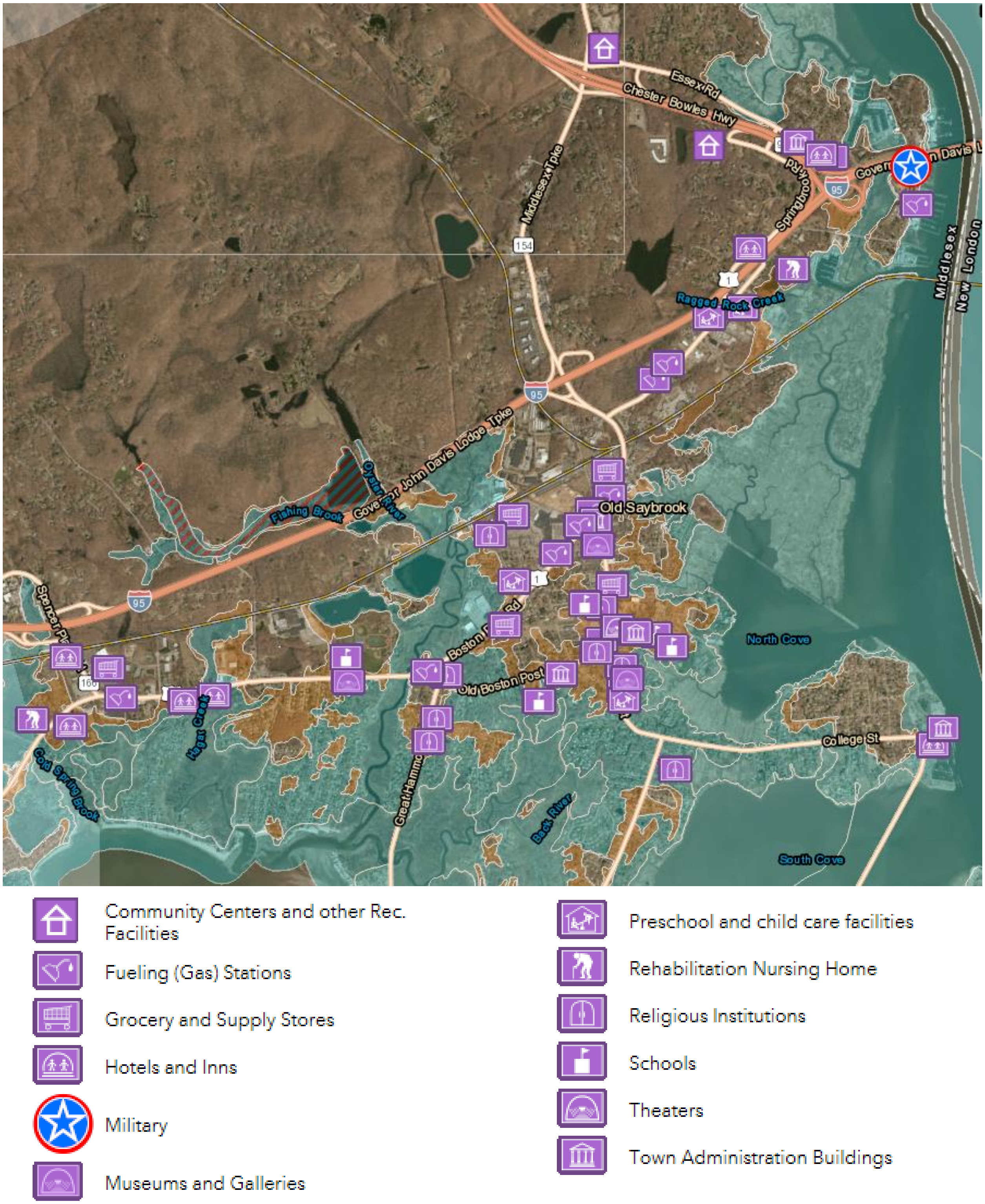


Figure 4-33 Support, High Occupancy and Vulnerable Population Facilities relative to FEMA Special Flood Hazard Zones

Note: FEMA AE zone limits shown in green and FEMA 500-year recurrence interval flood limits shown in brown.

Roads, Bridges and Culverts

Attachment 4: Vulnerability and Risk

Roads, Bridges and Culverts

TRANSPORTATION INFRASTRUCTURE: ROADWAYS, BRIDGES AND CULVERTS

The Town is served by major highways (Interstate 95 and Route 9), major arterials such as U.S. Route 1, CT Route 154 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, bridges and culverts, by jurisdiction, is presented below and is followed by a detailed list of each road and bridge included for analysis for this evaluation.

Roads

The State roads make up approximately 47 miles of total roadway within Old Saybrook. The four (4) key State roads include:

- Interstate I-95 (Connecticut Turnpike)
- Route 9 (Chester Bowles Highway)
- Route 1 (Boston Post Road)
- Route 154 (Main Street and College Street; Bridge Street and Maple Avenue; Indianola Drive; Plum Bank Road and Great Hammock Road; South Cove Causeway)
- Route 166 (Spencer Plain Road)

Municipal roads make up approximately 88 miles of total roadway within Old Saybrook. "Key" roads (including both municipal and State roads) are the main arteries serving Old Saybrook 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 to the State roads, key municipal roads include the following:

- Essex Road
- Ferry Road
- Springbrook Road
- Elm Street
- Lynde Street
- Pennywise Lane
- Sheffield Street
- Old Boston Post Road
- Chalker Beach Road
- Baum Avenue
- Sea Lane

Bridges

There are 22 bridges in Old Saybrook, including bridges where I-95 (Connecticut Turnpike) overpasses Town and State roads, Amtrak rail bridges overpassing Town and State roads, culverts supporting roadways at rivers, and the South Cove Causeway.

Six (6) I-95 (Connecticut Turnpike) bridges located within the Town limits:

- I-95 Bridge over School House Road
- I-95 Bridge over Elm Street
- I-95 Bridge over Middlesex Turnpike
- I-95 Bridge over Springbrook Road
- I-95 Bridge over Essex Road
- I-95 Bridge over Route 9

Three (3) Amtrak Rail bridges:

- Amtrak Rail Bridge over the Connecticut River
- Amtrak Bridge over Elm Street
- Amtrak Bridge over the Oyster River

Five (5) State bridges, including three bridge structures that are part of the South Cove Causeway:

- Raymond E. Baldwin Bridge over the Connecticut River
- Route 1 Bridge over the Oyster River
- Causeway Middle Bridge over South Cove (Route 154)
- Causeway North Bridge over South Cove (Route 154)
- Causeway South Bridge over South Cove (Route 154)

Eight (8) Town bridges:

- Great Hammock Road Bridge over Back River
- Ingham Hill Road Bridge over Amtrak
- Nehantic Trail Bridge over Hager Creek
- Plum Bank Road Bridge over Plum Bank Creek
- School House Road Bridge over Amtrak
- Sequassen Avenue Bridge over Crab Creek (in Borough of Fenwick)
- Spencer Plain Rd Bridge over I-95
- Spencer Plain Road Bridge over Amtrak

Culverts

There are 111 culverts within Old Saybrook, most of which are used to support road waterway crossings.

Figure 4-34 presents the locations of the key roadways and the Amtrak rail line, including bridges, roadway culverts, the Old Saybrook Train Station, bus station and the ferry terminal. Primary, key roads are loosely identified as the State roads providing ingress and egress to the Town as well as the major neighborhood arteries that access these roads. **Figure 4-35** presents the piers, docks and marinas.

TRANSPORTATION INFRASTRUCTURE: VULNERABILITY EVALUATION

A discussion of the transportation infrastructure component and system vulnerability is presented below.

Roads, Bridges and Culverts

The roads, bridges and culverts, collectively, make up the Town's roadway system. Flooding of some or all of these components will affect the utility of the roadway system and (at least temporarily) make these roadways inaccessible to vehicles. Flooding may also result in physical damage of the roadway system, repair and/or replacement cost and longer-term disruption of roadway availability.

GZA analyzed coastal flooding of the Towns roadway system in order to estimate the location and extent of roadway inundation under current coastal flood conditions, including storm events corresponding to the following recurrence intervals: 2-year; 10-year; 20-year; 50-year; 100-year; and 500-year. The results are presented in **Figures 4-36 through 4-41**. The results indicate the probability, location and extent of roadway being impacted under the current coastal flood risk associated with each flood recurrence interval.

Figure 4-34: Old Saybrook Transportation System

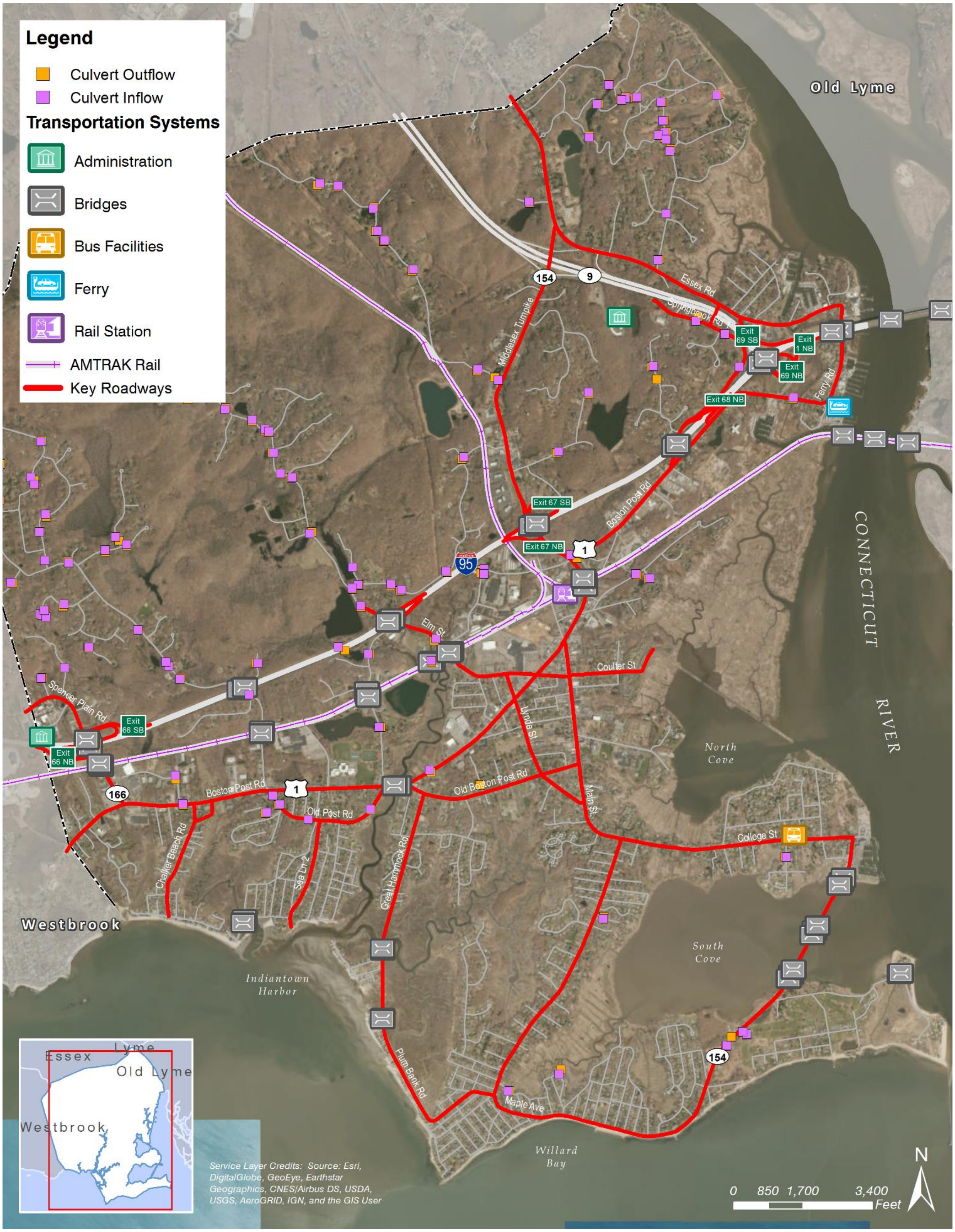


Figure 4-35: Piers, Docks and Marinas

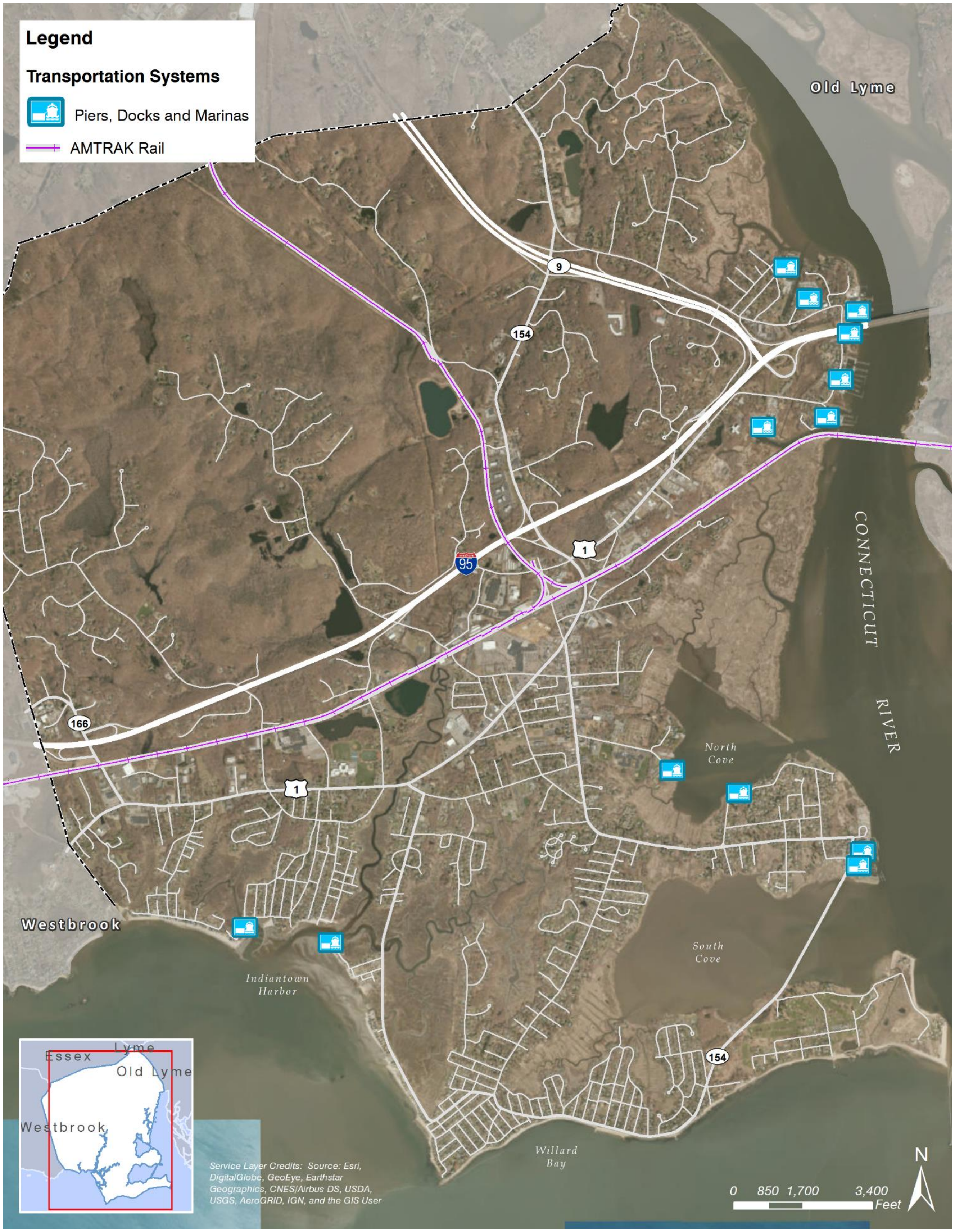


Figure 4-36: Current 2-year Recurrence Interval Flood Risk Roadway Inundation

Figure 4-37: Current 10-year Recurrence Interval Flood Risk Roadway Inundation

Figure 4-38: Current 20-year Recurrence Interval Flood Risk Roadway Inundation

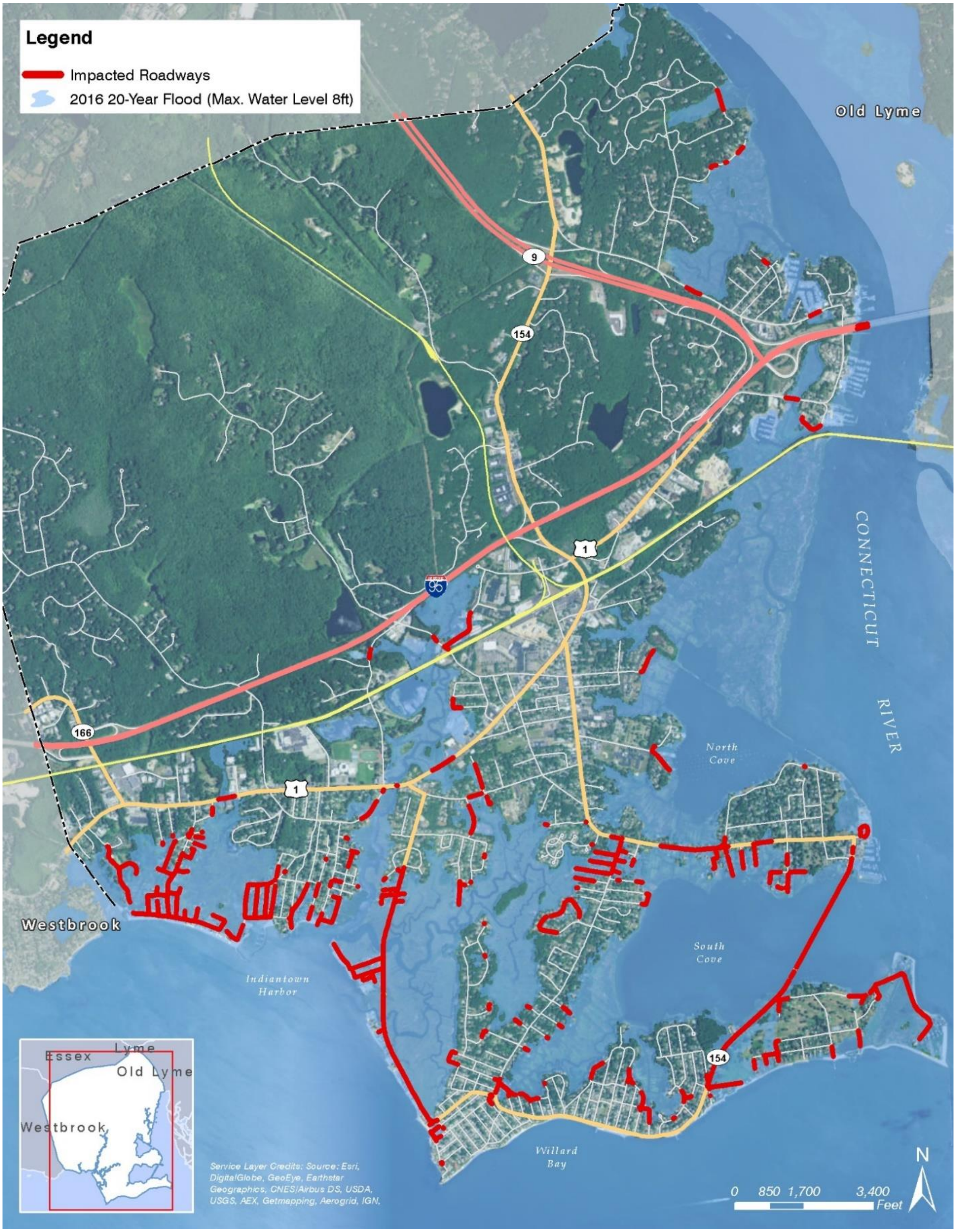


Figure 4-39: Current 50-year Recurrence Interval Flood Risk Roadway Inundation

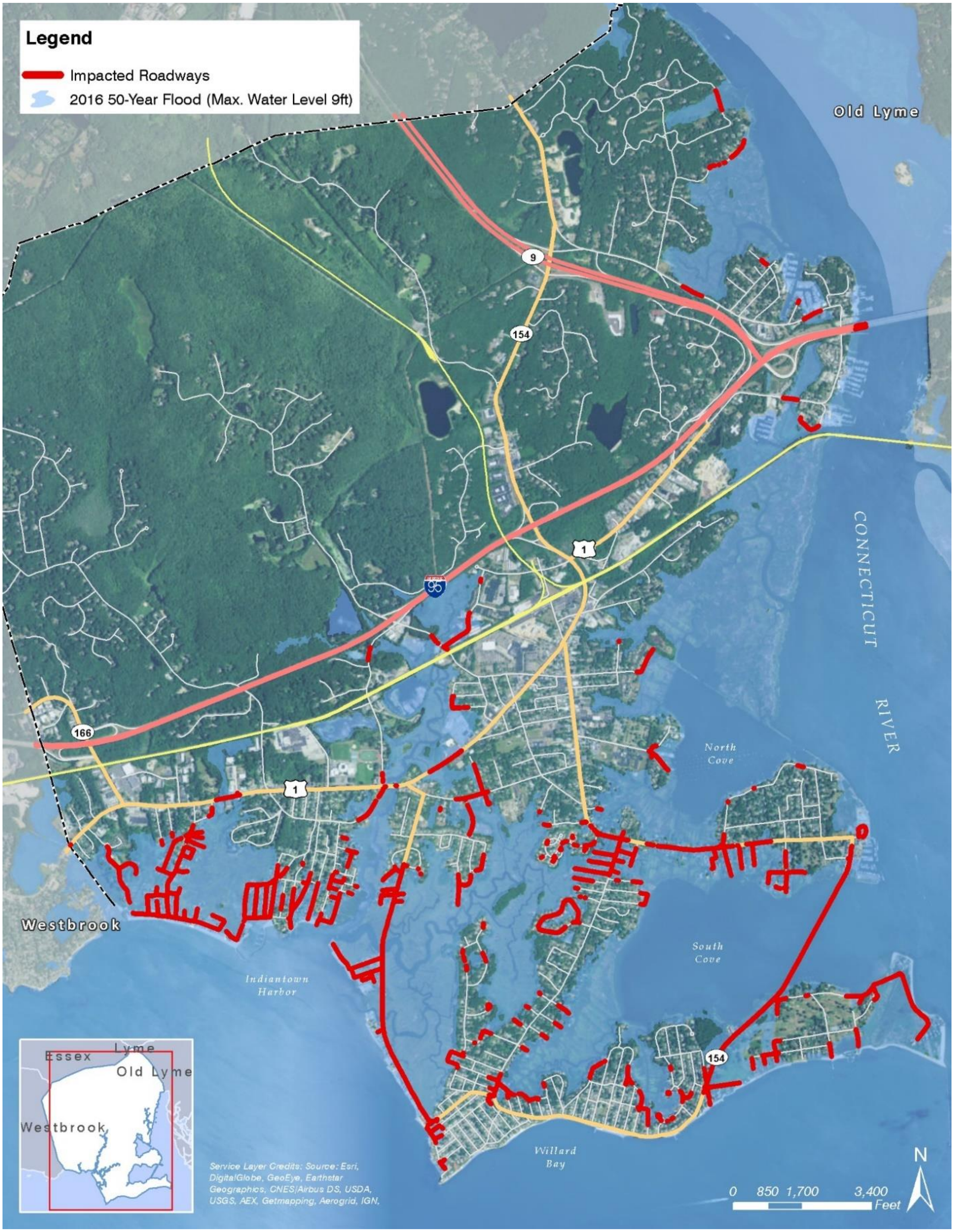


Figure 4-40: Current 100-year Recurrence Interval Flood Risk Roadway Inundation

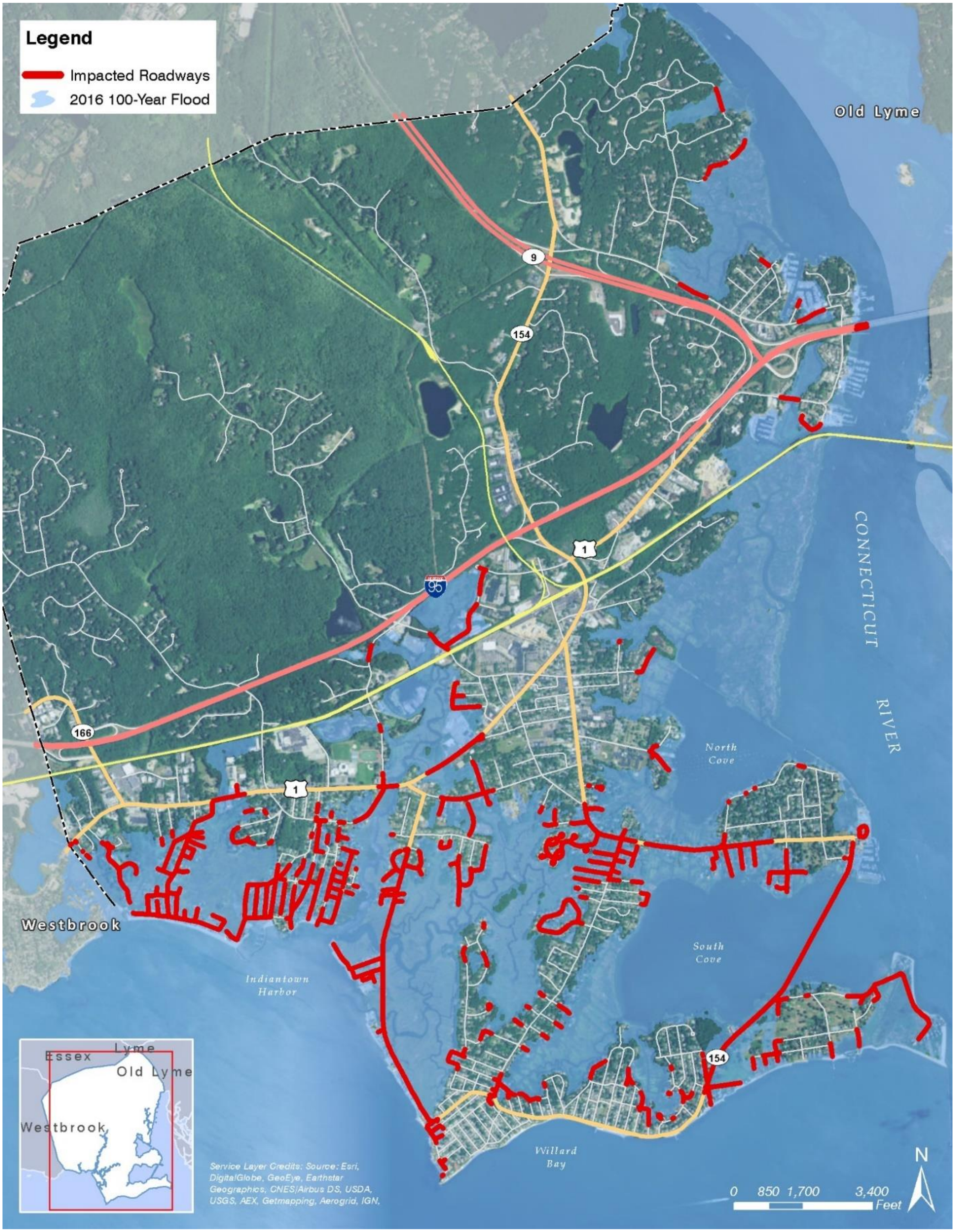


Figure 4-41: Current 500-year Recurrence Interval Flood Risk Roadway Inundation

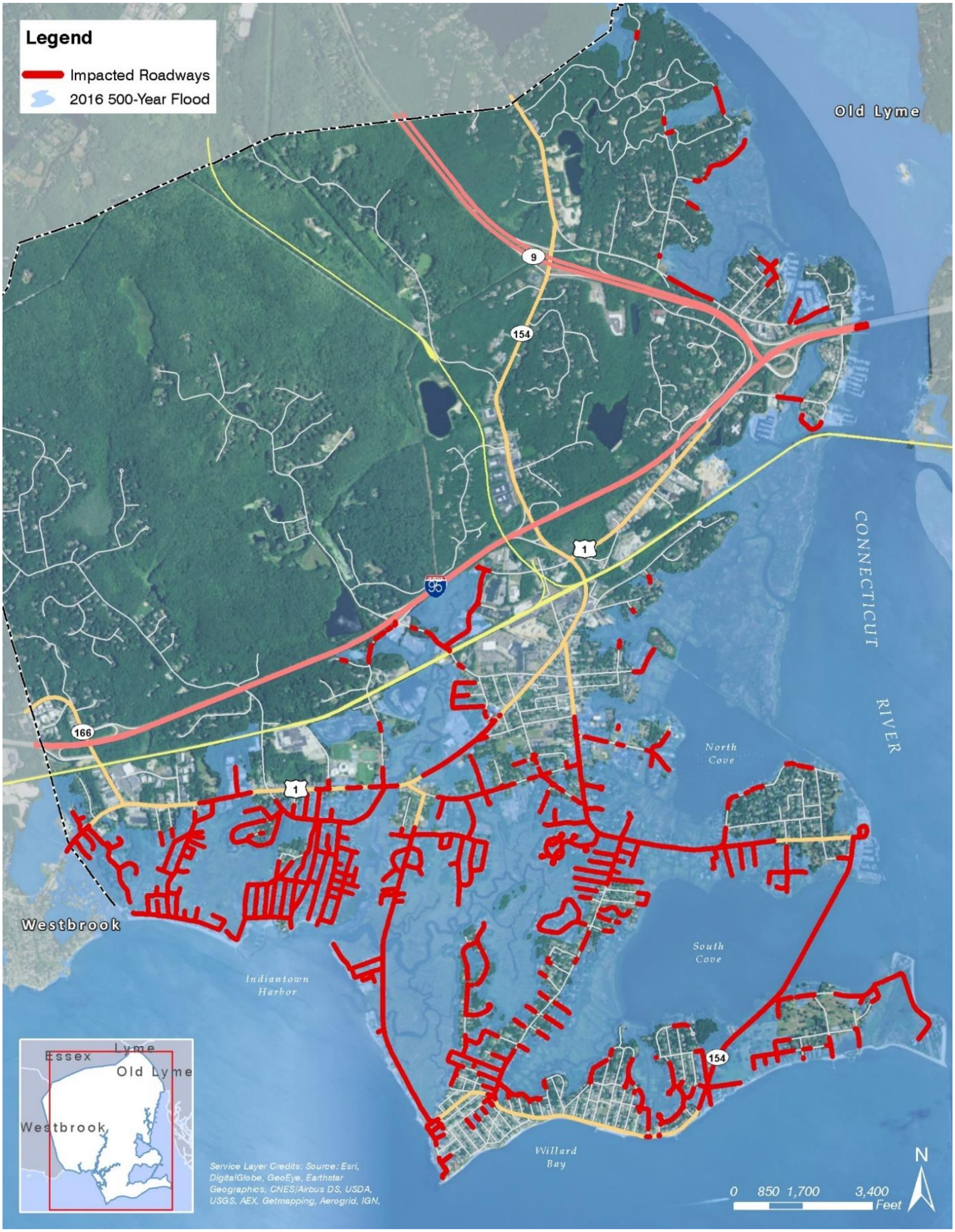


Table 4-14 and **Figure 4-42** present the percentage (and miles) of roadways flooded by coastal flood events in terms of recurrence interval. As presented on **Table 4-14** and **Figure 4-42**, about 24 miles and 36 miles of roadway are vulnerable under the current coastal flood risk scenarios of the 100-yr and 500-yr return period floods, respectively. These flood recurrence intervals represent the appropriate evaluation risk levels for transportation infrastructure investment planning at State and municipal levels. The total impacted roadway under these coastal flood scenarios represent about 24% to 36%, respectively, of the roads within the Town. More frequent flood events, such as the 2-year and 10-year return periods should also be considered due to their high frequency and "chronic flood inundation" potential.

Figure 4-42: Probability of Roadway Flood Inundation (in Miles) Due to Coastal Flooding Under the Current Flood Risk

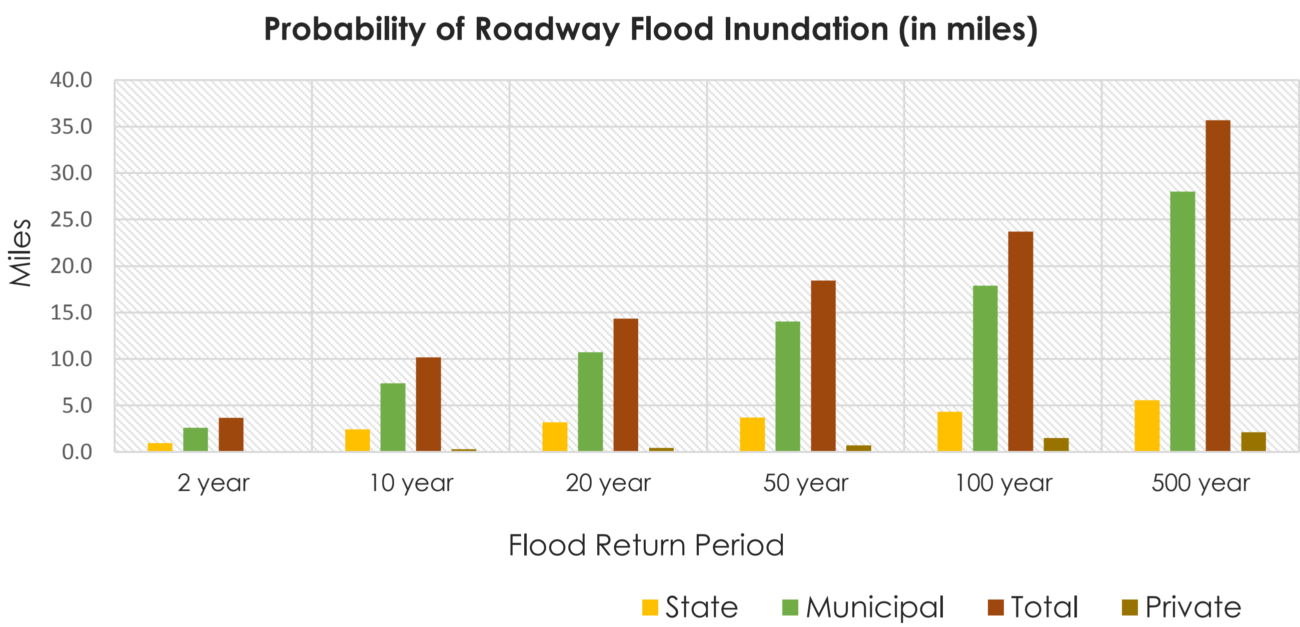


Table 4–14: Probability of Roadway Flood Inundation (in percentage) Due to Coastal Flooding under the Current Flood Risk

	2-year	10-year	20-year	50-year	100-year	500-year
State	2.9%	7.4%	9.6%	11.3%	13.1%	16.9%
	1 mile	2.4 mile	3.2 mile	3.7 mile	4.3 mile	5.6 mile
Municipal	3%	8.5%	12.4%	16.2%	20.6%	32.3%
	2.6 mile	7.4 mile	10.7 mile	14.0 mile	17.9 mile	28.0 mile
Private	3.6%	10.5%	15%	23.7%	50.4%	71.4%
	0.1 mile	0.3 mile	0.4 mile	0.7 mile	1.5 mile	2.1 mile
Total	+/4 miles	+/-10 miles	+/-14 miles	+/-18.5 miles	+/-24 miles	+/-36 miles

Chronic Roadway Flood Inundation and Nuisance Roadway Flooding

The term "chronic flood inundation" applies a specific quantitative flood criterion - specifically an average of 26 times per year. Chronic flood inundation has significant implications relative to roadway use limitations and associated negative impacts to businesses and residents. **Figure 4-43** (the current 2-year recurrence interval flood risk) provides a reasonable representation of roadway sections that have both a high probability of being flooded today (in any year, about a 50% chance) and the potential to be chronically flooded by about the year 2050. This represents about 4 miles of roadway.

According to the 2014 Natural Hazard Mitigation Plan Update, a number of roads (listed below) are subject to "nuisance" flooding. Nuisance flooding generally refers to frequent, shallow coastal flooding due to extreme high tides; however, a few of the roads listed below experience flooding due to heavy precipitation and ponding of stormwater run-off, not coastal flooding.

- portions of Elm Street
- 37 College Street near North Cove Road
- Banbury Crossing
- South Cove Causeway
- Plum Bank Road and Salt Meadow Road near Cornfield Park
- Sandy Point Road
- Shetucket Trail
- Fourth Avenue
- Sunset Avenue
- Old Post Road (eastern end)
- Owaneco Trail
- Obed Trail
- Nehantic Trail
- Mohican Trail
- Red Bird Trail; and
- Maple Ave near its intersection at Main and College Streets.

Vulnerable Key Roadways

Figures 4-44 through 4-48 illustrate flood inundation of the key roadways and transportation features during the current 2-year; 10-year; 20-year; 50-year; 100-year; and 500-year recurrence interval floods. **Figure 4-49** indicates the predicted (approximate) flood depths associated with the current 100-year recurrence interval. **Figure 3-52** indicates 100-year recurrence interval wave heights.

Bridges

Eight (8) bridges have bridge decks that will be inundated and exposed to wave action during the current 100-year return period flood (see **Table 4-15**). Three (3) of the bridges are along the South Cove Causeway. Amtrak and I-95 bridge decks are not flooded during the current 100-year recurrence interval flood.

Table 4-15: Summary of Bridges Inundated during Current 100-year Recurrence Interval Coastal Flood

Overtopped Bridges	Approximate Bridge Deck Elevation (feet, NAVD88)[1]	Estimated 2016 100-year return period stillwater elevation (feet, NAVD88)	Estimated 2016 100-year return period wave crest elevation (feet, NAVD88)[2]
South Cove Causeway:			
North Bridge over South Cove	6	10	15 (VE)
Middle Bridge over South Cove	6	10	15 VE)
South Bridge over South Cove	8	10	15 (VE)
Great Hammock Road Bridge over Back River	6	10.5	13 (Coastal AE)
Nehantic Trail Bridge over Hagar Creek	10	10.5	14 (VE)
Plum Blank Road Bridge over Plum Blank Creek	7	10	14 (VE)
Route 1 Bridge over Oyster River	13	11.5	12.5
Sequassen Avenue Bridge over tidal creek	6	10	13 (VE)

Notes:

1. Bridge deck elevations were estimated based on available LiDAR data and are approximate.

2. The greater of either the GZA simulated wave crest elevation of the effective FEMA Base Flood Elevation (BFE) are indicated in this column. Where the FEMA FIRM was used, the FEMA special flood hazard zone is indicated.

Based on the flood elevations relative to bridge deck elevation, a preliminary evaluation of bridge damage potential during the 2016 100-year return period flood is:

- South Cove Causeway Bridges: High
- Great Hammock Road Bridge over Back River: High
- Nehantic Trail Bridge over Hager Creek: Moderate
- Plum Bank Road Bridge over Plum Bank Creek: High
- Route 1 Bridge over Oyster River: Low
- Sequassen Avenue Bridge over tidal creek: High

Based on the flood elevations relative to bridge deck elevation, a preliminary evaluation of bridge damage potential during the 2016 100-year return period flood is:

- South Cove Causeway Bridges: High
- Great Hammock Road Bridge over Back River: High
- Nehantic Trail Bridge over Hager Creek: Moderate
- Plum Bank Road Bridge over Plum Bank Creek: High
- Route 1 Bridge over Oyster River: Low
- Sequassen Avenue Bridge over tidal creek: High

Amtrak Railway and Shoreline East Rail Station

The Amtrak Rail lines and Shoreline East Rail Station are located outside current FEMA special flood hazard zones.

Culverts

GZA's evaluation identified roadway culverts that are located within roadway sections that are inundated during the 100-yr return period flood under current and future (2041, 2066 and 2116) conditions. This information provides an initial assessment of roadway culverts at risk. GZA has not evaluated the hydraulic capacity of the culverts as part of this study and additional analysis is recommended to evaluate the hydraulic performance of the culverts under different flood conditions including the effect of additional surface run-off.

Table 4-16: Summary of Roadway Culverts Inundated during 100-year Return Period Coastal Flood

100-year Return Period Flood	Number of Culverts
2016	18
2041	18
2066	19
2116	22

Figure 4-43: Current 2-year Return Period Flood Risk Key Road Inundation

Figure 4-44: Current 10-year Return Period Key Road Flood Inundation

Figure 4-45: Current 20-year Return Period Key Road Flood Inundation

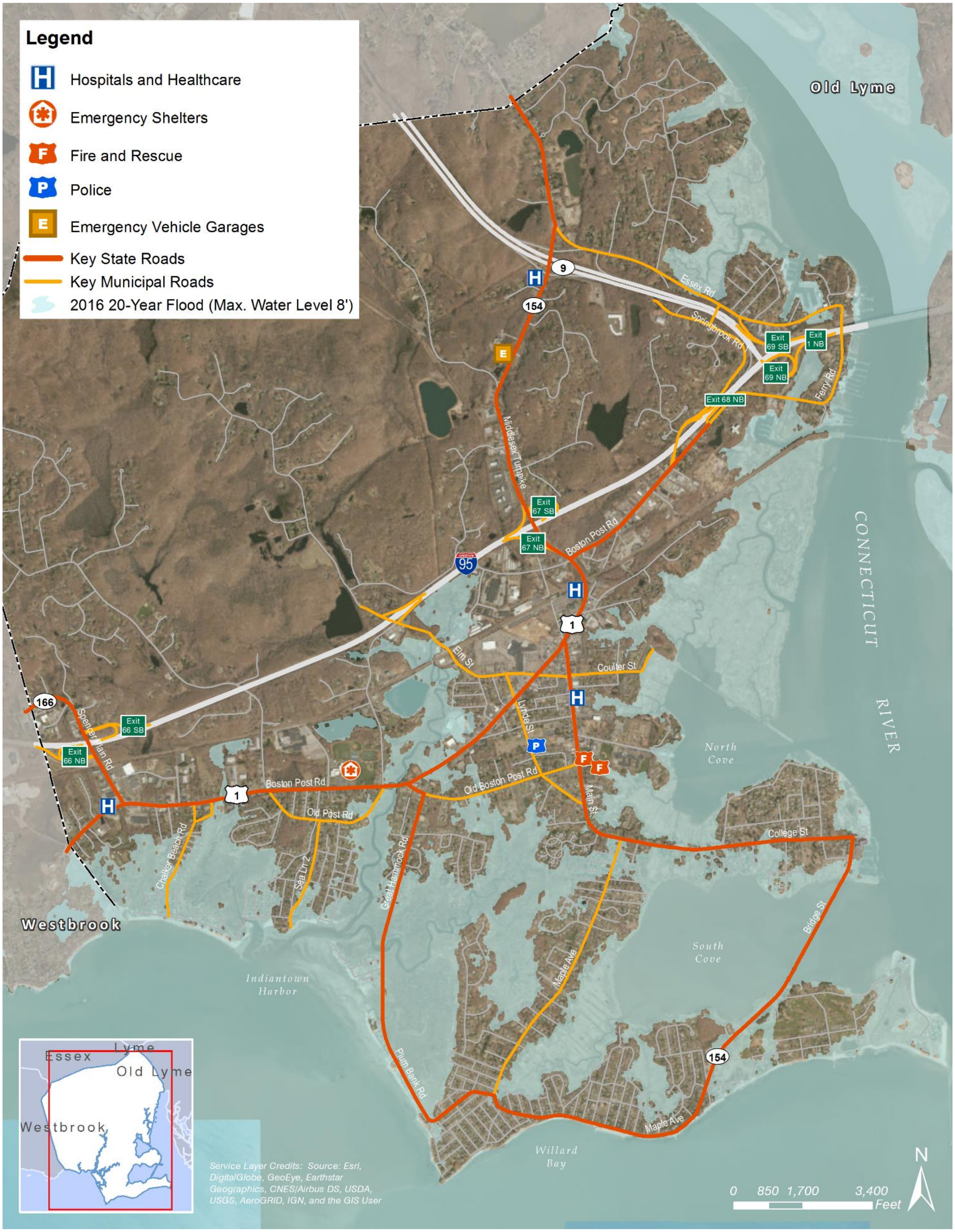


Figure 4-46: Current 50-year Return Period Key Road Flood Inundation

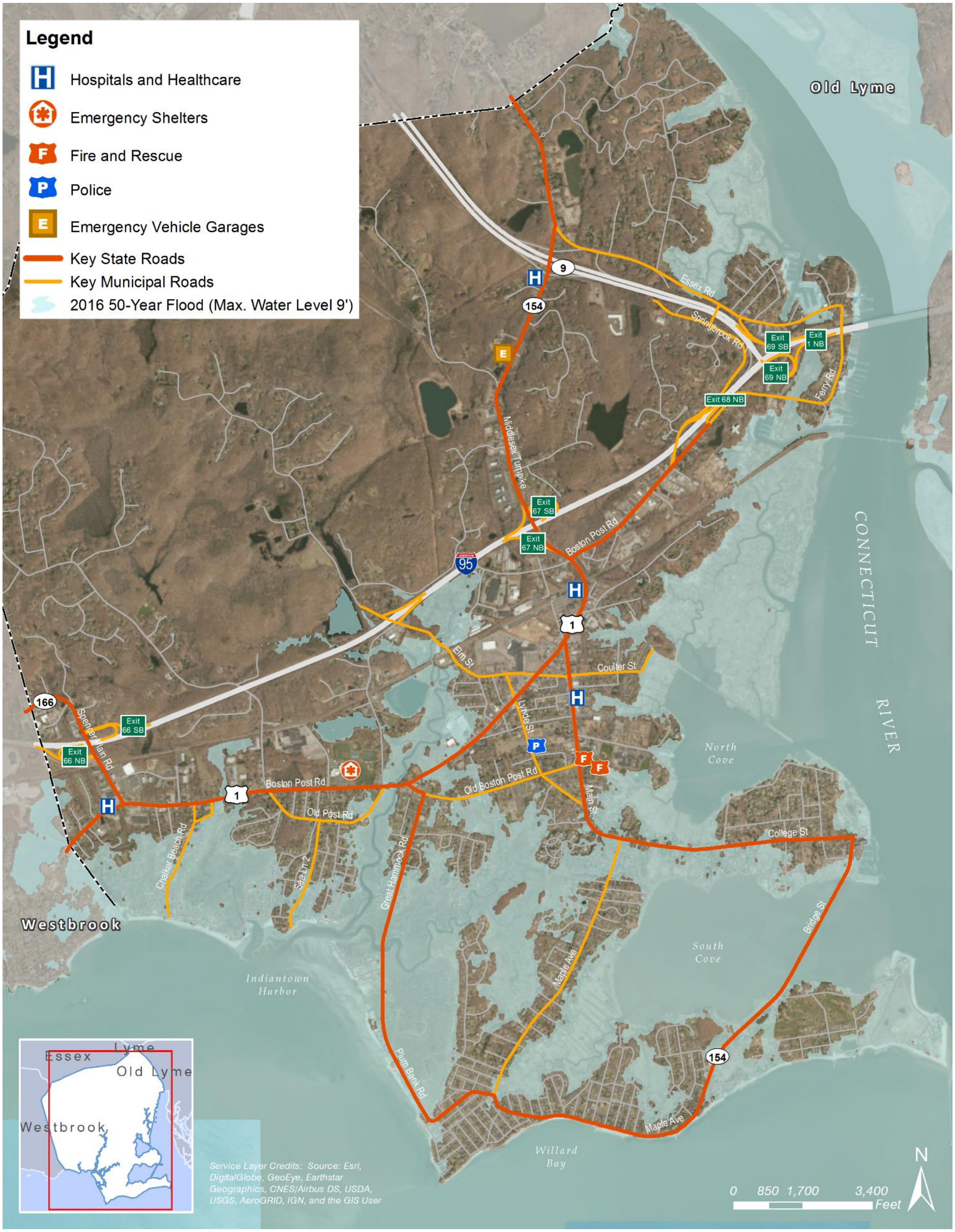


Figure 4-47: Current 100-year Return Period Key Road Flood Inundation

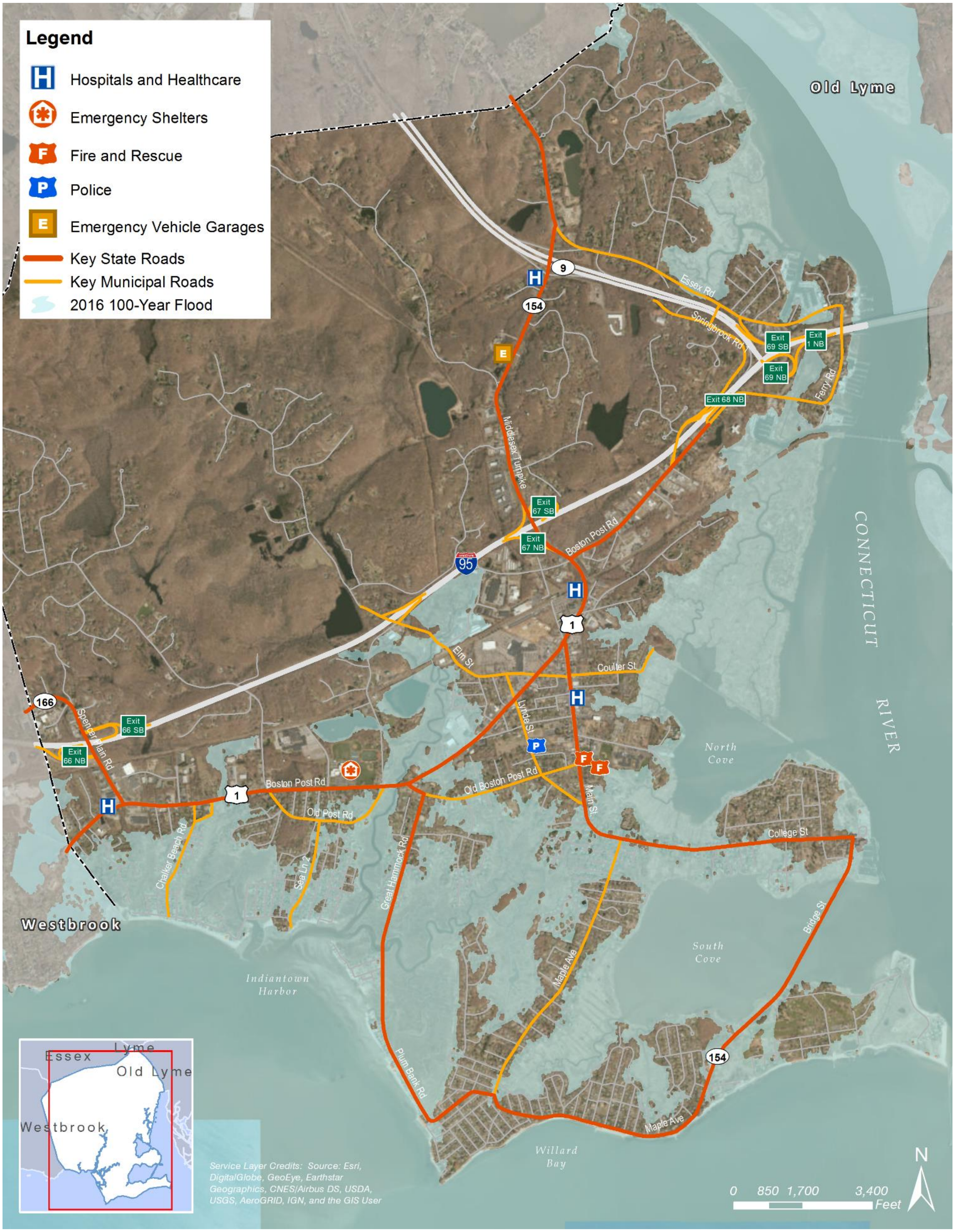


Figure 4-48: 500-year Return Period (2016) Flood Risk Key Road Inundation

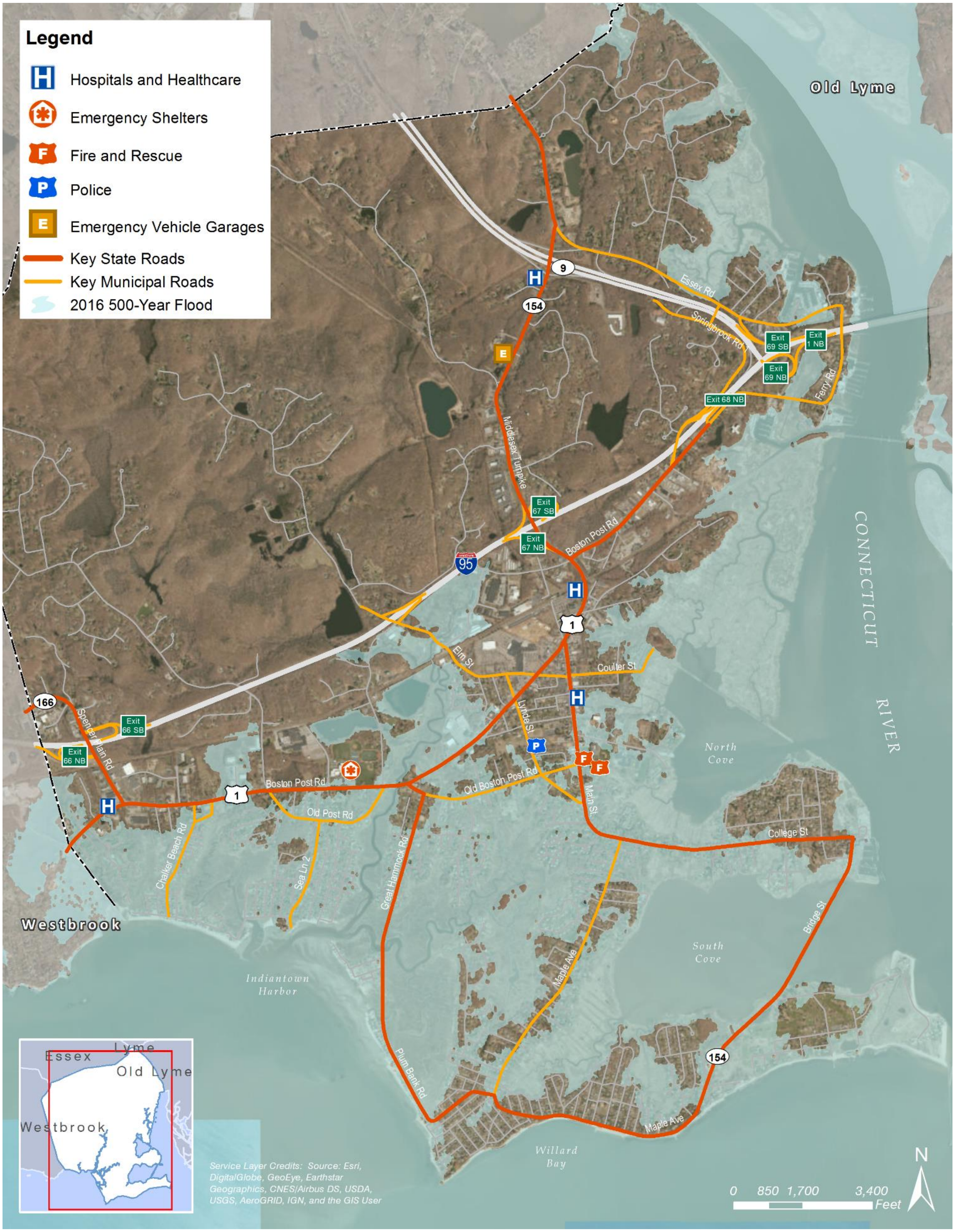


Figure 4-49: 100-year Return Period (2016) Roadway Flood Inundation Depths

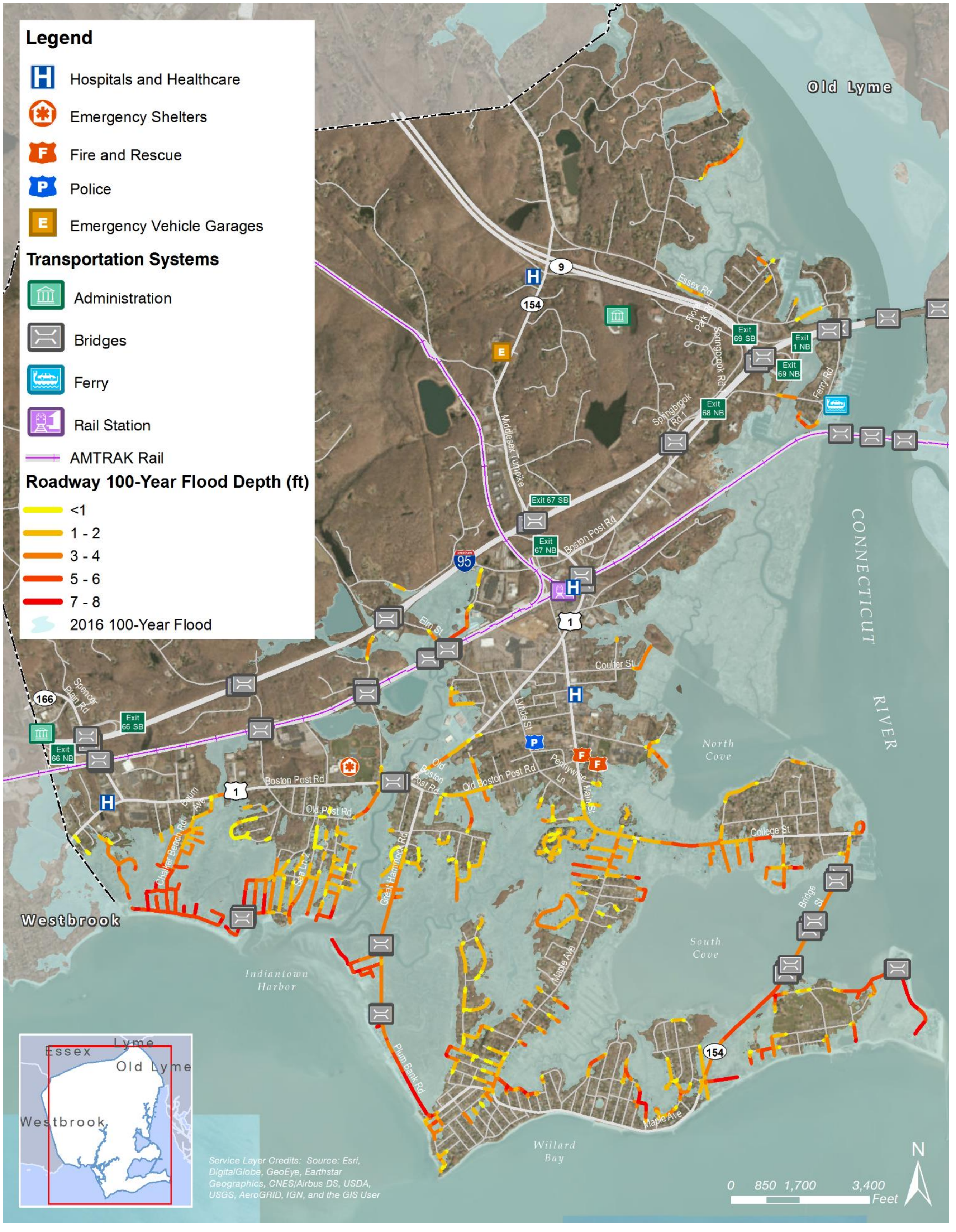
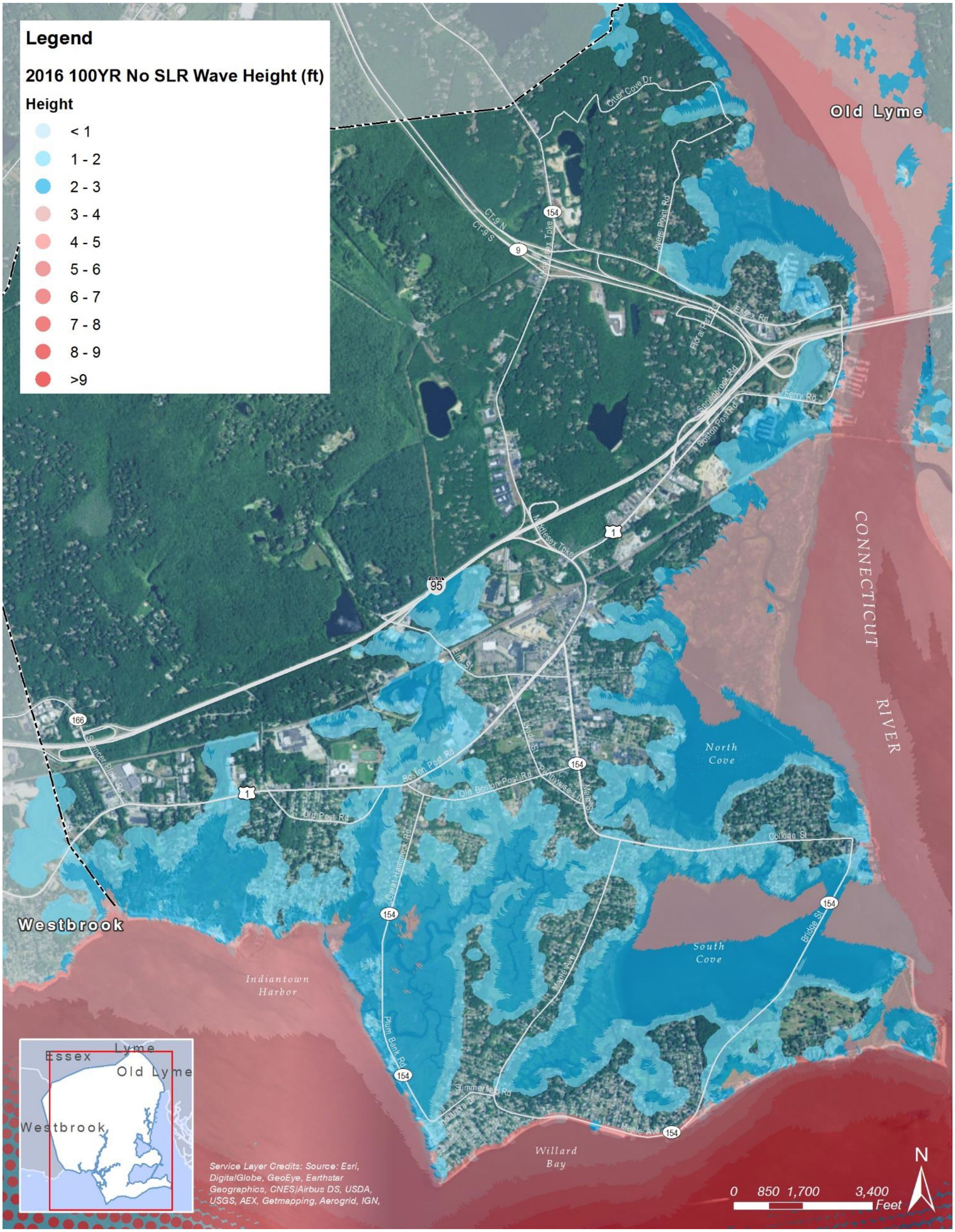


Figure 4-50: 100-year Return Period (2016) Wave Heights



Stormwater Management Infrastructure

Stormwater Management Infrastructure

Stormwater within Old Saybrook 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 sixty percent (%) of the town-wide system. While the data collected to-date is not complete, the data collected to-date includes:

- 108 Culvert Inflows
- 101 Culvert Outflows
- 2,217 storm water catch basins
- 204 outfalls
- 8 stormwater manholes

Figures 4-51 and 4-**52** present the mapped location of tide gates, catch basins, manholes, culverts and outfalls.

Piped stormwater is discharged via gravity flow to drainage outfalls to the Connecticut 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. (There are two tide gates in town that are used for control of tidal flow: one at Chalker Beach and another on the Oyster River just south of I-95 near Elm Street. The Chalker Beach tide gate is owned and managed by the Chalker Beach Association and Summerwood Condominiums. The Chalker Beach tide gate functions as a backflow reducer without manual controls. The Oyster River tide gate is owned and operated by the State of Connecticut and can be manually opened and closed.)

There is not, currently, available adequate information to do a detailed assessment of the effects of coastal flooding and sea level rise on the Town's stormwater management system. However, certain challenges to the Town's stormwater management system are evident:

- within low-lying areas such as the beach communities, there is limited elevation change to support gravity flow (either piped or surface run-off) during combined precipitation and coastal flood events, resulting in ponding and street flooding during these events;
- sea level rise will further reduce the hydraulic efficiency of stormwater infrastructure, and in low-lying areas outfalls without tide gates may experience surcharge of the system during high tides and frequent flood events;
- many outfalls are located in shoreline areas subject to erosion, scour and damage from long term and episodic beach erosion and wave-related damage;
- during extreme flood events, most of the stormwater catch basins and manholes located south of Interstate 95 will become inundated, resulting in significant maintenance requirements including sediment removal, etc. and potential for untreated discharge of pollutants that became mobilized during the flood;
- there are specific cases, such as Elm Street at Research Parkway where tidal and flood elevation at the outfall is expected to surcharge the system resulting in street flooding; and
- a likely outcome of climate change will be an increase in the intensity of precipitation (more precipitation and more frequent extreme precipitation events) resulting in greater demand on stormwater infrastructure.

While the stormwater management system is not expected to drain during extreme coastal flood events, it is important that it: 1) does not provide a source of localized flooding due to surcharging of catch basins and manholes; and 2) needs to be operable immediately after the storm to drain flooded areas. The stormwater management system south of I-95 is considered vulnerable to coastal flooding since most outfalls, catch basins and manholes do not have backflow prevention measures.

During the current 100-year recurrence interval flood (see **Figures 4-53** and **4-54**), the following structures will be inundated, with the potential for debris, sediment and pollutant impacts.

- Catch basins: 366 out of 2,217
- Culvert inflows: 13 out of 108
- Culvert Outflows: 20 out of 102
- Manholes: 4 out of 8
- Outfalls: 76 out of 204

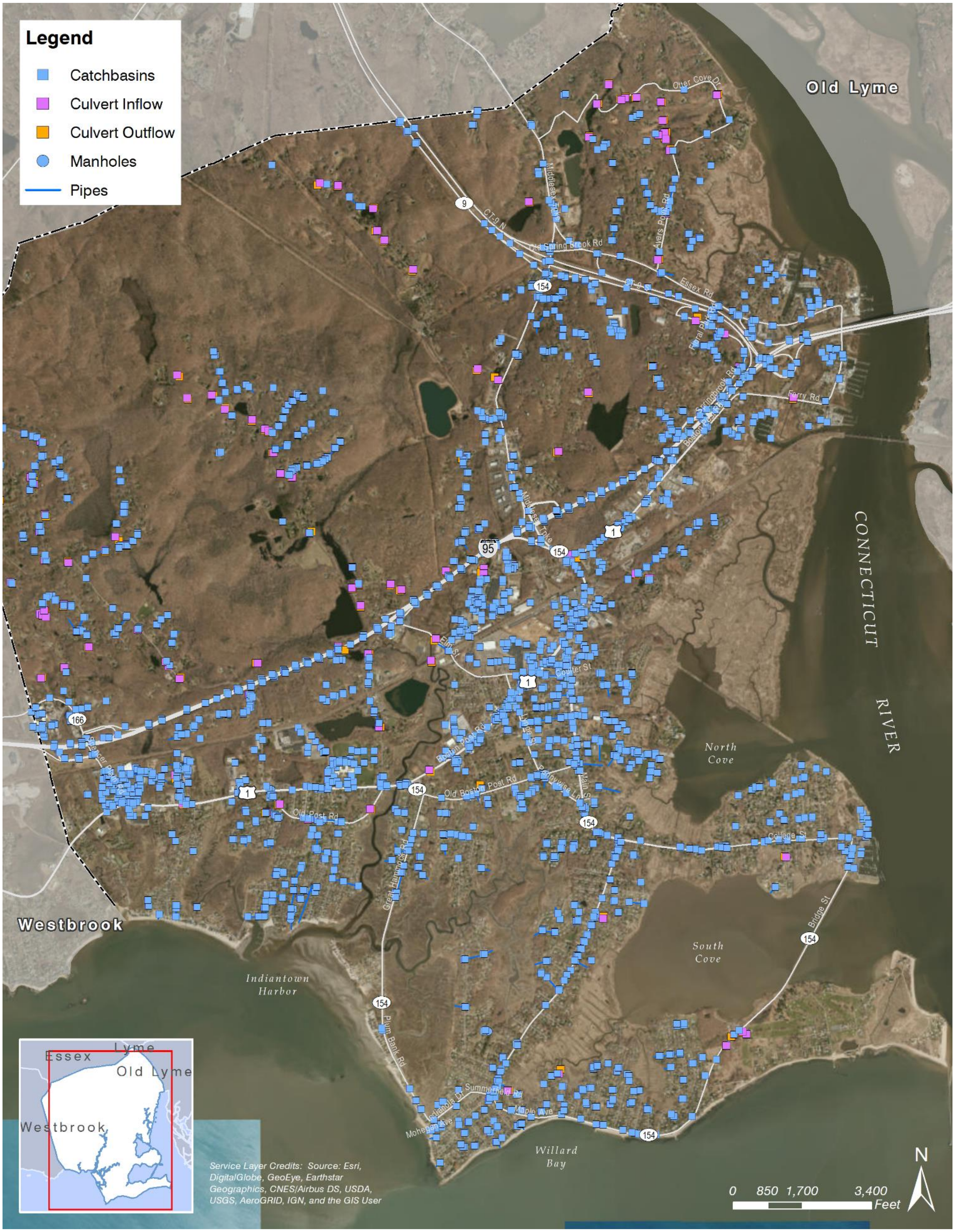


Figure 4-51: Stormwater Catch Basins and Culvert Inflows/Outflows

Figure 4-52: Stormwater Outfalls and Tide Gates

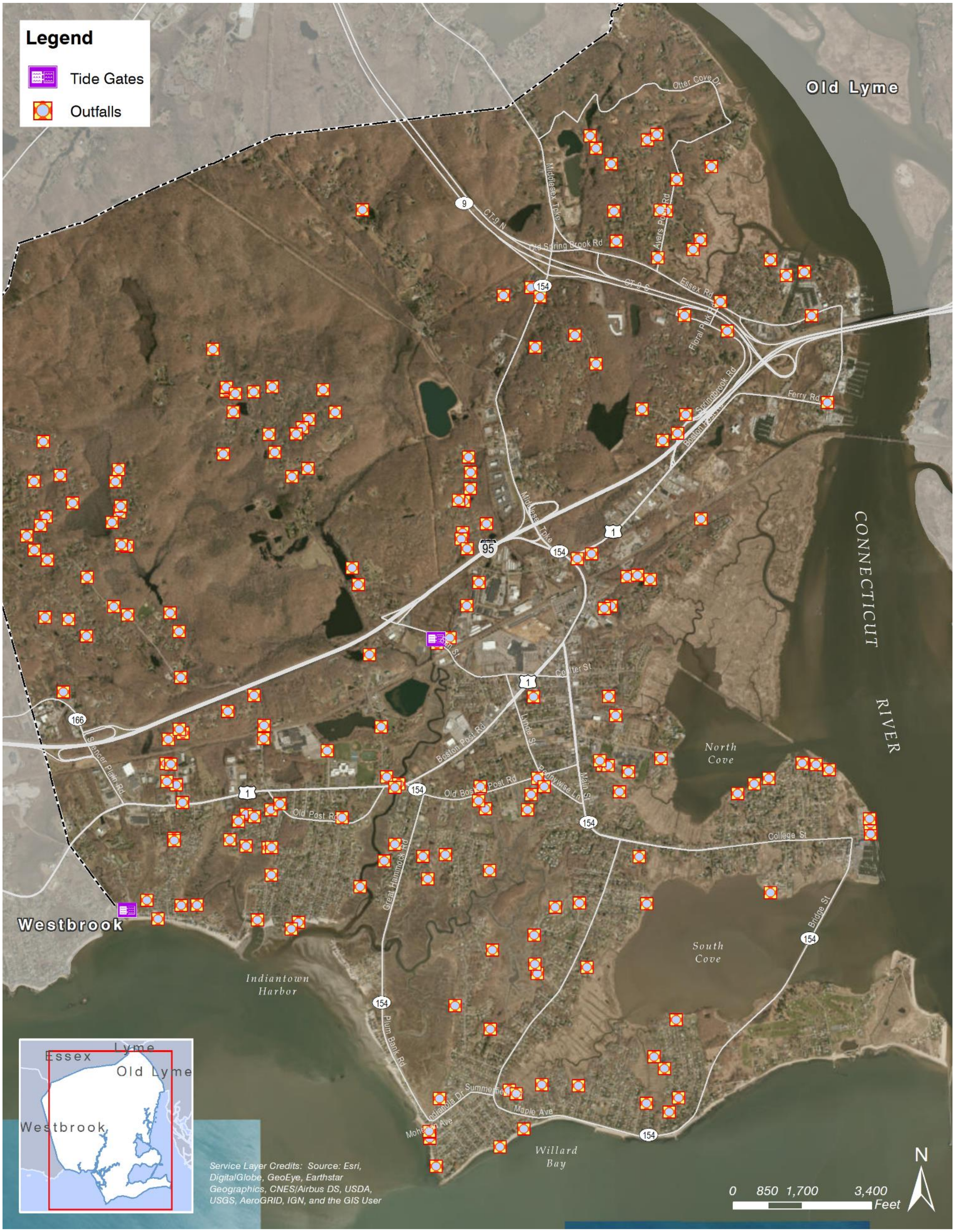


Figure 4-53: Stormwater Catch Basins, Manholes and Culverts and 100-year Recurrence Interval Flood Inundation

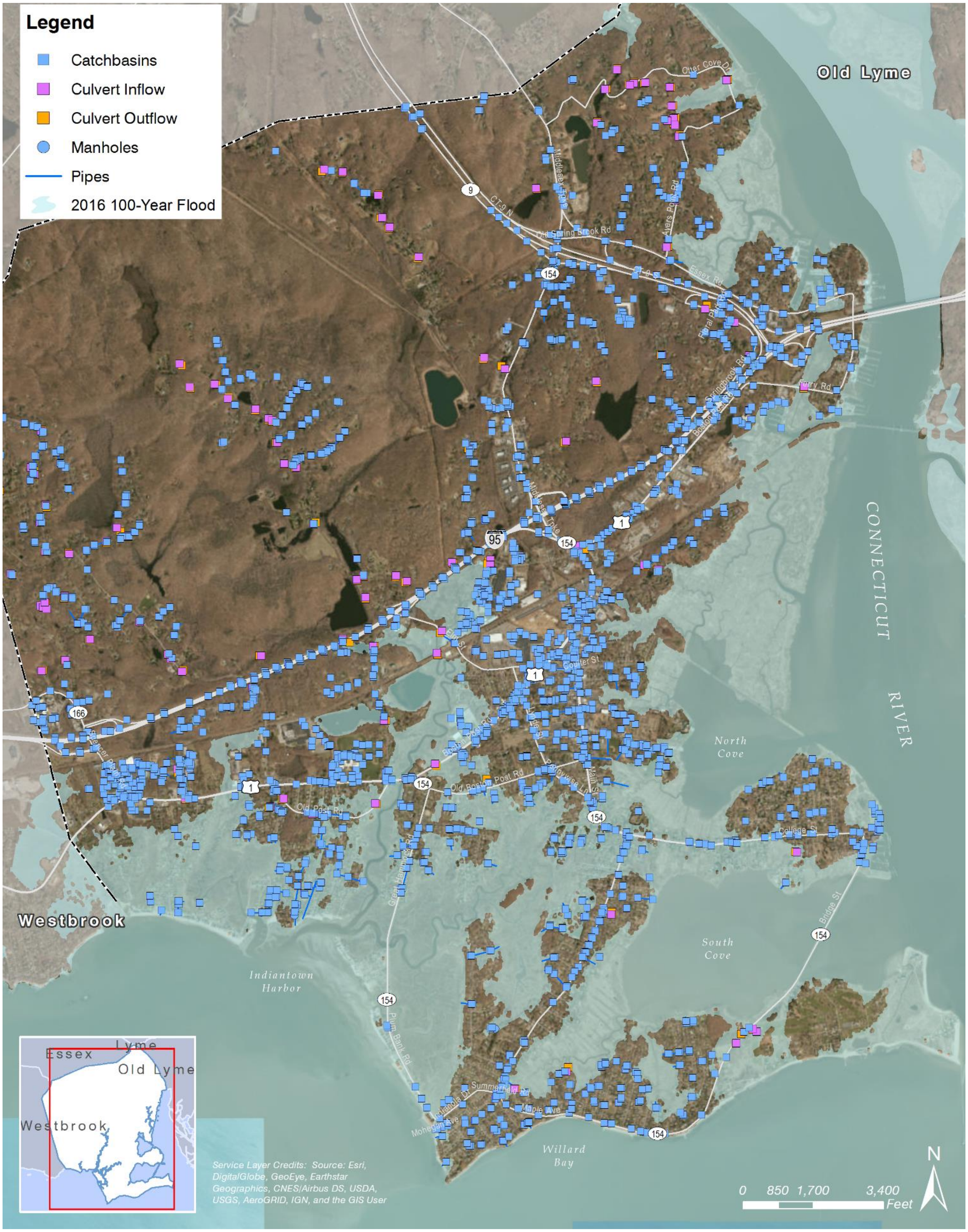
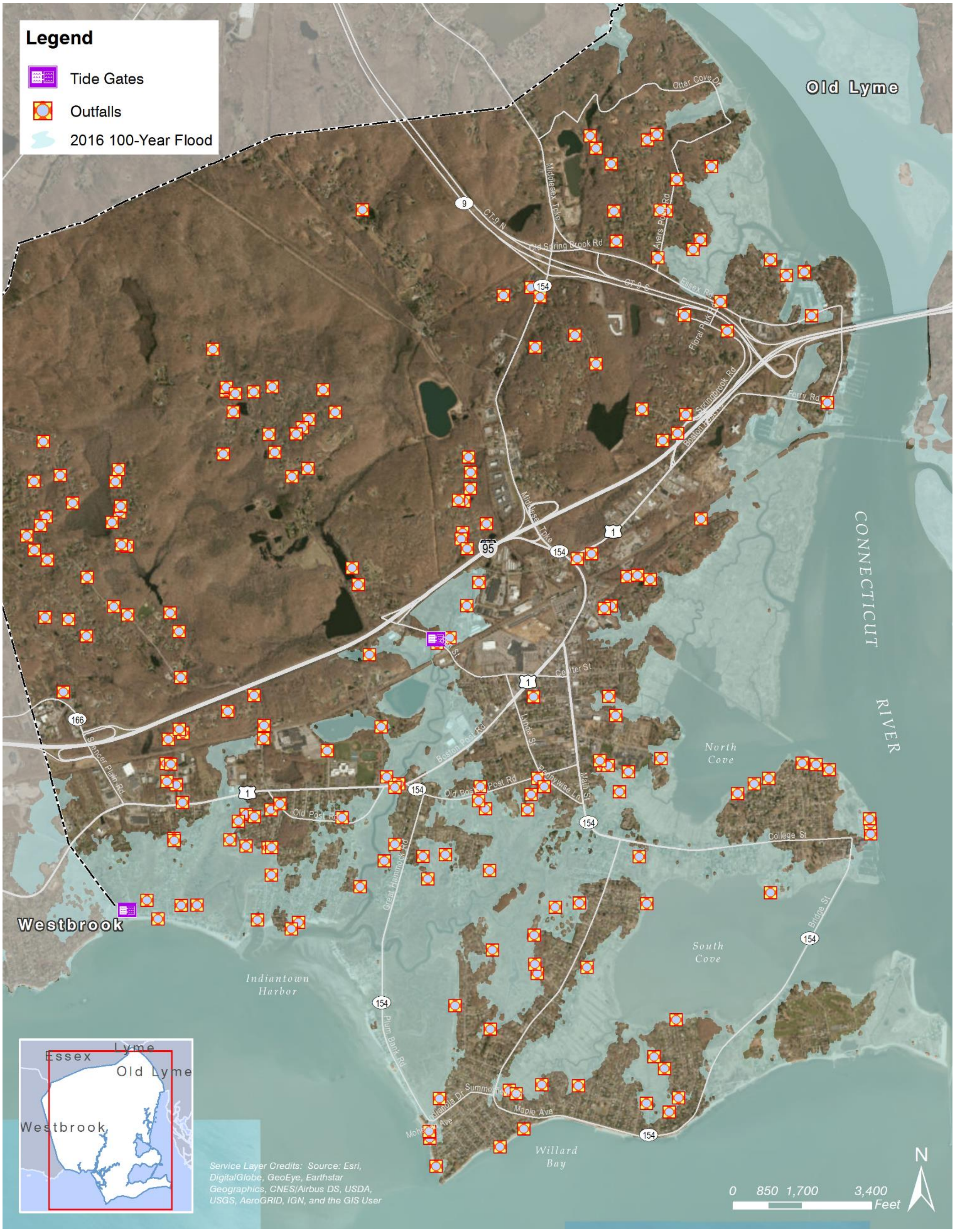


Figure 4-54: Stormwater Outfalls; Tide Gates and 100-year Recurrence Interval Flood Inundation



Natural Resources - Marshes

Natural Resources - Marshes

This section discusses the vulnerability of the Town's tidal salt marshes to coastal flooding and the effects of sea level rise. Maintaining the marshes in the future will require on-going management and restoration activities, planning to accommodate potential changes to habitat, and possible changes to Town land use policies. This section utilizes the results of two key marsh studies:

1. An assessment performed by the Nature Conservancy, entitled "A Salt Marsh Advancement Zone Assessment of Old Saybrook, Connecticut"; and
2. The study "Application of the Sea-Level Affecting Marsh Model to Coastal Connecticut", prepared for the New England Interstate Water Pollution Control Commission by Warren Pinnacle Consulting, Inc.

Tidal Marshes and Wetlands: Much of the Old Saybrook land area south of Interstate 95 consists of intertidal salt marshes and tidal wetlands. The largest intertidal marsh systems are: 1) the Plum Bank Marsh Wildlife Area (around the Plum Bank, Oyster and Back Rivers and abutting Long Island Sound); 2) Ragged Rock Creek Marsh Wildlife Area (located around the Ragged Rock Creek and abutting the Lower Connecticut River); 3) the Hager Creek Marsh Wildlife Area (located around Hager and Mud Creeks, abutting Long Island Sound); 4) the Ferry Point Marsh Wildlife Area (abutting the Lower Connecticut River); and 5) the South Cove Wildlife Area (around Beamon Creek and abutting the South Cove).

Lower Connecticut River: In the vicinity of Old Saybrook, the Lower Connecticut River is a tidal estuary and has extensive fresh and brackish tidal wetlands. It also has diverse and critical habitat and is recognized as containing "Wetlands of International Importance" under the intergovernmental Ramsar Convention. As a tidal estuary, with direct connection to Long Island Sound, the Lower Connecticut River shorelines experience water level fluctuations from both tides and coastal storm surges.

Brooks, Creeks and Rivers: The Old Saybrook tidal wetlands and marshes are fed and drained by brooks, creeks and rivers, which discharge into the Lower Connecticut River and Long Island Sound. These include Ragged Rock Creek (Lower Connecticut River), Beamon Creek (South Cove and the Lower Connecticut River), Plum Bank, Back, Hagar and Mud Creeks, Oyster River and Back River (Long Island Sound). Several of these waterways extend upland of the tidal marshes and wetlands, including Oyster River and Fishing Brook, which are hydraulically connected. Coastal flooding propagates inland up these rivers and connect to lakes and ponds (Crystal Lake, Chalkers Millpond and Ingham Ponds).

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.

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.

MARSH VULNERABILITY- SEA LEVEL RISE

The following paragraphs are drawn extensively from "Application of the Sea-Level Affecting Marsh Model to Coastal Connecticut", prepared for the New England Interstate Water Pollution Control Commission by Warren Pinnacle Consulting, Inc.

The marshes provide ecological and human benefits, including habitat for fish, shellfish, birds, and other wildlife as well as recreational value and some protection for inland areas from coastal flooding. However, they are highly susceptible to sea level rise and climate change due to:

- land subsidence;
- rapid changes to water depth;
- marsh substrate;
- sea level rise rate relative to sedimentation rate;
- frequency of inundation;
- changes in tidal flow patterns;
- landward migration of tidal waters;
- changes in salinity, water acidity and oxygen content;
- increased flood vulnerability; and
- species diversification.

Climate-related changes to precipitation rates can also impact freshwater inflows and sediment delivery. Each of these effects can result in habitat stress and loss. The interaction of each of these conditions is very complex. In general, the amount of habitat stress and loss is a function of how fast sea levels will rise relative to plant growth and sediment accretion rates and the rate of below-ground decomposition. If the vertical build rate of the tidal marshes is not fast enough to keep pace with sea level rise, the wetlands will convert to open water or tidal flats.

Because of the complexity of the various factors affecting a marsh's fate, a simple comparison of current marsh elevations to future projections of sea level does not accurately predict wetland vulnerability to sea level rise. Model evaluations of Connecticut's tidal wetlands have been performed by others using the Sea Level Affecting Marshes Model (SLAMM). SLAMM is widely recognized as an effective model to predict wetland response to long term sea level rise. A fundamental assumption in SLAMM is that individual wetland types inhabit a range of vertical elevation that is a function of the local tide range. The SLAMM model computes relative sea level rise for each area at different time steps that is offset by observed and modeled marsh accretion and other factors affecting marsh surface elevation. The following figure, reproduced from the study (with an original source of Titus and Wang, 2008) illustrates the relationship between tides, wetlands and reference elevations for estuarine marsh profiles.

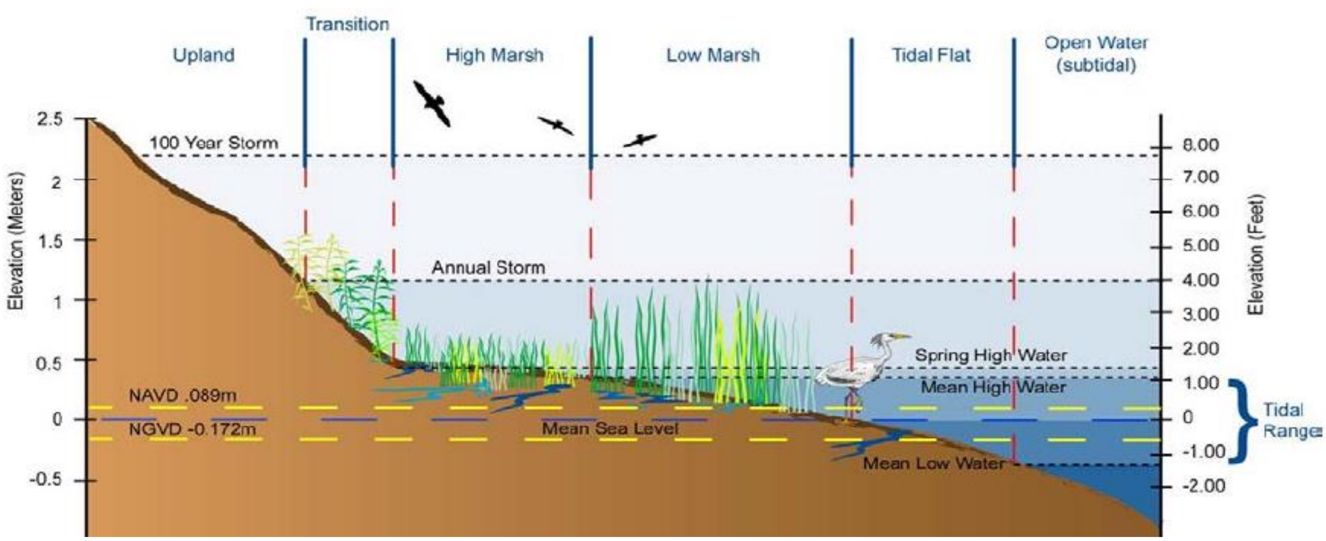


Figure 4-55: Relationship between Tides, Wetlands and Reference Elevations for Typical Connecticut Estuarine Marsh Profiles

As shown on the figure, tidal marshes are typically categorized into two distinct zones: the lower or intertidal marsh and the upper or high marsh. In saline tidal marshes, the low marsh is normally covered and exposed daily by the tide. It is predominantly covered by the tall form of Smooth Cordgrass **(**Spartina alterniflora**).** The high marsh is covered by water only sporadically and is characterized by Short Smooth Cordgrass, Spike Grass and Saltmeadow Rush (Juncus gerardii). Saline marshes support a highly specialized set of life adapted for saline conditions.

SLAMM simulations were run in the study from the date of the initial wetland cover layer to 2100. Maps and numerical data were output for the years 2025, 2055, 2085, and 2100. The following table shows SLR rates relative to the base year of 2002 used in the four scenarios applied to the Connecticut SLAMM model.

Scenario	2025 (meters/feet)	2055 (meters/feet)	2085 (meters/feet)	2100 (meters/feet)
Global Climate Model Maximum	0.13/0.4	0.31/1.0	0.58/1.9	0.72/2.4
1 m by 2100	0.13/0.4	0.43/1.4	0.81/2.7	1.0/3.3
Rapid Ice Melt Minimum	0.13/0.4	0.48/1.6	1.0/3.3	1.3/4.3
Rapid Ice Melt Maximum	0.25/0.8	0.74/2.4	1.4/4.6	1.72/5.6

Table 4-17: Sea Level Rise under Different Climate Change Scenarios Relative to the Base Year of 2002 assumed in SLAMM Simulations (from "Application of SLAMM to Coastal Connecticut", Final Report, 2015)

The "Old Saybrook Coastal Community Resilience Study" provides a detailed discussion of sea level rise projections applicable to Old Saybrook. Historic sea level rise in Long Island Sound has been on the order of 2.56 mm/yr to 2.85 mm/yr. The following table and figure summarize relative sea level rise projections utilized by NOAA and the US Army Corps of Engineers (USACE) for the New London NOAA tide gage. Projected sea level rise for 2025 ranges from 0.3 to 0.5 foot; 2055 ranges from 0.2 to 2.2 feet; 2085 ranges from 0.4 to 4.8 feet; and 2100 ranges by 0.5 to 6.5 feet.

The SLAMM Global Climate Change Model Maximum sea level rise scenario is slightly higher than the USACE Intermediate projection. The USACE Intermediate projection has "possible to certain" chance of occurrence by 2100. The SLAMM Rapid Ice Melt Maximum sea level rise scenario is slightly lower than the USACE High projection. The USACE High RSLC projection has a "very low to moderate" chance of occurrence.

The wetland boundary elevation (WBE) in SLAMM defines the boundary between coastal wetlands and dry lands (including non-tidal wetlands). Generally, the elevation defining the upland boundary of coastal wetlands (from dry lands and non-coastal wetlands) is approximated by the elevation inundated once every 30 days, during spring high water. For Connecticut, however, this boundary was determined in the study using the mean higher, high water (MHHW) elevation taken from a 5 year analysis of NOAA tide gauge data.

In tidal marshes, increasing inundation can lead to additional deposition of inorganic sediment that can help tidal wetlands keep pace with rising sea levels (original source Reed 1995). It is also observed that salt marshes will often grow more rapidly at lower elevations allowing for further inorganic sediment trapping (original source Morris et al. 2002). SLAMM considers such feedback loops in its modelling of marsh surface elevation change.

8461490, New London, CT
NOAA's Published Rate: 0.00738 feet/yr
All values are expressed in feet relative to NAVD88

Year	USACE Low NOAA Low	USACE Int NOAA Int Low	NOAA Int High	USACE High	NOAA High
2002	-0.2	-0.2	-0.2	-0.2	-0.2
2005	-0.2	-0.2	-0.2	-0.1	-0.1
2010	-0.2	-0.1	-0.1	-0.0	-0.0
2015	-0.1	-0.1	0.0	0.1	0.1
2020	-0.1	-0.0	0.1	0.2	0.3
2025	-0.1	0.0	0.3	0.3	0.5
2030	-0.0	0.1	0.4	0.5	0.7
2035	0.0	0.2	0.5	0.7	1.0
2040	0.1	0.3	0.7	0.9	1.2
2045	0.1	0.3	0.9	1.1	1.5
2050	0.1	0.4	1.1	1.4	1.8
2055	0.2	0.5	1.3	1.6	2.2
2060	0.2	0.6	1.5	1.9	2.6
2065	0.2	0.7	1.8	2.2	3.0
2070	0.3	0.8	2.0	2.5	3.4
2075	0.3	0.9	2.3	2.9	3.8
2080	0.4	1.0	2.6	3.2	4.3
2085	0.4	1.2	2.9	3.6	4.8
2090	0.4	1.3	3.2	4.0	5.3
2095	0.5	1.4	3.5	4.4	5.9
2100	0.5	1.5	3.8	4.8	6.5

Print Table

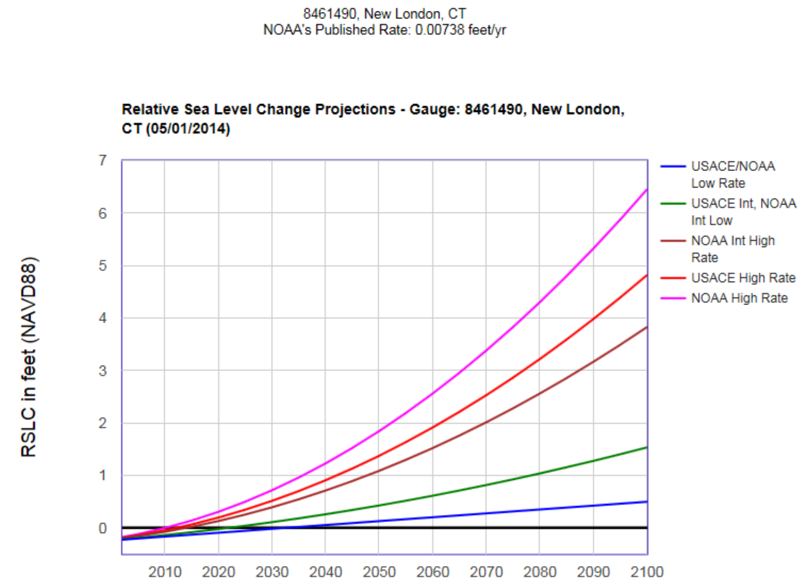
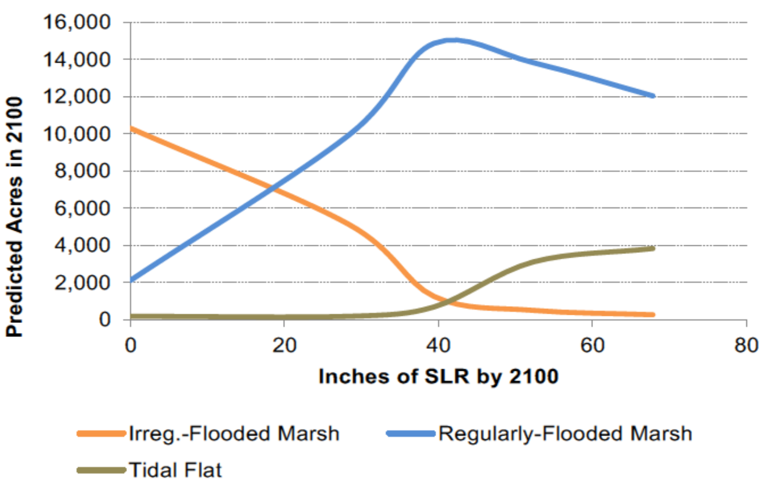


Table 4-18 and Figure 4-56: US Army Corps of Engineers Relative Sea Level Rise Change (RSLC) Projections (2002 to 2100)

The following figure shows the relationship between salt marsh types as SLR increases for the entire coastal Connecticut. Similar to Old Saybrook, irregularly-flooded (high) marsh currently dominates the Connecticut intertidal landscape. However, as relative sea level rise increases, more frequent inundation will increase the salinity in these marshes and lower their elevation relative to the tides, converting them to the regularly-flooded or low marsh. The predicted year 2100 marshes will little resemble the 2010 high marsh-low marsh complex compositions. As shown in **Figure 4-57**, under the 1 meter (40 inches) SLR by 2100 scenario, low marsh also begins to decline when SLR exceeds 40 inches as it is largely replaced with non-vegetated tidal flats or open water.

Figure 4-57: Relationship between Marsh Transformation and Sea Level Rise



One trend noted throughout the SLAMM study area is that as the tide range decreases from west to east along Connecticut's coast, marshes are predicted to be more vulnerable to SLR along this geographic gradient (e.g., Old Saybrook). This is because intertidal marsh is generally restricted to elevations between mean low water to spring high tide. A greater tidal range in the west, therefore, provides a greater vertical elevation range capable of supporting marsh vegetation than regions to the east with a smaller tide range. Applying a uniform relative sea level rise rate throughout Long Island Sound, and assuming that other factors affecting marsh sustainability (e.g., available upland marsh migration areas, marsh crab herbivory, etc.) are held constant, will result in a greater proportion of existing marsh conversions in eastern Long Island Sound.

Similarly, the long-term sustainability of a marsh is affected by the position of its platform, or surface, within its tidal frame. For example, two marshes with similar tidal ranges but different initial marsh surface elevations can respond differently under the same relative sea level rise scenario. Higher elevation marshes are described as having more 'elevation capital' and are therefore able to withstand additional sea level rise before converting to a tidal flat or open water or 'drowning.'

Figure 4-58 presents the SLAMM model 2010 Initial Land Cover map and indicates the current status of the marshes and tidal wetlands within Old Saybrook. Most of the tidal marshes are characterized as irregularly-flooded marsh (High Marsh), with sections of the marshes inundated tidally. High Marshes are general located between the MHHW elevation and the 1-year return period flood.

Figures 4-59 through **4-60** presents the SLAMM model results for Global Climate Change Model Maximum sea level rise scenario. Under this scenario, significant changes to the marshes do not begin to occur until the year 2085, corresponding to about < 2 feet of relative sea level rise. At this amount of sea level rise, portions of the irregular flooded marsh (High Marsh) converts to regularly flooded marsh (Low Marsh). This process continues through 2100 (about 2.5 feet relative sea level rise) with increased percentage of the marsh converting to regularly flooded marsh (Low Marsh). At this point about half of Old Saybrook's marshes are Low Marsh.

Figures 4-61 through **4-62** presents the SLAMM model results for Rapid Ice Melt maximum sea level rise scenario. Under this scenario, significant changes to the marshes begin between 2025 and 2055, at which point most of Old Saybrook's marshes have converted into Low Marsh. Significant loss of beach has also occurred. By 2085, much of the marsh has converted to tidal flat. By 2100, almost all of the marsh is lost and has converted to open estuary water and tidal flat, with almost no beach barrier.

Comparison between these two sets of figures illustrates that the effect of sea level rise is not just a function of the amount of sea level rise but also the rate of relative sea level change. The higher rate of sea level change under the SLAMM Rapid Ice Melt Maximum sea level rise scenario, relative to the SLAMM Global Climate Change Model Maximum sea level rise scenario, results in more significant marsh transformation since the rate of sea level rise under the former scenario is occurring faster than the natural marsh accretion rates.

Figure 4-58: SLAMM Initial Land Cover

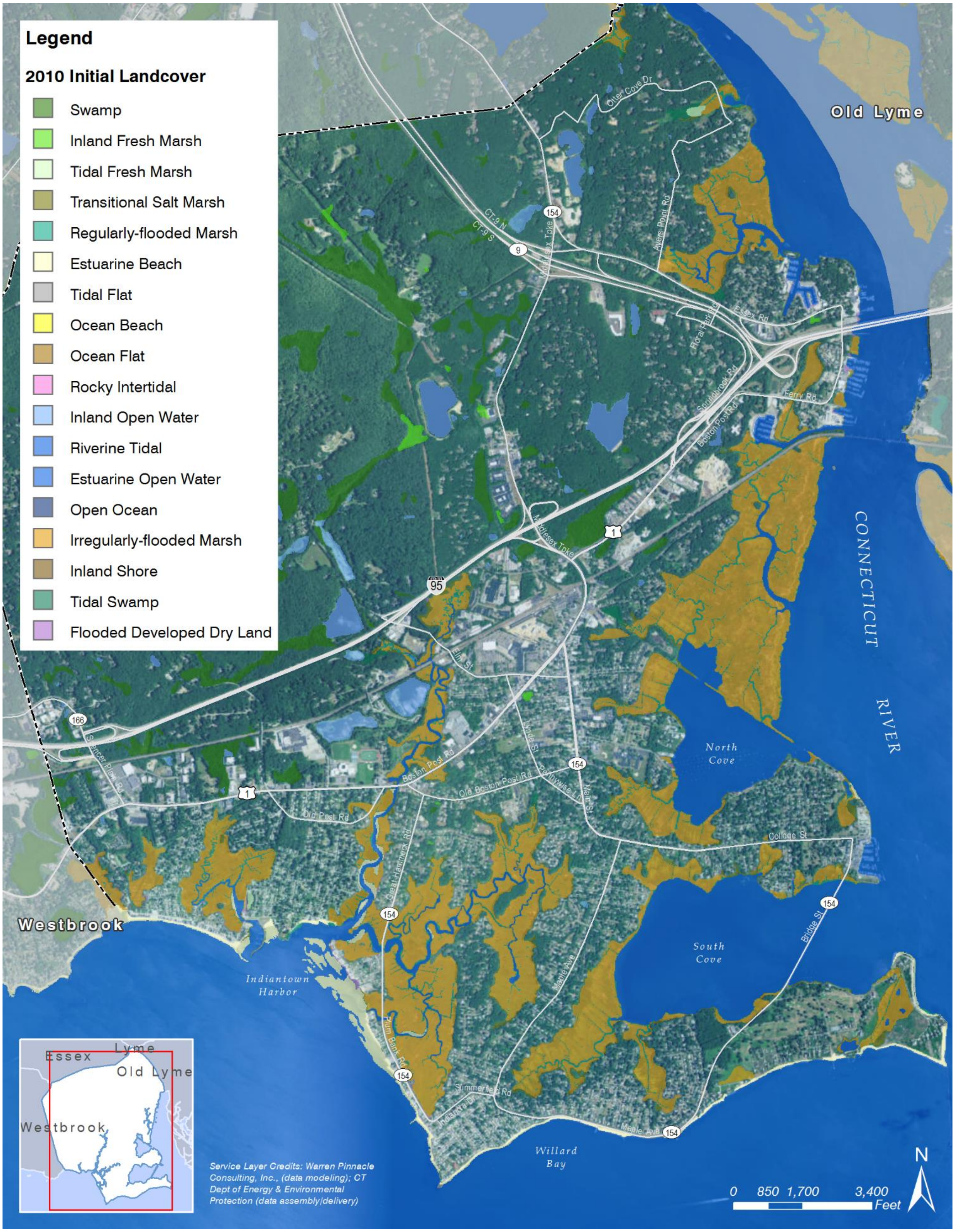


Figure 4-59: SLAMM 2025 Model Maximum Sea Level Rise

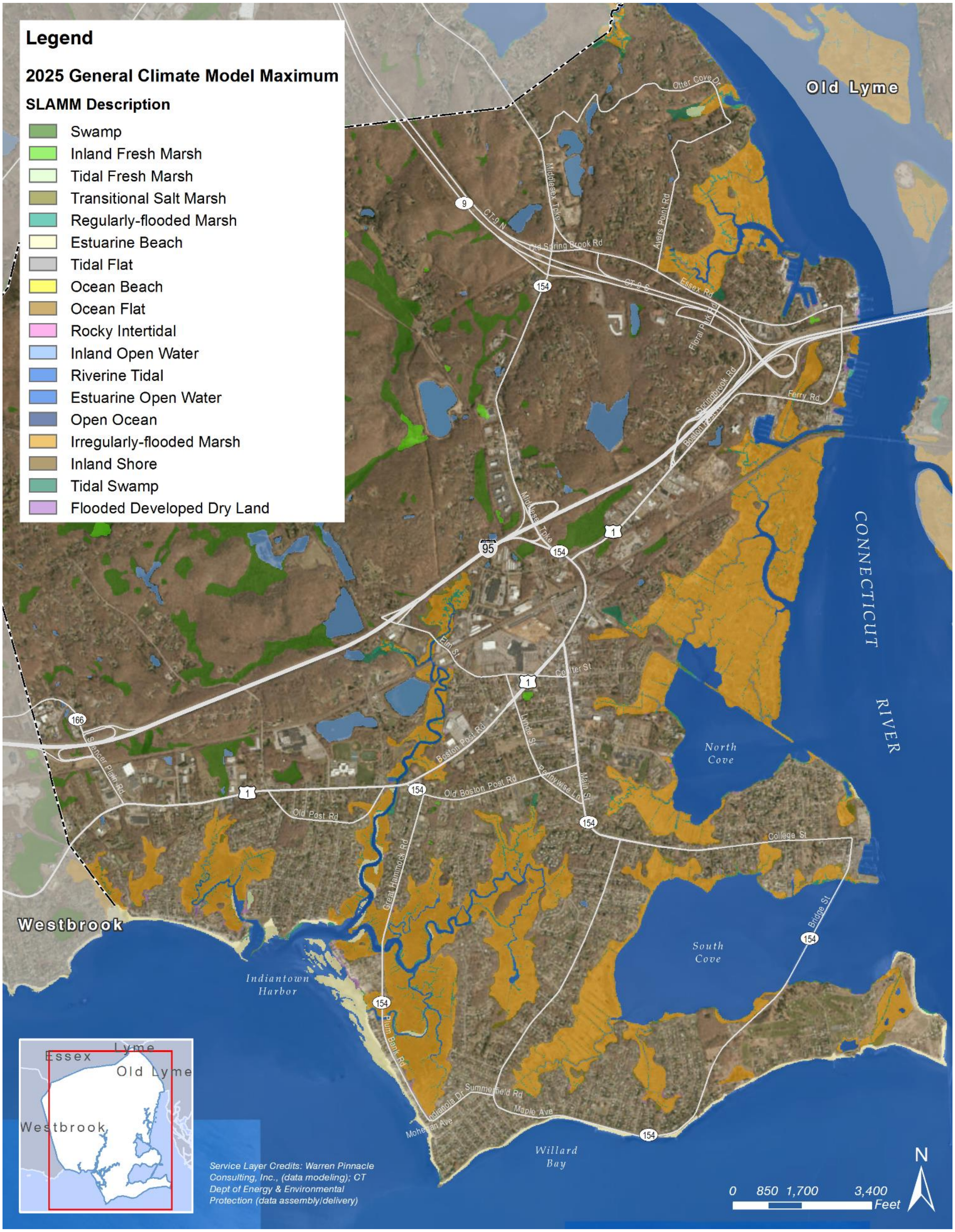


Figure 4-60: SLAMM 2055 Model Maximum Sea Level Rise

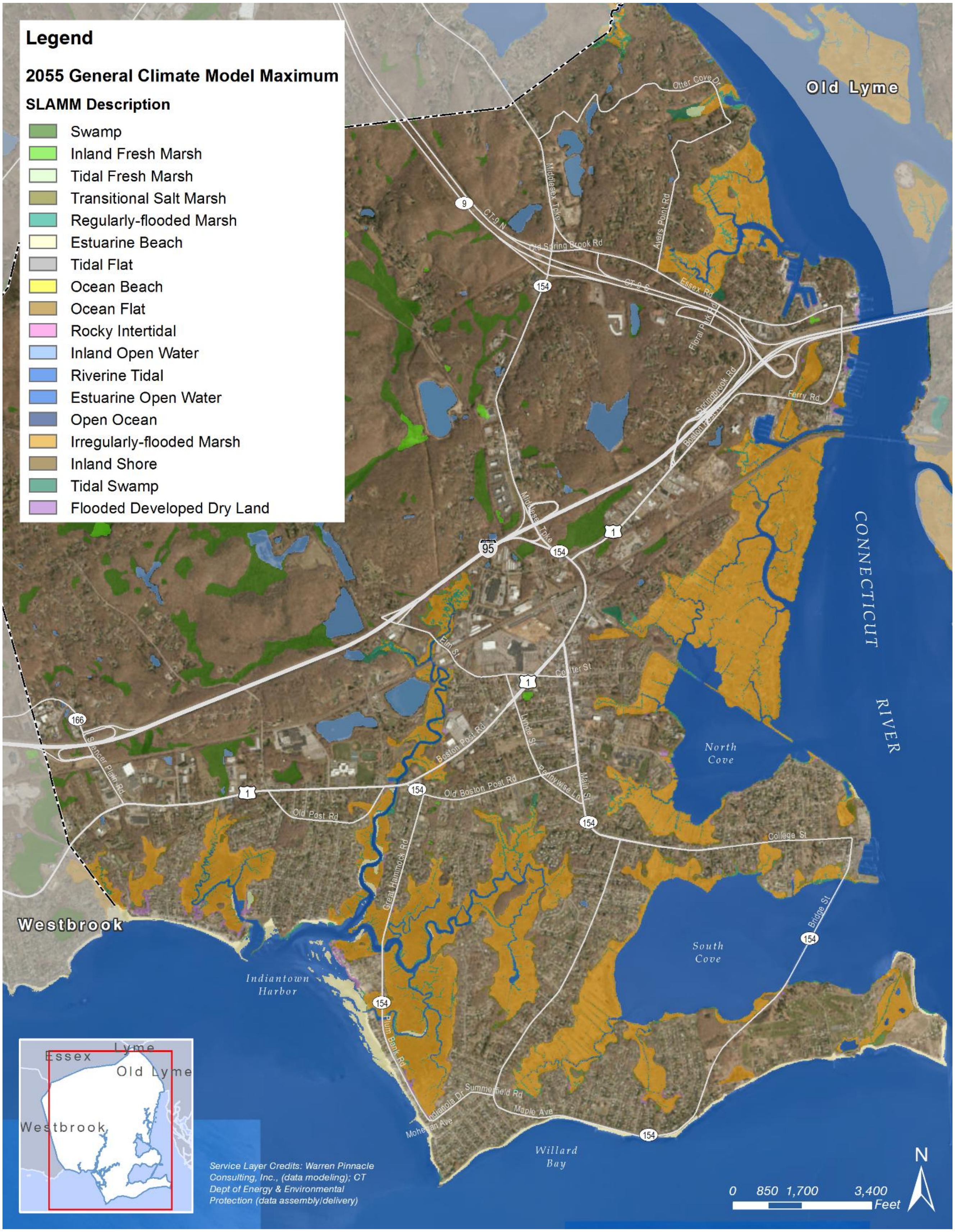


Figure 4-61: SLAMM 2085 Model Maximum Sea Level Rise

Figure 4-62: SLAMM 2100 Model Maximum Sea Level Rise

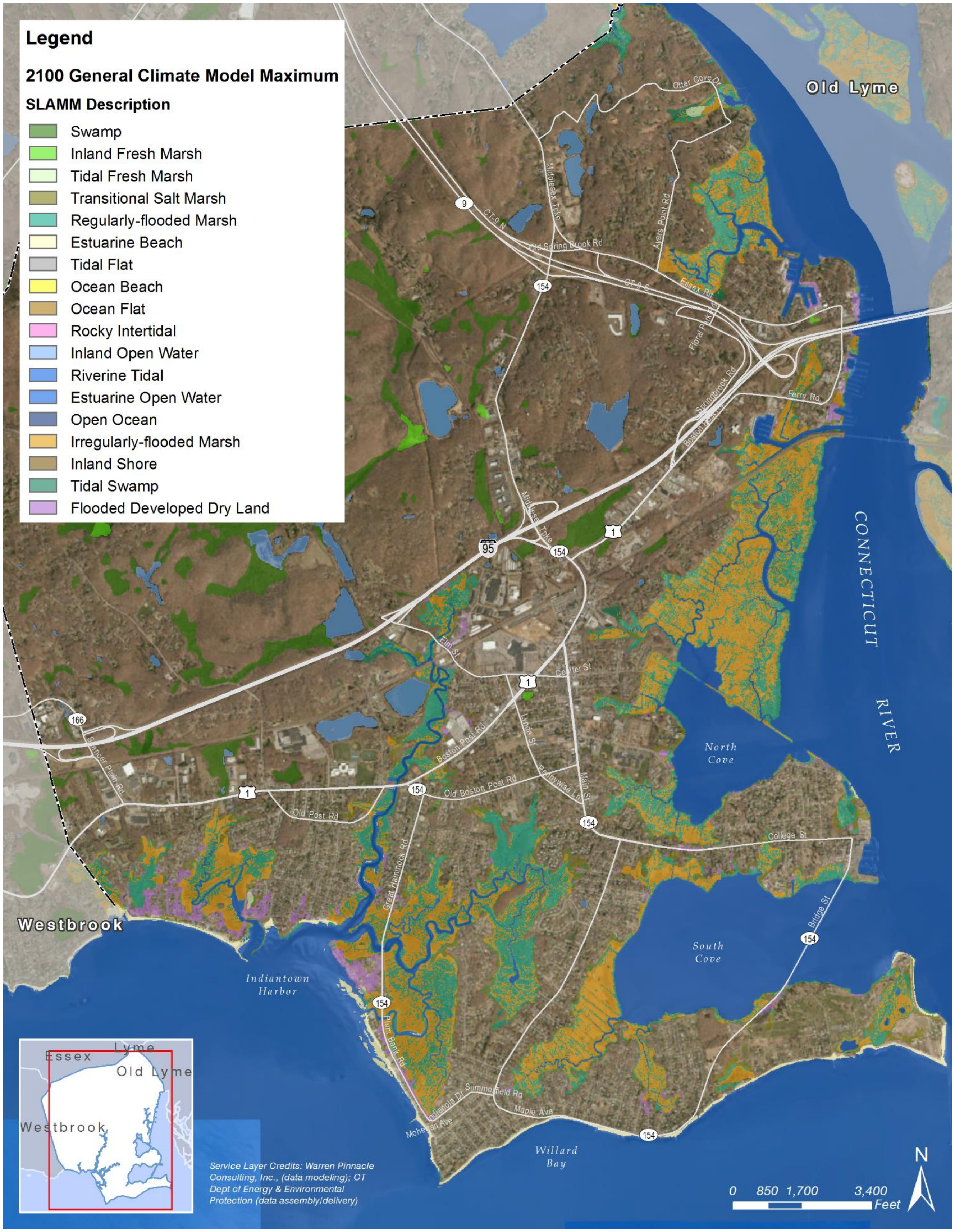


Figure 4-63: SLAMM 2025 Rapid Ice Melt Sea Level Rise

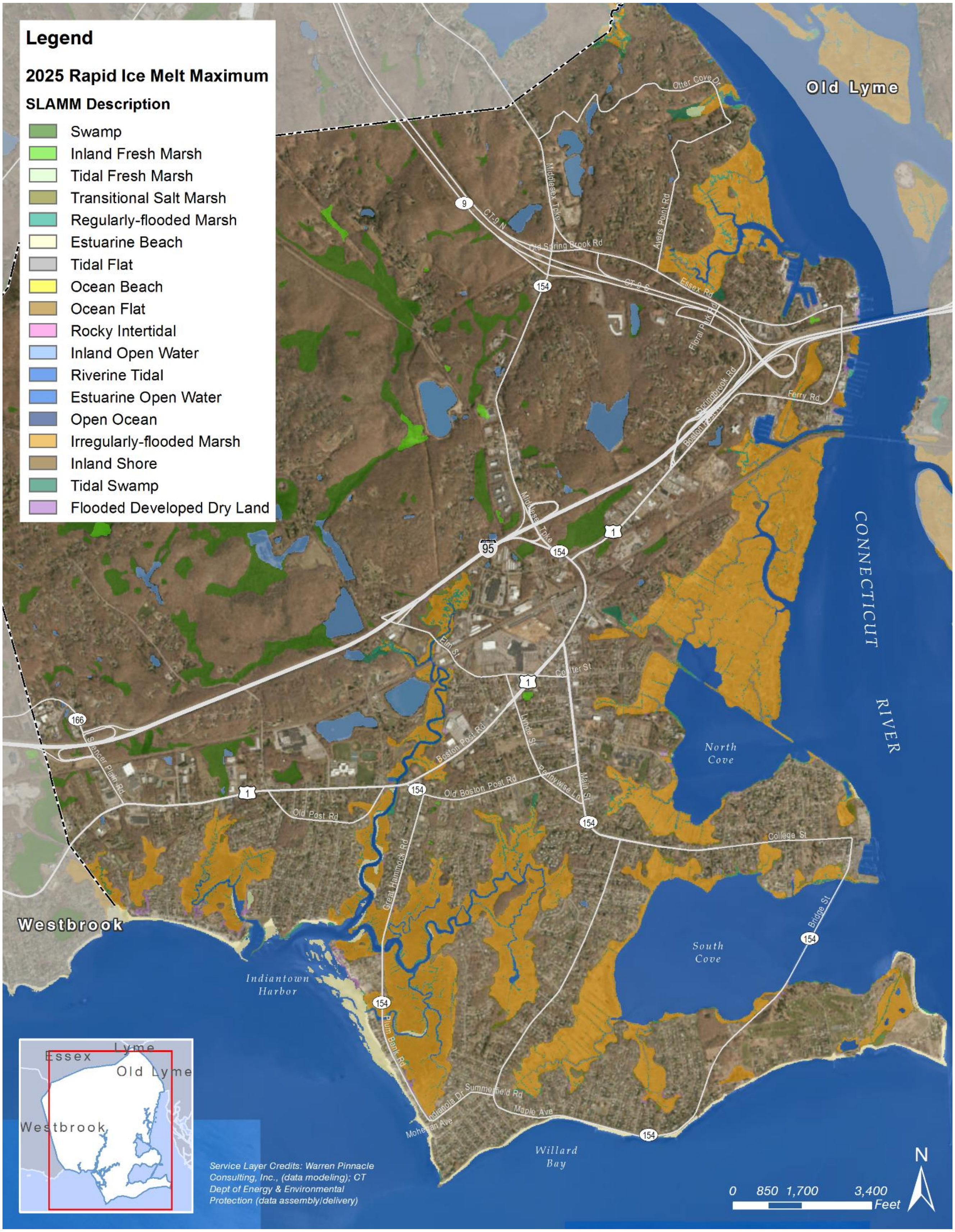


Figure 4-64: SLAMM 2055 Rapid Ice Melt Sea Level Rise

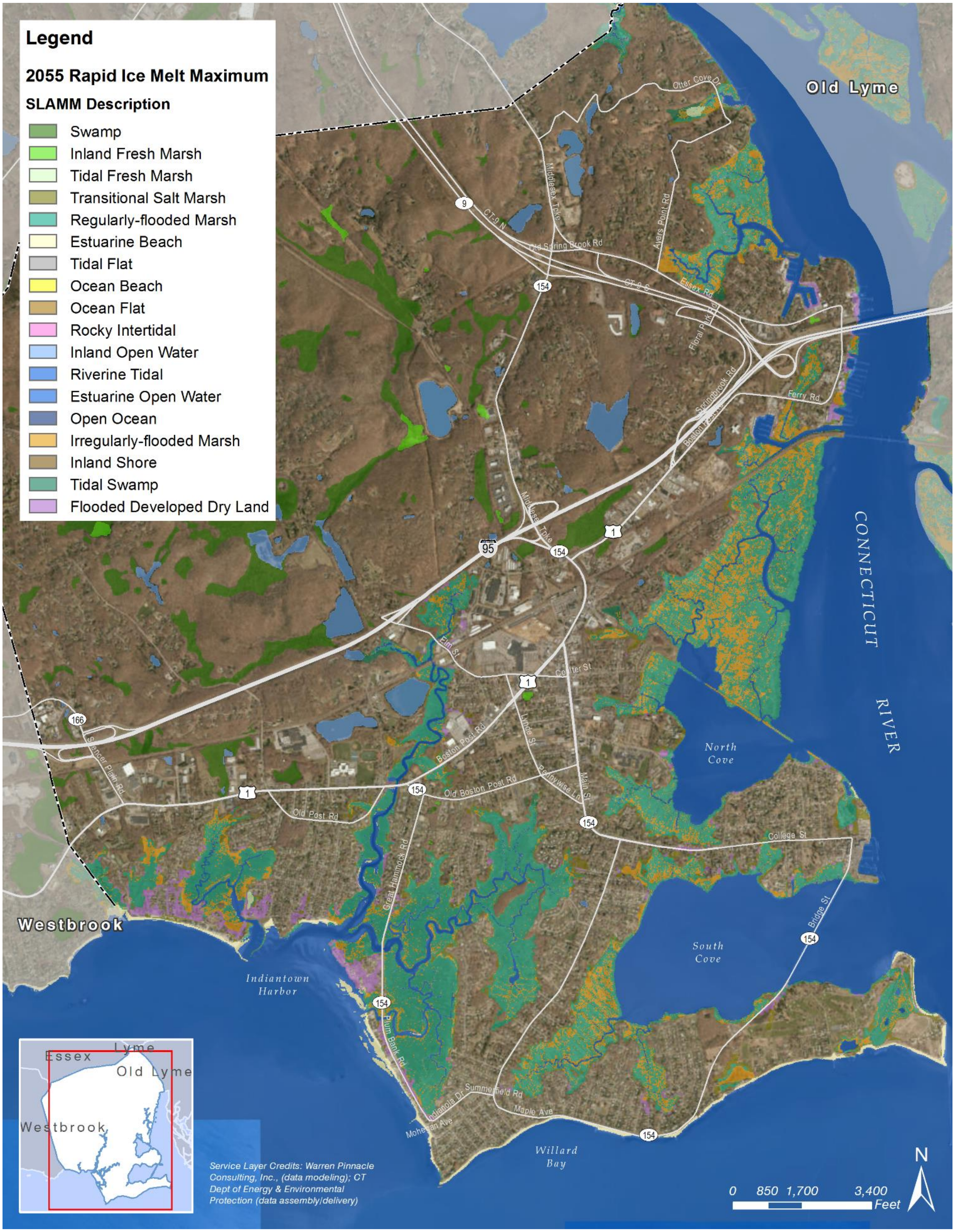


Figure 4-65: SLAMM 2085 Rapid Ice Melt Sea Level Rise

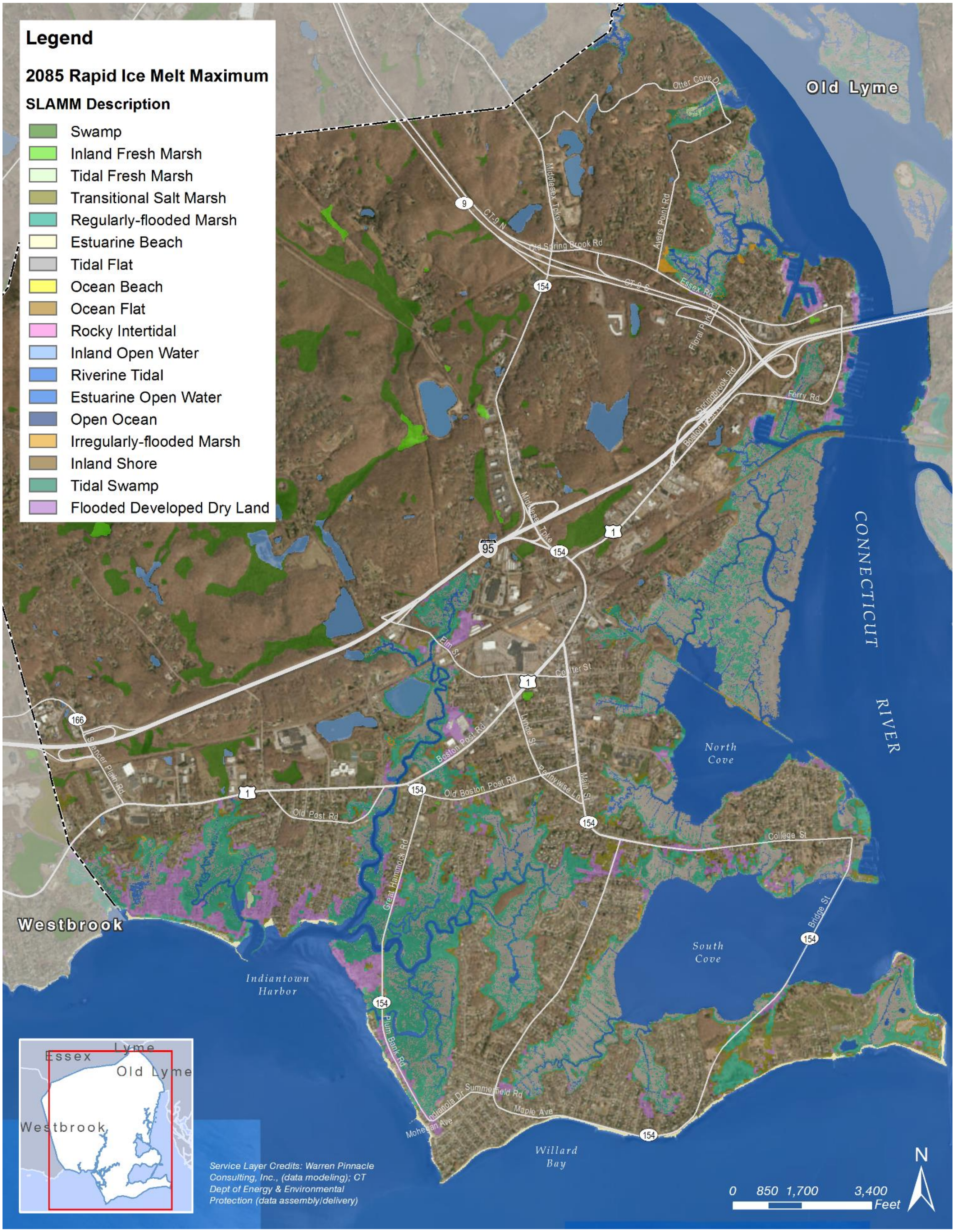
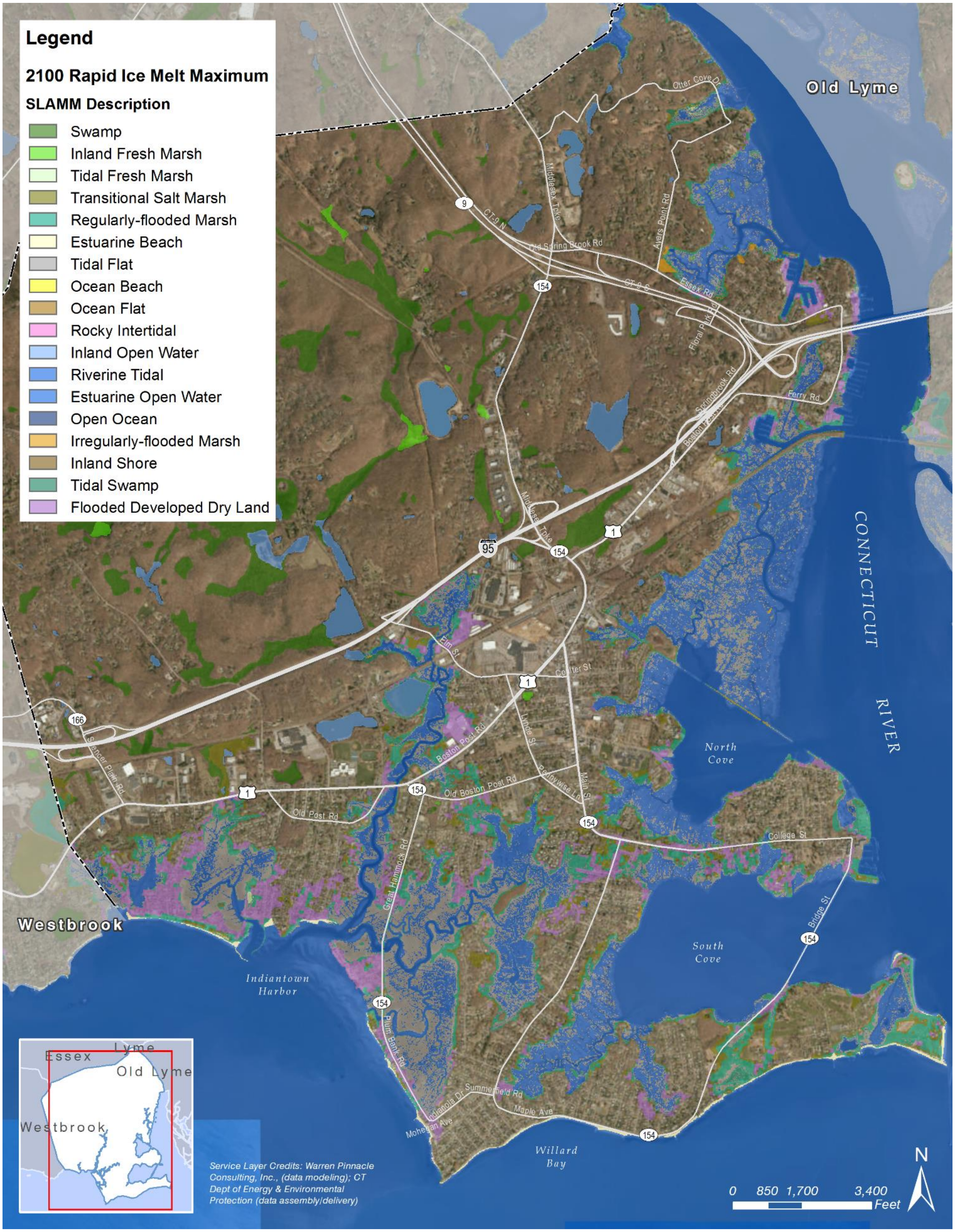


Figure 4-66: SLAMM 2100 Rapid Ice Melt Sea Level Rise



MARSH ADVANCEMENT

Most of the existing tidal marshes are bordered by developed property, which will restrict their lateral expansion. During 2013 and 2014, The Nature Conservancy (TNC) completed a study "A Salt Marsh Advancement Zone Assessment and presents an assessment (on a parcel basis) of upland migration of marsh with sea level rise. This study predates the SLAMM modeling presented above although used a similar methodology. Some difference in model results between the two analyses should be anticipated.

This TNC study provides a detailed assessment of projected marsh advancement and identifies specific parcels as opportunities for land acquisition. The detailed results of this report are not repeated here and the reader is referred to the study documents.

Natural Resources - Beaches

Attachment 4: Vulnerability and Risk

Natural Resources – Beaches

Old Saybrook's southern shoreline includes 14 beaches:

- Chalker Beach
- BelAire Manor Beach
- Indiantown Baby Beach & Marina (Red Bird Trail)
- Indiantown Shetucket Trail Beach (Shetucket Trail)
- Saybrook Manor Beach (Hartford Avenue)
- Saybrook Manor Beach (Middletown Avenue)
- Saybrook Manor Beach (8 Bayside Avenue)
- Saybrook Manor Beach (2 Bayside Avenue)
- Saybrook Manor Cove Beach (14 Bayside Avenue)
- Harvey's Beach
- Town Beach (Plum Bank)
- Cornfield Point Assoc. Beach
- Knollwood Beach Association Beach
- Fenwood Beach

Compared to the rest of the Atlantic seaboard, Long Island Sound is a relatively low energy system. The Old Saybrook coastline is located in a shoreline district characterized by the USACE as District E – Glacial Drift and Beaches. Areas of Old Saybrook consisting of glacial moraine deposits (e.g., Cornfield Point) are more resistant to erosion. About 8 miles of the Old Saybrook shoreline is potentially erodible, of which about 2 miles has been significantly affected by erosion. Typical of the Connecticut coast, Old Saybrook's beach consist of barrier spits and pocket beaches. Beach shoreline protection in the forms of groins and jetties and beach nourishment has been constructed at most of the beaches in Old Saybrook. Areas that have been historically affected by shoreline erosion include: Chalker Beach, Chapman Beach, Westbrook, Plum Beach and Great Hammock Beach.

The Connecticut shoreline, at any point in time, reflects the effects of both longshore sediment transport and cross-shore (on-shore - offshore) sediment transport. Longshore transport is primarily a function of the direction of the prevailing waves and tidal currents. Wave direction along the Connecticut Long Island Sound shoreline, in turn, is mostly a function of local wind direction (except areas to the east of Old Saybrook where the coast is also exposed to swells from the Atlantic Ocean). As a result, sediment transport and beach shoreline change are highly variable and localized. Along the Connecticut shoreline, the net longshore transport is generally east to west, but varies locally due to the irregular shoreline.

The Connecticut River is a significant source of sand that nourishes the beaches. Near the mouth of the Connecticut River, strong tidal currents can act to supplement weak, wave-induced littoral drift and can play a dominant role in the erosion process. Jetties and groins are built to trap longshore littoral drift, and these structures are numerous along Old Saybrook's shoreline.

Cross-shore sediment transport resulting in beach erosion is typically episodic and due to extreme flood conditions (storm surge and waves) associated with hurricanes and Nor-Easters. Given the predominance of Nor'easters in the Fall, Winter and Spring, cross shore beach erosion often occurs during that time of year, contributing to a seasonable effect of eroded beaches during the Winter and built-up beaches in the Summer. Tropical storms and hurricanes occur predominantly between June and November; although rare these storms can cause significant beach erosion.

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. A Geographic Information System (GIS) time series analysis was conducted using maps of the Connecticut shoreline from several different time periods between 1870 and 2006 to provide a high-level, quantifiable assessment of Connecticut shoreline trends from both a statewide and a localized perspective.

For each type of geographic area (by town and by shoreline district), the Connecticut shoreline change project data are presented as tables of values as well as charts. The tables provide numeric values of the minimum and maximum values for the change metrics (Net Shoreline Movement, End Point Rate, and Linear Regression Rate) as well as associated averages and uncertainty ranges. The charts provide a visual display of the actual change values along an axis representing the coast with common or unique places or landforms identified for context. In this way, users can see the progression and magnitude changes moving across the entire Connecticut coastline.

The causes of shoreline change can vary, but generally include:

- changes due to naturally-occurring trends given the specific physical characteristics of the area;
- changes due to a variety of man-made influences such as building structures that impede or restrict sediment transport, filling of wetlands, adding sand to nourish beaches, etc.; and
- a combination of both.

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 4-67 and 4-68** present the shoreline change statistics for the long-term and short term, respectively. The values calculated for Old Saybrook include:

<u>Old Saybrook – Long Island Sound Beaches</u>

Short-Term (1983 to 2006):

- Net Shoreline Movement:
  - Minimum: -19.9 meters
  - Maximum: 23.8 meters
  - Average: -2.6 meters
- End Point Rate (average): -0.12 meters/year

Long-Term (1880 to 2006):

- Net Shoreline Movement:
  - Minimum: -67.5 meters
  - Maximum: 212.9 meters
  - Average: -4.3 meters
- End Point Rate (average): -0.03 meter/year

<u>Old Saybrook – Connecticut River Shoreline</u>

Short-Term (1983 to 2006):

- Net Shoreline Movement:
  - Minimum: -20.5 meters
  - Maximum: 2.8 meters
  - Average: 6.2 meters
- End Point Rate (average): 0.28 meter/year

Long-Term (1880 to 2006):

- Net Shoreline Movement:
  - Minimum: -26.4 meter
  - Maximum: 258.3 meter
  - Average: 12.0 meter
- End Point Rate (average): 0.10 meter/year

The longterm effects of sea level rise on the beaches will be increased erosion and migration of barrier beaches and spits landward. The barrier beaches typically erode from the Long Island Sound side and will either: 1) wash overland and remain intact; or 2) break up and disappear (leaving open water and a shoreline at the current marsh boundary. Climate change may also have long term effects on the flow (and bedload sediment) of the Connecticut River, which in turn could affect long term beach shoreline change. Climate change can also result in long term changes to prevailing wind direction and velocity, which in turn would affect shoreline change.

Attachment 4: Vulnerability and Risk

In general, the beaches of Old Saybrook (consistent with almost all of Connecticut's beaches) are moving landward due to gradual sea level rise and the net effect of storms. 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 Old Saybrook, sediment supply is limited, and the large number of coastal structures impedes natural sediment transport.

The following presents a more detailed look at beach shoreline change in Old Saybrook.

Figure 4-67: Long Term Shoreline Change (meters/year)

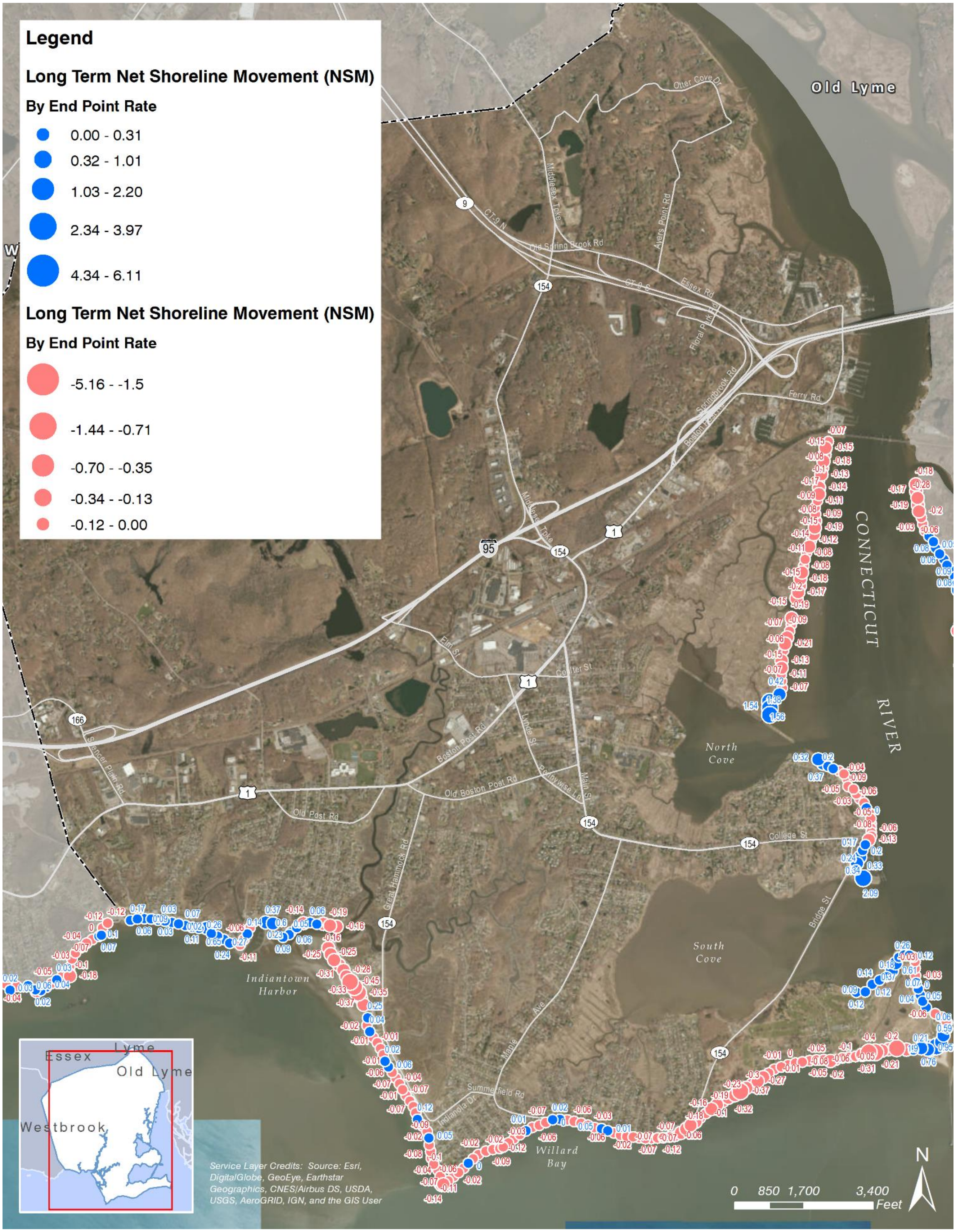
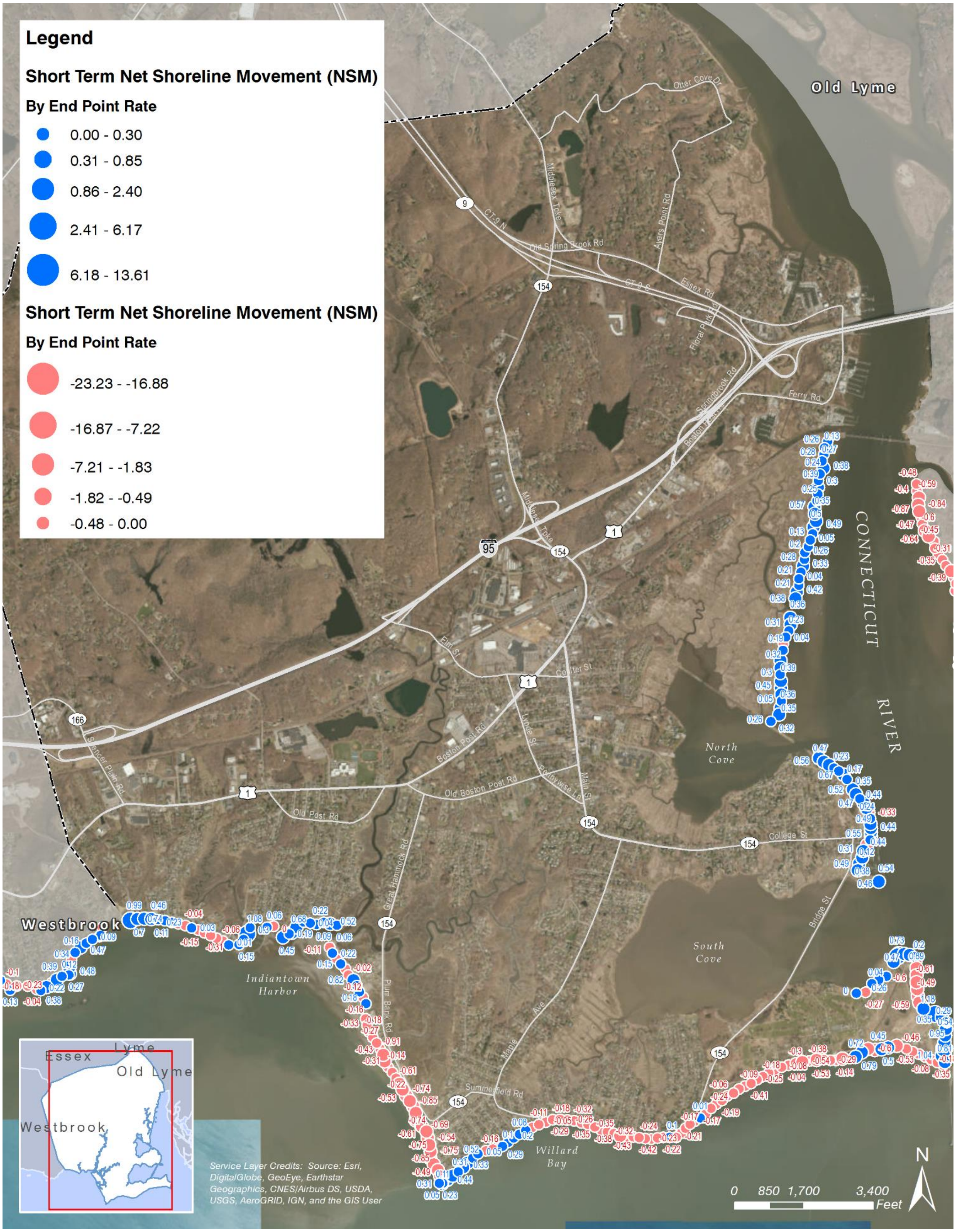


Figure 4-68: Short Term Shoreline Change (meters/year)



DETAILED REVIEW OF BEACH SHORELINE CHANGE

Figure 3-71 shows the NOAA navigation chart for the area, with bathymetry shown as depth below mean lower low water (MLLW).

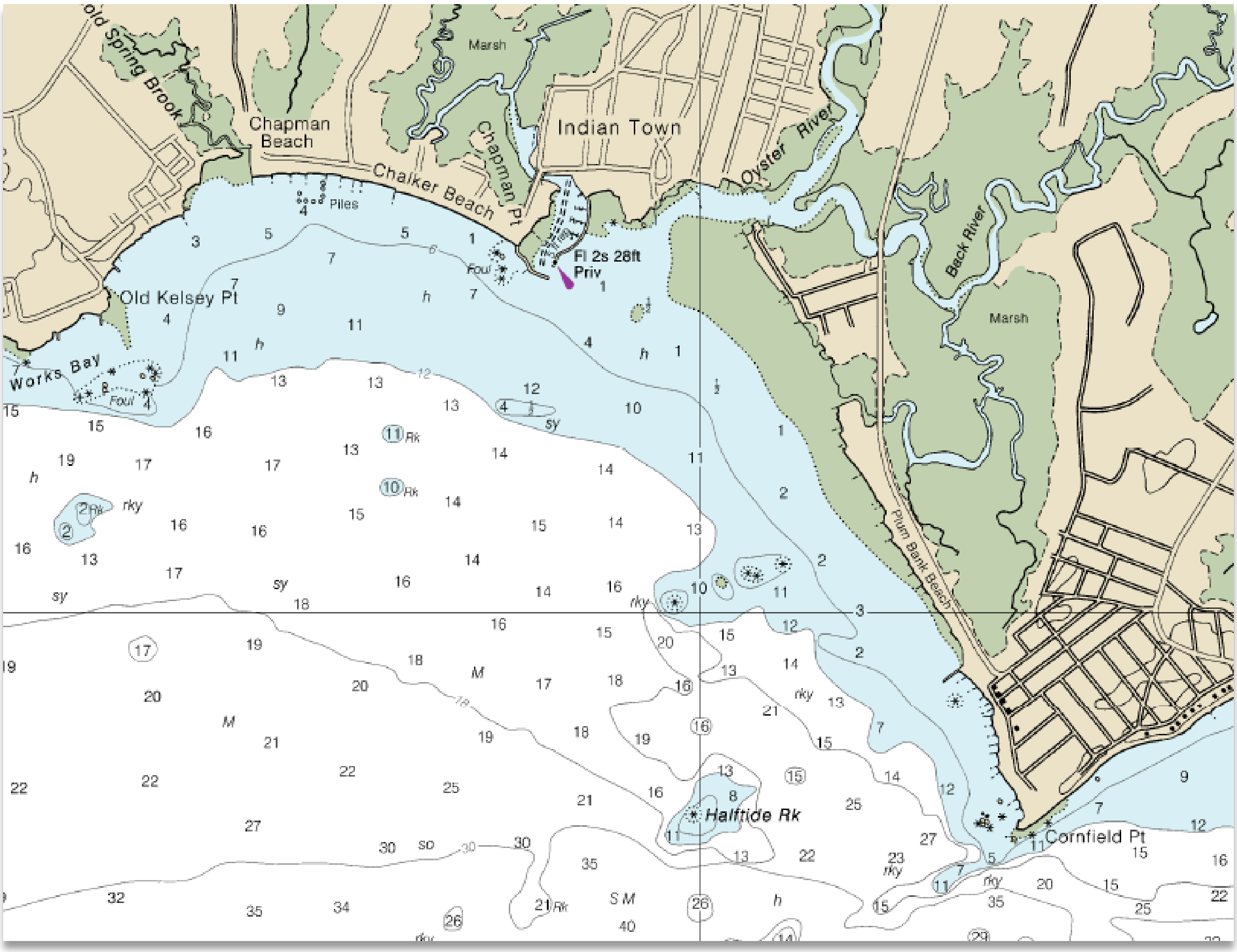
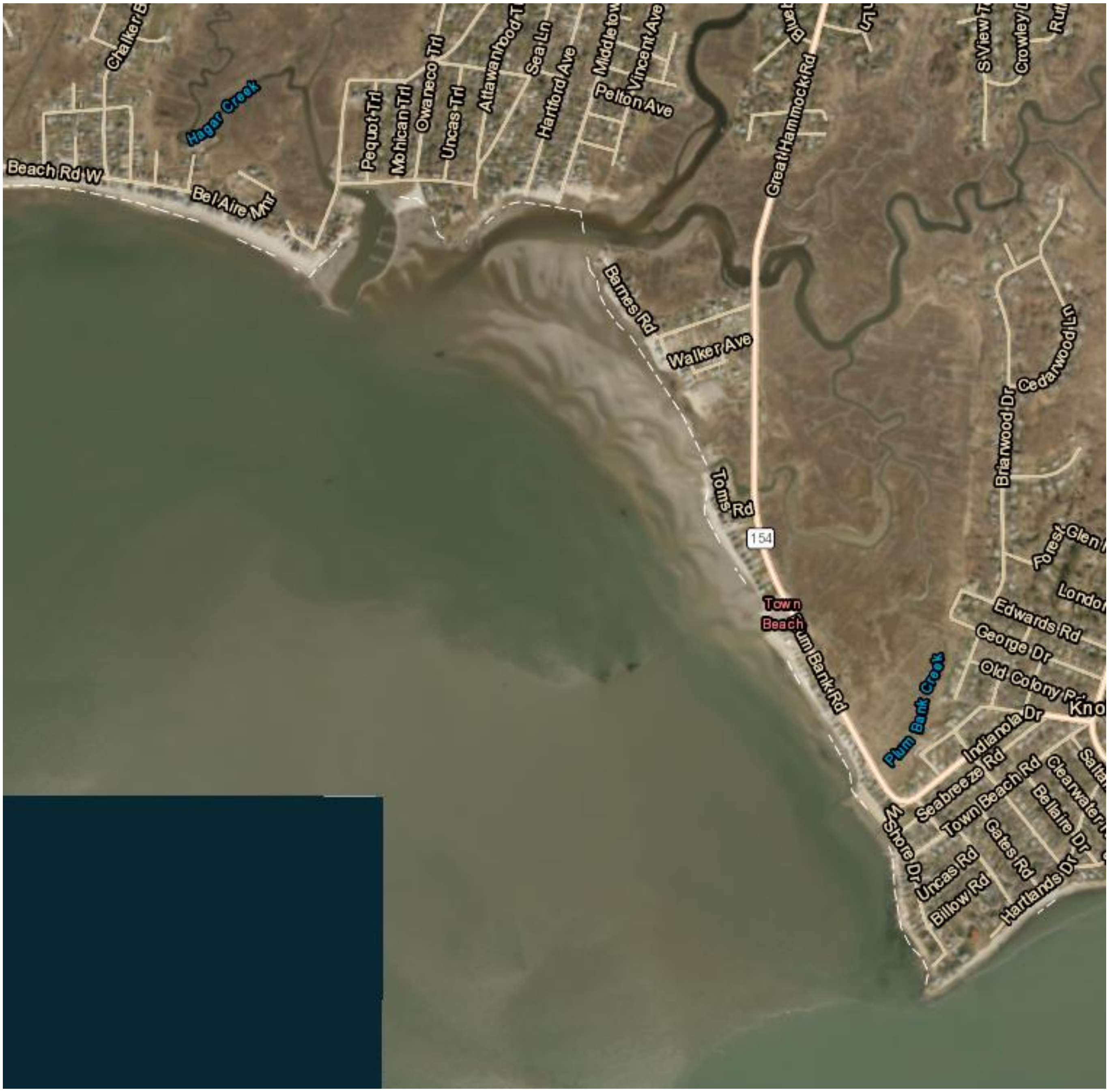


Figure 4-69: NOAA Navigation Chart

The NOAA navigation plot identifies some key feature of this stretch of shoreline. From Chalker Beach to Indian Town Beach, the shoreline faces south-southwest. The shoreline from Indian Town to Cornfield Point faces west-southwest. Around Indian Town and to the east of Indian Town, sediment transport is influenced by both coastal wave action and the effects of flow from Oyster River. There is a large area of tidal flat along the southwest-facing shore, south of Oyster River. As indicated above by shallow water depths, shallow deposits of sediment extend seaward about 800 feet from the shore and tidal flats. The shoreline has numerous shoreline structures, including small to large groins and the jetties at the inlet with Hager Creek. The nearshore topography is also characterized by shallow rock outcrops, in particular outcrops around Cornfield Point, Halftide Rock, the large set of outcrops that extend approximately perpendicular to the shore across from the Town Beach (Plum Bank Beach). The deeper water close to Cornfield Point (as well as wave transformation due to Cornfield Point) supports larger waves in the area between Cornfield Point and Plum Island Beach.

Figure 4-70 is a recent aerial photograph of this stretch of shoreline. The extent of shallow and nearshore suspended sediment is observable in this photograph. In particular, the influence of the rock outcrops (located perpendicular to the shoreline, across from the Town Beach) on wave attenuation and sediment distribution is apparent on sediment transport.

Figure 4-70: Aerial Photograph Showing Suspended Sediment Distribution



Figures 4-71 and **4-77** present aerial photographs and short-term (1983 – 2006) shoreline change statistics for the shoreline from Chalker Beach to Cornfield Point. For comparison, in Connecticut, erosion rates of about 1 foot per year or less are considered minor. Erosion rates on the order of 1 to 2 feet per year are considered moderate and erosion rates greater than 2 feet per year are considered severe.

Figure 4-71: Aerial Photograph and Short-Term Shoreline Change - Chalker Beach to Bel Aire Manor Beach

This stretch of shoreline is characterized by artificial fill placed within the marsh and estuarine beach deposits, with the beach characterized as a barrier spit. The shoreline is fortified with groins and sea walls. The upland ground surface elevation is about 4 to 6 feet NAVD88.

The calculated shoreline change rate along Beach Road, which indicates (on average) accretion, has likely been affected by repairs and modifications made to the groins during the period of record (around 1984). While the average shoreline change rates indicate accretion; minor to moderate erosion is expected to be the representative long term beach state. The shoreline change along Bel Aire Manor Road has been erosion. The observed net longshore sediment transport direction is locally variable, with a slight westward component.

Figure 4-72: Aerial Photograph and Short-Term Shoreline Change – Indiantown Beach to Old Saybrook Manor Beach

This stretch of shoreline is characterized by artificial fill placed within the marsh. The shoreline is fortified with groins, revetments and sea walls. This stretch of shoreline also includes the man-made inlet to Hager Creek, including the inlet jetties and dredged harbor/inlet channel. The upland ground surface elevation is about 4 to 6 feet NAVD88, and gets lower to the east and north to about Elevation 2 feet NAVD88 along Plum Bank Road. The nearshore area is characterized as dynamic tidal flat and estuarine beach. Sediment transport here is affected by both longshore currents and flow from Oyster River to the north.

The observed shoreline change is minor, with average change rates indicating accretion. The observed net longshore sediment transport direction is mixed and locally variable.

Figure 4-73: Aerial Photograph and Short-Term Shoreline Change – South of Oyster River

This stretch of shoreline is characterized by man-made fill placed within the marsh. The shoreline is fortified with groins, revetments and sea walls. The upland ground surface elevation is about 4 to 6 feet NAVD88, and gets lower to the east and north to about Elevation 2 feet NAVD88 along Plum Bank Road. The nearshore area is characterized as dynamic tidal flat and estuarine beach. Sediment transport here is affected by both longshore currents and flow from Oyster River to the north.

The observed shoreline change is minor. The observed net longshore sediment transport direction is mixed and locally variable.

Figure 4-74: Aerial Photograph and Short-Term Shoreline Change – Vicinity of Plum Bank Creek

This stretch of shoreline is characterized as a barrier spit (beach), marsh and man-made fill (to the north) and includes the mouth of Plum Bank Creek. The developed part of the shoreline is fortified with groins. For the most part, this shoreline consists of a low lying barrier spit, with the beach separating the marsh from Long Island Sound. The beach elevation high is about 10 feet NAVD88, and gets lower to the east to about Elevation 2 feet NAVD88 along Plum Bank Road. The nearshore area is characterized as dynamic tidal flat and estuarine beach.

The observed shoreline change in the vicinity of Plum Bank Creek is moderate erosion (average rates of about 1 to 1.5 feet per year. The observed shoreline change is typical of barrier spits which tend to erode and migrate landward into the marsh. Flow into and out of Plum Bank Creek prevents beach formation along the northern portion of shoreline shown here. This condition is also affected by the presence of the sea wall and groin/jetty at the creek mouth.

The observed net longshore sediment transport is to the north-northeast.

Figure 4-75: Aerial Photograph and Short-Term Shoreline Change – Town Beach

The observed shoreline change from the area of the Town Beach south to Cornfield Point is moderately to severely eroding (average rates of about 1.5 to 3 feet per year, with lessor rates to the immediate south of the Town Beach groins and a greater rate to the immediate north of the Town Beach north groin). Sediment is generally accreting to the south of the southern Town Beach groin and eroding north of the northern groin. North of the Town Beach, the average shoreline change is erosion at the rate of about 0.5 foot to 1.6 feet per year). The tidal flats expand in this area relative to the shoreline to the south. The observed shoreline change is typical of barrier spits which tend to erode and migrate into the marsh.

The observed net longshore sediment transport is to the north-northeast). Extensive rock outcrops are present across from the Town Beach, trending approximately east-west perpendicular to the beach, which have some impact on longshore sediment transport.

Figure 4-76: Aerial Photograph and Short-Term Shoreline Change – South of Town Beach

This stretch of shoreline is characterized as a barrier spit (beach). The shoreline is fortified with groins. For the most part, this shoreline consists of a low-lying barrier spit, with the beach separating the marsh from Long Island Sound. The beach elevation high is about 5 feet NAVD88, and gets lower to the east to about Elevation 2 feet NAVD88 along Plum Bank Road. This section also represents the southern extent of tidal flats, with a small section of tidal flat present. The shoreline change transects indicate that the current shoreline is located about midway between the observed extremes over the period of analysis (1983 to 2006). That is, during this period, the shoreline has been in a more eroded condition than currently observed and that both accretion and erosion has occurred, with the average shoreline change condition at a rate of about 1.5 to 2.5 feet per year. The observed direction of longshore sediment transport is to the north-northwest.

Figure 4-77: Aerial Photograph and Short-Term Shoreline Change – Near Cornfield Point

This stretch of shoreline is characterized predominantly as glacial moraine bluff. The topography ranges from Mean Sea Level at the beach to about Elevation 10 to 12 feet NAVD88 in the bordering upland areas. The shoreline is also fortified with revetments and groins, as well as natural rock outcrops. The shoreline change transects indicate that the current shoreline is located about midway between the observed extremes over the period of analysis (1983 to 2006). That is, during this period, the shoreline has been in a more eroded condition than currently observed and that both accretion and erosion has occurred, with the average shoreline change condition at a rate of about 1.5 to 2.5 feet per year. The observed direction of longshore sediment transport is to the north-northeast.

Figure 4-78: Aerial Photograph and Short-Term Shoreline Change – Cornfield Point to Fenwick

The shoreline from Cornfield Point to Fenwick is characterized by moraine and glacial drift bluffs. The elevation of the upland areas are generally 15 to 20 feet NAVD88. The shoreline is fortified in certain areas with revetments (e.g., along Maple Avenue Route 154) and the beaches are primarily pocket beaches between natural promontories and groins. The beaches range from medium grained sand to gravel with cobbles, typical of glacial drift and moraine bluff material sources.

As shown of **Figure 4-78**, the average shoreline change rates indicate minor to moderate erosion and accretion (less than 0.5 foot per year to 1.5 feet per year). The direction of longshore sediment transport is variable locally but generally is to the east-northeast. Areas with beaches are generally eroding. Areas with revetments (such as along Maple Avenue) have eroded to the base of the revetment.

CONCLUSIONS AND RECOMMENDATIONS

Old Saybrook beaches include: 1) barrier spits, separating the marsh from Long Island Sound, from Chalker Beach to just north of Cornfield Point; and 2) pocket beaches between shoreline structures and natural promontories, from Cornfield Point to Old Saybrook Point. The shoreline has been heavily fortified by hard shoreline structures including groins, revetments and seawalls.

Both types of shoreline identified above general face south-southwest and are exposed to long fetches and Long Island Sound waves. The prevailing wind and wave direction, affecting longshore sediment transport, is from the southwest. The direction of longshore sediment transport from Cornfield Point to Indian Town is typically to the north-northeast. The direction of sediment transport from Indian Town to Chalker Beach (including Chalker Beach), varies locally. The direction of sediment transport along the shoreline from Cornfield Point to Old Saybrook Point varies locally but is generally to the east-northeast.

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.

The morphology of the shoreline extending from Chalker Beach (including Chalker Beach) to just north of Cornfield Point consists predominantly of barrier spits (beaches) and marsh. The barrier spits are separated by river and creek inlet channels, creating large areas of shallow sediment and tidal flat in the vicinity of these features. Certain portions of this stretch of shoreline also include artificial fill placed within former marsh. Barrier spit and marsh morphologies are, by nature, very dynamic. Absent man-made structures, the natural morphological change consists of: 1) migration of the barriers spits inland over the marsh; 2) dynamic movement of the river and creek inlets; and 3) dynamic movement of shallow sediment areas/tidal flats.

This type of shoreline is generally characterized by erosion and dynamic movement of sediment. Sea level rise will accelerate the natural landward movement of the barrier spits. The shoreline, however, has been heavily modified by: 1) construction of hard shoreline structures, in particular groins designed to interrupt longshore transport; 2) development with roads and houses; and 3) placement of artificial fill. Although these structures affect the natural coastal processes, they do not, on net, prevent the natural tendency of the shoreline toward dynamic movement change and often increase erosion. The groins have been successful in trapping sand locally, but overall they drastically impact the natural longshore sediment transport. In addition, the overall availability of sediment is diminished within Long Island Sound.

The net, long term effect for the Old Saybrook shoreline including Chalker Beach to just north of Cornfield Point is long term, moderate (1 to 2 feet per year) erosion of the beaches with highly impactful, episodic erosion associated with coastal storm flooding and wave action. Sea level rise will amplify and accelerate shoreline change. Inadequate sediment supply to replace alongshore and offshore transport will require beach nourishment to mitigate erosion. The morphology of the shoreline extending from Cornfield Point to Old Saybrook Point consists of glacial moraine and drift bluffs. Major sections of shoreline are fortified with revetments. The average shoreline change rates indicate minor to moderate erosion and accretion (less than 0.5 foot per year to 1.5 feet per year). Under a natural setting, the glacial drift deposits provide a source of beach sediment. Under a developed setting, such as the Old Saybrook shoreline, revetments and seawalls: 1) eliminate this sediment source; and 2) create wave reflection and erosion, such that the shoreline erodes to the base of the revetment or sea wall.

Appendix A

Wastewater Treatment Coastal Flood Risk Memorandum

FINAL Memorandum -

Old Saybrook Wastewater Management District

This memorandum presents coastal flood information relevant to the Old Saybrook Wastewater Management District, including tides, sea level rise and storm surge and waves. This information is presented for planning purposes. Additional analyses, including detailed numerical modeling, are recommended for design once additional system details are available. This memorandum has also been included as part of GZA Old Saybrook Coastal Resilience Study report.

Background

Town residents and businesses are currently serviced exclusively by on-site septic systems. The Town established a Decentralized Wastewater Management District (WWMD) in August, 2009 for the purpose of protecting the public health and the environment through improvements to the treatment of wastewater (per Article II of Chapter 173). Decentralized wastewater management approaches seek to deal with wastewater needs closer to the source of wastewater generation using smaller, dispersed (decentralized) treatment and disposal/recharge methods. This keeps the wastewater management more local than sewer approaches which tend to centralize treatment and discharge. Enhancing the existing on-site wastewater systems through the use of a Decentralized Wastewater Management Program (DWMP) proactively upgrades certain on-site systems and increases the extent of management of these systems.

The Town adopted: 1) WWMD boundaries that include approximately 1900 lots located within 15 neighborhood focus areas; and 2) Upgrade Program Standards for improvements. The areas were selected primarily based on physical characteristics such as density of houses, proximity to water bodies and marshes and shallow depth to groundwater.

The Upgrade Program Standards specify the types of improvements required for existing septic systems as part of the DWMP. The type of upgrades required for a given lot are, generally, based on the adequacy of the current septic system to meet current Public Health Code (PHC) requirements with a few modifications to enhance protection of the environment. Upgrades may be similar to conventional septic systems or they may include advanced treatment systems. Newer code-compliant septic systems typically will not need to make any modifications. Advanced Treatment (NI) systems will be required on 400 to 500 properties, for two main reasons: 1) where lots are very small and cannot accommodate the leaching area required by the PHC for the number of bedrooms and the soil characteristics on a given lot (the DEEP has agreed that properties with two-thirds or more of the required leaching area may remain if depth to groundwater is adequate); and 2) all waterfront lots. For purposes of this program, waterfront means any lot that abuts a surface water body (e.g., river or Long Island Sound), but does not include lots abutting marshes or other wetlands.

The Town has applied a phased approach to the implementation of improvements to existing on-site septic upgrades with an estimated nine-year expected build-out. The 15 neighborhood focus areas located within the WWMD include:

- Chalker Beach
- Meadow Brook
- Indiantown
- Saybrook Manor
- Great Hammock Beach
- Plum Bank
- Oyster River East
- Cornfield Point
- Cornfield Point Park
- Fenwood
- Saybrook Acres
- Maple Avenue North

- Saybrook Point
- Ingham Hill
- Thompson

As of 2016, the program is in the 2nd Phase with over 500 on-site septic systems installed and over 800 designated "Upgrade Compliant" that include on-site septic systems in 10 of the 15 focus areas.
(Reference https://www.oswpca.org/).

The Town is in the process of conducting a study "Old Saybrook Wastewater Pollution Control Authority [WPCA]) Draft Study" (2016-17) to evaluate the use of a Community System to improve the remaining 800 systems. These 800 properties are located in 5 focus areas all of which include high numbers of residential properties located on Long Island Sound that will be the most vulnerable to future saltwater intrusion as sea levels rise from groundwater infiltration. The focus areas include:

- Chalker Beach
- Great Hammock Beach
- Indiantown
- Plum Bank
- Saybrook Manor

The study will include a cost and feasibility evaluation of following three options:

1. On-site Repairs
2. Community System(s) with dispersal of wastewater into the ground
3. Community System(s) with dispersal of wastewater into the Connecticut River

The locations of the neighborhood focus areas and the potential effluent disposal areas are shown in Attachment 1 (figures prepared by Wright-Pierce). Community systems will require the use of sanitary residential piping, municipal underground piping, municipal pump stations and municipal disposal locations. Effluent disposal is currently planned to utilize leach fields.

Climate Change and Coastal Resilience Issues

Climate change and coastal resilience must be considered in evaluation of the existing systems as well as design and construction of the proposed new systems. Issues include:

- Flood vulnerability of alternative wastewater treatment and disposal systems.
- The effectiveness of, and limitations with, on-site septic systems, including municipal leach fields, located in areas with shallow groundwater and increasing groundwater elevations due to sea level rise, in particular in areas with small lots (prohibiting mounded leach fields).
- Groundwater and surface water quality impacts due to inadequately treated effluent (nitrogen, bacteria).
- Changes in water chemistry (i.e., pH, salt content, dissolved oxygen).
- Increased precipitation.
- Scour and erosion of beach communities, resulting in damage to utilities.

Coastal Flooding

To evaluate the coastal flood hazards affecting the WWMD, GZA performed:

1. a metocean analysis of observed wind, wave and water level data;
2. review of published flood hazard data including the Federal Emergency Management Agency (FEMA) effective Flood Insurance Rate Map (FIRM) and the FEMA Flood Insurance Study (FIS), the National Oceanic and Atmospheric Agency (NOAA), tide gage data and the U.S. Army Corps of Engineers (USACE) North Atlantic Coast Comprehensive Study (NACCS);

3. review of USACE and National Oceanic and Atmospheric Agency (NOAA) sea level rise projections; and
4. numerical hydrodynamic modeling of tides, storm surge and waves using the Advanced Circulation Model (ADCIRC) and the Simulating WAves Nearshore (SWAN) models.

The results of the coastal flooding analysis are presented in GZA's Old Saybrook resilience Study report. The following summarizes key findings relevant to the Wastewater Management District and effluent disposal areas.

Tides and Sea Level Rise

Projected sea level rise and tidal elevations in the vicinity of Old Saybrook were developed using data from the New London NOAA tide gage. The historical tide gage data indicate a mean sea level rise trend of 2.55 millimeters (mm) per year (about 0.1 inch per year) (with a 95% confidence interval of +/- 0.23 mm per year).

Over the most recent 25 years, the data indicates that the mean rate of sea level rise is increasing and the rate of sea level rise is predicted to increase further. The predicted sea level rise at New London (the closest NOAA tide station to Old Saybrook), between the years 2016 and 2116, are summarized in Table1, below:

Table 1 - Sea Level Rise Projections at Old Saybrook (using the USACE Sea Level Rise Calculator at New London, in feet)

Year	NOAA (LOW)	USACE (LOW)	NOAA (INT-LOW)	USACE (INT)	NOAA (INT-HIGH)	USACE (HIGH)	NOAA (HIGH)
2016	-	-	-	-	-	-	-
2041	0.07	0.07	0.29	0.29	0.78	1.00	1.35
2066	0.25	0.25	0.75	0.75	1.86	2.34	3.13
2116	0.62	0.62	2.01	2.01	5.09	6.42	8.60

These projections were developed using the USACE Sea Level Rise Calculator (version 2017.42) and are based on USACE 2013/NOAA 2012 projections. NOAA sea level rise projections were revised subsequent to completion of GZA's analysis. The 2017 NOAA projections are presented in Figure 1 and Table 2. Based on different emissions models, the USACE Intermediate projections are predicted (at this time) to have a high probability of occurrence (about 50 to 100 percent). The USACE High projections have a low to moderate probability of occurrence (about 1 to 17 percent). For mid-term risk (say, over the next 35 years), the USACE Intermediate projection is a reasonable "lower bound" for flood mitigation sea level rise planning and the USACE High is a reasonable "upper bound". However, recent observations and modeling of accelerated ice loss from Greenland and Antarctica indicate that the 2017 NOAA High to Extreme projections (or higher) are possible by the year 2117.

Figure 1 - NOAA 2017 Sea Level Rise Projections at New London, in feet relative to NAVD88

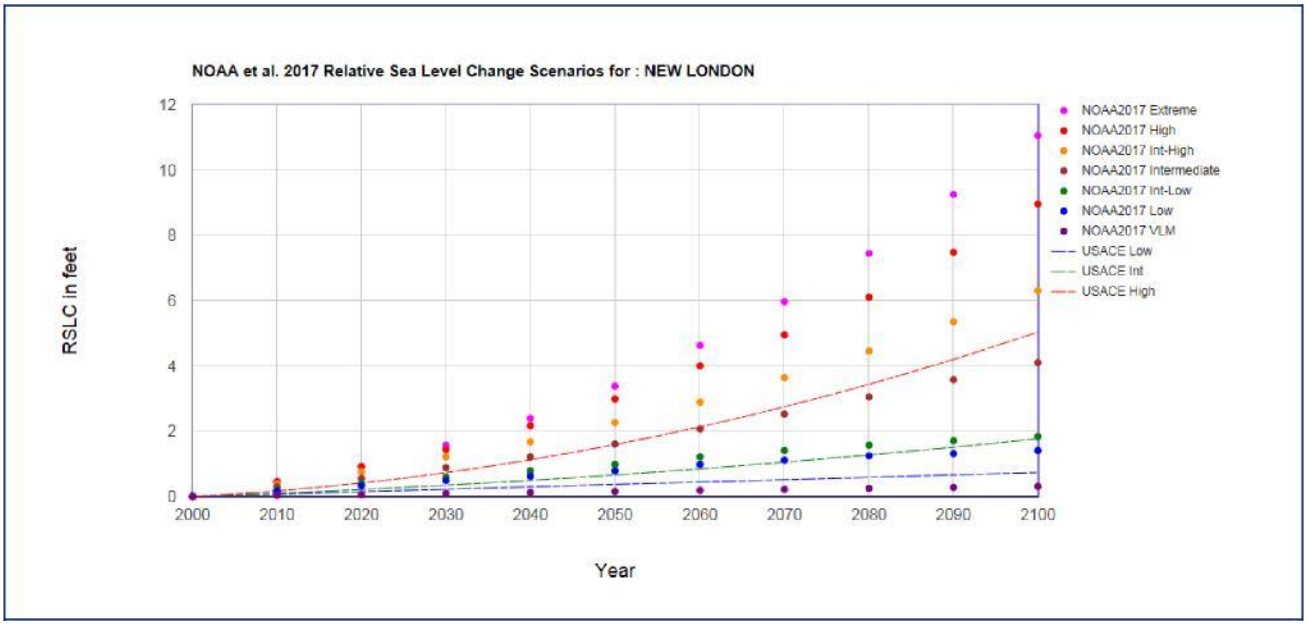


Table 2 - NOAA 2017 Sea Level Rise Projections at New London, in feet relative to NAVD88

Scenarios for NEW LONDON
NOAA2017 VLM: 0.00308 feet/yr
All values are expressed in feet

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.03	0.16	0.20	0.30	0.39	0.46	0.46
2020	0.06	0.33	0.39	0.56	0.75	0.92	0.92
2030	0.09	0.49	0.59	0.89	1.21	1.44	1.57
2040	0.12	0.62	0.79	1.21	1.67	2.17	2.40
2050	0.15	0.79	0.98	1.61	2.26	2.99	3.38
2060	0.19	0.98	1.21	2.07	2.89	4.00	4.63
2070	0.22	1.12	1.41	2.53	3.64	4.95	5.97
2080	0.25	1.25	1.57	3.05	4.46	6.10	7.45
2090	0.28	1.31	1.71	3.58	5.35	7.48	9.25
2100	0.31	1.41	1.84	4.10	6.30	8.96	11.06

Assuming linear superposition of sea level rise on the current tides, the current and predicted changes to the tidal elevations at Old Saybrook due to sea level rise are presented in Table 3 for the years 2042, 2067 and 2117.

Table 3 - NOAA 2017 Sea Level Rise Projections at New London, in feet relative to NAVD88

Tidal Datums (ref. feet, NAVD88)	Current	2041			2066			2116		
		High SLR	Int SLR	Low SLR	High SLR	Int SLR	Low SLR	High SLR	Int SLR	Low SLR
MSL	-0.3	0.7	-0.01	-0.23	2.04	0.45	-0.05	6.12	1.71	0.32
MHW	0.92	1.92	1.21	0.99	3.26	1.67	1.17	7.34	2.93	1.54
MHHW	1.21	2.21	1.5	1.28	3.55	1.96	1.46	7.63	3.22	1.83
HAT	2.04	3.04	2.33	2.11	4.38	2.79	2.29	8.46	4.05	2.66
MLW	-1.65	-0.65	-1.36	-1.58	0.69	-0.9	-1.4	4.77	0.36	-1.03
MLLW	-1.84	-0.84	-1.55	-1.77	0.5	-1.09	-1.59	4.58	0.17	-1.22

Extreme Coastal Flood Events

Extreme coastal flooding, including storm surge and waves, were also evaluated including the effects of sea level rise. Attachment 2 presents the typical predicted nearshore 100-year and 500-year return period flood elevations in the vicinity of Old Saybrook (2017 through 2117) and the modeled 100-year and 500-year flood elevations at the five Community System neighborhood focus areas (2016 through 2116).

The modeled significant wave heights and wave crest elevation (feet NAVD88) at the five Community System neighborhood focus areas are also presented for the 100-year and 500-year return period flood events during 2016.

Coastal Flood Vulnerability

Figure 2 presents the limits of flood inundation during the Mean Higher High Water (MHHW) tide during the years 2016 through 2116. Figure 3 presents the flood hazard zones based on the effective FEMA Flood Insurance Rate Maps. Figure 4 presents the limits of flood inundation (floodplain) during the 500-year return period flood during the years 2016 through 2116. Attachment 2 presents predicted and modeled stillwater flood elevations, wave heights and wave crest elevations.

The stillwater flood elevation refers to the water flood elevation in the absence of waves. The wave crest elevation refers to the maximum water level associated due to both stillwater and wave height. Wave heights greater than 3 feet are associated with significant structure damage and storm-related beach erosion and scour. Wave heights between 1.5 and 3.0 feet can also result in some building damage and moderate beach storm-related beach erosion.

Wastewater system planning for flooding and sea level rise typically utilizes a risk-informed approach. TR-16 “Guides for Wastewater Treatment Works” (2016 revisions) include the following criteria:

- Watertight manholes should be used when located within the 100-year return period floodplain. Alternatively, raise manholes above the 100-year flood level.
- New treatment plants and pump stations should: 1) provide for uninterrupted operation of all units during the 100-year return period flood; and 2) be placed above, or protected against, the structural, process and electrical equipment damage that might occur in an event that results in a water elevation above the 100-year return period flood.
- Critical equipment should be protected against damage up to a water surface elevation of 3 feet above the 100-year return period flood elevation and non-critical equipment should be protected against damage up to a water elevation of 2 feet above the 100-year return period flood elevation.
- Certain agencies may also require, as a minimum, that flood protection be required to the 500-year return period flood, if greater.

ASCE 24-14 "Flood Resistant Design and Construction" also provides flood protection criteria for critical public utilities (considered Flood Design Class 4):

- Coastal High Hazard Areas and Coastal A Zones Bottom of Lowest Supporting Horizontal Structural Member): Base Flood Elevation plus 2 feet or the 500-year flood
- A-Zone (Elevation of Top of Lowest Floor): Base Flood Elevation plus 2 feet or the 500-year flood

To apply these criteria to Old Saybrook for the current sea level conditions:

- Use the 100-year wave crest elevations (presented in Attachment 2 where Base Flood Elevations are referred to in regulation and guidance.
- Use the 500-year stillwater elevations presented in Attachment 2.

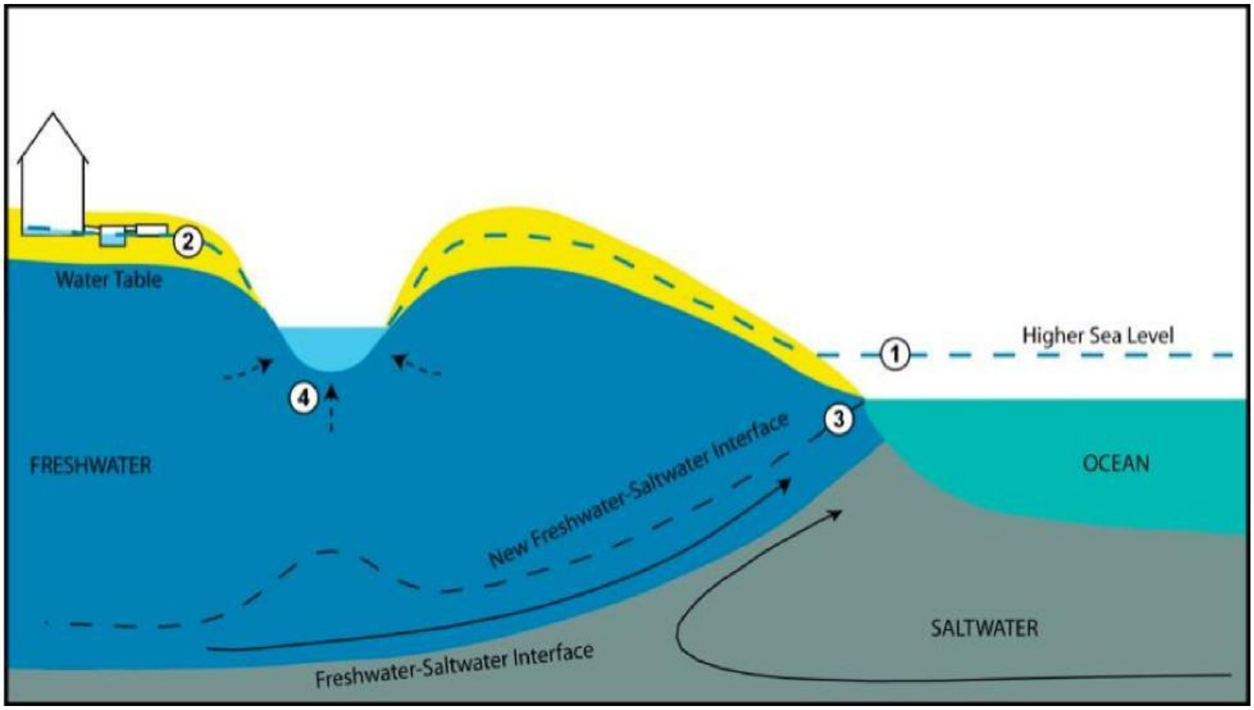
In general, all of the Wastewater Management Districts are located with coastal floodplains (see Figures 3 and 4). The effluent discharge sites currently under consideration are impacted as follows:

- Site 29 - Gardella Property (Mulchaey Rd):
    - Located within effective FEMA 100-year and 500-year flood hazard zones
    - Located just outside GZA modeled 100-year and 500-year flood limits
- Site 31 - Spencer Plain Rd:
    - Located outside effective FEMA 100-year and 500-year flood hazard zones
    - Located outside GZA modeled 100-year and 500-year flood limits
- Sites 36 and 42 - On Ingham Hill Rd D:
    - Located outside effective FEMA 100-year and 500-year flood hazard zones
    - Located outside GZA modeled 100-year and 500-year flood limits
- Site 38 - Roam Tree Road:
    - Located outside effective FEMA 100-year and 500-year flood hazard zones
    - Located outside GZA modeled 100-year and 500-year flood limits
- Sites 1 and 2 (High School and Donnelly Property:
    - Portions located within effective FEMA 500-year return period flood hazard zone
    - Portions located within GZA modeled 500-year flood limits
    - The parking lot at the Old Saybrook High School is flooded but the buildings and the effluent site locations # 1 and 2 remain unflooded.
- Site 18 Fenwick Golf Course:

- Portions located within effective FEMA 100-year and 500-year return period flood hazard zone
- Portions located within GZA modeled 100-year and 500-year flood limits

Predicted Effects of Sea Level Rise on Groundwater Elevations

A rise in sea-level can affect ground-water elevations and flow in coastal aquifers such as those at Old Saybrook. An increase in the elevation of the water table (see dashed–blue line in the figure, below) may result in flooding and compromise on-site, subsurface septic systems. A rise in sea level may also result in an upward and landward shift in the position of the freshwater-saltwater interface. Where streams are present, an increase in the water-table elevation also may increase ground-water discharge to streams and result in local changes in the underlying freshwater-saltwater interface.



The approximate depth to groundwater at the Wastewater Treatment Districts is summarized in the table below (from 2009 study).

Old Saybrook Wastewater Facilities Plan
Summary of Study Area Characteristics
Table 4-1

Study Area	Current No. of Dev Properties	From 1998 Phase I - Refinement of Study Areas Report No. of Properties	No. of Dev Properties	Total Acreage	Typ Lot Size, ac	% Seasonal	Ave Depth to GW	Est WW Flow, gpd	Fut WW Flow, gpd
Chalker Beach	247	263	252	82	0.25	60	1.58	48,500	49,000
Indiantown	178	233	184	78	0.20	46	2.84	35,200	36,000
Saybrook Manor	240	300	252	115	0.15	30	4.22	47,500	48,000
Great Hammock Beach	79	96	80	17	0.16	88	4.15	15,400	16,000
Plum Bank (2)	77		80					13,700	14,000
Cornfield Point	305	361	319	65	0.15	38	14.44	59,500	60,000
Cornfield Park	98	98	98	25	0.20	38	1.05	18,900	19,000
Maple Ave. North	197	253	202	96	0.25	6	6.82	37,900	39,000
Saybrook Point	35	38	35	15	0.40	11	13.68	6,700	7,000
Fenwood	116	117	116	40	0.25	2	10.68	22,300	23,000
Saybrook Acres	104	107	168	58	0.30	0	6.20	20,200	21,000
Oyster River East	79	91	78	57	0.04	33	6.28	15,000	16,000
Meadowood	73	79	74	53	0.30	25	4.44	13,900	15,000
Ingham Hill	23	20	19	13	0.20	0	4.81	3,500	4,000
Thompson	47	62	52	30	0.40	12	3.48	10,000	11,000
Totals (3)	1898	2118	2009	744				368,200	378,000

Notes: 1. The number of developed properties differs between current and 1998 counts due to refinements in study area limits.
2. Plum Bank was a late addition/breakout in the 1998 report, and not all the data were developed at that time
3. Totals for no. of properties and total acreages do not include Plum Bank.

A 2002 well survey (2009 study) indicates the following additional groundwater depth data. Note that Table 1 of Appendix B of the 2002 well survey report was not available to GZA.

Study Area	Mean Depth to Groundwater	Depth to Groundwater Maximum	Depth to Groundwater Minimum
Meadowood	2.71	2.72	2.70
Oyster River East	6.75	10.44	4.44
Saybrook Acres	5.16	6.84	4.26
Cornfield Park	10.09	13.91	7.89
Cornfield Point	15.86	19.22	11.83
Maple Ave North	6.57	11.28	3.35
Saybrook Point	18.25	19.50	17.00
Ingham Hill	NA	4.72	NA
Fenwood	12.97	15.85	9.87
Thompson	3.15	3.20	3.10
Great Hammock	2.98	4.90	1.05
Plum Bank	3.10	3.93	2.27

Detailed groundwater modeling is required to predict changes to groundwater elevation and water quality. Recent USGS analyses at Cape Cod indicate that there is an approximately 1:3 ratio of groundwater rise to sea level rise. However, given the high permeability of the Old Saybrook low beach communities and close proximity to the shoreline, the low beach communities may experience groundwater increases between 1:1 and 1:3 ratios.

Based on the observed groundwater elevations and the predicted sea level rise, on-site septic systems are expected to be unusable at the low beach communities unless upgrades are made using a viable advanced treatment system.

Predicted Beach Erosion and Scour

Beach erosion and scour, both chronic and episodic (coastal storm-related) can result in damage to underground piping, manholes, pump stations, etc. The low beach communities are most vulnerable to erosion and scour, in particular beach area located along Long Island Sound.

GZA has not performed detailed erosion and scour analyses. However, general conclusions are made relative to erosion and scour vulnerability:

- As shown on Figure 5, Plum Bank and portions of Great Hammock Beach and Indiantown beaches are chronically eroding, at an approximate rate of 0.1 to 0.9 meters per year.
- Significant storm-related scour should be anticipated during the 100-year and 500-year return period flood events. Wave heights on the order of 4 to 6 feet are predicted. These wave heights, along with storm surge, can result in lateral loss of beach on the order of 50 to 150 feet and vertical scour on the order of 5 to 10 feet.
- Existing shoreline protection is intermittent and, in general. Inadequate to resist 100-year and 500-year return period flood events. However, the presence of shoreline protection will affect the location and extent of beach erosion and scour.
- Sediment transport modeling should be performed during design to better predict scour and erosion.

Conclusions and Recommendations

Coastal flooding, including the effects of sea level rise, will affect the performance of wastewater treatment infrastructure and should be considered during design, construction and operation. Predictions of sea level rise and extreme flood conditions (including water levels and waves) are presented in this memorandum. Potential effects include:

- Coastal flood inundation as characterized by predicted stillwater elevations and wave crest elevations, including flood loads.
- Wave effects resulting in wave loads, scour and erosion, as characterized by wave heights.
- Damage, including corrosion, due to salt water and sea spray exposure.
- Increasing groundwater elevations due to sea level rise.
- Changes to water salinity related to inland migration of the freshwater/saltwater interface, due to sea level rise.
- Changes in water chemistry due to increased sea water acidity and reduced pH.

Wastewater system planning and design for flooding and sea level rise should utilize a risk-informed approach, as defined by regulation and industry design guidance:

- Critical equipment should be protected against damage up to a water surface elevation of 3 feet above the 100-year return period flood elevation and non-critical equipment should be protected against damage up to a water elevation of 2 feet above the 100-year return period flood elevation.
- Certain agencies may also require, as a minimum, that flood protection be required to the 500-year return period flood, if greater.

In general, all of the Community System neighborhood focus areas are located with coastal floodplains (see Figures 2 and 3). Most, but not all, of the effluent discharge sites currently under consideration are located outside coastal flood zones. To apply the flood protection criteria presented above, for the current sea level conditions:

- Use the 100-year wave crest elevations (presented in Attachment 2 where Base Flood Elevations are referred to in regulation and guidance.
- Use the 500-year stillwater elevations presented in Attachment 2.

Based on the observed groundwater elevations and the predicted sea level rise, on-site septic systems are expected to be unusable at the low beach communities unless mounded systems are used.

In general, the risk of scour and erosion is very high within the low beach communities and should be a design consideration of all wastewater treatment infrastructure. The location of underground piping and infrastructure should be away from the beach side and all piping should be designed to be structurally supported in the event of scour and resistant to flood loads (hydrostatic, hydrodynamic, wave and debris impact loads).

It is recommended that:

1. Future groundwater elevations and water chemistry be considered during planning and system design. Numerical modeling is recommended to better predict groundwater elevation and water chemistry changes. Groundwater elevations and water chemistry should also be monitored on an annual basis to identify future changes with sea level rise.
2. System design should take into account the current and future predicted flood inundation limits and elevations and be consistent with industry design guidance and regulations, including a design basis using current and future (over system design life) 100-year and 500-year return flood elevations and designated freeboard.
3. System design, including electrical components, should consider the effects of salt water and salt spray.
4. Systems should be designed to resist flood loads, including hydrostatic, hydrodynamic, wave and debris impact loads.
5. Locations of systems within the low beach communities should plan for long-term beach erosion.
6. Locations of systems within the low beach communities should plan for episodic, storm-related beach erosion and scour, and scour protection should be provided.

Figure 2 - Predicted Mean Higher High Water, in feet relative to NAVD88

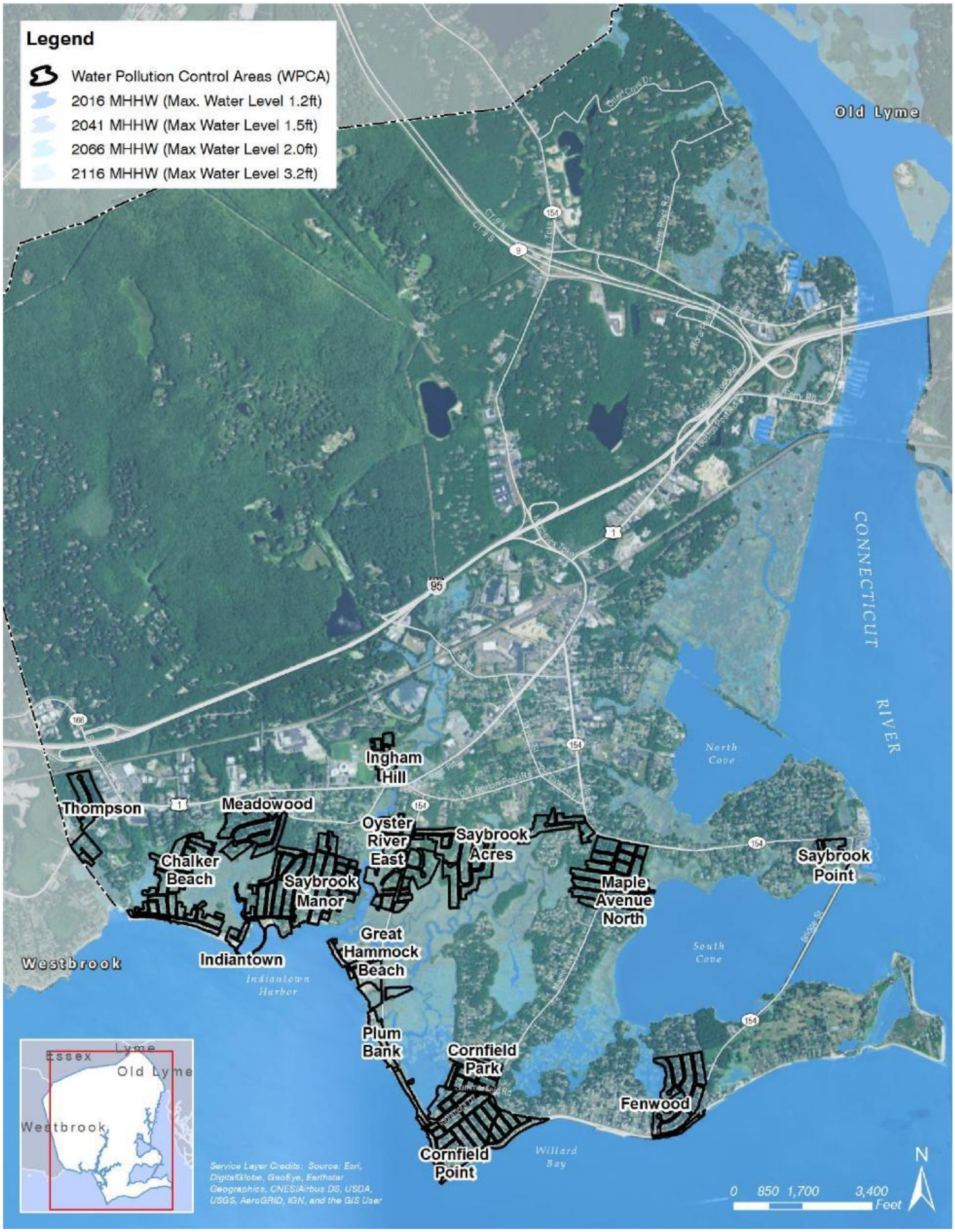


Figure 3 - Effective FEMA Floodplain

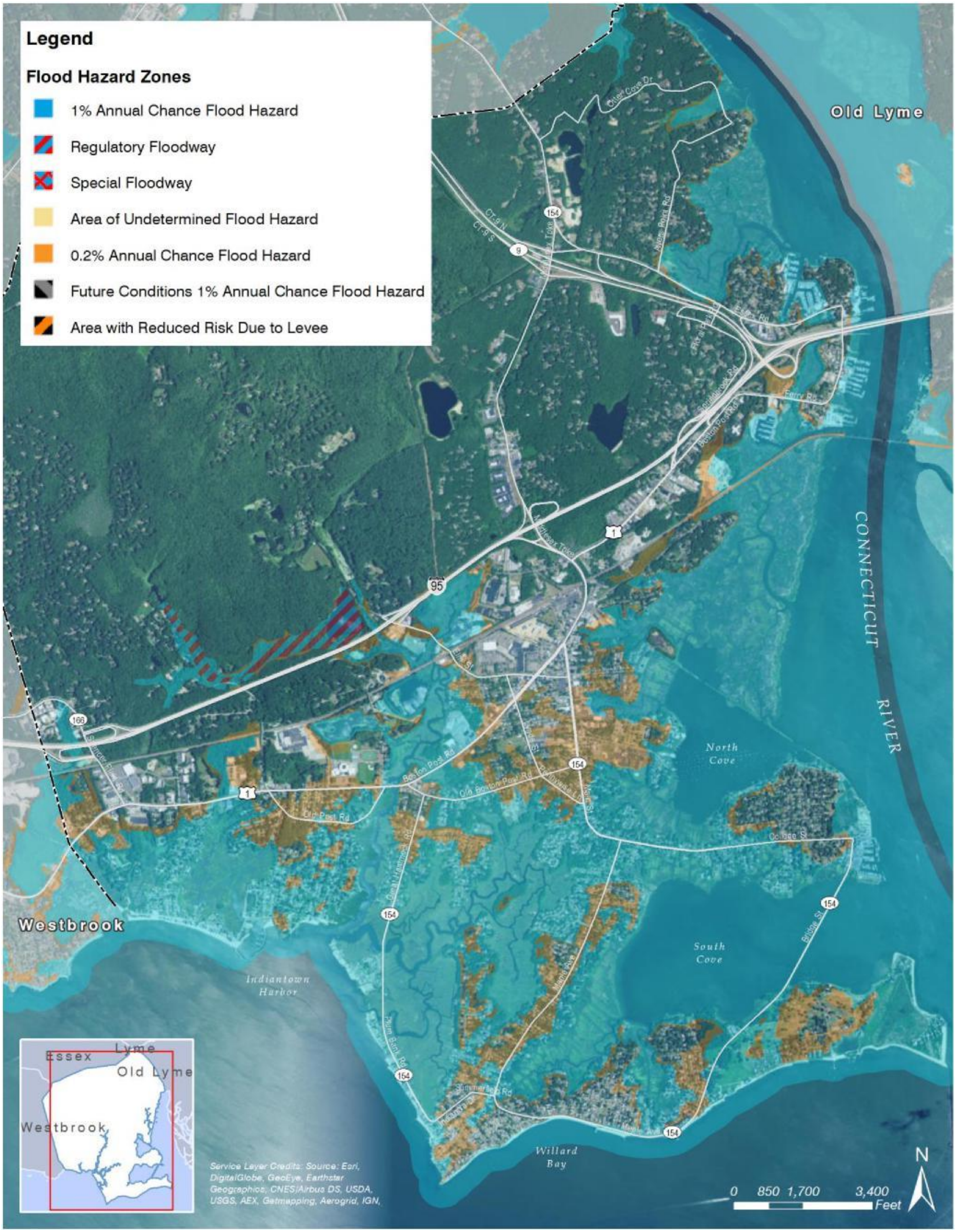


Figure 4 – Modeled 500-year return period flood limits

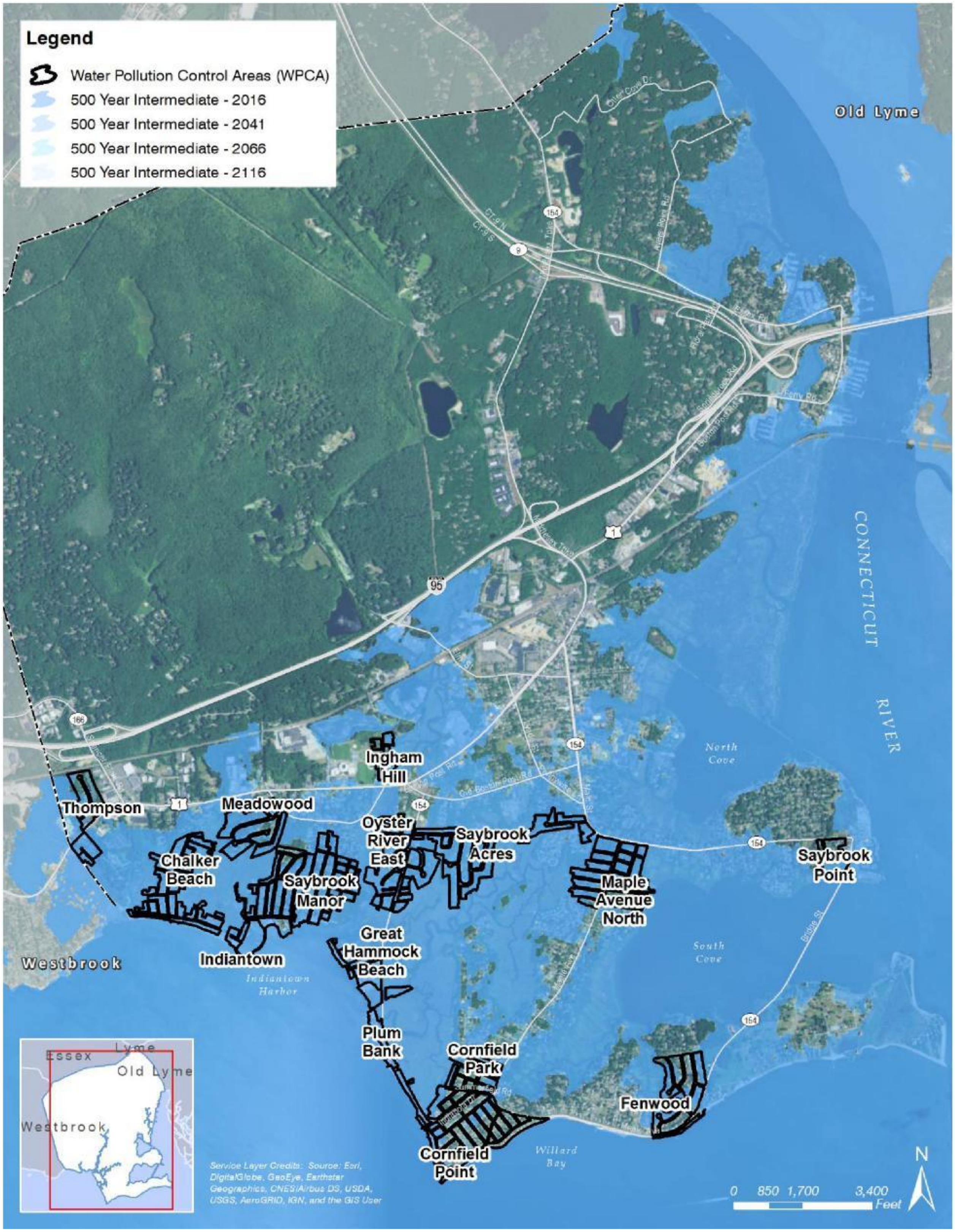
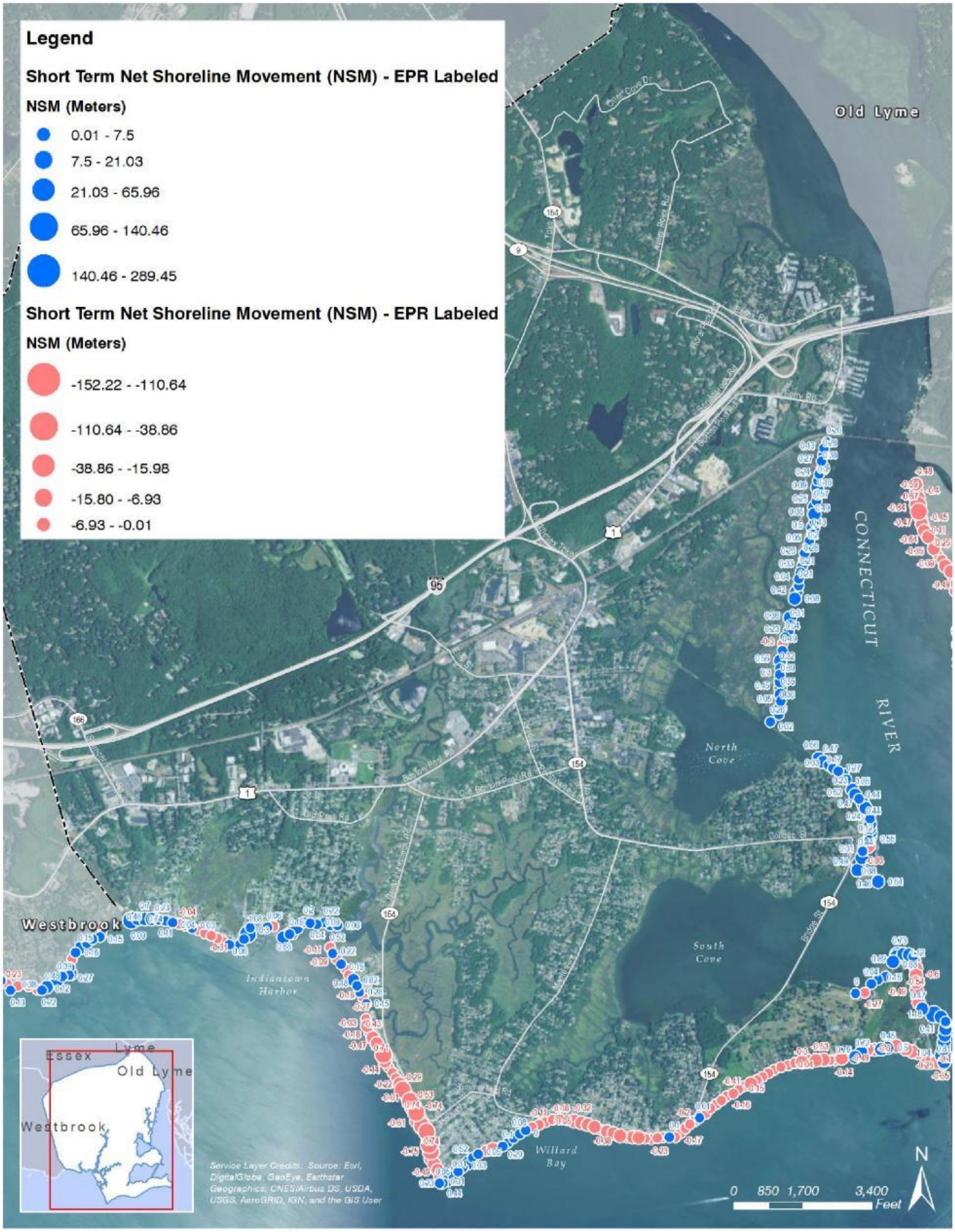
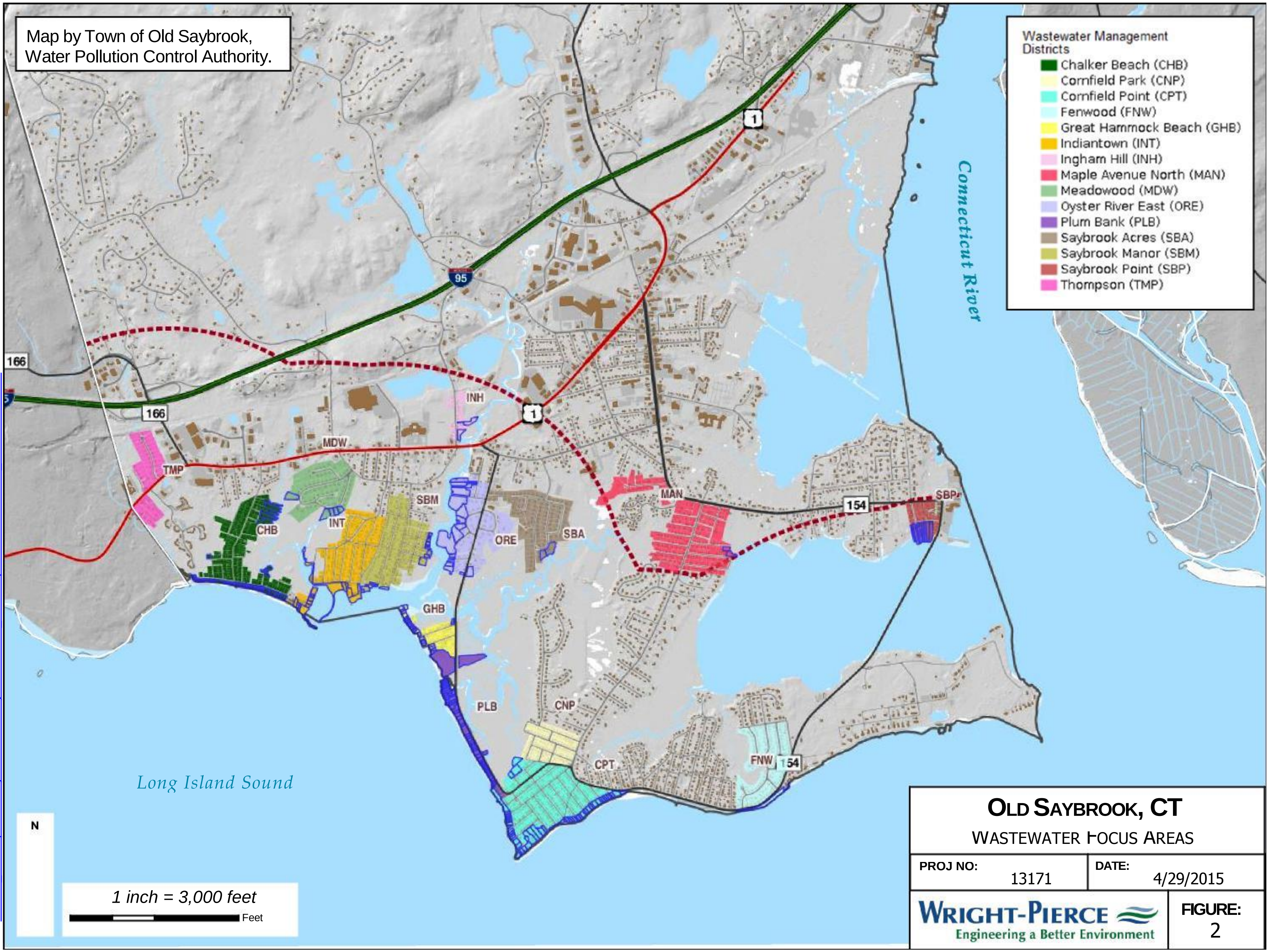


Figure 5 – Observed Shoreline Change



Attachment 1



OLD SAYBROOK, CT

WASTEWATER FOCUS AREAS

PROJ NO: 13171	DATE: 4/29/2015
WRIGHT-PIERCE Engineering a Better Environment	FIGURE: 2

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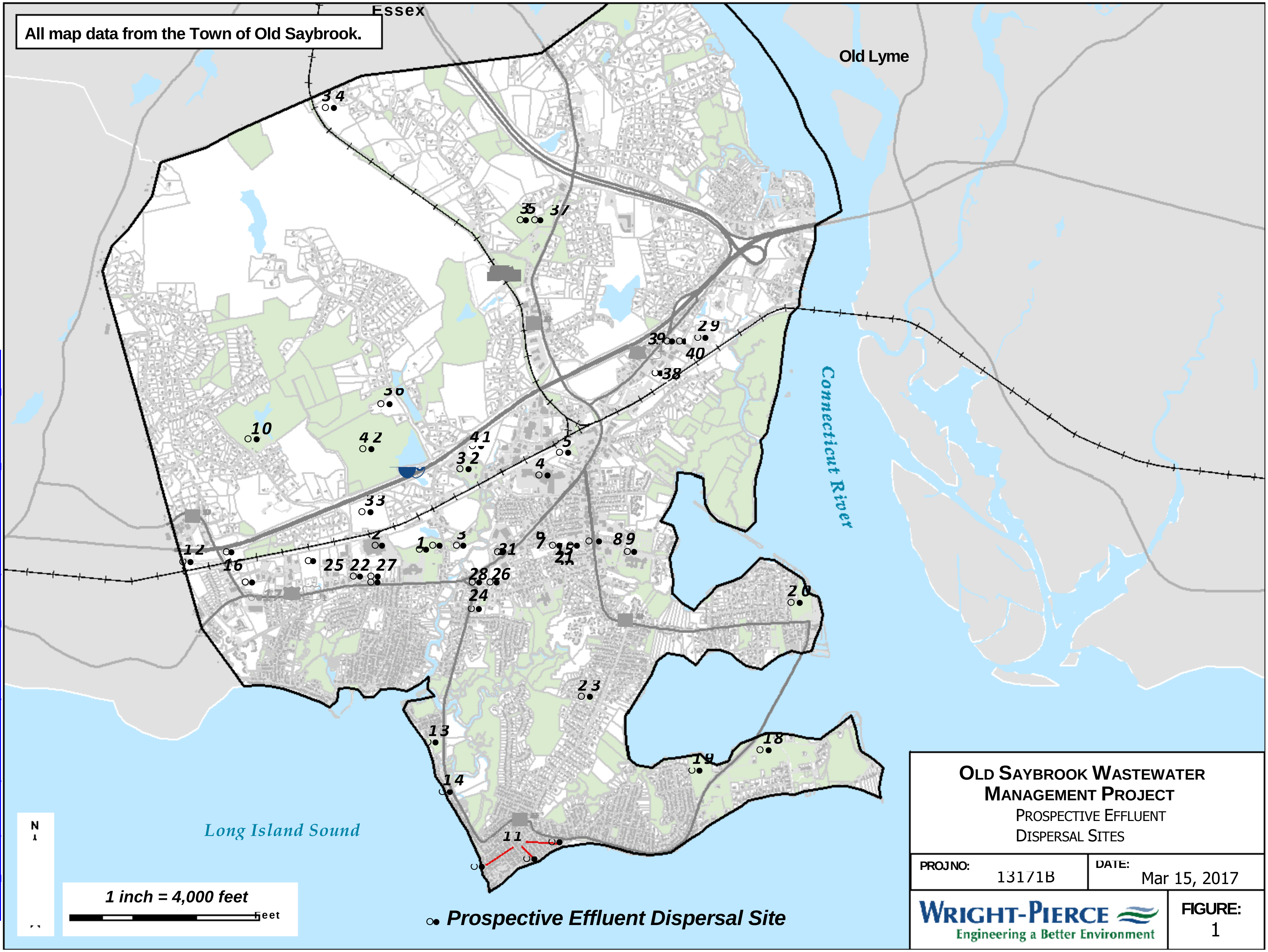


OLD SAYBROOK WASTEWATER MANAGEMENT PROJECT

PROSPECTIVE EFFLUENT DISPERSAL SITES

PROJ NO: 13171B	DATE: Mar 15, 2017

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE: 1

JMN W:\GIS_Development\Projects\CT\OldSaybrook\13171_WW-DispersalSites\MXDs\2_EffluentSites_v4.mxd

Attachment 2

Table 2-1- Predicted Flood Stillwater Elevations in Vicinity of Old Saybrook, in feet relative to NAVD88

Return Period	1-yr	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr	1,000-yr
2017:										
NOAA MEAN	2.3	3.5	4.4	5.0	5.6	6.6	7.5	8.4		
NOAA UB	2.3	3.7	4.7	5.7	6.7	8.6	10.3	12.6		
NOAA LB	2.3	3.3	4.1	4.5	5.0	5.7	6.2	6.8		
FEMA				5.5		7.7	9.2		15.3	
USACE MEAN	3.9	4.8	5.9	6.7	7.4	8.3	9.2	10.3	11.8	12.8
USACE UB	6.9	7.7	8.7	9.6	10.4	11.8	12.9	14.1	15.6	16.6
USACE LB	0.9	2.0	3.1	3.7	4.3	4.9	5.5	6.4	7.9	9.0
2042:										
USACE MEAN (LOW SLR)	4.0	4.9	6.0	6.8	7.5	8.4	9.3	10.4	11.9	12.9
USACE MEAN (INT SLR)	4.2	5.1	6.2	7.0	7.7	8.6	9.5	10.6	12.1	13.1
USACE MEAN (HIGH SLR)	4.9	5.8	6.9	7.7	8.4	9.3	10.2	11.3	12.8	13.8
2067:										
USACE MEAN (LOW SLR)	4.2	5.1	6.2	7.0	7.7	8.6	9.5	10.6	12.1	13.1
USACE MEAN (INT SLR)	4.7	5.6	6.7	7.5	8.2	9.1	10.0	11.1	12.6	13.6
USACE MEAN (HIGH SLR)	6.2	7.1	8.2	9.0	9.7	10.6	11.5	12.6	14.1	15.1
2117:										
USACE MEAN (LOW)	4.5	5.4	6.5	7.3	8.0	8.9	9.8	10.9	12.4	13.4
USACE MEAN (INT SLR)	5.9	6.8	7.9	8.7	9.4	10.3	11.2	12.3	13.8	14.8
USACE MEAN (HIGH SLR)	10.3	11.2	12.3	13.1	13.8	14.7	15.6	16.7	18.2	19.2

Table 2-2 Predicted Flood Stillwater Elevations at Coastal Wastewater Management Districts, in feet relative to NAVD88

Return Period	Existing Ground Elevation, feet NAVD88	100-yr	500-yr
2017:			
Chalker Beach	0 to 5 Beach 0 to 4 Marsh 5 to 10 Land	10.4 to 10.8	13.2 to 13.6
Indiantown	0 to 5 Beach 0 to 4 Marsh 5 to 10 Land	10.4 to 10.9	13.1 to 13.7
Saybrook Manor	0 to 5 Beach 0 to 4 Marsh 5 to 10 Land	10.4 to 10.9	13.2 to 13.7
Great Hammock	0 to 5 Beach 0 to 4 Marsh 0 to 6 Land	10.2 to 10.3	12.9 to 13.0
Plum Bank	0 to 5 Beach 0 to 4 Marsh 0 to 10 Land	9.9 to 10.2	12.7 to 13.0
2042 USACE Intermediate SLR Projection:			
Chalker Beach		10.6 to 11.1	13.4 to 13.8
Indiantown		10.6 to 11.2	13.3 to 13.9
Saybrook Manor		10.7 to 11.2	13.4 to 14.0
Great Hammock		10.5 to 10.6	13.2 to 13.3
Plum Bank		10.3 to 10.5	13.0 to 13.2
2067 USACE Intermediate SLR Projection:			
Chalker Beach		11.1 to 11.5	13.8 to 14.2
Indiantown		11.0 to 11.6	13.7 to 14.2
Saybrook Manor		11.1 to 11.5	13.9 to 14.3
Great Hammock		10.9 to 11.0	13.6 to 13.7

Plum Bank		10.6 to 10.9	13.5 to 13.6
2117 USACE Intermediate SLR Projection:			
Chalker Beach		12.2 to 12.6	14.5 to 14.9
Indiantown		12.2 to 12.7	14.4 to 14.9
Saybrook Manor		12.2 to 12.7	14.6 to 15.0
Great Hammock		12.1 to 12.1	14.3 to 14.4
Plum Bank		11.7 to 12.0	13.9 to 14.3

Table 2-3 - Predicted Significant Wave Height and Wave Crest Elevation at Coastal Wastewater Management Districts, in feet relative to NAVD88

	Significant Wave Height, feet		Approximate Wave Crest Elevation, feet	
Return Period	100-yr	500-yr	100-yr	500-yr
2017:				
Chalker Beach	4.0 to 4.5 Beach 2.0 to 3.0 Marsh 1.0 to 3.0 Land	5.0 to 6.0 Beach 3.5 to 4.0 Marsh 2.5 to 5.0 Land	14.0 13.0 14.0	18.0 16.5 17.0
Indiantown	4.0 to 4.5 Beach 2.0 to 2.5 Marsh 1.0 to 2.0 Land	5.0 to 5.5 Beach 2.5 to 4.0 Marsh 1.5 to 2.0 Land	14.0 13.0 12.0	17.0 16.5 15.0
Saybrook Manor	4.0 to 4.5 Beach 2.0 to 3.0 Marsh 1.0 to 3.0 Land	5.0 to 5.5 Beach 3.0 to 4.0 Marsh 1.0 to 4.0 Land	14.0 13.0 13.0	17.0 16.0 16.0
Great Hammock	3.0 to 4.0 Beach 2.0 to 3.0 Marsh 1.5 to 2.5 Land	4.5 to 5.0 Beach 3.0 to 4.0 Marsh 4.0 to 4.5 Land	14.0 13.0 13.0	17.0 16.0 16.5
Plum Bank	3.5 to 5.0 Beach 2.5 to 3.0 Marsh 1.5 to 3.0 Land	4.5 to 5.5 Beach 3.5 to 4.0 Marsh 2.0 to 4.0 Land	14.0 13.0 to 14.0 13.0 to 14.0	17.0 16.0 16.0

Attachment 5: Neighborhood Resilience and Adaptation

INTRODUCTION

A *Neighborhood Resilience and Adaptation Study* was performed as part of the Old Saybrook Coastal Community Resilience Study. The neighborhood study focused on developing an understanding of the specific risks, challenges and resilience and adaptation opportunities at the neighborhood scale within Old Saybrook. Two "neighborhoods" were selected: 1) the Chalker Beach Community, which is representative of the Low Beach Communities; and 2) the Rt. 154 "Resilience Corridor", which is representative of Saybrook Point and Town Center.

Each of these neighborhoods were impacted by Superstorm Sandy. For each neighborhood, the resilience team:

performed a detailed evaluation of flood vulnerability and risk;

coordinated with neighborhood representatives;

conducted stakeholder workshops; and

developed concepts for neighborhood-specific adaptation and resilience strategies.

This attachment summarizes the results of these efforts.

The frequency and intensity of coastal floods will increase in the future, primarily as a result of sea level rise. Over the last 100 years the, sea level within Long Island Sound has risen about 0.8 foot. Over the next 100 years sea levels are projected to rise, with a reasonable probability, another 4 to 6 feet and may increase as much as 15 feet. During the next 100 years, regardless of the actual amount of sea level rise, the rate of sea level rise will steadily increase. The on-going, incremental effects of rising sea levels will require that neighborhoods adapt.

Neighborhood resilience and adaptation strategies should consider the stakeholder perspectives, issues, opportunities, geography and history that are unique to that neighborhood. They also need to consider the functional, spatial and symbolic roles played by the neighborhood in relation to the Town and the State. In this sense, each neighborhood should be understood within a larger set of geographic relationships and in relation to very local conditions.

LOW BEACH COMMUNITIES - CHALKER BEACH

The Low Beach Communities represent a fundamental part of the history and character of Old Saybrook. With frontage on Long Island Sound and surrounded by tidal marsh, however, the Low Beach Communities (including Chalker Beach; Indiantown; Saybrook Manor; Great Hammock Beach and Plum Bank) are highly vulnerable to coastal flooding. These communities are located almost entirely within the current FEMA AE zone (representing the 100-year and 500-year recurrence interval floods). The beaches, which are developed with residences, front the Sound and are exposed to high waves and located within a FEMA VE zone. Upland areas of these communities are also surrounded by tidal marsh.

These communities are also vulnerable to frequent flooding, and the frequency of flooding will consistently increase with sea level rise. Portions of these neighborhoods will be chronically flooded (i.e., flooding on average 26 times per year) by the years 2040 to 2050.

The flood risks that are specific to, or amplified by, the coastal setting of these neighborhoods include the following:

- The neighborhoods are vulnerable to flooding from both Long Island Sound (overtopping the beaches) and the tidal marsh – basically, flood inundation advances from all sides.
- The beaches, which form the frontage of these communities, are dynamic systems and subject to erosion and short-term and long term shoreline change. Active measures (such as beach nourishment) can be expected to be required to maintain the shoreline location.
- The location of structures within VE zones are particularly vulnerable to flood-related damage as most structural damage is a result of wave action. Elevating these structures, by itself, does not eliminate coastal flood hazards.
- Structures located within these neighborhoods, due to their high flood vulnerability, have the potential to become repetitive insurance loss properties impacting the overall cost of insurance within Old Saybrook.
- The ground surface elevation throughout most of the land area of these communities is quite low relative to sea level. This has implications to: a) frequency of flooding; b) performance of on-site, subsurface wastewater disposal systems; and c) stormwater run-off, with ponding and flooding due solely to heavy rainfall.
- Street flooding will become frequent events.

These neighborhoods also have other coastal flood challenges that are somewhat specific. These include:

- The beaches are generally private, with access and use limited to the community residents. This may, increasingly, become an issue if the cost of maintaining the beaches (even if only for flood and shoreline protection purposes) are borne by all the Town residents (many of whom do not have rights to use the beach).
- The very high flood vulnerability of these communities results in a situation where these communities represent a disproportionately high coastal flood risk (and subsequent costs for public safety, public works, wastewater management, etc.) relative to the Town as a whole.
- The high value of waterfront properties results in a situation where major contributors to real estate tax revenue are also properties that are the most vulnerable to coastal flooding.
- The cost to provide necessary public infrastructure improvement (e.g., elevating roads) within these communities may not be sustainable.
- Resistance to retreating from these areas is both understandable and is to be expected. However, as flooding becomes more frequent, the perspective of residents about retreat (e.g., voluntary buybacks) will likely change.

Chalker Beach Overview

Relative to coastal flood vulnerability, the Chalker Beach Community is characterized by three separate areas:

1. The area to the south of Beach Road West, Beach Road East and Bel Air Manor Road, including the beach (a barrier spit) and the houses constructed on the beach. The ground surface elevation is low, ranging from about 0 (mean sea level) to about 7 feet NAVD88, with the elevation around the houses generally ranging from 5 to 7 feet NAVD88. The beach is about 80 to 120 feet in width and 2,200 feet in length and the shoreline includes 8 groins that were constructed for the purpose of trapping sediment. The groins were repaired during the 1980s. Since that time, the beach has experience net accretion. The eastern portion of the beach, across from Bel Aire Manor Road, is eroding. No groins are present along this section of beach. This area is very vulnerable to both flood inundation due to storm surge and wave effects and is completely within the current FEMA VE zone, with a Base Flood Elevation of 14 feet NAVD88. The predicted 100-year recurrence interval currently located south of Beach Road, on the beach and within the FEMA VE zone. wave heights at the building faces are about 3 to 4 feet. About 50 houses are
2. The area immediately to the north of Beach Road West, Beach Road East and Bel Air Manor Road, including the roads and land area between the roads and the tidal marsh. This east-west trending area consists of artificially-filled marsh. This area is flat and low-lying, with ground surface elevations ranging from about 4 to 5 feet NAVD88. This area is very vulnerable to flood inundation due to storm surge and, to a lesser degree, wave effects. It is located completely within the current FEMA AE zone, with a Base Flood Elevation of 12 feet NAVD88. In the absence of the existing structures along the beach, 100-year recurrence interval wave heights within this area would be around 2 to 3 feet in height. Due to its poor drainage (the ground typically slopes less than 1%), the area is also flood during periods of heavy precipitation.
3. The third area includes Chalker Beach Road, which runs north-south, and the houses on either side of the road between the road and the tidal marsh. This area consists of natural glacial meltwater deposits, and the ground surface is higher than along the beach. Ground surface elevations range from about 6 feet NAVD88 along the south end of Chalker Beach Road to about Elevation 10 to 12 feet NAVD88 at the north end near Route 1 Boston Post Road. This area, except for the very north end near Boston Post Road, is located completely within the current FEMA Coastal AE zone, with a Base Flood Elevation of 12 feet NAVD88. This area initially floods due to floodwaters encroaching from the tidal marsh; however, for floods greater than the 2-year recurrence interval flood (with a stillwater elevation of about 5 feet NAVD88), floodwaters encroach directly from both Long Island Sound and the tidal marshes, and the entire area of the Chalker Beach Community is under water.

Economic aspects of the Chalker Beach Community are summarized in **Table 5-1**, below.

Table 5-1: Chalker Beach Economic Relationship to Town

$169,840,286	Estimated market value of property off Chalker Beach Road and Indian Town
$118,888,200	Estimated total assessed value
$0.01966	Town mill rate
$2,337,342	Estimated property tax revenue
$40,543,368	Town-wide property tax revenue
5.8%	Percent from study area
$5,300,000	Hazus estimated Average Annualized Loss (AAL)

The Chalker Beach Community is managed by the Chalker Beach Improvement Association (CBIA). The CBIA was formed in 1931, and is recognized by the State of Connecticut as a special taxing district. This status authorizes the CBIA to levy property taxes in addition to those levied by the Town to pay for services including but not limited to:

- maintain and regulate the beaches, swimming areas, and recreational facilities;
- construct and maintain roads;
- provide fire, police, or security protection; and
- maintain flood or erosion control systems (e.g., dams, ditches, retaining walls, and waterfronts).

One of CBIA's goals is to proactively preserve the shoreline. The CBIA has independently executed several adaptation projects as a special taxing district including replenishment and nourishment of beaches, construction eight groins and recent repair of two groins, and installation and maintenance of a tide gate at the west end of the beach.

Community Workshop/Stakeholder Outreach

The resilience and adaptation planning team, led by GZA, held a workshop on August 19, 2017 to present the coastal flood risk and discuss some of the issues presented above.

Over seventy participants attended the workshop. During the workshop, the team reviewed the near to long-term risks and engaged with residents and members of this area in an interactive dialogue to review and discuss adaptation options.

Through the workshop process, the team assessed stakeholder goals and the willingness of the residents and community leaders (Chalker Beach Improvement Association [CBIA]) to contribute resources, and make compromises, to achieve coastal resilience and adapt to rising sea levels. Top priorities identified from group discussions and polling included:

1. Investment in protective infrastructure such as perimeter berms and beach nourishment.
2. Prioritize investment into low-lying areas.
3. Make infrastructure investment to make community ingress and egress roads for chronic flooding and high probability (e.g., 2-year recurrence interval floods).
4. Prepare for evacuation during larger, less frequent flood events.
5. Perimeter flood protection berms of up to six feet in height would be acceptable (from an aesthetics, water access perspective).
6. Unwillingness to entertain buyouts and relocation.
7. Willingness to contribute to an adaptation fund of an amount no more than $10,000 per household for "one-time" measures and $1,000 per household on a recurring 10-year basis.

Topics without a clear consensus from the discussions and polling were:

- How to deploy perimeter berms (easements, design guidelines, voluntarily or otherwise).
- If perimeter flood protection berms, located on private property, should also be used as recreational, public access greenways.
- Whether property should be dedicated to allow for lateral advancement of tidal marsh (or whether marsh advancement is important to the residents).
- Whether zoning regulations should dictate the visual and aesthetic requirements for elevating houses.

Resilience and Adaptation Strategies

The resilience and adaptation team operationalized the workshop's outcomes into the following resilience and adaptation priorities:

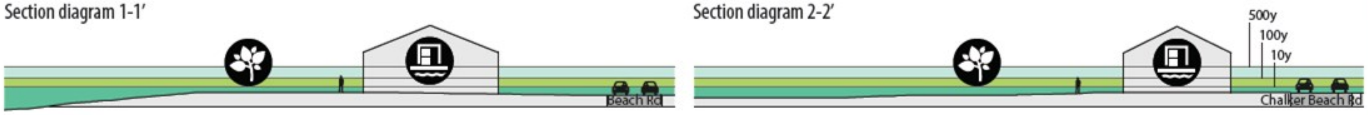
1. Ensure evacuation during flood levels greater than the 10-year recurrence interval flood, including access to the Town's public shelter.
2. Ensure that the Town's Essential and Lifeline facilities are protected to the 500-year recurrence interval floods.
3. Use alternative emergency response capabilities, such as amphibious vehicles during floods when roads are flooded.
4. Conditionally support the community residents' goal of staying in the community (i.e., not retreating) and using a strategy of flood protection at the property scale (i.e., elevated structures, consistent with building codes) in the near and medium term, while considering each project's long-term survivability and potential for repetitive loss.
5. Use an integrated approach to adapt to flood protection and adaptation, using a variety of strategies and measures.

A number of alternative strategies were presented and discussed during the workshop. These are presented on **Figures 5-2** through **5-4** and summarized in **Table 5-2**.

Table 5-2: Chalker Beach Resilience and Adaption Strategies

Strategy	Benefits/Limitations
Strategic Realignment: • Voluntary, managed retreat from VE Zones and other high flood vulnerability areas. • Create natural barrier spit beach and dune. • Allow natural beach migration and marsh advancement. • Publically-owned beaches and greenways.	**Benefits:** • Will reduce future Town costs associated with repetitive loss, public safety, public works and wastewater management. • Provides a valuable, public, natural and recreational resource. • Improves ecology and habitat. **Limitations:** • Loss of tax revenue (unless property owners relocate somewhere else in Town). • Retreat is not desirable to community residents.
Adaptive Environments: • Elevate structures • Floodable roads (or elevated roads) • Elevated pedestrian boardwalks • Off-site wastewater treatment • Beaches remain private • Beach nourishment • Engineered dunes, beach berms • Improved stormwater management, including green infra-structure	**Benefits:** • Residents remain and the community continues. • Cost of building flood protection borne by the property owner – not the Town taxpayers. • Cost of beach nourishment, maintenance of coastal structures, etc. borne by the community – not the Town taxpayers. **Limitations:** • Future increased Town costs associated with repetitive loss, public safety, public works and wastewater management. • Future increased Town costs associated with repetitive loss, public safety, public works and wastewater management. • Cost of elevating roads will be high and likely require municipal bonds. • No public (Town residents) access to beach and shore.
Perimeter Protection: • Construct flood protection landscaped earthen berms along perimeter of tidal marshes • Elevate structures • Beaches remain private • Possibly use berms as public greenways • Engineered dunes, beach berms • Beach nourishment • Improved stormwater management, including green infra-structure	**Benefits:** • Residents remain and the community continues. • Cost of beach nourishment, maintenance of coastal structures, etc. borne by the community – not the Town taxpayers. • Perimeter protection provides flood protection to both private property and public infrastruc-ture. • Berms used as greenways provides valuable, public recreational resource. **Limitations:** • While the berms will reduce flood risk, it will not likely be feasible to construct berms that quali-fy as FEMA-certified levees; therefore, nor reduction in flood insurance or regulatory flood re-quirements will result. • Cost of perimeter flood protection berms is high; responsibility for cost is undetermined. • Construction of berms is technically and legally challenging because all property along the berm alignment is divided by parcel and privately owned. • No public (Town residents) access to beach and shore.

Adaptation Alternative A: Strategic Realignment



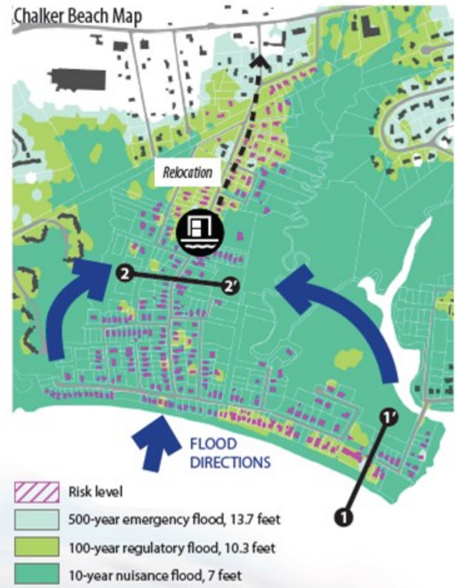
Strategy

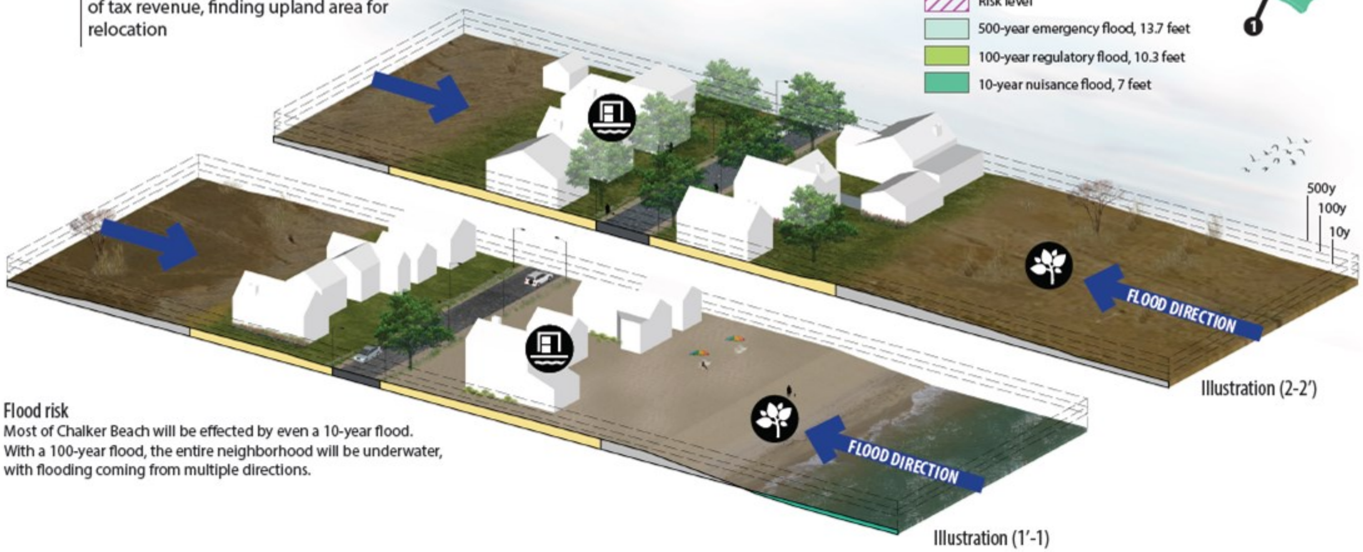
Retreat programs favor removing or relocating structures further back from the shoreline rather than repeatedly repairing storm damaged structures and hardening the shoreline.

A Strategic Realignment approach typically involves establishing thresholds to trigger demolition or relocation of structures threatened by coastal risks, including erosion and sea level rise. This approach is frequently coupled with several other planning and regulatory techniques, such as identifying high-risk areas and instituting relocation assistance and/or buy-back programs to help with relocation costs or compensate property owners when their property becomes unusable.

what	**Managed Retreat**
why	Create natural coastal area that provides protective functions, long term solution, and habitat
initiator	Town of Old Saybrook, Property owners
who benefits	Ecosystems, habitat creation
issues	Diminished emergency services along corridor, property loss, space for relocation

what	**Removal and relocation**
why	Eliminate threats from sea level rise by moving threatened structures and infrastructure
initiator	Town of Old Saybrook, Property owners
who benefits	Ecosystems, habitat creation
issues	Potential buy-back assistance costs, loss of tax revenue, finding upland area for relocation





Flood risk

Most of Chalker Beach will be effected by even a 10-year flood. With a 100-year flood, the entire neighborhood will be underwater, with flooding coming from multiple directions.

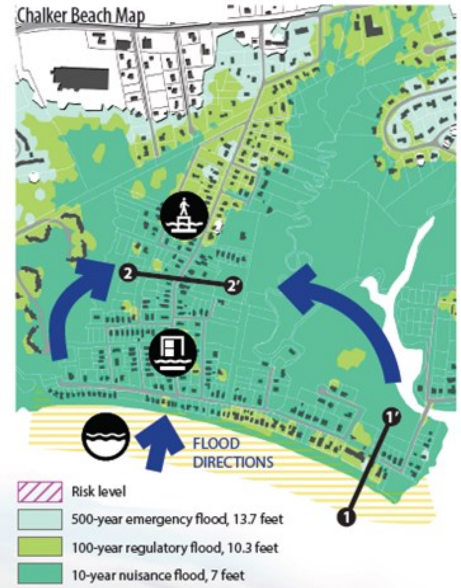
Beach Community Workshop

Old Saybrook Community Coastal Resilience Study
Community Workshop

Stantec

Figure 5-2: Adaptation Strategy A - Strategic Realignment

Adaptation Alternative B: Adaptive Environments



Strategy

Individual owners may continue to invest in flood-proofing their structures. However, as Chalker Beach Road is effectively a cul-de-sac, it is unlikely that the Town of Old Saybrook or the State would invest in raising critical infrastructure to provide emergency services. That being said, the northern part of Chalker Beach Road is on more robust soil type, is slightly higher in elevation, and may be considered as a lifeline for the rest of the Chalker Beach community in the event of an emergency.

Allow the streets to flood, centralized parking, elevated timber boardwalks, aesthetic standards for raising housing. Design floodable roads.

Beach nourishment is placing sand on a beach to buffer against wave action and flooding. A project typically lasts between three and ten years

what	**Flood-proof construction**
why	Protection from flood events and low impact on surrounding environment, such as home raising
initiator	Property owners
who benefits	Property owners, natural areas
issues	Non-flood-proof septic systems

what	**Beach nourishment**
why	Sandy dredging material from rivers replaces erosion losses and protects from storms
initiator	Property owners, Army Corp of Engineers
who benefits	Residents
issues	Potential cost to residents

what	**Elevated boardwalk, floodable road**
why	Enhances access during chronic flood events and improves resilience to sea level rise
initiator	Chalker Beach Association, Town of Old Saybrook
who benefits	Residents
issues	Does not protect buildings. May impact access to non-elevated buildings. Will not provide vehicular access during flood events.

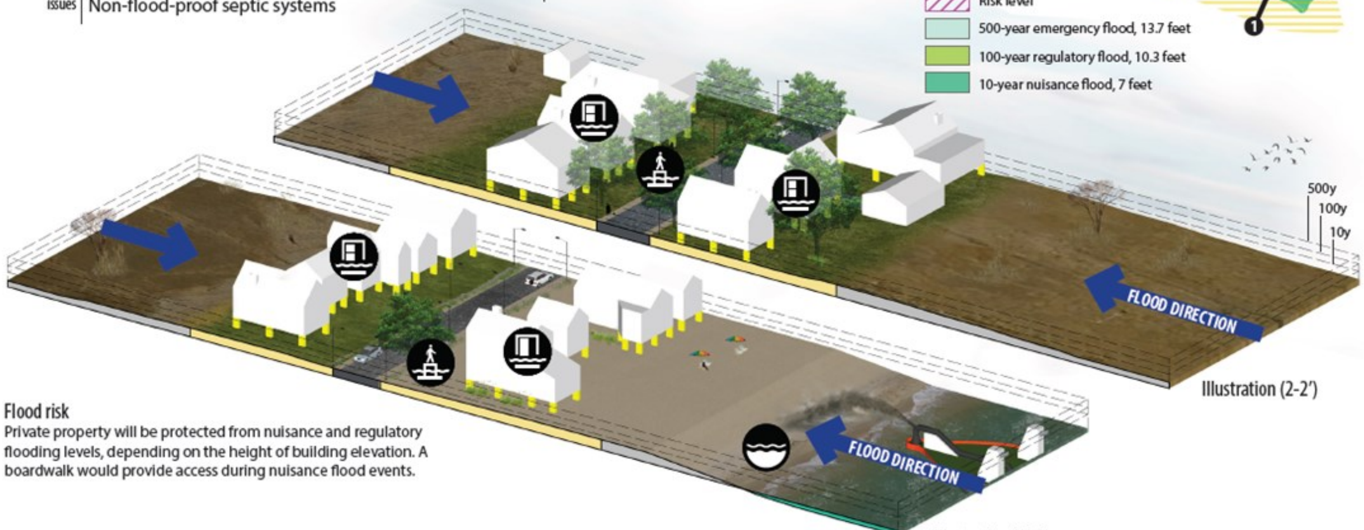


Illustration (2-2')

Illustration (1'-1)

Flood risk

Private property will be protected from nuisance and regulatory flooding levels, depending on the height of building elevation. A boardwalk would provide access during nuisance flood events.

Beach Community Workshop

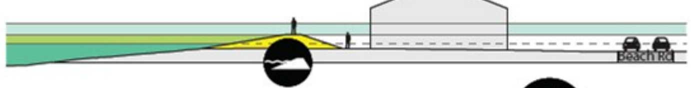
Old Saybrook Community Coastal Resilience Study
Community Workshop

GZA Stantec UD LAB

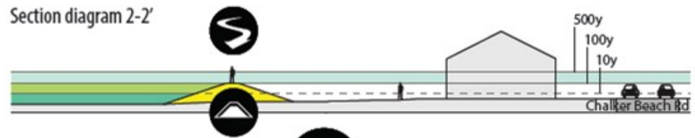
Figure 5-3: Adaptation Strategy B – Adaptive Environments

Adaptation Alternative C: Perimeter Protection

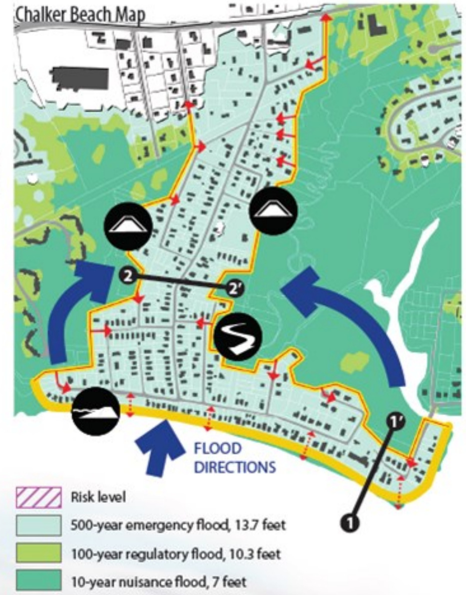
Section diagram 1-1′



Section diagram 2-2′



Chalker Beach Map



Strategy

Perimeter berms at the edge between relatively high-ground and existing marshes can be used to create a flood-protected area that would include both private property and roads for egress. The berm structures could double as a recreational and transportation corridor for walking and biking. Inside of the berm, approaches to dealing with rainwater may include green infrastructure, such as drainage channels and constructed wetlands, and water discharge, such as pumping stations.

Perimeter berm issues

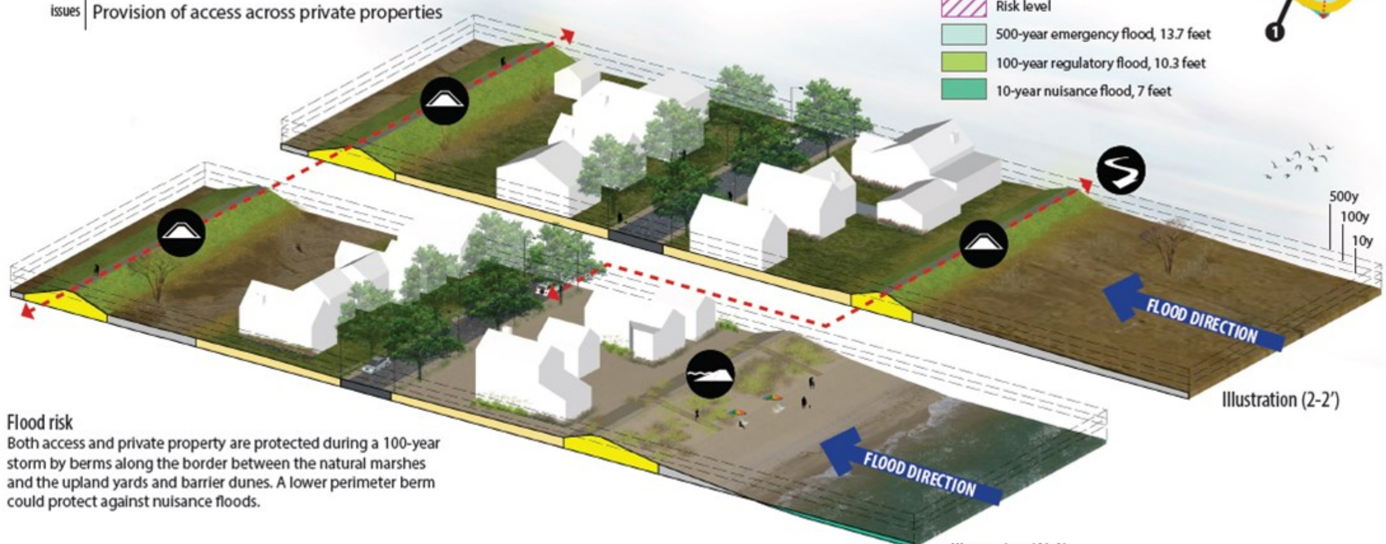
Most of the perimeter is in private property (about 80 different lots). Easement acquisition is required if the Town is responsible for construction. A berm for a 100-year flood will be 30 to 35 feet wide. A perimeter flood wall could work as well, but with the some of the same issues as the berm. Low berms (1-2 feet) to protect against nuisance flooding with fixed or deployable walls for extreme floods is also an option.

As an alternative to easements, the Town could develop standard details for berms and make it a requirement by ordinance–similar to how requirements for on-site septic systems are implemented and enforced.

what	**Recreation and transportation link**
why	Strengthen the ecological and recreational potential, link the town to the marshland, transportation route
initiator	Town of Old Saybrook, Property owners
who benefits	Residents, visitors, tourists
issues	Provision of access across private properties

what	**Barrier dune reinstatement**
why	Protection of property, ecological restoration
initiator	Property owners
who benefits	Residents
issues	Expense to residents

what	**Perimeter berm**
why	Protection of critical infrastructure and private property
initiator	Town of Old Saybrook, Property owners
who benefits	Residents
issues	Easement on private property. Rainwater run-off impact. Impacted views to wetlands.



Flood risk

Both access and private property are protected during a 100-year storm by berms along the border between the natural marshes and the upland yards and barrier dunes. A lower perimeter berm could protect against nuisance floods.

Illustration (2-2′)

Illustration (1′-1)

Beach Community Workshop

Old Saybrook Community Coastal Resilience Study
Community Workshop

GZA Stantec UED LAB

Figure 5-4: Adaptation Strategy C – Perimeter Protection

Rt 154 RESILIENCE CORRIDOR

Route 154 is a major Town arterial. Running approximately east-west, it connects Saybrook Point to the Town Center as well the Cornfield Point to Fenwood neighborhoods located to the south via Maple Avenue. It provides access to homeowners in the area, abuts several historic properties, and serves commercial and recreational facilities at Saybrook Point. It is also highly vulnerable to coastal flooding, resulting in roadway flooding, disruption to services and customers to local area businesses, and limited capacity for ingress and egress of residents.

This area was selected for a Neighborhood Study since it is representative of a common coastal flood condition that occurs throughout the portion of Old Saybrook located south of Interstate 95 - during coastal floods the roads flood and higher elevation areas effectively become "islands" with no access in or out during the flood.

The flood risks that are specific to the flooding of major arterials in Old Saybrook are:

- Flooding of the roods during major storms impacts the Town's capability to provide emergency response services;
- Flood-related damage of roadways will result in increased public works costs;
- Frequent roadway flooding disrupts access to homes and businesses;
- Roadway flood mitigation improvements, such as elevating roads, are both technically challenging and very expensive. For example, elevating roads affects adjacent driveways and homes (many of which are historical properties) and existing mature landscaping; and
- Elevating roadways could also change the character of Old Saybrook.

Rt 154 Resilience Corridor Overview

Figure 5-5 shows the limits of flood inundation in the area of the Rt 154 Resilience Corridor based on the current FEMA special flood hazard area mapping, corresponding to the 100-year recurrence interval flood. **Figure 5-6** and **Figure 5-7** shows the limits of the 2-year and 10-year recurrence interval floods, respectively, in the area of the Rt 154 Resilience Corridor. These figures show both the extent and the frequency of flooding around this section of Rt 154. The current 2-year recurrence interval flood is consistent with the chronic flood inundation that will occur around the years 2040 to 2050; at that time, this degree of flooding is predicted to occur on average about 26 times per year. Flood inundation simultaneously encroaches on inland areas from the North, South Cove and the Connecticut River shoreline.

Figure 5-5: Limits of FEMA Special Flood Hazard Area around Route 154

Figure 5-6: Limits of 2-year Recurrence Interval Flood around Route 154

Figure 5-7: Limits of 10-year Recurrence Interval Flood around Route 154

Community Workshop/Stakeholder Outreach

Workshop 1:

The resilience and adaptation planning team, led by GZA, held workshops on June 20, 2017 and August 1, 2017 to present the coastal flood risk and discuss some of the issues presented above.

Seventeen participants attended the first workshop on June 20, 2017. During the workshop, the team reviewed the near to long-term risks and engaged with residents and members of this area in an interactive dialogue to review adaptation options for near, mid, and long-term future coastal flooding and sea level rise scenarios. Through the workshop, the team assessed the stakeholder goals and the willingness of decision makers to contribute resources and to make tradeoffs to achieve adaptation options. This workshop resulted in the identification of adaption options and the associated tradeoffs for further assessment.

Figure 5-8: A group reporting their results during the first Resilient Corridor workshop

Workshop takeaways

1. Issues raised at multiple tables:
    - Safe egress routes from isolated areas;
        - Preserve open space for marshes and marsh migration;
        - Voluntary buyout and relocation program to upland areas.
2. Values with selective support:
    - Elevate road at lowest portion, preferable with low bridge;
    - Strategically implement multi-use berms; and
    - Flood risk is the responsibility for property owners only.

Principles derived from the workshop

- Embrace a changing landscape due to sea level rise and storms while ensuring safe egress routes and protecting essential and lifeline facilities during major storm events.
- Preserve marshes, views of marshes, and open space for marsh migration.
- Provide options for voluntary buyout and relocation of at-risk property.

The workshop's participants broke into four tables to discuss adaption options and reach a shared vision. **Table 5-2** presents the approaches each of the four tables developed and presented at the conclusion of the workshop.

Table 1 **Minimal intervention**	**Table 2** **Adaptive engineering**	**Table 3** **Mixed strategy**	**Table 4** **"Barbell" solution**
Let the water in and preserve the marshes	Two new berms, one becomes new road	Use top of berm for a recreation trail	Berm where needed around Saybrook Point & downtown
Owners responsible for flood protection	Multi-use berms for recreation and septic	Voluntary program allowing home buy-out and relocation	Run berm into elevated road at the neck on Main Street
Protect only important buildings and infrastructure	Elevated bridge in place of existing road	Raised bridge	Relocate volunteer residences from the neck on Main Street
Relocate to upland and diversity of housing types	Elevate East Street and allow Maple Street to flood	Designate egress corridors, elevate one road per area	Create space for marsh to migrate where possible

Table 5-3: Approaches from Table Discussions

Workshop 2:

Fourteen participants attended the second workshop on August 1, 2017. The workshop gathered additional input from representatives of Old Saybrook, state of Connecticut's Department of Energy and Environmental Protection (DEEP), University of Connecticut's Center for Land Use Education and Research and CIRCA, and from residents in interactive discussions and exercises about the adaptation alternatives and trade-offs. A series of goals were developed in discussion with the workshop participants that contributed to the conceptual design development.

The participants established seven goals for a resilience approach:

1. Emergency response service during storm events
2. Accommodate frequent flooding
3. Support essential and lifeline facilities
4. Work with homeowners
5. Function as a public amenity with multiple benefits
6. Provide economic value/land development
7. Preserve the historic and natural character of Old Saybrook

Top priorities from the discussions and polling were as follows:

- Creating a program to raise roads to provide access to the largest number of homes.
- Egress routes as more important that protection of low-lying areas.
- Providing egress and mobility during frequent Sandy-sized storms, but not necessarily during the 1% annual-chance flood levels (aka 100-year return period flood).
- Having evacuation policies for Sandy-sized and larger storms.
- Providing sloped access to private driveways off of raised roads.
- Creating floodable (green) streets for non-critical routes.
- Creating recreational trails along the marshes, either with or without berms, and/or along rights-of-way.
- Building perimeter berms two to six feet tall.
- Leaving the responsibility of raising structures up to owners.

One topic without a clear consensus from the discussions and polling was how to deploy perimeter berms (easements, design guidelines, voluntarily, or otherwise).

Resilience and Adaptation Strategies

The concept of a state-wide Resilience Corridor was developed for the State of Connecticut's National Disaster Resilience Competition submission for the U.S. Department of Housing and Urban Development (HUD) (2016). The concept creates a Connecticut Resilience Corridor that couples critical transportation infrastructure, public safety objectives and smart economic investment to create long-term State and community viability in the face of sea level rise and coastal flood risk. Building upon the idea of transit-oriented developments, the Resilience Corridor connects the coastal areas of Connecticut through the major coastal East-West transportation corridors (Route 1, Interstate 95, the Merritt Parkway and Metro North rail), which in turn connect to other areas of the state.

The Resilience Corridor concept is supported by Connecticut's coastal geology which consists of elevated glacial ice-laid deposits (glacial till) and bedrock. Low-lying, glacial meltwater deposits (glacial drift) and post-glacial beach and marsh deposits are present to the south of the East-West transportation corridors, along the shoreline. The major East-West transportation corridors are, for the most part, located along the higher elevation glacial till and bedrock deposits and higher elevation areas of glacial meltwater deposits, at elevations typically higher (>15 feet NAVD88) than coastal flood elevations.

The state-wide Resilience Corridor connects the more vulnerable coastal communities, providing ingress and egress, evacuation routes and access for State and federal emergency response and recovery services. **Figure 5-10** conceptually illustrates the state-wide Resilience Corridor. The Route 154 Resilience Corridor, is conceptually, a part of the state-wide resilience corridor. It is also a major arterial that connects the areas of Saybrook Point, parts of the Town center and Cornfield Point to Fenwood to Route 1 and Interstate 95.

The resilience and adaptation team operationalized the workshop's outcomes into the following resilience and adaptation priorities:

1. Elevate the roadway (Main Street and intersection with Maple Avenue), including the use of low bridges, is desired. However, the technical feasibility and cost will prohibit significant grade increase (e.g., above the 100-year return period flood). Lower increase in grade, along smaller stretches of road, may be feasible.
2. Consider perimeter berms are an appropriate flood mitigation alternative to elevating roadways.
3. Ensure evacuation during flood levels greater than the 10-year recurrence interval flood, including access to the Town's public shelter.
4. Ensure that the Town's Essential and Lifeline facilities are protected to the 500-year recurrence interval floods and that emergency response service can be provided – even over flooded roads.

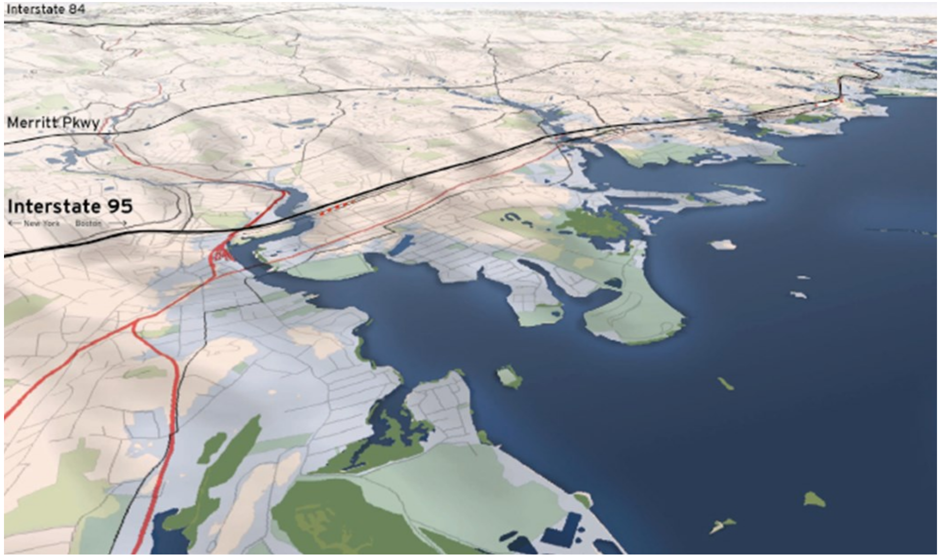


Figure 5-10: Illustration of State-Wide Resilient Corridor

5. Use an integrated approach to adapt to flood protection and adaptation, using a variety of strategies and measures.
6. Ensure that resilience investments result in **multi-functional public amenities**.
7. **Preserve the character** of Old Saybrook by maintaining view corridors, marshes, historic structures, and other characteristics.
8. Where reasonable, **accommodate frequent flooding** to maintain productive land uses.
9. Property owners are responsible for **protecting structures** during severe storms (up to the 1%-annual-chance flood level) as dictated in the building code.

Table 5-4: Resilient Corridor Design Solutions with Benefits and Limitations

Resilience alternative	Benefits	Limitations and risks
Elevated roads to the level of frequent flooding (e.g. 10-year recurrence interval flood)	Provides egress and emergency services during frequent storms Does not overly impact Old Saybrook's character by preserving views and access to historic structures Can be combined with public amenities such as bike lanes	Does not protect from severe floods Elevating homes is still required The landscape is not protected from floods May incentivize further investment into flood-prone areas
Perimeter berms selectively applied to the level of chronic and/or frequent floods	Protects landscape such that uses including parking and recreation are possible during chronic and frequent floods Can create redundant resilience when combined with elevated roads and elevated structures Can support public amenities such as recreation and open space Extends the life of landscape to retain property tax value	Does not protect from less frequent and catastrophic floods Does not provide FEMA-accredited risk reduction May build false sense of security Drainage of water from inside the berm, such as rainwater, needs to be managed Uncertainty around delivery mechanism (property taking, easements, design guideline, or voluntary buy-out) May incentivize further investment into flood-prone areas
Floodable areas	Long-term solution to sea level rise and flooding by allowing landscape to change Low cost approach Dis-incentivizes further investment into flood-prone areas Creates more room for flooding, open space, and natural systems	Uses such as parking and recreation are not possible with even chronic floods Flooded areas will eventually result in decreasing property tax revenue for the town over the long-term
Elevated structures to the level of regulatory floods	Reduces flood insurance Property tax revenue is retained Can be combined with floodable areas to allow landscape adaptation over time	Does not protect from catastrophic floods Expensive for property owners, and not mandatory unless major renovations resulting in a substantial improvement or new building construction, so non-conforming structures are likely Does not apply to historic structures
Amphibious emergency response during and after severe flood levels	Protect human life and property to some extent when roadways are flooded (in combination with early warning systems and evacuation) Less expensive than elevating roadways to higher flood levels throughout the town's low-lying areas	Emergency response during storms is unlikely, and would require waiting until storm conditions have passed Amphibious emergency response may be more limited than conventional response Potential risk to emergency responders operating in flood conditions

Figures 5-11 through **5-13** presents schematic representations of alternatives.

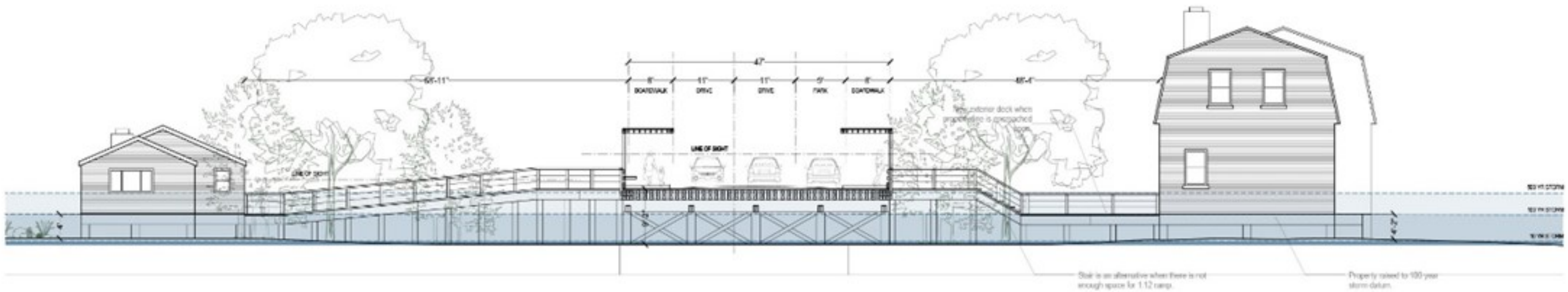


Figure 5-10: Illustration of State-Wide Resilient Corridor

Elevated roadways with either embankments or low bridges, depending on underlying ecology and abutting land uses, will improve accessibility and egress along major roads during chronic and frequent flood events. The new elevation of roads will balance increased operability during higher flood levels and negative visual impacts; access challenges; horizontal space for embankments; and the costs associated with elevation roadway grades. As elevating roads to the 100-year recurrence interval flood would require road raising by at least 5 to 6 feet in some locations (which is technically challenging, impactful to the existing character of Old Saybrook and cost prohibitive), the recommended solution is to elevate the road to accommodate frequent flooding. Elevated roads could be accompanied by a public amenity, such as sidewalks, multiuse trails, and/or bike lanes.

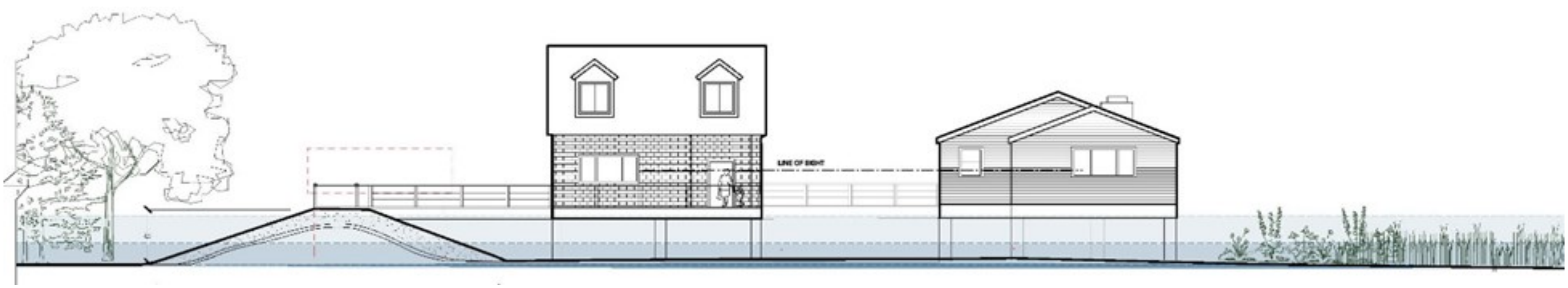


Figure 5-11: IPerimeter Berm Concept

The "upland" functionality of the landscape, for example parking and recreation, can be extended with low **perimeter berms** to protect private property and roadways from chronic and/or frequent floods. Like elevated roads, the height of perimeter berms is a compromise between increased protection from higher flood levels and preserving the character of Old Saybrook by maintaining a visual connection to the marshes; expenses associated with higher berms and wider footprint; and horizontal space required for embanked slopes. A perimeter berm strategy could be accompanied by a public amenity, such as a multiuse trail along the top or waterside toe of the berm.

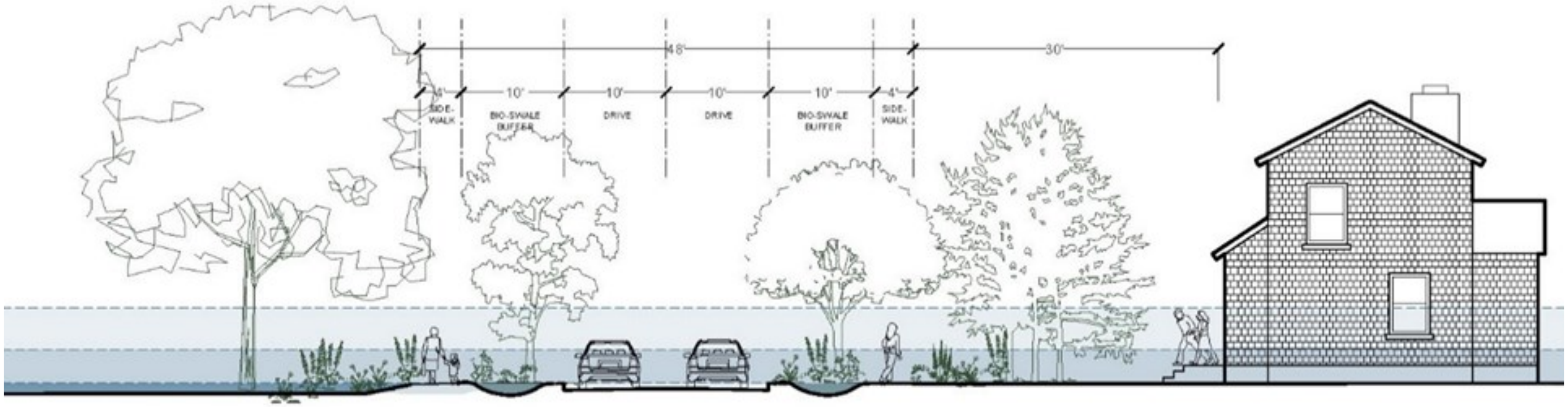


Figure 5-12: Floodable Streets

As sea level rise exacerbates accessibility challenges in Old Saybrook, **amphibious emergency response** may be more effective than raising all major access routes to low probability flood levels. Residents would evacuate for severe flood events and amphibious response capacity would continue delivering emergency services before and after the major storm events. Providing emergency response assistance during a major storm event may not be possible for local public safety officials. Such support is not recommended if the conditions may result in jeopardizing emergency responders' life-safety and for emergency responders without the appropriate training and equipment.

Attachment 6: Coastal Structures Evaluation

GZA performed a desk-top, screening level analysis of the coastal structures in Old Saybrook. This screening-level analysis included: 1) development of an inventory of coastal structures, including structure type, material and length; 2) estimation of the structure top and bottom elevations using available Lidar data (for most structures the minimum elevation corresponds to ground surface at the structure toe or bottom); 3) comparison of the structure elevations to the stillwater elevations and wave heights at the structure location, corresponding to the 2-year, 10-year, 20-year, 50-year, 100-year and 500-year recurrence interval coastal flood; and 4) a screening-level evaluation of the potential for structure damage associated with different recurrence interval floods based on approximate correlations of damage to water level and wave heights and engineering judgement.

The screening level analysis was performed solely based on remotely-collected data (GIS and aerial photograph data for structure type, material and length and available Lidar) and should be considered highly approximate and unsuitable for evaluation of any individual structure. *No visual inspections or condition surveys were performed for this study. The purpose of the screening level analysis was to get an approximate idea of the degree of damage that can be expected on a Town-wide basis due to coastal flooding and sea level rise. Structure-specific survey and engineering calculations are required to evaluate individual structures.*

Old Saybrook coastal structures are a mix of privately-owned and Town-owned and managed structures. Most of the docks, groins, piers and seawalls are privately owned by residents, beach communities or commercial marinas. The structures are used for a combination of: 1) water access (piers and docks); 2) beach management/sediment trapping (groins); 3) wave attenuation (jetties and breakwater); and 4) shoreline and flood protection (bulkheads, seawalls and revetments).

The coastal structures within the Town (including Fenwick) include:

- Breakwater: one, approximately 285 foot long, granite quarry stone offshore breakwater (in Fenwick).
- Bulkheads: about 27 individual bulkheads collectively about 15,000 linear feet, made of wood, stone, steel or timber.
- Seawalls: about 88 individual seawalls collectively about 32,000 linear feet, made of concrete, stone or wood.
- Jetties: about 15 individual jetties collectively about 8,000 linear feet, made of granite quarry stone (one timber).
- Groins: about 67 individual groins collectively about 6,850 linear feet, made of timber (24), concrete (4) or stone (39).
- Docks: about 192 individual wood docks collectively about 27,500 linear feet.
- Piers: 3 individual piers collectively about 60 linear feet made of concrete or stone.
- Reinforced Bluffs/revetments: about 7 separate bluffs collectively about 2,000 linear feet, reinforced with stone.

Table 6-1 presents a detailed inventory of the coastal structures located within Old Saybrook. The structure, material and length was obtained from Town-provided GIS layer. The stillwater elevations and wave heights were derived form GZA's coastal flood hazard characterization - see **Attachment 2**. Structure elevations have been inferred using GIS and available Lidar data. *These elevations should be considered highly approximate and were used only for purposes of this screening level evaluation. No field confirmation or survey was performed.*

Figures 6-1 through **Figure 6-6** indicate the locations of the structures.

Vulnerability Evaluation

The following provides a brief overview of the most vulnerable coastal structures within the Town.

Docks: There are about 192 individual wood docks within Old Saybrook, collectively adding up to about 27,500 linear feet (average length of about 143 feet and a median length of about 91 feet). Almost all of the docks (if not all) appear to be privately owned with residences or marinas. The typical dock width appears to be about 4 feet (indicating about 110,000 square feet of dockage). The docks are timber and pile supported (the majority of residential docks appear to be fixed docks and marina docks are expected to be a combination of fixed and floating docks). The elevation of fixed docks is inferred based on available data to be on the order of 4 to 5 feet NAVD88. Most of these docks, in particular those with exposure to the Sound, Connecticut River, North Cove or South Cove are highly vulnerable to damage during coastal flood events greater than the 2-year recurrence interval flood. The estimate replacement value of the docks (based on typical construction costs) is on the order of $5M (based on a unit cost of $45/s.f.).

Groins: There are about 70 groins, collectively adding up to about 6,800 linear feet. The groins, which have an average length of about 100 feet and a median length of about 90 feet, are owned and managed by the beach communities. About 24 of the groins are constructed of wood and the remainder are constructed of stone or concrete. All of the groins are vulnerable to damage from coastal flooding. The wood groins are particularly vulnerable and in general, the majority of existing groins are likely undersized relative to surviving large coastal flood events (e.g., 100-year recurrence interval flood). New groin construction is not expected to be allowed in the future.

Seawalls: There are about 88 seawalls, collectively adding up to about 31,800 liner feet in Old Saybrook. The majority of the seawalls were constructed for private property and the material, height and condition of the seawalls is highly variable. In general, the majority of existing seawalls (excluding the large, Town-managed seawalls) are likely undersized relative to surviving large coastal flood events (e.g., 100-year recurrence interval flood). Based on inferred structure elevations, most of the existing seawalls (excluding the large, Town-managed seawalls) will be overtopped (if not significantly damaged) during more frequent flood events. The estimated replacement cost of the seawalls (based on a mid-range unit cost of $400/linear foot for a low seawall) is about $10.8M (excluding the large, Town-managed seawalls).

Major Coastal Structures

The Town's major coastal structures include the following. Note that the jetties were not considered in this analysis and that the responsibility for management and maintenance of the jetties identified below was not determined.

1. The seawalls/revetments that provide shoreline protection and flood protection along the portions of Maple Avenue (Rt. 154) that fronts directly on Long Island Sound and is vulnerable to coastal flood inundation and wave actions. These include the following. Based on a limited visual observations these structures appear to be of robust construction. A potential, issue is overtopping of the wall crest elevations during coastal floods. A more detailed analysis is required to confirm the structure crest elevation, overtopping probability and structural capacity of these structures. Seawall SW-101 may be vulnerable to damage or loss during a large coastal flood event.

    - SWL-94, an approximately 1,200 linear foot combined revetment and seawall, consisting of a concrete section and a grouted stone section. This revetment/seawall ends to the east at the Town pier (Pier-95) and to the west at a stairwell separating the revetment/seawall for a lightly-reinforced bluff with a low seawall (SWL-93). Based on available Lidar data, the top of the wall elevation ranges from about 20 feet NAVD88 along the western side to about 16 feet at the eastern end.
    - SWL-96, an approximately 100 foot long concrete seawall located to the east of Town Pier-95. Based on available Lidar, the top of the wall is about Elevation 10 feet NAVD88 and the toe of wall is about Elevation 4 feet NAVD88.
    - SWL-97, an approximately 1,560 long concrete and grouted stone revetment/seawall. Based on available Lidar, the top of the wall is about Elevation 14 feet NAVD88 and the toe of wall is about Elevation 4 feet NAVD88 (along the western section of wall) and is fronted by beach. The top of the wall along the eastern section drops down to about Elevation 10 feet NAVD88 and the toe of the wall is at about Elevation 0 feet, fronted by a cobble beach.
    - SW-101, an approximately 910 foot long grouted stone revetment/ seawall. Based on available Lidar, the top of the wall is about Elevation 11 to 14 feet NAVD88 and the toe of wall is about Elevation 2 to 3 feet NAVD88. Along a small section at the western end of this wall, there is a second seaward concrete separated by a narrow beach. Based on available Lidar, the top of the seaward wall is about Elevation 4 feet NAVD88 and the toe of wall is about Elevation 0 feet NAVD88. The toe of the seaward wall is protected with a loose rubble revetment.

2. Piers 95 and 99 and Groins 307 and 100. The piers provide water access and both the piers and groins serve to manage sediment transport and maintain adequate beach in front of the Town seawalls/revetments identified above. Based on a limited visual observations these structures appear to be of robust construction.

3. SW-146, an approximately 1,600 foot long section of stone bulkhead (north side) and sheetpile bulkhead (south side) fronting private and Town-owned property along the Connecticut River at Saybrook Point. Based on available Lidar, the top of the wall is about Elevation 5 feet NAVD88 and the toe of wall is about Elevation 0 feet NAVD88. The construction and condition of this bulkhead is uncertain. Elevating and replacing the bulkhead will likely be required in the future, in particular if completed in conjunction with other flood mitigation measures within Saybrook Point. Assuming a replacement cost of about $2,000/liner foot, replacement of this bulkhead will cost on the order of $3.2M.

4. The two jetties (JTY139 and JTY 303) that create the navigation entrance at the mouth of the Connecticut River. These are major, robust navigation structures that are maintained by the US Army Corps of Engineers.

5. Quarry stone jetties JTY-11 and JTY-12, which create the inlet to Hager Creek at Indiantown and are collectively about 1,300 feet in length.

Figure 6-1: Coastal Structures starting from western Town border

Figure 6-2: Coastal Structures cont.

Figure 6-3: Coastal Structures cont.

Figure 6-4: Coastal Structures cont.

Figure 6-6: Coastal Structures cont.

Figure 6-5: Coastal Structures cont.

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
Breakwater		**1**		**283**												
BWR-1	304	Breakwater	Stone	283	-4.2	-2.2	5.0	7.0	9.0	10.3	7.9	VE	13	12.2	8.9	Sound
Bulkheads		**27**		**14,879**												
BHD-19	154	Bulkhead	Wood	133	-2.1	4.3	5.0	7.0	9.0	10.3	2.2	VE	15	13.1	2.9	North Cove
BHD-20	155	Bulkhead	Wood	282	-1.0	4.4	5.0	7.0	9.0	10.3	2.1	VE	15	13.1	2.7	North Cove
BHD-21	157	Bulkhead	Wood	584	-1.9	10.2	5.0	7.0	9.0	10.3	2.5	VE	15	13.1	3.0	North Cove
BHD-22	158	Bulkhead	Stone	435	-1.7	2.9	5.0	7.0	9.0	10.3	4.0	VE	15	13.9	4.6	Connecticut River
BHD-3	160	Bulkhead	Wood	230	-0.6	4.8	5.0	7.0	9.0	10.3	1.7	AE	11	13.9	1.2	Connecticut River
BHD-4	161	Bulkhead	Concrete	684	0.2	5.5	5.0	7.0	9.0	10.3	3.2	AE	11	13.9	3.9	Connecticut River
BHD-5	162	Bulkhead	Wood	200	-1.7	5.6	5.0	7.0	9.0	10.3	3.9	AE	11	13.9	4.5	Connecticut River
BHD-6	163	Bulkhead	Stone	433	-1.7	4.8	5.0	7.0	9.0	10.3	3.7	AE	11	13.9	4.2	Connecticut River
BHD-7	164	Bulkhead	Wood	574	-2.0	2.9	5.0	7.0	9.0	10.3	3.7	AE	11	13.9	4.3	Connecticut River
BHD-8	165	Bulkhead	Wood	1813	-1.9	5.8	5.0	7.0	9.0	10.3	3.4	AE	11	14.0	3.9	Connecticut River
BHD-9	166	Bulkhead	Concrete	160	0.4	5.0	5.0	7.0	9.0	10.3	3.2	AE	11	14.1	3.7	Connecticut River
BHD-10	167	Bulkhead	Concrete	576	-1.4	5.0	5.0	7.0	9.0	10.3	3.4	AE	11	14.1	3.8	Connecticut River
BHD-11	168	Bulkhead	Wood	355	-1.5	4.0	5.0	7.0	9.0	10.3	3.4	AE	11	14.2	3.8	Connecticut River
BHD-12	169	Bulkhead	Wood	275	-0.9	5.0	5.0	7.0	9.0	10.3	3.3	AE	11	14.2	3.8	Connecticut River
BHD-13	173	Bulkhead	Concrete	95	-1.1	5.0	5.0	7.0	9.0	10.3	1.3	AE	11	14.2	1.7	Harbor
BHD-14	174	Bulkhead	Wood	4050	-1.8	6.9	5.0	7.0	9.0	10.3	2.1	AE	9	14.1	2.1	Harbor
BHD-15	175	Bulkhead	Wood	774	-0.3	6.0	5.0	7.0	9.0	10.3	1.8	AE	11	14.2	2.0	Harbor
BHD-16	180	Bulkhead	Concrete	163	0.8	4.5	5.0	7.0	9.0	10.3	1.8	AE	11	15.0	2.0	Connecticut River
BHD-17	201	Bulkhead	Wood	102	-0.1	2.2	5.0	7.0	9.0	10.3	1.4	AE	11	14.2	2.3	Connecticut River
BHD-18	217	Bulkhead	Wood	145	-1.2	4.6	5.0	7.0	9.0	10.3	3.3	AE	11	14.2	3.7	Connecticut River
BHD-2	248	Bulkhead	Steel	1820	-2.3	5.0	5.0	7.0	9.0	10.3	2.2	AE	11	14.1	2.9	Harbor
BHD-1	280	Bulkhead	Wood	34	0.3	3.5	5.0	7.0	9.0	10.3	2.5	VE	15	13.1	2.9	Connecticut River
BHD-23	329	Bulkhead	Unknown	77	4.2	5.5	5.0	7.0	9.0	10.3	2.7	AE	11	13.4	3.6	Oyster River
BHD-24	330	Bulkhead	Stone revetment	116	3.0	4.0	5.0	7.0	9.0	10.3	2.2	AE	11	13.4	3.1	Oyster River
BHD-25	335	Bulkhead	Wood	279	0.1	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	13.4	2.7	Oyster River
BHD-26	336	Bulkhead	Concrete	129	1.2	3.0	5.0	7.0	9.0	10.3	1.8	AE	11	13.4	2.7	Oyster River
BHD-27	362	Bulkhead	Concrete	361	-1.4	5.0	5.0	7.0	9.0	10.3	1.3	AE	11	14.0	1.4	Oyster River
Docks		**192**		**27,430**												
DCK-182	182	Dock	Wood	96	-1.4	5.0	5.0	7.0	9.0	10.3	2.2	AE	11	14.9	2.6	Connecticut River
DCK-183	183	Dock	Wood	51	1.4	5.0	5.0	7.0	9.0	10.3	2.5	AE	11	14.9	2.8	Connecticut River
DCK-184	184	Dock	Wood	130	-1.5	5.0	5.0	7.0	9.0	10.3	1.6	AE	11	14.9	2.0	Connecticut River
DCK-185	185	Dock	Wood	172	-1.5	5.0	5.0	7.0	9.0	10.3	2.7	AE	11	14.8	3.1	Connecticut River
DCK-186	186	Dock	Wood	134	-0.8	5.0	5.0	7.0	9.0	10.3	2.9	AE	11	14.8	3.3	Connecticut River
DCK-187	187	Dock	Wood	344	-1.5	5.0	5.0	7.0	9.0	10.3	3.0	AE	11	14.8	3.5	Connecticut River
DCK-188	188	Dock	Wood	175	-1.5	5.0	5.0	7.0	9.0	10.3	2.8	AE	11	14.8	3.2	Connecticut River
DCK-189	189	Dock	Wood	151	-1.4	5.0	5.0	7.0	9.0	10.3	2.8	AE	11	14.8	3.2	Connecticut River
DCK-190	190	Dock	Wood	162	-0.1	5.0	5.0	7.0	9.0	10.3	2.9	AE	11	14.8	3.3	Connecticut River
DCK-192	192	Dock	Wood	42	-1.6	4.0	5.0	7.0	9.0	10.3	3.5	AE	11	14.6	3.9	Connecticut River
DCK-193	193	Dock	Wood	149	-1.9	4.0	5.0	7.0	9.0	10.3	3.4	AE	11	14.6	3.9	Connecticut River
DCK-194	194	Dock	Wood	206	-1.5	4.0	5.0	7.0	9.0	10.3	3.3	AE	11	15.0	3.9	Connecticut River
DCK-195	195	Dock	Wood	403	-1.7	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.2	2.1	Connecticut River
DCK-196	196	Dock	Wood	347	-1.6	4.0	5.0	7.0	9.0	10.3	2.0	AE	11	14.2	2.1	Connecticut River
DCK-197	197	Dock	Wood	146	-1.6	4.0	5.0	7.0	9.0	10.3	1.6	AE	11	14.2	2.3	Connecticut River
DCK-198	198	Dock	Wood	23	-1.7	4.0	5.0	7.0	9.0	10.3	2.0	AE	11	14.2	2.3	Connecticut River
DCK-199	199	Dock	Wood	25	-1.8	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.2	2.3	Connecticut River
DCK-200	200	Dock	Wood	14	-1.8	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.2	2.3	Connecticut River
DCK-202	202	Dock	Wood	58	-1.2	3.0	5.0	7.0	9.0	10.3	1.4	AE	11	14.2	2.3	Connecticut River
DCK-203	203	Dock	Wood	10	-1.2	3.0	5.0	7.0	9.0	10.3	1.2	AE	11	14.2	1.9	Connecticut River
DCK-204	204	Dock	Wood	38	-1.4	3.0	5.0	7.0	9.0	10.3	1.2	AE	11	14.2	1.9	Connecticut River
DCK-205	205	Dock	Wood	213	-0.6	4.0	5.0	7.0	9.0	10.3	1.9	AE	11	14.2	2.1	Harbor

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
DCK-206	206	Dock	Wood	211	-0.5	4.0	5.0	7.0	9.0	10.3	1.9	AE	10	14.1	2.1	Harbor
DCK-207	207	Dock	Wood	211	-0.5	4.0	5.0	7.0	9.0	10.3	1.9	AE	10	14.1	2.1	Harbor
DCK-208	208	Dock	Wood	198	-0.2	4.0	5.0	7.0	9.0	10.3	1.9	AE	10	14.1	2.0	Harbor
DCK-209	209	Dock	Wood	83	-0.2	4.0	5.0	7.0	9.0	10.3	2.0	AE	9	14.1	2.1	Harbor
DCK-210	210	Dock	Wood	43	-0.4	4.0	5.0	7.0	9.0	10.3	2.1	AE	9	14.1	2.0	Harbor
DCK-211	211	Dock	Wood	161	-0.4	4.0	5.0	7.0	9.0	10.3	2.1	AE	9	14.1	2.0	Harbor
DCK-212	212	Dock	Wood	41	-1.9	4.0	5.0	7.0	9.0	10.3	1.3	AE	10	14.2	1.8	Harbor
DCK-213	213	Dock	Wood	18	-1.9	4.0	5.0	7.0	9.0	10.3	1.3	AE	10	14.2	1.8	Harbor
DCK-214	214	Dock	Wood	153	-2.0	4.0	5.0	7.0	9.0	10.3	1.0	AE	11	14.2	1.2	Connecticut River
DCK-215	215	Dock	Wood	128	-1.9	4.0	5.0	7.0	9.0	10.3	1.0	AE	11	14.2	1.7	Connecticut River
DCK-218	218	Dock	Wood	113	-1.8	4.0	5.0	7.0	9.0	10.3	3.5	AE	11	14.2	3.9	Connecticut River
DCK-219	219	Dock	Wood	186	-1.9	4.0	5.0	7.0	9.0	10.3	3.4	AE	11	14.2	3.9	Connecticut River
DCK-220	220	Dock	Wood	368	-1.7	4.0	5.0	7.0	9.0	10.3	3.5	AE	11	14.2	4.0	Connecticut River
DCK-221	221	Dock	Wood	326	-0.7	4.0	5.0	7.0	9.0	10.3	3.6	AE	11	14.2	4.0	Connecticut River
DCK-222	222	Dock	Wood	338	-2.2	4.0	5.0	7.0	9.0	10.3	3.6	AE	11	14.2	4.0	Connecticut River
DCK-223	223	Dock	Wood	51	-2.2	4.0	5.0	7.0	9.0	10.3	3.8	AE	11	14.2	4.2	Connecticut River
DCK-224	224	Dock	Wood	317	-2.2	4.0	5.0	7.0	9.0	10.3	3.9	AE	11	14.0	4.3	Connecticut River
DCK-225	225	Dock	Wood	88	-1.9	4.0	5.0	7.0	9.0	10.3	4.0	AE	11	14.0	4.4	Connecticut River
DCK-226	226	Dock	Wood	318	-2.0	4.0	5.0	7.0	9.0	10.3	3.9	AE	11	14.0	4.3	Connecticut River
DCK-227	227	Dock	Wood	88	-1.9	4.0	5.0	7.0	9.0	10.3	4.0	AE	11	14.0	4.5	Connecticut River
DCK-228	228	Dock	Wood	377	-1.9	4.0	5.0	7.0	9.0	10.3	3.9	AE	11	14.0	4.3	Connecticut River
DCK-229	229	Dock	Wood	237	-1.9	4.0	5.0	7.0	9.0	10.3	4.0	AE	11	14.0	4.5	Connecticut River
DCK-230	230	Dock	Wood	384	-1.8	4.0	5.0	7.0	9.0	10.3	3.8	AE	11	14.0	4.3	Connecticut River
DCK-231	231	Dock	Wood	36	-1.8	4.0	5.0	7.0	9.0	10.3	4.0	AE	11	14.0	4.5	Connecticut River
DCK-232	232	Dock	Wood	360	-1.9	4.0	5.0	7.0	9.0	10.3	3.7	AE	11	14.0	4.2	Connecticut River
DCK-233	233	Dock	Wood	72	-1.9	4.0	5.0	7.0	9.0	10.3	4.0	AE	11	14.0	4.5	Connecticut River
DCK-234	234	Dock	Wood	370	-1.9	4.0	5.0	7.0	9.0	10.3	3.7	AE	11	14.0	4.2	Connecticut River
DCK-235	235	Dock	Wood	592	-2.0	4.0	5.0	7.0	9.0	10.3	3.9	AE	11	14.0	4.4	Connecticut River
DCK-236	236	Dock	Wood	29	-2.0	4.0	5.0	7.0	9.0	10.3	4.1	AE	11	14.0	4.6	Connecticut River
DCK-237	237	Dock	Wood	71	-2.1	4.0	5.0	7.0	9.0	10.3	3.8	AE	11	13.9	4.3	Connecticut River
DCK-238	238	Dock	Wood	99	-2.1	4.0	5.0	7.0	9.0	10.3	3.8	AE	11	13.9	4.3	Connecticut River
DCK-239	239	Dock	Wood	286	-2.2	4.0	5.0	7.0	9.0	10.3	3.8	AE	11	13.9	4.4	Connecticut River
DCK-240	240	Dock	Wood	30	-1.8	4.0	5.0	7.0	9.0	10.3	4.0	AE	11	13.9	4.6	Connecticut River
DCK-241	241	Dock	Wood	323	-2.0	4.0	5.0	7.0	9.0	10.3	3.9	AE	11	13.9	4.5	Connecticut River
DCK-242	242	Dock	Wood	181	-1.9	4.0	5.0	7.0	9.0	10.3	4.1	AE	11	13.9	4.7	Connecticut River
DCK-243	243	Dock	Wood	132	-2.2	4.0	5.0	7.0	9.0	10.3	3.5	AE	11	13.9	4.0	Connecticut River
DCK-244	244	Dock	Wood	151	-0.8	4.0	5.0	7.0	9.0	10.3	3.3	AE	11	13.9	3.9	Connecticut River
DCK-245	245	Dock	Wood	250	-2.4	4.0	5.0	7.0	9.0	10.3	3.9	AE	11	13.9	4.4	Connecticut River
DCK-246	246	Dock	Wood	64	-2.4	4.0	5.0	7.0	9.0	10.3	3.8	AE	11	13.9	4.4	Connecticut River
DCK-247	247	Dock	Wood	55	-2.2	4.0	5.0	7.0	9.0	10.3	3.8	AE	11	13.9	4.4	Connecticut River
DCK-249	249	Dock	Wood	18	-0.7	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.1	2.8	Connecticut River
DCK-250	250	Dock	Wood	217	-1.8	5.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.1	2.7	Harbor
DCK-251	251	Dock	Wood	91	-1.4	5.0	5.0	7.0	9.0	10.3	2.2	AE	11	14.1	3.2	Harbor
DCK-252	252	Dock	Wood	280	-2.0	5.0	5.0	7.0	9.0	10.3	2.2	AE	11	14.1	3.0	Harbor
DCK-253	253	Dock	Wood	320	-2.1	5.0	5.0	7.0	9.0	10.3	2.2	AE	11	14.1	3.0	Harbor
DCK-254	254	Dock	Wood	296	-2.3	5.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.1	2.9	Harbor
DCK-255	255	Dock	Wood	182	-2.3	5.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.1	2.9	Harbor
DCK-256	256	Dock	Wood	138	-2.3	5.0	5.0	7.0	9.0	10.3	2.1	AE	11	14.1	2.8	Harbor
DCK-257	257	Dock	Wood	293	-0.9	5.0	5.0	7.0	9.0	10.3	2.3	AE	11	14.0	2.8	Connecticut River
DCK-258	258	Dock	Wood	308	-0.2	5.0	5.0	7.0	9.0	10.3	3.9	AE	11	14.0	4.5	Connecticut River
DCK-259	259	Dock	Wood	46	-1.4	3.0	5.0	7.0	9.0	10.3	3.3	VE	15	13.8	4.3	Marsh
DCK-260	260	Dock	Wood	443	-0.7	4.0	5.0	7.0	9.0	10.3	3.2	VE	15	13.8	4.1	Marsh
DCK-261	261	Dock	Wood	55	-1.9	4.0	5.0	7.0	9.0	10.3	2.5	VE	15	13.0	3.0	North Cove
DCK-262	262	Dock	Wood	69	-1.9	4.0	5.0	7.0	9.0	10.3	2.4	VE	15	13.0	2.9	North Cove
DCK-263	263	Dock	Wood	66	-2.0	3.0	5.0	7.0	9.0	10.3	2.3	VE	15	13.0	2.9	North Cove

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
DCK-264	264	Dock	Wood	208	-2.1	5.0	5.0	7.0	9.0	10.3	2.0	VE	15	13.0	2.7	North Cove
DCK-265	265	Dock	Wood	95	-2.3	3.0	5.0	7.0	9.0	10.3	2.3	VE	15	13.0	2.9	North Cove
DCK-266	266	Dock	Wood	19	-0.9	3.0	5.0	7.0	9.0	10.3	2.4	VE	15	12.9	3.1	North Cove
DCK-267	267	Dock	Wood	18	-0.6	3.0	5.0	7.0	9.0	10.3	2.4	VE	15	12.9	3.0	North Cove
DCK-268	268	Dock	Wood	64	-1.0	3.0	5.0	7.0	9.0	10.3	2.2	VE	15	12.9	2.9	North Cove
DCK-269	269	Dock	Wood	168	0.7	5.0	5.0	7.0	9.0	10.3	2.1	VE	15	12.8	2.7	North Cove
DCK-270	270	Dock	Wood	124	-1.4	5.0	5.0	7.0	9.0	10.3	2.0	VE	15	12.8	2.7	North Cove
DCK-271	271	Dock	Wood	97	-1.2	5.0	5.0	7.0	9.0	10.3	1.7	VE	15	12.8	2.4	North Cove
DCK-272	272	Dock	Wood	59	-1.9	5.0	5.0	7.0	9.0	10.3	1.6	VE	15	12.9	2.1	North Cove
DCK-273	273	Dock	Wood	57	-1.7	5.0	5.0	7.0	9.0	10.3	1.1	VE	15	13.0	1.6	North Cove
DCK-274	274	Dock	Wood	103	-1.8	5.0	5.0	7.0	9.0	10.3	1.2	VE	15	13.0	1.6	North Cove
DCK-275	275	Dock	Wood	15	-1.7	5.0	5.0	7.0	9.0	10.3	1.2	VE	15	13.0	1.6	North Cove
DCK-276	276	Dock	Wood	16	2.7	5.0	5.0	7.0	9.0	10.3	1.9	VE	15	13.0	2.3	North Cove
DCK-277	277	Dock	Wood	173	-1.7	5.0	5.0	7.0	9.0	10.3	1.5	VE	15	13.0	1.8	North Cove
DCK-278	278	Dock	Wood	41	-1.8	4.0	5.0	7.0	9.0	10.3	2.6	VE	15	13.1	2.9	Connectuct River
DCK-279	279	Dock	Wood	79	-1.9	4.0	5.0	7.0	9.0	10.3	2.6	VE	15	13.1	2.9	Connectuct River
DCK-281	281	Dock	Wood	98	-2.0	5.0	5.0	7.0	9.0	10.3	1.6	VE	15	13.1	2.1	Connectuct River
DCK-282	282	Dock	Wood	71	-1.9	5.0	5.0	7.0	9.0	10.3	1.6	VE	15	13.1	2.1	Connectuct River
DCK-283	283	Dock	Wood	87	-1.8	5.0	5.0	7.0	9.0	10.3	1.7	VE	15	13.1	2.2	Connectuct River
DCK-284	284	Dock	Wood	26	-1.6	5.0	5.0	7.0	9.0	10.3	3.8	VE	15	12.9	4.5	Connecticut River
DCK-285	285	Dock	Wood	78	-1.9	5.0	5.0	7.0	9.0	10.3	3.8	VE	15	12.9	4.5	Connecticut River
DCK-286	286	Dock	Wood	20	0.7	5.0	5.0	7.0	9.0	10.3	3.7	VE	15	12.9	4.4	Connecticut River
DCK-287	287	Dock	Wood	40	-1.1	5.0	5.0	7.0	9.0	10.3	3.7	VE	15	12.9	4.4	Connecticut River
DCK-288	288	Dock	Wood	771	-1.7	5.0	5.0	7.0	9.0	10.3	3.8	VE	15	12.8	4.5	Connecticut River
DCK-289	289	Dock	Wood	210	-1.7	5.0	5.0	7.0	9.0	10.3	3.9	VE	15	12.8	4.6	Connecticut River
DCK-290	290	Dock	Wood	44	-1.7	5.0	5.0	7.0	9.0	10.3	3.8	VE	15	12.8	4.5	Connecticut River
DCK-291	291	Dock	Wood	250	-0.6	5.0	5.0	7.0	9.0	10.3	3.4	VE	15	12.8	4.1	Connecticut River
DCK-292	292	Dock	Wood	34	-0.9	5.0	5.0	7.0	9.0	10.3	3.6	VE	15	12.8	4.3	Connecticut River
DCK-293	293	Dock	Wood	281	-1.5	5.0	5.0	7.0	9.0	10.3	3.3	VE	15	12.8	4.0	Connecticut River
DCK-294	294	Dock	Wood	304	-0.7	5.0	5.0	7.0	9.0	10.3	3.2	VE	15	12.8	3.9	Connecticut River
DCK-295	295	Dock	Wood	64	-1.8	5.0	5.0	7.0	9.0	10.3	3.3	VE	15	12.8	4.1	Connecticut River
DCK-296	296	Dock	Wood	523	-2.1	5.0	5.0	7.0	9.0	10.3	2.9	VE	15	12.8	3.8	Connecticut River
DCK-297	297	Dock	Wood	81	1.9	5.0	5.0	7.0	9.0	10.3	3.4	VE	15	12.8	4.1	Connecticut River
DCK-298	298	Dock	Wood	262	-2.1	5.0	5.0	7.0	9.0	10.3	3.9	VE	15	12.8	4.5	Connecticut River
DCK-299	299	Dock	Wood	149	-2.1	5.0	5.0	7.0	9.0	10.3	3.7	VE	15	12.8	4.4	Connecticut River
DCK-300	300	Dock	Wood	75	-3.4	4.0	5.0	7.0	9.0	10.3	1.3	VE	15	12.4	2.2	South Cove
DCK-301	301	Dock	Wood	93	-3.2	8.0	5.0	7.0	9.0	10.3	1.4	VE	15	12.4	2.1	South Cove
DCK-302	302	Dock	Wood	164	-2.4	8.0	5.0	7.0	9.0	10.3	2.9	VE	15	12.5	3.8	Connecticut River
DCK-305	305	Dock	Wood	98	-4.1	4.0	5.0	7.0	9.0	10.3	5.9	VE	13	12.2	7.0	Sound
DCK-306	306	Dock	Wood	129	-4.3	4.0	5.0	7.0	9.0	10.3	5.3	VE	14	12.2	6.5	Sound
DCK-313	313	Dock	Wood	26	-1.8	3.0	5.0	7.0	9.0	10.3	1.8	VE	14	12.8	2.6	Plum Bank Creek
DCK-315	315	Dock	Wood	25	-0.7	6.0	5.0	7.0	9.0	10.3	3.8	VE	14	13.2	4.7	Sound
DCK-316	316	Dock	Wood	30	-1.0	6.0	5.0	7.0	9.0	10.3	3.9	VE	14	13.2	4.8	Sound
DCK-317	317	Dock	Wood	30	-1.0	6.0	5.0	7.0	9.0	10.3	3.9	VE	14	13.2	4.8	Sound
DCK-318	318	Dock	Wood	30	-1.2	4.0	5.0	7.0	9.0	10.3	3.9	VE	14	13.0	4.8	Sound
DCK-321	321	Dock	Wood	91	-2.0	4.0	5.0	7.0	9.0	10.3	3.3	VE	14	13.1	4.4	Oyster River
DCK-322	322	Dock	Wood	30	-2.0	4.0	5.0	7.0	9.0	10.3	3.4	VE	14	13.2	4.3	Oyster River
DCK-323	323	Dock	Wood	40	-1.9	4.0	5.0	7.0	9.0	10.3	3.4	VE	14	13.2	4.3	Oyster River
DCK-325	325	Dock	Wood	322	-1.6	4.0	5.0	7.0	9.0	10.3	2.9	AE	11	13.4	3.8	Oyster River
DCK-326	326	Dock	Wood	276	-0.9	4.0	5.0	7.0	9.0	10.3	3.2	VE	14	13.2	4.2	Oyster River
DCK-327	327	Dock	Wood	30	-0.4	4.0	5.0	7.0	9.0	10.3	2.8	VE	14	13.2	3.6	Oyster River
DCK-328	328	Dock	Wood	58	-1.6	4.0	5.0	7.0	9.0	10.3	2.8	VE	14	13.2	3.6	Oyster River
DCK-331	331	Dock	Wood	14	0.3	4.0	5.0	7.0	9.0	10.3	2.2	AE	11	13.4	3.1	Oyster River
DCK-332	332	Dock	Wood	33	-1.0	4.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.4	3.3	Oyster River
DCK-333	333	Dock	Wood	104	0.8	5.0	5.0	7.0	9.0	10.3	2.2	AE	11	13.4	3.1	Oyster River

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
DCK-334	334	Dock	Wood	63	-1.1	4.0	5.0	7.0	9.0	10.3	2.2	AE	11	13.4	3.0	Oyster River
DCK-339	339	Dock	Wood	17	0.7	4.0	5.0	7.0	9.0	10.3	1.9	AE	11	13.4	2.6	Oyster River
DCK-340	340	Dock	Wood	28	-1.5	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	13.4	2.7	Oyster River
DCK-341	341	Dock	Wood	21	-1.7	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	13.4	2.7	Oyster River
DCK-342	342	Dock	Wood	30	-1.4	4.0	5.0	7.0	9.0	10.3	2.0	AE	11	13.4	2.6	Oyster River
DCK-343	343	Dock	Wood	31	-1.0	4.0	5.0	7.0	9.0	10.3	2.0	AE	11	13.4	2.6	Oyster River
DCK-344	344	Dock	Wood	27	-1.2	4.0	5.0	7.0	9.0	10.3	2.0	AE	11	13.4	2.6	Oyster River
DCK-345	345	Dock	Wood	312	-0.6	4.0	5.0	7.0	9.0	10.3	2.2	AE	11	13.4	2.9	Oyster River
DCK-346	346	Dock	Wood	138	-0.4	4.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.7	3.2	Oyster River
DCK-347	347	Dock	Wood	66	-1.6	4.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.7	3.2	Oyster River
DCK-348	348	Dock	Wood	14	-0.9	4.0	5.0	7.0	9.0	10.3	2.3	AE	11	13.7	3.1	Oyster River
DCK-349	349	Dock	Wood	42	-1.0	4.0	5.0	7.0	9.0	10.3	2.3	AE	11	13.7	3.0	Oyster River
DCK-350	350	Dock	Wood	85	-1.8	4.0	5.0	7.0	9.0	10.3	2.1	AE	11	13.7	2.8	Oyster River
DCK-351	351	Dock	Wood	76	-1.4	4.0	5.0	7.0	9.0	10.3	2.2	AE	11	13.7	2.9	Oyster River
DCK-352	352	Dock	Wood	335	-0.6	4.0	5.0	7.0	9.0	10.3	2.5	AE	11	13.7	3.1	Oyster River
DCK-353	353	Dock	Wood	239	-1.4	4.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.7	3.0	Oyster River
DCK-354	354	Dock	Wood	330	-0.6	4.0	5.0	7.0	9.0	10.3	2.2	AE	11	13.7	2.8	Oyster River
DCK-355	355	Dock	Wood	304	-1.7	4.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.7	3.0	Oyster River
DCK-356	356	Dock	Wood	401	-1.3	4.0	5.0	7.0	9.0	10.3	2.0	AE	11	13.7	2.7	Oyster River
DCK-357	357	Dock	Wood	10	-0.4	3.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.7	2.9	Oyster River
DCK-358	358	Dock	Wood	364	-1.8	6.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.7	3.0	Oyster River
DCK-359	359	Dock	Wood	88	-1.9	4.0	5.0	7.0	9.0	10.3	2.0	AE	11	13.7	2.5	Oyster River
DCK-360	360	Dock	Wood	121	-1.3	7.0	5.0	7.0	9.0	10.3	2.3	AE	11	13.7	2.8	Oyster River
DCK-361	361	Dock	Wood	321	-2.5	5.5	5.0	7.0	9.0	10.3	2.1	AE	11	13.7	2.5	Oyster River
DCK-363	363	Dock	Wood	21	-1.4	4.0	5.0	7.0	9.0	10.3	3.9	VE	14	13.2	4.8	Sound
DCK-364	364	Dock	Wood	34	-1.0	4.0	5.0	7.0	9.0	10.3	4.0	VE	14	13.2	4.6	Sound
DCK-365	365	Dock	Wood	150	-2.2	6.0	5.0	7.0	9.0	10.3	4.1	VE	14	13.2	4.8	Sound
DCK-366	366	Dock	Wood	36	-1.2	6.0	5.0	7.0	9.0	10.3	3.5	VE	14	13.2	4.3	Sound
DCK-369	369	Dock	Wood	46	-1.2	-0.8	5.0	7.0	9.0	10.3	4.1	VE	14	13.2	5.0	Sound
DCK-370	370	Dock	Wood	130	-1.0	4.7	5.0	7.0	9.0	10.3	4.1	VE	14	13.2	5.1	Behind Jetty
DCK-371	371	Dock	Wood	83	-1.0	5.0	5.0	7.0	9.0	10.3	4.0	VE	14	13.2	4.9	Behind Jetty
DCK-372	372	Dock	Wood	122	-1.6	5.0	5.0	7.0	9.0	10.3	3.1	VE	14	13.2	4.1	Behind Jetty
DCK-373	373	Dock	Wood	21	-1.5	5.0	5.0	7.0	9.0	10.3	3.1	VE	14	13.2	5.1	Behind Jetty
DCK-374	374	Dock	Wood	17	-1.6	5.0	5.0	7.0	9.0	10.3	3.2	VE	14	13.2	4.1	Behind Jetty
DCK-375	375	Dock	Wood	14	-0.5	5.0	5.0	7.0	9.0	10.3	3.3	VE	14	13.2	4.2	Behind Jetty
DCK-376	376	Dock	Wood	19	-0.5	5.0	5.0	7.0	9.0	10.3	3.3	VE	14	13.2	4.2	Behind Jetty
DCK-377	377	Dock	Wood	20	-0.8	5.0	5.0	7.0	9.0	10.3	3.4	VE	14	13.2	4.3	Behind Jetty
DCK-378	378	Dock	Wood	12	-0.6	5.0	5.0	7.0	9.0	10.3	3.4	VE	14	13.2	4.3	Behind Jetty
DCK-379	379	Dock	Wood	16	-1.2	5.0	5.0	7.0	9.0	10.3	3.7	VE	14	13.2	4.6	Behind Jetty
DCK-380	380	Dock	Wood	62	-0.9	4.0	5.0	7.0	9.0	10.3	4.3	VE	14	13.2	5.3	Behind Jetty
DCK-381	381	Dock	Wood	162	-1.7	4.0	5.0	7.0	9.0	10.3	4.2	VE	14	13.2	5.2	Behind Jetty
DCK-382	382	Dock	Wood	46	-1.1	4.0	5.0	7.0	9.0	10.3	4.3	VE	14	13.2	5.3	Behind Jetty
DCK-383	383	Dock	Wood	160	-1.8	4.0	5.0	7.0	9.0	10.3	4.2	VE	14	13.2	5.2	Behind Jetty
DCK-384	384	Dock	Wood	213	-1.7	4.0	5.0	7.0	9.0	10.3	2.7	AE	12	13.4	3.5	Marsh
DCK-385	385	Dock	Wood	383	-1.1	4.0	5.0	7.0	9.0	10.3	2.6	AE	12	13.4	3.7	Marsh
DCK-386	386	Dock	Wood	399	-0.3	4.0	5.0	7.0	9.0	10.3	2.6	AE	12	13.4	3.7	Marsh
DCK-387	387	Dock	Wood	403	-1.3	5.0	5.0	7.0	9.0	10.3	2.7	AE	12	13.4	3.7	Marsh
DCK-388	388	Dock	Wood	393	-1.9	4.0	5.0	7.0	9.0	10.3	2.7	AE	12	13.4	3.9	Marsh
DCK-389	389	Dock	Wood	76	-1.7	4.0	5.0	7.0	9.0	10.3	2.3	VE	14	13.1	3.6	Back River
DCK-390	390	Dock	Wood	237	-1.7	4.0	5.0	7.0	9.0	10.3	2.5	VE	14	13.1	3.6	Back River
DCK-391	391	Dock	Wood	24	-1.0	4.0	5.0	7.0	9.0	10.3	2.4	VE	14	13.1	3.6	Back River
DCK-392	392	Dock	Wood	25	-0.8	4.0	5.0	7.0	9.0	10.3	2.5	VE	14	13.1	3.6	Back River
DCK-393	393	Dock	Wood	23	-0.9	4.0	5.0	7.0	9.0	10.3	2.5	VE	14	13.1	3.6	Back River
DCK-394	394	Dock	Wood	23	-0.9	4.0	5.0	7.0	9.0	10.3	2.5	VE	14	13.1	3.6	Back River
DCK-395	395	Dock	Wood	23	-0.8	4.0	5.0	7.0	9.0	10.3	2.6	VE	14	13.1	3.6	Back River

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
DCK-396	396	Dock	Wood	72	-1.4	5.0	5.0	7.0	9.0	10.3	3.9	VE	14	13.2	4.9	Behind Jetty
DCK	New	Dock	Wood	425	0.0	4.0	5.0	7.0	9.0	10.3	3.0	VE	14	13.2	4.0	Oyster River
DCK	New	Dock	Wood	110	0.0	5.0	5.0	7.0	9.0	10.3	4.0	VE	14	13.0	5.0	Sound
DCK	New	Dock	Wood	45	0.0	6.0	1.0	7.0	9.0	10.3	4.0	VE	14	13.0	5.0	Sound
DCK	New	Dock	Wood	50	0.0	6.0	5.0	7.0	9.0	10.3	4.0	VE	14	13.0	5.0	Sound
Groins		**67**		**6,836**												
GRN-15	15	Groin	Stone	186	-2.0	4.0	5.0	7.0	9.0	10.3	4.3	VE	14	13.2	5.0	Sound
GRN-21	21	Groin	Stone	124	-0.6	4.0	5.0	7.0	9.0	10.3	4.0	VE	14	13.2	4.8	Sound
GRN-23	23	Groin	Stone	128	-0.3	4.0	5.0	7.0	9.0	10.3	3.8	VE	14	13.2	4.7	Sound
GRN-34	34	Groin	Stone & Wood	126	-1.8	3.9	5.0	7.0	9.0	10.3	3.9	VE	14	12.9	4.7	Sound
GRN-35	35	Groin	Wood	127	-0.9	4.4	5.0	7.0	9.0	10.3	3.8	VE	14	12.9	4.7	Sound
GRN-36	36	Groin	Stone	79	0.3	4.0	5.0	7.0	9.0	10.3	3.4	VE	14	13.2	4.1	Sound
GRN-37	37	Groin	Wood	194	-2.3	4.0	5.0	7.0	9.0	10.3	4.6	VE	14	13.2	5.6	Sound
GRN-38	38	Groin	Wood	152	-2.1	4.0	5.0	7.0	9.0	10.3	4.6	VE	14	13.2	5.6	Sound
GRN-39	39	Groin	Wood	146	-2.0	4.0	5.0	7.0	9.0	10.3	4.6	VE	14	13.2	5.6	Sound
GRN-40	40	Groin	Wood	150	-1.8	4.0	5.0	7.0	9.0	10.3	4.6	VE	14	13.2	5.6	Sound
GRN-41	41	Groin	Wood	156	-2.1	4.0	5.0	7.0	9.0	10.3	4.7	VE	14	13.2	5.7	Sound
GRN-42	42	Groin	Wood	152	-1.9	4.0	5.0	7.0	9.0	10.3	4.4	VE	14	13.2	5.5	Sound
GRN-43	43	Groin	Wood	152	-2.0	4.0	5.0	7.0	9.0	10.3	4.6	VE	14	13.2	5.7	Sound
GRN-44	44	Groin	Wood	291	-2.0	4.0	5.0	7.0	9.0	10.3	4.5	VE	14	13.2	5.4	Sound
GRN-54	54	Groin	Wood	140	-1.6	4.5	5.0	7.0	9.0	10.3	4.3	VE	14	12.5	5.1	Sound
GRN-55	55	Groin	Wood	150	-3.2	5.0	5.0	7.0	9.0	10.3	4.2	VE	14	12.5	5.1	Sound
GRN-56	56	Groin	Wood	79	-2.5	5.5	5.0	7.0	9.0	10.3	4.5	VE	14	12.5	5.3	Sound
GRN-57	57	Groin	Wood	98	-3.2	4.5	5.0	7.0	9.0	10.3	4.5	VE	14	12.5	5.3	Sound
GRN-58	58	Groin	Wood	49	-2.1	3.0	5.0	7.0	9.0	10.3	4.5	VE	14	12.5	5.3	Sound
GRN-62	62	Groin	Stone	282	-3.2	5.0	5.0	7.0	9.0	10.3	4.8	VE	18	12.5	5.5	Sound
GRN-63	63	Groin	Stone	88	-4.1	3.0	5.0	7.0	9.0	10.3	4.4	VE	18	12.5	5.0	Sound
GRN-65	65	Groin	Stone	145	-3.7	5.0	5.0	7.0	9.0	10.3	4.1	VE	18	12.4	4.7	Sound
GRN-66	66	Groin	Stone	47	-1.4	4.0	5.0	7.0	9.0	10.3	3.6	VE	18	12.4	4.3	Sound
GRN-67	67	Groin	Stone	73	-2.8	4.0	5.0	7.0	9.0	10.3	4.1	VE	18	12.4	4.7	Sound
GRN-70	70	Groin	Stone	98	-3.5	4.0	5.0	7.0	9.0	10.3	4.1	VE	18	12.4	4.7	Sound
GRN-71	71	Groin	Stone	106	-4.2	8.5	5.0	7.0	9.0	10.3	4.0	VE	16	12.4	4.7	Sound
GRN-73	73	Groin	Concrete	68	-4.1	9.7	5.0	7.0	9.0	10.3	4.1	VE	16	12.4	4.8	Sound
GRN-74	74	Groin	Stone	82	0.0	0.0	5.0	7.0	9.0	10.3	4.1	VE	16	12.4	4.8	Sound
GRN-75	75	Groin	Concrete	113	-3.4	4.0	5.0	7.0	9.0	10.3	3.9	VE	16	12.4	4.7	Sound
GRN-76	76	Groin	Concrete	42	-2.1	4.0	5.0	7.0	9.0	10.3	4.1	VE	16	12.4	4.9	Sound
GRN-77	77	Groin	Stone	29	-2.9	4.0	5.0	7.0	9.0	10.3	4.2	VE	16	12.4	4.9	Sound
GRN-80	80	Groin	Stone	178	-4.4	4.0	5.0	7.0	9.0	10.3	4.3	VE	16	12.4	4.9	Sound
GRN-81	81	Groin	Stone	67	-3.4	2.0	5.0	7.0	9.0	10.3	3.9	VE	16	12.4	4.3	Sound
GRN-82	82	Groin	Concrete	69	-2.6	2.7	5.0	7.0	9.0	10.3	4.6	VE	14	12.5	5.3	Sound
GRN-88	88	Groin	Stone	73	-4.1	2.0	5.0	7.0	9.0	10.3	5.3	VE	14	12.5	6.3	Sound
GRN-100	100	Groin	Stone	136	-3.9	2.0	5.0	7.0	9.0	10.3	6.0	VE	19	12.2	7.2	Sound
GRN-103	103	Groin	Stone	66	-3.6	2.0	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	6.6	Sound
GRN-104	104	Groin	Stone	75	-3.1	4.0	5.0	7.0	9.0	10.3	5.0	VE	14	12.2	6.1	Sound
GRN-105	105	Groin	Stone	113	-3.0	4.0	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	5.9	Sound
GRN-106	106	Groin	Stone	66	-1.5	4.0	5.0	7.0	9.0	10.3	4.8	VE	14	12.2	6.0	Sound
GRN-108	108	Groin	Stone	97	-3.8	4.0	5.0	7.0	9.0	10.3	5.3	VE	14	12.2	6.5	Sound
GRN-109	109	Groin	Stone	108	-1.0	5.0	5.0	7.0	9.0	10.3	5.3	VE	14	12.2	6.5	Sound
GRN-112	112	Groin	Stone	34	-3.6	2.0	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	6.5	Sound
GRN-113	113	Groin	Stone	50	-3.9	2.0	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	6.5	Sound
GRN-114	114	Groin	Stone	56	-4.0	2.0	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	6.6	Sound
GRN-115	115	Groin	Stone	44	-4.0	2.0	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	6.6	Sound
GRN-116	116	Groin	Stone	34	-3.6	2.0	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	6.6	Sound
GRN-122	122	Groin	Stone	90	-3.1	2.0	5.0	7.0	9.0	10.3	6.2	VE	14	12.2	7.2	Sound

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
GRN-123	123	Groin	Stone	72	-3.0	2.0	5.0	7.0	9.0	10.3	6.1	VE	13	12.2	7.1	Sound
GRN-124	124	Groin	Stone	87	-3.4	2.0	5.0	7.0	9.0	10.3	5.7	VE	13	12.2	6.8	Sound
GRN-125	125	Groin	Stone	85	-3.8	2.0	5.0	7.0	9.0	10.3	5.7	VE	13	12.2	6.8	Sound
GRN-126	126	Groin	Stone	79	-4.1	2.0	5.0	7.0	9.0	10.3	5.9	VE	13	12.2	7.0	Sound
GRN-127	127	Groin	Stone	71	-3.7	2.0	5.0	7.0	9.0	10.3	5.9	VE	13	12.2	7.0	Sound
GRN-128	128	Groin	Stone	100	-3.1	3.0	5.0	7.0	9.0	10.3	6.1	VE	13	12.2	7.2	Sound
GRN-130	130	Groin	Stone	95	-3.5	5.0	5.0	7.0	9.0	10.3	6.2	VE	13	12.2	7.3	Sound
GRN-132	132	Groin	Stone	140	-3.8	4.0	5.0	7.0	9.0	10.3	5.6	VE	13	12.2	6.8	Sound
GRN-137	137	Groin	Stone	62	-1.7	4.0	5.0	7.0	9.0	10.3	5.5	VE	13	12.2	6.6	Sound
GRN-216	216	Groin	Wood	71	-1.8	2.0	5.0	7.0	9.0	10.3	3.2	AE	11	14.2	3.6	Connecticut River
GRN-307	307	Groin	Stone	192	-4.3	2.0	5.0	7.0	9.0	10.3	5.7	VE	19	12.2	6.7	Sound
GRN-308	308	Groin	Wood	48	-2.5	3.0	5.0	7.0	9.0	10.3	4.6	VE	14	12.5	5.3	Sound
GRN-309	309	Groin	Wood	50	-2.7	5.0	5.0	7.0	9.0	10.3	4.5	VE	14	12.5	5.3	Sound
GRN-310	310	Groin	Wood	76	-0.4	5.0	5.0	7.0	9.0	10.3	3.7	VE	14	12.5	4.7	Sound
GRN-311	311	Groin	Wood	93	-0.5	5.0	5.0	7.0	9.0	10.3	4.0	VE	14	12.5	4.9	Sound
GRN-312	312	Groin	Wood	34	0.2	3.5	5.0	7.0	9.0	10.3	3.4	VE	14	12.5	4.3	Sound
GRN-337	337	Groin	Wood	52	-0.1	4.0	5.0	7.0	9.0	10.3	1.9	AE	11	13.4	2.8	Oyster River
GRN-338	338	Groin	Wood	57	0.2	4.0	5.0	7.0	9.0	10.3	2.4	AE	11	13.4	3.2	Oyster River
GRN-367	367	Groin	Wood	60	-1.8	3.0	5.0	7.0	9.0	10.3	3.8	VE	14	13.2	4.9	Behind Jetty
GRN-368	368	Groin	Wood	106	-1.9	4.0	5.0	7.0	9.0	10.3	3.7	VE	14	13.2	4.7	Behind Jetty
Jetties		**15**		**7,925**												
JTY-11	11	Jetty	Stone	457	-1.8	5.0	5.0	7.0	9.0	10.3	4.4	VE	14	13.2	5.5	Sound
JTY-12	12	Jetty	Stone	878	-1.7	4.0	5.0	7.0	9.0	10.3	4.0	VE	14	13.2	5.1	Sound
JTY-51	51	Jetty	Wood	132	-1.3	3.4	5.0	7.0	9.0	10.3	3.4	VE	14	12.8	4.4	Sound
JTY-133	133	Jetty	Stone	177	-3.8	3.4	5.0	7.0	9.0	10.3	6.4	VE	13	12.2	7.5	Sound
JTY-134	134	Jetty	Stone	173	-3.8	3.2	5.0	7.0	9.0	10.3	6.4	VE	13	12.2	7.4	Sound
JTY-136	136	Jetty	Stone	188	-3.9	3.8	5.0	7.0	9.0	10.3	6.4	VE	13	12.2	7.4	Sound
JTY-139	139	Jetty	Stone	2201	-4.5	3.4	5.0	7.0	9.0	10.3	8.6	-	-	12.1	9.6	Sound
JTY-159	159	Jetty	Stone	265	-1.4	5.7	5.0	7.0	9.0	10.3	3.9				4.5	
JTY-177	177	Jetty	Stone	346	-0.3	4.9	5.0	7.0	9.0	10.3	3.4	AE	11	14.6	3.9	Connecticut River
JTY-178	178	Jetty	Stone	374	-0.9	2.0	5.0	7.0	9.0	10.3	3.5	AE	11	14.6	3.8	Connecticut River
JTY-179	179	Jetty	Stone	139	-0.8	4.4	5.0	7.0	9.0	10.3	2.1	AE	11	15.0	2.5	Connecticut River
JTY-181	181	Jetty	Stone	44	0.2	2.2	5.0	7.0	9.0	10.3	2.4				2.8	
JTY-191	191	Jetty	Stone	138	-1.4	4.0	5.0	7.0	9.0	10.3	3.5	AE	11	15.0	3.9	Connecticut River
JTY-303	303	Jetty	Stone	2261	-4.6	-0.9	5.0	7.0	9.0	10.3	7.5	-	-	12.1	8.6	Sound
JTY-324	324	Jetty	Stone	151	-1.7	0.5	5.0	7.0	9.0	10.3	3.9	VE	14	13.1	4.8	Sound
Piers		**3**		**626**												
PIER-95	95	Pier	Concrete	160	-4.5	12.6	5.0	7.0	9.0	10.3	4.9	VE	19	12.2	6.0	Sound
PIER-99	99	Pier	Stone	172	-4.5	3.3	5.0	7.0	9.0	10.3	6.2	VE	19	12.2	7.3	Sound
PIER-131	131	Pier	Concrete	294	-4.1	4.6	5.0	7.0	9.0	10.3	6.3	VE	13	12.2	7.3	Sound
Seawalls		**88**		**31,770**												
SWL-1	1	Seawall	Concrete	1051	3.9	5.0	5.0	7.0	9.0	10.3	3.5	VE	14	13.2	4.7	Sound
SWL-2	2	Seawall	Concrete	170	3.3	5.0	5.0	7.0	9.0	10.3	4.1	VE	14	13.2	5.2	Sound
SWL-3	3	Seawall	Concrete	1360	3.1	5.0	5.0	7.0	9.0	10.3	2.5	VE	14	13.2	4.0	Sound
SWL-4	4	Seawall	Concrete	212	5.4	7.0	5.0	7.0	9.0	10.3	3.5	VE	14	13.2	4.6	Sound
SWL-5	5	Seawall	Concrete	204	7.1	7.0	5.0	7.0	9.0	10.3	1.9	VE	14	13.2	3.4	Sound
SWL-6	6	Seawall	Concrete	52	6.5	7.0	5.0	7.0	9.0	10.3	2.4	VE	14	13.2	3.8	Sound
SWL-7	7	Seawall	Stone	239	1.4	5.0	5.0	7.0	9.0	10.3	3.1	VE	14	13.2	4.4	Sound
SWL-8	8	Seawall	Unknown	240	2.6	6.5	5.0	7.0	9.0	10.3	3.6	VE	14	13.2	4.8	Behind Jetty
SWL-9	9	Seawall	Concrete	290	-1.8	5.0	5.0	7.0	9.0	10.3	3.3	VE	14	13.2	4.4	Behind Jetty
SWL-10	10	Seawall	Concrete	1063	1.3	9.9	5.0	7.0	9.0	10.3	1.7	VE	14	13.1	3.2	Behind Jetty
SWL-13	13	Seawall	Stone	718	2.0	7.0	5.0	7.0	9.0	10.3	3.2	VE	14	13.2	4.1	Sound

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
SWL-14	14	Seawall	Concrete	152	2.9	7.0	5.0	7.0	9.0	10.3	3.6	VE	14	13.2	4.4	Sound
SWL-16	16	Seawall	Concrete	125	3.5	6.0	5.0	7.0	9.0	10.3	2.6	VE	14	13.2	3.6	Sound
SWL-17	17	Seawall	Stone	41	4.4	6.0	5.0	7.0	9.0	10.3	2.8	VE	14	13.2	3.7	Sound
SWL-18	18	Seawall	Concrete	150	4.7	6.0	5.0	7.0	9.0	10.3	2.8	VE	14	13.2	3.8	Sound
SWL-19	19	Seawall	Concrete	266	1.1	4.0	5.0	7.0	9.0	10.3	4.2	VE	14	13.2	4.9	Sound
SWL-20	20	Seawall	Stone	100	0.6	4.0	5.0	7.0	9.0	10.3	3.9	VE	14	13.2	4.7	Sound
SWL-22	22	Seawall	Wood	131	-1.0	1.0	5.0	7.0	9.0	10.3	4.2	VE	14	13.2	4.9	Sound
SWL-24	24	Seawall	Stone	113	3.6	6.0	5.0	7.0	9.0	10.3	3.2	VE	14	13.2	4.3	Sound
SWL-25	25	Seawall	Wood	95	0.6	2.9	5.0	7.0	9.0	10.3	3.3	VE	14	13.1	4.5	Osyter River
SWL-26	26	Seawall	Stone	123	0.6	5.4	5.0	7.0	9.0	10.3	3.4	VE	14	13.1	4.4	Oyster River
SWL-27	27	Seawall	Stone	567	0.4	5.5	5.0	7.0	9.0	10.3	3.8	VE	14	13.1	4.7	Oyster River
SWL-28	28	Seawall	Concrete	88	2.1	3.4	5.0	7.0	9.0	10.3	3.7	VE	14	13.0	4.6	Sound
SWL-29	29	Seawall	Stone	140	1.5	3.5	5.0	7.0	9.0	10.3	3.8	VE	14	13.0	4.7	Sound
SWL-30	30	Seawall	Concrete	207	1.4	3.9	5.0	7.0	9.0	10.3	3.5	VE	14	13.0	4.5	Sound
SWL-31	31	Seawall	Concrete	161	2.5	3.6	5.0	7.0	9.0	10.3	3.8	VE	14	12.9	4.7	Sound
SWL-32	32	Seawall	Stone	90	3.3	4.9	5.0	7.0	9.0	10.3	3.2	VE	14	12.9	4.2	Sound
SWL-33	33	Seawall	Stone	52	2.6	4.3	5.0	7.0	9.0	10.3	3.6	VE	14	12.9	4.5	Sound
SWL-45	45	Seawall	Concrete	77	0.0	7.6	5.0	7.0	9.0	10.3	2.1	VE	14	12.8	3.2	Marsh
SWL-46	46	Seawall	Stone	21	2.8	4.5	5.0	7.0	9.0	10.3	2.0	VE	14	12.8	2.9	Marsh
SWL-47	47	Seawall	Wood	68	-0.1	3.1	5.0	7.0	9.0	10.3	2.0	VE	14	12.8	2.8	Marsh
SWL-48	48	Seawall	Wood	112	-1.1	2.6	5.0	7.0	9.0	10.3	1.9	VE	14	12.8	2.7	Marsh
SWL-49	49	Seawall	Wood	134	0.4	3.7	5.0	7.0	9.0	10.3	2.1	VE	14	12.8	3.3	Marsh
SWL-50	50	Seawall	Wood	283	-1.0	7.3	5.0	7.0	9.0	10.3	2.6	VE	14	12.8	3.6	Plum Bank Creek
SWL-52	52	Seawall	Concrete	804	3.2	8.9	5.0	7.0	9.0	10.3	3.7	VE	14	12.8	4.7	Sound
SWL-53	53	Seawall	Concrete	426	2.0	7.0	5.0	7.0	9.0	10.3	3.8	VE	14	12.5	4.8	Sound
SWL-59	59	Seawall	Concrete	118	4.5	8.2	5.0	7.0	9.0	10.3	3.8	VE	14	12.7	4.8	Sound
SWL-60	60	Seawall	Concrete	1067	-0.5	7.2	5.0	7.0	9.0	10.3	3.4	VE	14	12.5	4.5	Sound
SWL-61	61	Seawall	Concrete	246	-0.7	8.0	5.0	7.0	9.0	10.3	3.4	VE	14	12.5	4.4	Sound
SWL-64	64	Seawall	Stone	529	2.9	9.0	5.0	7.0	9.0	10.3	4.3	VE	18	12.4	4.9	Sound
SWL-68	68	Seawall	Concrete	74	5.0	9.0	5.0	7.0	9.0	10.3	3.1	VE	18	12.4	3.3	Sound
SWL-69	69	Seawall	Steel	139	2.2	9.0	5.0	7.0	9.0	10.3	3.7	VE	18	12.4	4.3	Sound
SWL-72	72	Seawall	Concrete	379	2.4	11.0	5.0	7.0	9.0	10.3	4.1	VE	16	12.4	2.1	Sound
SWL-74	74	Seawall	Stone	135	1.5	11.0	5.0	7.0	9.0	10.3	4.1	VE	16	12.4	4.9	Sound
SWL-79	79	Seawall	Stone	404	2.0	8.0	5.0	7.0	9.0	10.3	2.9	VE	16	12.4	3.9	Sound
SWL-86	86	Seawall	Concrete	134	2.4	13.0	5.0	7.0	9.0	10.3	5.3	VE	24	12.2	6.2	Sound
SWL-87	87	Seawall	Concrete	406	1.2	17.6	5.0	7.0	9.0	10.3	5.6	VE	24	12.2	6.6	Sound
SWL-92	92	Seawall	Concrete	93	6.2	8.0	5.0	7.0	9.0	10.3	5.2	VE	24	12.3	3.4	Sound
SWL-93	93	Seawall	Concrete	667	2.8	8.0	5.0	7.0	9.0	10.3	5.3	VE	19	12.2	6.3	Sound
SWL-94	94	Seawall	Stone	1222	0.0	15.0	5.0	7.0	9.0	10.3	5.4	VE	19	12.2	6.4	Sound
SWL-96	96	Seawall	Concrete	100	4.0	10.0	5.0	7.0	9.0	10.3	5.4	VE	19	12.2	6.4	Sound
SWL-97	97	Seawall	Stone	1560	4.0	12.0	5.0	7.0	9.0	10.3	4.6	VE	19	12.1	5.6	Sound
SWL-98	98	Seawall	Stone	299	-0.2	6.0	5.0	7.0	9.0	10.3	5.9	VE	19	12.1	7.1	Sound
SWL-101	101	Seawall	Concrete	912	2.1	12.0	5.0	7.0	9.0	10.3	5.7	VE	19	12.1	6.8	Sound
SWL-102	102	Seawall	Concrete	222	-0.5	3.5	5.0	7.0	9.0	10.3	4.0	VE	14	12.2	5.4	Sound
SWL-107	107	Seawall	Concrete	241	3.6	8.5	5.0	7.0	9.0	10.3	4.0	VE	14	12.2	3.9	Sound
SWL-110	110	Seawall	Stone	344	5.2	7.9	5.0	7.0	9.0	10.3	3.4	VE	14	12.2	4.9	Sound
SWL-111	111	Seawall	Stone	240	1.4	4.6	5.0	7.0	9.0	10.3	5.4	VE	14	12.2	6.5	Sound
SWL-117	117	Seawall	Stone	65	0.7	4.5	5.0	7.0	9.0	10.3	5.0	VE	14	12.2	6.2	Sound
SWL-118	118	Seawall	Stone	42	1.4	5.1	5.0	7.0	9.0	10.3	4.2	VE	14	12.2	5.6	Sound
SWL-119	119	Seawall	Stone	29	5.1	6.5	5.0	7.0	9.0	10.3	4.7	VE	14	12.2	5.9	Sound
SWL-120	120	Seawall	Concrete	221	2.1	5.7	5.0	7.0	9.0	10.3	3.6	VE	13	12.2	5.0	Sound
SWL-121	121	Seawall	Concrete	502	1.9	5.1	5.0	7.0	9.0	10.3	4.2	VE	13	12.2	5.6	Sound
SWL-129	129	Seawall	Concrete	1285	-0.5	5.9	5.0	7.0	9.0	10.3	5.9	VE	13	12.2	6.7	Sound
SWL-135	135	Seawall	Concrete	495	0.4	4.2	5.0	7.0	9.0	10.3	6.1	VE	13	12.2	7.2	Sound
SWL-138	138	Seawall	Concrete	54	1.1	3.0	5.0	7.0	9.0	10.3	4.7	VE	13	12.2	5.9	Sound

Table 6-1: Inventory of Old Saybrook Coastal Structures

Asset ID	OBJECTID	Category	Material	Length, feet	Min. Elevation (ft, NAVD88)	Max. Elevation (ft, NAVD88)	2 yr rec. int. stillwater elevation (ft, NAVD88)	10 yr rec. int. stillwater elevation (ft, NAVD88)	50 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. stillwater elevation (ft, NAVD88)	100 yr rec. int. wave ht. (ft)	FEMA Zone	FEMA BFE (ft, NAVD88)	500 yr rec. int. stillwater elevation (ft, NAVD88)	500 yr rec. int. wave Ht.	Exposure
SWL-140	140	Seawall	Concrete	459	-2.9	7.0	5.0	7.0	9.0	10.3	5.0	VE	15	12.3	6.0	Connecticut River
SWL-141	141	Seawall	Concrete	428	1.3	15.0	5.0	7.0	9.0	10.3	1.4	VE	15	12.4	1.9	South Cove
SWL-142	142	Seawall	Unknown	177	0.8	3.7	5.0	7.0	9.0	10.3	3.2	VE	13	12.6	3.8	South Cove
SWL-143	143	Seawall	Unknown	213	1.0	4.1	5.0	7.0	9.0	10.3	3.3	VE	13	12.6	4.0	South Cove
SWL-144	144	Seawall	Stone	740	-1.8	5.9	5.0	7.0	9.0	10.3	3.5	VE	15	12.8	4.3	Connecticut River
SWL-145	145	Seawall	Unknown	1606	-0.6	6.8	5.0	7.0	9.0	10.3	2.3	VE	15	12.8	3.4	Connecticut River
SWL-146	146	Seawall	Concrete	1022	-0.9	5.1	5.0	7.0	9.0	10.3	3.6	VE	15	12.9	4.3	Connecticut River
SWL-147	147	Seawall	Stone	864	0.9	5.6	5.0	7.0	9.0	10.3	1.6	VE	15	13.1	2.1	Connecticut River
SWL-148	148	Seawall	Unknown	538	1.6	5.2	5.0	7.0	9.0	10.3	1.0	VE	15	13.0	1.0	North Cove
SWL-149	149	Seawall	Concrete	565	-1.5	5.2	5.0	7.0	9.0	10.3	1.9	VE	15	13.0	2.3	North Cove
SWL-150	150	Seawall	Concrete	857	-0.9	7.8	5.0	7.0	9.0	10.3	1.2	VE	15	12.9	1.3	North Cove
SWL-151	151	Seawall	Wood	322	1.5	7.5	5.0	7.0	9.0	10.3	1.1	VE	15	12.9	1.3	North Cove
SWL-152	152	Seawall	Stone	89	1.7	4.0	5.0	7.0	9.0	10.3	1.1	VE	15	12.9	1.6	North Cove
SWL-153	153	Seawall	Concrete	365	2.0	6.2	5.0	7.0	9.0	10.3	1.1	VE	15	12.9	1.9	North Cove
SWL-156	156	Seawall	Stone	56	0.9	3.3	5.0	7.0	9.0	10.3	2.4	VE	15	12.9	2.9	North Cove
SWL-170	170	Seawall	Wood	323	24.3	30.5	5.0	7.0	9.0	10.3	2.6	AE	11	14.2	2.8	Connecticut River
SWL-171	171	Seawall	Stone	72	5.5	6.2	5.0	7.0	9.0	10.3	1.1	AE	11	14.2	1.1	Connecticut River
SWL-172	172	Seawall	Stone	288	7.7	14.2	5.0	7.0	9.0	10.3	1.0	AE	11	14.2	1.0	Connecticut River
SWL-176	176	Seawall	Stone	258	1.5	4.3	5.0	7.0	9.0	10.3	3.1	AE	11	14.6	3.6	Connecticut River
SWL-314	314	Seawall	Concrete	58	1.5	7.6	5.0	7.0	9.0	10.3	2.1	VE	14	12.8	3.2	Plum Bank Creek
SWL-319	319	Seawall	Concrete	54	1.8	4.1	5.0	7.0	9.0	10.3	3.3	VE	14	13.0	4.4	Sound
SWL-320	320	Seawall	Concrete	69	2.2	5.1	5.0	7.0	9.0	10.3	3.7	VE	14	13.0	4.6	Sound
Bluffs		**7**		**2,002**												
BLF-1	78	Bluff	Stone	446	1.3	10.7	5.0	7.0	9.0	10.3	5.2	VE	13	12.2	6.3	Sound
BLF-2	83	Bluff	Stone	335	1.6	11.7	5.0	7.0	9.0	10.3	5.3	VE	13	12.2	6.4	Sound
BLF-3	84	Bluff	Loose stone	262	3.2	8.8	5.0	7.0	9.0	10.3	5.3	VE	13	12.2	6.3	Sound
BLF-4	85	Bluff	Stone	471	4.5	8.9	5.0	7.0	9.0	10.3	3.9	VE	13	12.2	5.2	Sound
BLF-5	89	Bluff	Stone	121	3.7	7.0	5.0	7.0	9.0	10.3	4.0	VE	24	12.2	5.3	Sound
BLF-6	90	Bluff	Stone	164	6.0	7.4	5.0	7.0	9.0	10.3	4.4	VE	24	12.2	5.6	Sound
BLF-7	91	Bluff		201	7.1	8.5	5.0	7.0	9.0	10.3	4.8	VE	24	12.2	5.9	Sound

Notes:

1. Structure Asset ID, Category, Material and Length obtained from Old Saybrook GiS Data Table
2. Stillwater elevations and wave heights derived from GZA Coastal Flood Hazard characterization presented in Attachment 2.
3. Structure elevations obtained based on GIS analysis using available Lidar data. These values are inferred and should be considered highly approximate. No field survey has been performed to confirm structure elevations.
4. The maximum elevation represents the inferred top of structure elevation. The minimum elevation represents the inferred ground elevation at the bottom of structure.
5. FEMA flood hazard zones and Base Flood Elevations obtained from the effective FEMA Flood Insurance Study and Insurance Rate Maps. See Attachment 2.
6. Yellow highlighted structures represent the Town-managed major coastal structures.
7. See Town GIS layer for structure locations.

Attachment 7: Comprehensive Flood Mitigation Feasibility Study

This attachment presents the findings of the *Comprehensive Mitigations Items Feasibility Study* and looks at the feasibility of flood mitigation alternatives for key Town assets. **Attachment 4** presents a detailed evaluation of the vulnerability and risk of these assets.

- Roads and Bridges;
- Essential Facilities;
- Commercial and Industrial Districts;
- Historical Properties; and
- Natural Resources.

Of all the Town's assets, the most significant coastal flood risk is the Town's roadway system. The Town's roadway system, which includes both municipal and state roads, is highly vulnerable to coastal flooding. Almost all of the Town's roads servicing areas located to the south of I-95 flood during extreme coastal flood events and a portion of the Town's roads now flood frequently (every year or so). These sections of roadway (generally defined by the limits of the current 2-year recurrence interval flood, will become chronically flooded in the future (around 2040 to 2050) as a result of sea level rise.

Roadway flooding disrupts the use of the roads, isolates neighborhoods, affects the Town's capability to evacuate and provide emergency services and results in roadway damage. As such, it represents a major liability to the Town.

Sanitary wastewater treatment is also significant issue relative to shallow groundwater and frequent coastal flooding. The Town established a Decentralized Wastewater Management District (WWMD) in August, 2009 and adopted: 1) WWMD boundaries that include approximately 1900 lots located within 15 neighborhood areas; and 2) Upgrade Program Standards for on-site septic system improvements. GZA evaluated the coastal flood risk and presented relevant information via a separate memorandum to the Town for use in the "Old Saybrook Wastewater Pollution Control Authority [WPCA]) Study".

The Town's stormwater management system will also be affected by future flooding and sea level rise. At this time, there is inadequate information about the system details to perform a detailed assessment of these impacts. Stormwater management improvements are not included in this Study.

The coastal flood risk to the Town's Lifeline Facilities, including Electricity, Natural Gas, Water and Communication and Sewer, is relatively low (except sanitary waste water management, discussed above). The electrical substation located at Elm Street is vulnerable to coastal flood station. The substation is the responsibility of Eversource.

Roads, Bridges and Culverts

The Town is served by two major limited access highways, Interstate 95 and Route 9, as well as major arterials such as U.S. Route 1, CT Route 154 and Route 166. The Town also has a network of smaller roads that provide access throughout town and serve act 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 formerly part of the Town's transportation system, are available to provide water access and egress.

An overview of the roadways, bridges and culverts, by jurisdiction, is presented below and is followed by a detailed list of each road and bridge included for analysis for this evaluation. This section of the report supports the goal of the Town's updated Natural Hazard Risk Management Plan to evaluate flood risk to roads.

Roads

The State roads make up approximately 47 miles of total roadway within Old Saybrook. The four (4) key State roads include:

- Interstate I-95 (Connecticut Turnpike)
- Route 1 (Boston Post Road)
- Route 154 (Main Street and College Street; Plum Bank Road and Great Hammock Road; Maple Avenue; South Cove Causeway)
- Route 166 (Spencer Plain Road)

Municipal roads make up approximately 88 miles of total roadway within Old Saybrook.

Table 7-1 summarizes the length of roadway impacted under different coastal flood scenarios. **Attachment 4** presents a detailed vulnerability assessment.

	2-year	10-year	20-year	50-year	100-year	500-year
State	2.9%	7.4%	9.6%	11.3%	13.1%	16.9%
	1 mile	2.4 mile	3.2 mile	3.7 mile	4.3 mile	5.6 mile
Municipal	3%	8.5%	12.4%	16.2%	20.6%	32.3%
	2.6 mile	7.4 mile	10.7 mile	14.0 mile	17.9 mile	28.0 mile
Private	3.6%	10.5%	15%	23.7%	50.4%	71.4%
	0.1 mile	0.3 mile	0.4 mile	0.7 mile	1.5 mile	2.1 mile

Table 7-1: Summary of Impacted Roads Due to Coastal Flooding

Bridges

There are 22 bridges in Old Saybrook, including bridges where I-95 (Connecticut Turnpike) overpasses Town and State roads, Amtrak rail bridges overpassing Town and State roads, culverts supporting roadways at rivers, and the South Cove Causeway.

Six (6) I-95 (Connecticut Turnpike) bridges located within the Town limits:

- I-95 Bridge over School House Road
- I-95 Bridge over Elm Street
- I-95 Bridge over Middlesex Turnpike
- I-95 Bridge over Springbrook Road
- I-95 Bridge over Essex Road
- I-95 Bridge over Route 9

Three (3) Amtrak Rail bridges:

- Amtrak Rail Bridge over the Connecticut River
- Amtrak Bridge over Elm Street
- Amtrak Bridge over the Oyster River

Five (5) State bridges, including three bridge structures that are part of the South Cove Causeway:

- Raymond E. Baldwin Bridge over the Connecticut River
- Route 1 Bridge over the Oyster River
- Causeway Middle Bridge over South Cove (Route 154)
- Causeway North Bridge over South Cove (Route 154)
- Causeway South Bridge over South Cove (Route 154)

Eight (8) Town bridges:

- Great Hammock Road Bridge over Back River
- Ingham Hill Road Bridge over Amtrak
- Nehantic Trail Bridge over Hagar Creek
- Plum Bank Road Bridge over Plum Bank Creek
- School House Road Bridge over Amtrak
- Sequassen Avenue Bridge over tidal creek
- Spencer Plain Rd Bridge over I-95
- Spencer Plain Road Bridge over Amtrak

Overtopped Bridges	Approximate Bridge Deck Elevation (feet, NAVD88)	Estimated current 100-year return period stillwater elevation (feet, NAVD88)	Estimated current 100-year return period wave crest elevation (feet, NAVD88)
South Cove Causeway:			
North Bridge over South Cove	6	10	15 (VE)
Middle Bridge over South Cove	6	10	15 VE)
South Bridge over South Cove	8	10	15 (VE)
Great Hammock Road Bridge over Back River	6	10.5	13 (Coastal AE)
Nehantic Trail Bridge over Hagar Creek	10	10.5	14 (VE)
Plum Blank Road Bridge over Plum Blank Creek	7	10	14 (VE)
Route 1 Bridge over Oyster River	13	11.5	12.5
Sequassen Avenue Bridge over tidal creek	6	10	13 (VE)

Table 7-2: Summary of Bridges Inundated during the 100-year recurrence interval Coastal Flood

Eight (8) bridges have bridge decks that will be inundated and exposed to wave action during the 2016 100-year return period flood (see **Table 1-4**). Three (3) of the bridges are along the South Cove Causeway. **Figure 1-16** shows the location of the bridges relative to the 100-yr return period flood. Amtrak and I-95 bridge decks are not flooded during the 2016 100-year return period flood.

Based on the flood elevations relative to bridge deck elevation, a preliminary evaluation of bridge damage potential during the 2016 100-year return period flood is:

- South Cove Causeway Bridges: High
- Great Hammock Road Bridge over Back River: High
- Nehantic Trail Bridge over Hager Creek: Moderate
- Plum Bank Road Bridge over Plum Bank Creek: High
- Route 1 Bridge over Oyster River: Low
- Sequassen Avenue Bridge over tidal creek: High

Table 7-3: Summary of Roadway Culverts Inundated during 100-year Return Period Coastal Flood

100-year Return Period Flood	Number of Culverts
2016	18
2041	18
2066	19
2116	22

TRANSPORTATION INFRASTRUCTURE FLOOD MITIGATION CONSIDERATIONS

There are several considerations relative to identifying Old Saybrook's transportation system flood mitigation priorities and alternatives, including:

- Effects of Nuisance Flooding (i.e., Chronic Flood Inundation) versus Extreme Flood Events
- Emergency Response Capabilities
- Storm Evacuation Requirements
- Transportation Infrastructure Damage
- Technical Feasibility
- Cost

Nuisance Flooding

Nuisance flooding generally describes areas which are regularly flooded, including due to tides during "sunny sky" conditions. The term "chronic flood inundation" applies a specific quantitative guideline for nuisance flooding - specifically 26 times per year. Chronic flood inundation has significant implications relative to roadway use limitations and associated negative impacts to businesses and residents. **Figure 7-1** provides a reasonable representation of roadway sections that have a high probability of being flooded today and will be chronically flooded by about the year 2050. As shown on **Table 7-1**, about 3 miles of Town roads and 3 miles of State roads are impacted under this scenario.

Emergency Response

Populated Town areas and neighborhoods become isolated during coastal flooding due to road inundation and flood depths along both primary and secondary roadway can be significant. This impacts the ability of people to leave during the flood event as well as limits the Town's emergency response capabilities. The more limited the Town's emergency response capability becomes, the greater the requirement for, and frequency of evacuation, becomes. Another consideration is the capability of the Town's emergency response equipment relative to passaging flooded roads. Cars cannot, typically, passage greater than six inches (<1 foot) of water depth and heavy, high clearance 4 wheel drive vehicles cannot typically passage more than 24 inches (2 feet) water depth. As the flood depth increases to these depths, the vehicles speeds will reduce dramatically. The presence of high velocity water flow (such as from waves) will further significantly reduce passable depths.

Figure 7-1: 2-year Recurrence Interval Flood Roadway Impacts; Chronic Flooding by 2040 to 2050

Pre-Storm Evacuation

Storm evacuation capability is a key consideration relative to roadway accessibility. A detailed analyses of New England hurricane evacuation needs and capabilities is presented in "New England Hurricane Evacuation Study, Technical Data Report", June 2016, prepared by the USACE and FEMA. Per this study, evacuation people statistics indicate that: during Category 1 and 2 hurricanes between about 8,200 and 10,750 people may require evacuation during severe flood events; during Category 3 and 4 hurricanes, an 90 and 260 people may require evacuation during severe flood events; and additional people evacuating from inland areas located outside of coastal flood inundation may be between 440 and 800 additional people. The vulnerability of the Town's roads to flooding effects evacuation capability.

Transportation Infrastructure Damage

Roadway damage associated with coastal flooding typically occurs due to: 1) scour, erosion and subsidence of the road bed; 2) debris impact damage; 3) sand overwash (roads adjacent to beaches and dunes); 4) damage to utilities located within roadways (above ground and below ground); 5) saturation and destabilization of road base course; and 6) corrosion and salt-related material damage. Bridge damage associated with coastal flooding typically occurs as a result of wave action due to: 1) scour at bridge piers; 2) hydrodynamic and impact loads to bridge piers; and 3) uplift loads on bridge decking.

A preliminary overview of the damage potential of Old Saybrook's roadways indicates the following:

- Old Saybrook's roads located within flood hazard zones will be subject to both flood inundation and waves. Wave heights range from minimal damage potential (wave heights less than 1.5 feet) to moderate damage potential (wave heights ranging from 1.5 feet to 3 feet) to severe damage potential (greater than 3 feet). **Figure 7-2** shows the wave heights predicted for the 2016 100-year return period flood. Most roads appear to be in relatively low wave energy environments.
- Several of the Beach Community roads are expected to be vulnerable to severe damage during the 100-year return period flood (and possibly more frequent floods), including Beach Road, portions of Red Bird Trail, Bayside Avenue, portions of Vincent Avenue, portions of Hartford Avenue, portions of Middletown Avenue, Barnes Road, Walker Avenue and Plum Bank Road. An additional road that is vulnerable to severe damage, at least during the 100-year return period flood, is Dock Road.
- Primary, key roads vulnerable to severe damage due to waves include Bridge Street (including the South Cove causeway bridges).
- A primary, key roadway with the potential for future damage due to wave exposure is an approximately 4,000-foot long section of Maple Avenue (Route 154). The road surface grades along this section range from about Elevation 21 feet NAVD88 (to the west) to Elevation 11 feet (to the east). The 100-year and 500-year stillwater elevations along this stretch of Route 154 are about 9.5 feet and 12.6 feet NAVD88, respectively. Currently, this road is not predicted to be inundated during the 100-year return period flood with some inundation predicted during the 500-year return period flood. Wave heights on the order of 4 to 6 feet are predicted along this section of road during the current 100-year return period flood and 500-year return period floods. Therefore, roadway flooding due to wave overtopping will occur, likely making this section of road unpassable during these probability flood events. During the 500-year return period flood, the eastern portion of the road will also be inundated, in addition to wave effects. Based on the existing roadway grades, marginal sea level rise will significantly increase the flood risk of this road. This section of Route 154 has direct frontage on Long Island Sound and is protected against erosion with a concrete and masonry revetment.
- Based on the flood elevations relative to bridge deck elevation, bridges with a moderate to high bridge damage potential during the 2016 100-year return period flood include:

i.	South Cove Causeway Bridges:	High
ii.	Great Hammock Road Bridge over Back River:	High
iii.	Nehantic Trail Bridge over Hager Creek:	Moderate
iv.	Plum Bank Road Bridge over Plum Bank Creek:	High
v.	Sequassen Avenue Bridge over tidal creek:	High

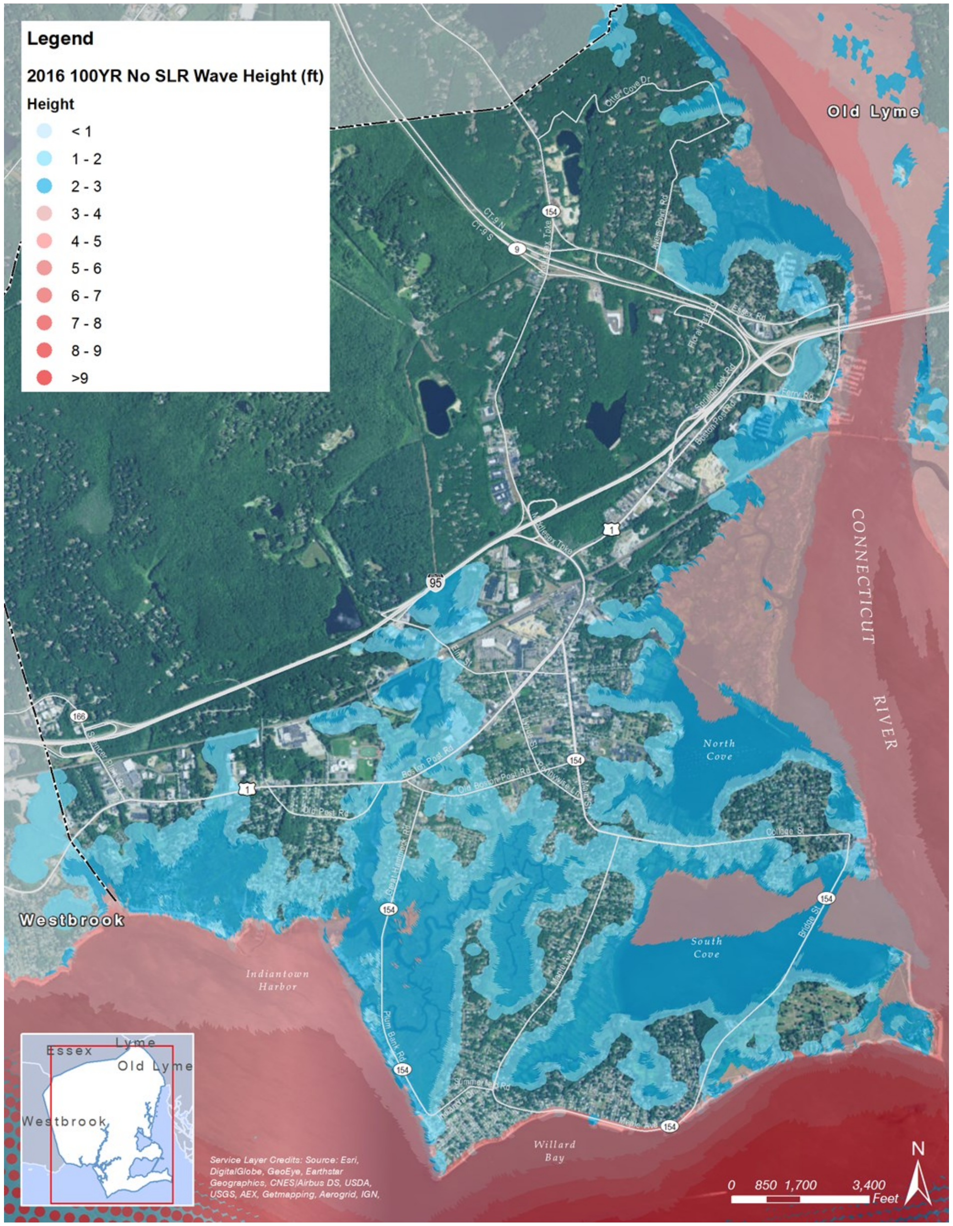


Figure 7-2: 100-year Recurrence Interval Flood Wave Heights

Technical Feasibility of Flood Mitigation Alternatives

Roadway flood mitigation alternatives typically include:

- Elevating the road, including bridges and replacement of roadway culverts
- Roadway perimeter flood protection including flood walls and berms
- Constructing a low bridge deck in lieu of a grade-supported road

Additional, passive, alternatives are: 1) to allow the road to temporarily flood (i.e., storm flood events) while minimizing flood-related damage; or 2) abandon the road.

There are several factors that limit the use of these alternatives. In particular, substantial roadway grade increases will need to accommodate existing intersections, driveways and abutting building first floor levels. Elevating roads more than about 3 feet (such as would be required over most of the inundated Old Saybrook roads to elevate them above the 100-year return period flood) will likely be technically challenging and cost prohibitive.

The other roadway flood mitigation alternatives requiring roadway modification will have similar issues. Perimeter berms and/or floodwalls will require openings at driveways that would need to be closed with deployable barriers during the flood event.

Installing bridge decks in lieu of elevating roads may be an effective alternative at specific roadways sections (such as along the section of College Street (Route 154) that is bounded by marsh on both sides.

Flood Mitigation Roadway Costs

A linear cost of roadway replacement for 2-lane undivided roads with elevation changes less than about 3 feet of $3 million per mile ($550 to $600 per linear foot) is appropriate for preliminary resilience planning (reference American Road & Transportation Builders Association). An additional linear cost to improve adjacent intersections, driveways and stormwater management of about $1 million per mile ($200 per linear foot) should also be assumed for preliminary resilience planning, for a total planning linear cost of $4 million per mile (+/- $750 per linear foot).

There is not, currently, much available, standardized data for roadway damage versus flood depth and waves. A preliminary, planning level, cost for roadway repair associated with flood damage is (ref. State of California, Department of Water Resources, Division of Flood Management, Flood Rapid Assessment Model (F-RAM, 2008):

- Cost per mile of highway inundated: $250,000
- Cost per mile of major road inundated: $100,000
- Cost per mile of minor road inundated: $30,000
- Cost per mile of gravel road inundated: $10,000

The unit costs presented above are not specific to Old Saybrook, are highly uncertain and should be used with caution by Old Saybrook. Although the repair and replacement unit costs presented above are highly approximate, they provide valuable insight for preliminary resilience planning and decision making:

- **Table 7-4** presents a (highly) approximate estimate of the cost to elevate all inundated roads assuming a unit cost of $4,000,000 per mile.
- **Table 7-4** does not include the potential cost of bridge replacement, including bridges that are components of key roadways. The (highly) approximate additional cost to include bridge replacement is shown below, based on Federal Highway Administration Bridges & Structures Bridge Replacement Unit Costs for 2017 (https://www.fhwa.dot.gov/bridge/nbi/sd2016.cfm).
    - i) South Cove Causeway Bridges:
        - 250 lf by 40 ft. @ $440/sf = $4,400,000
        - 250 lf by 40 ft. @ $440/sf = $4,400,000
        - 250 lf by 40 ft. @ $440/sf = $4,400,000
    - i) Great Hammock Road Bridge over Back River:
        - 35 lf by 30 ft @ $440 = $462,000
    - i) Nehantic Trail Bridge over Hager Creek:
        - 65 lf by 35 ft @ $440 = $1,001,000
    - i) Plum Bank Road Bridge over Plum Bank Creek:
        - 20 lf by 35 ft @ $440/sf = $308,000
    - i) Sequassen Avenue Bridge over tidal creek:
        - 30 lf by 20 ft @ $440/sf = $264,000
- Highly approximate cost estimates to repair roads with severe damage potential due to waves, assuming unit costs of $250,000 per mile (State), $100,000 per mile (key municipal roads), and $30,000 per mile (community roads) are presented as shown below. These estimates are associated with predicted damage from waves associated with the 2016 100-year return period flood. This was the only return period flood analyzed; however, given the high vulnerability of these roads to coastal flooding, similar losses are also likely for higher probability coastal flood events.
    - i) Beach Community Roads: 1.5 miles @ $30,000 per mile = +/- $50,000
    - ii) State Roads (including Plum Bank Road): 1.5 miles @$250,000 per mile = +/- $400,000

	2-year	10-year	20-year	50-year	100-year	500-year
Municipal	$10,467,645	$29,619,188	$42,898,839	$56,106,946	$71,543,954	$111,953,050
State	$3,806,263	$9,787,332	$12,703,164	$14,874,116	$17,247,326	$22,231,640
Primary (Key Roads)						
Municipal	$298,642	$2,904,597	$4,853,878	$6,814,851	$9,226,714	$13,844,748
State	$3,420,336	$9,401,405	$12,317,237	$14,488,189	$16,861,398	$21,845,712

Table 7-4: Approximate Estimate of Roadway Replacement Assuming All Inundated Roads are Elevated

TRANSPORTATION INFRASTRUCTURE FLOOD RESILIENCE STRATEGY

Developing a transportation infrastructure resilience strategy for Old Saybrook requires consideration of several factors including:

- the frequency and effects (i.e., disrupted use) of nuisance flooding (i.e., Chronic Flood Inundation);
- the effects of lower probability extreme flood events, including infrastructure damage;
- the implications of roadway flooding for evacuation and emergency response capabilities; and

the technical feasibility and cost of flood mitigation alternatives.

The Amtrak rail line (as well as the Old Saybrook Rail Station are not located within flood hazard zones (up to the 2016 500-year return period flood). Access to and from the Old Saybrook Essential Facilities (necessary for emergency response and shelter) is limited and impacted by roadway flooding. The major routes providing ingress and egress to the Town, including I-95 and Route 9 and access ramps are not located within flood hazard zones (up to the 2016 500-year return period flood).

However, as documented in detail in **Attachment 4**, much of the Town's roadway system south of I-95 is very vulnerable to coastal flooding. Developed areas south of I-95 become isolated "islands" during major flood events. Primary, key roads (i.e. higher trafficked and main routes) become inaccessible and not passable. These roads are particularly important since they represent the Town's main arteries and are also essential for emergency evacuation and access for emergency response. A portion of the Town's roads also flood on a frequent basis (see 2 and 10-year return period flood inundation figures) and are predicted to flood "chronically" (on average about 26 times per year) by the year 2050. Overall future sea level rise will increase the Town's roadway flood issues.

Transportation infrastructure flood mitigation alternatives include:

- Elevating the road, including bridges and replacement of roadway culverts;
- Roadway perimeter flood protection including flood walls and berms;
- Constructing a low bridge deck in lieu of a grade-supported road;
- Allowing the road to temporarily flood (i.e., storm flood events) while minimizing flood-related damage;
- Employ "flood applicable" emergency response vehicles and equipment capable of passing flooded roads; and
- Abandon select roadways.

Since it is unlikely that elevating or providing flood protection to all impacted roads to above the 100-year (or 500-year) return period flood elevations will be feasible from either a cost or technical perspective, the optimal resilience strategy will be to find a balance between: 1) near-term roadway improvements; 2) preventing future roadway damage; 3) ability to provide emergency response; 4) evacuation requirements; and 5) the effect of future sea level rise on each of these. The optimal strategy would also prioritize future actions (including considering and planning for some roadway abandonment) as well as support adaptation in the future.

Additional analyses and future Town discussion/meetings will be required to develop the transportation infrastructure strategy and long term Town plans for roadway improvements. A preliminary strategy is proposed as follows:

Step 1: Meet with ConnDOT to discuss the findings of the Town's Coastal Resilience study as they relate to State roads and discuss flood mitigation alternatives, funding and responsibility for improvement of State roads. These meetings will provide the Town with a reasonable understanding of what the State is prepared to do relative to State-managed roads, so the Town can plan accordingly.

Step 2: Work with the Town's Natural Hazard Risk Management and Emergency Response professionals to create/revise the Town's evacuation route in light of the findings of this study. Also discuss the feasibility of purchasing and training on "flood applicable" emergency response vehicles and equipment, recognizing that providing flood mitigation to all vulnerable roads may not be feasible.

Step 3: Identify near-term roadway improvements, prioritizing: 1) high trafficked roadways vulnerable to high frequency (future chronic) flooding, as identified by the 2 and 10-year return flood inundation analysis; 2) primary, key roads required for evacuation.

Step 4: Perform preliminary engineering analyses of the roads identified in Step 3 to establish appropriate flood mitigation approach and elevation.

Step 5: Estimate flood damage liability and evaluate benefits of investing in roadway protection versus post-disaster relief funding. In particular, consider future flood vulnerability of Rt. 154/Walnut Avenue with direct exposure to Long Island Sound.

Step 6: Several roads (e.g., Plum Bank Road) are located in highly vulnerable areas. The benefits of on-going repair and maintenance of these roads should be evaluated relative to abandonment at some point in the future.

Step 7: Prepare a Long-Term Roadway Improvement and Maintenance Plan, including cost projections, schedule and financing options.

TRANSPORTATION RESILIENCE FUNDING SOURCES

Applicable programs that serve as potential sources of funding for transportation infrastructure design and construction include:

- Transportation Investment Generating Economic Recovery (TIGER) program (FHWA and State of Connecticut);
- Nature-Based Resilience for Coastal Highways (FHWA);
- Municipal and Resilience Bonds; and
- Town taxes.

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

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:

https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/

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. Coastal green infrastructure includes dunes, wetlands, living shorelines, oyster reefs, beaches, and artificial reefs. These features may offer protection from waves, erosion, sea level rise, and storm surge.

This program may be a source of future funding for similar transportation projects that would require that the Town of Old Saybrook 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. Eligible expenses include staff or contractor hours to conduct the analysis and document the results.

Municipal and Resilience Bonds

Standard Municipal Bonds can be utilized for resiliency projects. Catastrophe Bonds can also be obtained by the Town to insure against natural hazard loss. Resilience bonds modify the existing catastrophe bond insurance market to capture the savings from a lowered risk of insurance payouts and then use that value as rebates to invest in resilient infrastructure projects.

Taxes

Taxes are also a source for roadway improvements.

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Elm Street: This stretch of Elm Street is highly vulnerable to flooding due to: 1) low elevation roadway grades; 2) proximately to tidal water body; and 3) surcharging of stormwater outfalls, piping and catch basins. Flood inundations limits based on the effective FEMA FIRM are shown here. Flood protection is complicated by the presence of Research Parkway and roadway flood mitigation of the roadway will also require flood protection here to prevent parking lot flooding from entering onto the road.

View toward roadway underpass beneath Amtrack (above) and toward culvert over Oyster River (below)

FEMA Special Flood Hazard Areas around Elm Street

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Main Street/College Street (Route 154): This portion of Main Street and College Street flood during coastal storm events due: 1) to proximity of tidal waters to the north and south; and 2) low elevation street grades. Flood inundations limits based on the effective FEMA FIRM are shown here. Flood mitigation is complex due to number of cross streets and driveways.

An alternative may be to modify less extent of the roadway. The limits of the current 10-year recurrence interval flood is shown below.

FEMA Special Flood Hazard Areas around Main Street and College Street (above). The GZA-predicted food limits from the current 10-year recurrence interval flood are shown below.

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Sections of Route 1 Post Road: Route 1 Boston Post Road is a primary, key road as well as the access route to the Town's emergency shelter. Sections of this road will flood during coastal flood events with probabilities as frequent as 5 to 10-year return period. The limits of the FEMA special flood hazard areas and GZA's predicted 10-year recurrence interval flood are shown below.

FEMA Special Flood Hazard Areas around Main Street and College Street (above). The GZA-predicted food limits from the current 10-year recurrence interval flood are shown below.

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Sections of Maple Avenue: The southern and northern portions of Maple Avenue flood during coastal flood events. Maple Avenue is a primary, key road as well as a likely evacuation route. Sections of this road will flood during coastal flood events with probabilities as frequent as the current 10-year return period flood. The limits of FEMA special flood hazard areas are shown below. Flood protection of the northern section of road could be integrated with flood protection of Main Street and College Street. Flood protection is complicated by the large number of cross roads and driveways.

FEMA Special Flood Hazard Areas around northern portion of Maple Avenue The GZA-predicted food limits from the current 10-year recurrence interval flood are also shown below.

FEMA Special Flood Hazard Areas around southern portion of Maple Avenue The GZA-predicted food limits from the current 10-year recurrence interval flood are also shown below.

Essential Facilities

Essential facilties are those facilities that are necessary for emergency response and recovery and pose a substantial, risk to the community at large in the event of failure, disruption of function, or damage by flooding. 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 Town's Essential Facilities include:

- 2 Police Facilities
- 5 Fire and Rescue Facilities
- 3 Healthcare Facilities
- 1 Emergency Shelters (including 1 school)
- 1 Public Works Garage

There are two police facilities including:

- the Old Saybrook Police Station located at 36 Lynde Street
- the police boat located at a marina just north of I-95

There are five fire and rescue facilities including:

- Old Saybrook Fire Department at 310 Main Street;
- Emergency Management Public Safety Office at 302 Main Street;
- Emergency Management Services Unit 6 Custom Drive;
- Fire Boat located at a marina just north of I-95; and
- Old Saybrook Ambulance Association at 316 Main Street.

The three healthcare facilities include:

- the Middlesex Hospital Urgent Care at 1687 Boston Post Road;
- Middlesex Hospital Primary Care at 154 Main Street; and
- the Connecticut Area River Health District (CRAHD) at 455 Boston Post Road.

The two Middlesex healthcare facilities include walk-in care for non-emergency medical service, laboratory services and X-rays (at the Urgent Care Facility). The Shoreline Medical Center in neighboring Westbrook provides 24/7 emergency care and outpatient diagnostic services.

Public Emergency Shelter:

- The Old Saybrook High School serves as the primary emergency shelter for the Town, and is located at 1111 Boston Post Road.

Attachment 4 presented a detailed evaluation of the coastal flood risk of the Town's' Essential Facilities. **Table 7-5** presents the Essential Facilities risk profile.

	CURRENT	2041	2066	2116
LOCATION				
POLICE STATION AT 36 LYNDE STREET	Low	Moderate	Moderate	Moderate
FIRE DEPARTMENT AT 310 MAIN STREET	High	High	High	High
EMERGENCY MANAGEMENT AT 302 MAIN STREET (TOWN HALL)	High	High	High	High
AMBULANCE ASSOCIATION AT 316 MAIN STREET	High	High	High	High
EMERGENCY SHELTER AT 1111 BOSTON POST ROAD (OLD SAYBROOK SENIOR HIGH SCHOOL)	Low	Moderate	High	High

Table 7-5: Essential Facilities Risk Profile

ESSENTIAL FACILITIES FLOOD MITIGATION CONSIDERATIONS

A requirement of Essential Facilities is that, in addition to protecting their buildings and the operations within these buildings, they have to have ready access into and out of the facility. Fire stations and ambulance facilities also need to have large garage doors that can be opened without risk of floodwaters entering the building. Further, under low probability floods, the roadways in the vicinity of the Essential Facilities will also be flooded. To meet these needs, permanent or deployable measures that provide flood protection to both building and exterior vehicle areas appear to be a reasonable flood mitigation strategy.

ESSENTIAL FACILITIES RESILIENCE AND ADAPTATION STRATEGY

Resilience and adaptation strategies to achieve flood mitigation include:

- permanent flood mitigation measures such as perimeter flood walls and flood protection berms;
- modifications to the buildings such as dry floodproofing; and
- temporary, deployable measures

Perimeter flood walls and deployable measures do not meet Federal, State and local flood regulations and ordinances. These regulations apply to new construction, a condition of substantial damage and a condition of substantial improvement. Each of these conditions will require compliance with applicable flood regulations and ordinances. The Old Saybrook Ambulance Facility is located within the current FEMA AE zone, making it particularly vulnerable to flooding. Relocation of the Town's Ambulance services should be considered.

Commercial and Industrial Districts

Attachment 4 presented a detailed evaluation of the coastal flood risk of the Town's' Commercial and Industrial Districts. **Table 7-6** presents the districts risk profile. The most significant districts in terms of commercial and recreational use and flood vulnerability are Saybrook Point SP-1 through SP-3. **Figure 7-4** shows the districts relative to FEMA special flood hazard areas.

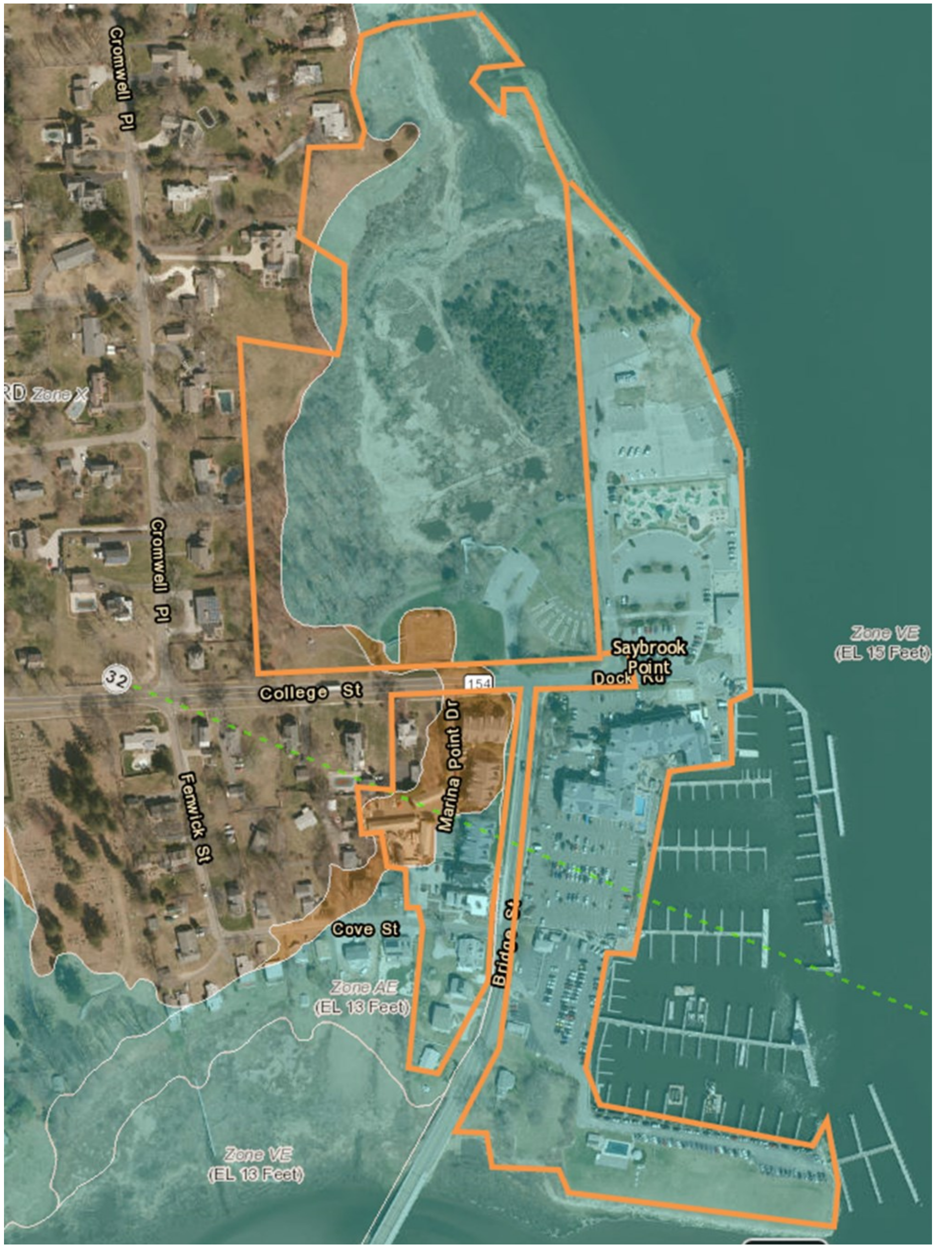


Figure 7-4: SP-1, SP-2 and SP-3 Commercial Districts at Saybrook Point

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	Current	2041	2066	2116
LOCATION				
SAYBROOK POINT SP-1 THROUGH SP-3	High	High	High	High
CENTRAL BUSINESS B-1	Low	Moderate	Moderate	Moderate
SHOPPING CENTER B-2	High	High	High	High
RESTRICTED BUSINESS B-3	High	High	High	High
GATEWAY BUSINESS B-4	Low	Moderate	High	High
INDUSTRIAL I-1	Low	Moderate	High	High
MARINE COMMERCIAL DISTRICT	Low	Moderate	High	High

Table 7-6: Commercial and Industrial Districts Risk Profile

SAYBROOK POINT ADAPTATION STRATEGY

Saybrook Point floods from overtopping of the existing waterfront bulkeads. approximately 1,600 foot long section of stone bulkhead (north side) and sheetpile bulkhead (south side) fronting private and Town-owned property along the Connecticut River at Saybrook Point. Based on available Lidar, the top of the wall is about Elevation 5 feet NAVD88 and the toe of wall is about Elevation 0 feet NAVD88. The developed area inland of the bulkhead is low-lying, with ground surface elevations generally between 5 and 10 feet, which means that it floods frequently - it is vulnerable to flooding with a 2-year and greater recurrence interval. Based on the Town's assessors data, the waterfront parcels are privately-owned.

Given the high value of these waterfront parcels, and the likelihood that will be partially or completely re-developed, creation of an overlay zone for future commercial development within these districts (the Town currently zones for 6 overlay districts).

The overlay zone would achieve resilience and adaption during new development by:

- By specifying minimum grade and building levels based on a Design Flood Elevation that is compliant with flood regulations and ordinances but also considers sea level rise;
- Construction of a new combined bulkhead/seawall; and
- Perimeter flood protection around existing commercial structures to remain, noting that substantial improvement or new construction would require compliance with flood regulations and ordinances and the requirements of the overlay zone.

Historic Properties

There are three historic districts and 335 historic properties located within Old Saybrook. The Historic Districts include: 1) the North Cove Historic District; 2) the South Green Historic District; and 3) the Fenwick Historic District. The first two historic districts are included in this study. **Attachment 4** provides a detailed assessment of the flood vulnerability of these properties.

The NFP defines a "historic structure" as "any structure that is:

- Listed individually in the National Register of Historic Places (a listing maintained by the Department of Interior) or preliminarily determined by the Secretary of the Interior as meeting the requirements for individual listing on the National Register; (This includes structures that are determined to be eligible for listing by the Secretary of the Interior as a historic structure. A determination of "eligibility" is a decision by the Department of the Interior that a district, site, building, structure or object meets the National Register criteria for evaluation although the property is not formally listed in the National Register.).
- Certified or preliminarily determined by the Secretary of the Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined by the Secretary to qualify as a registered historic district;
- Individually listed on a state inventory of historic places in states with historic preservation programs which have been approved by the Secretary of the Interior; or
- Individually listed on a local inventory of historic places in communities with historic preservation programs that have been certified either:
    - i. By an approved state program as determined by the Secretary of the Interior or
    - ii. Directly by the Secretary of the Interior in States without approved programs."

NFIP gives special consideration to the unique value of historic buildings, landmarks, and sites in two ways:

1. Historic structures do not have to meet the floodplain management requirements of the program as long as they maintain their historic structure designation. They do not have to meet the new construction, substantial improvement, or substantial damage requirements of the program. This exclusion from these requirements serves as an incentive for property owners to maintain the historic character of the designated structure (44 CFR §60.3). It may also serve as an incentive for an owner to obtain historic designation of a structure.
2. A designated historic structure can obtain the benefit of subsidized flood insurance through the NFIP even if it has been substantially improved or substantially damaged so long as the building maintains its historic designation. The amount of insurance premium charged the historic structure may be considerably less than what the NFIP would charge a new non-elevated structure built at the same level. Congress requires that the NFIP charge actuarial rates for all new construction and substantially improved structures (National Flood Insurance Act of 1968, 42U.S.C. 4015).

RESILIENCE AND ADAPTATION STRATEGY FOR HISTORIC PROPERTIES

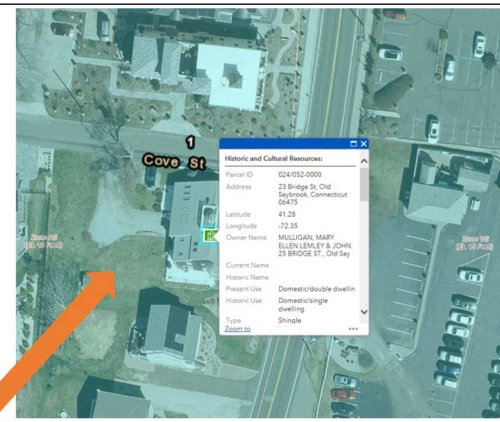
The challenges of providing flood mitigation for historic structures are that they ownership is a mix of public and private properties, they are located in low-lying areas that are highly vulnerable to flooding and most typical flood modifications would negatively affect the historical character of the structures and neighborhood aesthetics.

Given the exemption of these structures from State and federal flood regulations, there are more options available for flood mitigation of these structures than would normally be allowed under federal and State flood regulations. A reasonable strategy would be to provide flood protection at the property scale using:

- Perimeter landscaped flood walls; or
- Temporary, deployable flood protection measures.

For the former, the Town should establish standards and guidance for flood protection walls that are consistent with zoning and the aesthetic and historical character of the districts and modify the zoning regulations accordingly. The responsibility for the flood mitigation installation and cost would be the property owner.

Example



Risk Profile:

- Flood vulnerability: 20-year recurrence interval flood (10-yr between 2020 and 2040
- Coastal AE Zone Elevation 13 feet NAVD88
- Ground Surface: Elevation +/- 7 feet NAVD88
- 100 yr recurrence interval wave height: 1.5 feet

Natural Resources (Beaches)

Attachment 3 presents a detailed evaluation of shoreline change, including beach erosion. Old Saybrook beaches generally include: 1) barrier spits, separating the marsh from Long Island Sound, from Chalker Beach to just north of Cornfield Point; and 2) pocket beaches between shoreline structures and natural promontories, from Cornfield Point to Old Saybrook Point. Both types of shoreline identified general face south-southwest and are exposed to long fetches and Long Island Sound waves.

The morphology of the shoreline extending from Chalker Beach (including Chalker Beach) to just north of Cornfield Point consists predominantly of barrier spits (beaches) and marsh. The barrier spits are separated by river and creek inlet channels, creating large areas of shallow sediment and tidal flat in the vicinity of these features. Certain portions of this stretch of shoreline also include artificial fill placed within former marsh. Barrier spit and marsh morphologies are, by nature, very dynamic. Absent man-made structures, the natural morphological change consists of: 1) migration of the barriers spits inland over the marsh; 2) dynamic movement of the river and creek inlets; and 3) dynamic movement of shallow sediment areas/tidal flats.

This type of shoreline is generally characterized by erosion and dynamic movement of sediment. Sea level rise will accelerate the natural landward movement of the barrier spits. The shoreline, however, has been heavily modified by: 1) construction of hard shoreline structures, in particular groins designed to interrupt longshore transport; 2) development with roads and houses; and 3) placement of artificial fill. Although these structures affect the natural coastal processes, they do not, on net, prevent the natural tendency of the shoreline toward dynamic movement change and often increase erosion. The groins have been successful in trapping sand locally, but overall they drastically impact the natural longshore sediment transport. In addition, the overall availability of sediment is diminished within Long Island Sound.

The net, long term effect for the Old Saybrook shoreline including Chalker Beach to just north of Cornfield Point is long term, moderate (1 to 2 feet per year) erosion of the beaches with highly impactful, episodic erosion associated with coastal storm flooding and wave action. Sea level rise will amplify and accelerate shoreline change. Inadequate sediment supply to replace alongshore and offshore transport will require beach nourishment to mitigate erosion.

The morphology of the shoreline extending from Cornfield Point to Old Saybrook Point consists of glacial moraine and drift bluffs. Major sections of shoreline are fortified with revetments. The average shoreline change rates indicate minor to moderate erosion and accretion (less than 0.5 foot per year to 1.5 feet per year).

Under a natural setting, the glacial drift deposits provide a source of beach sediment. Under a developed setting, such as the Old Saybrook shoreline, revetments and seawalls: 1) eliminate this sediment source; and 2) create wave reflection and erosion, such that the shoreline erodes to the base of the revetment or sea wall.

The beaches of Old Saybrook provide recreational and ecological value, shoreline protection and (to a lesser extent) flood mitigation. However, the effect of sea level rise will be to accelerate shoreline erosion, in particular within areas characterized by barrier spit beach and marsh morphology. These areas are highly dynamic. They are also, typically low-lying and highly vulnerable to flood inundation and high velocity wave effects. The presence of groins and other shoreline structures have localized benefit but, negatively impact the overall shoreline system.

BEACH ADAPTATION STRATEGY

For shoreline areas experiencing moderate to severe erosion, there are limited options to mitigate long term erosion. These include:

- Do nothing, which will ultimately require retreat;
- Managed, voluntary retreat from the beaches;
- Periodic beach nourishment;
- Beach nourishment with vegetated dune construction; and
- Living Shorelines.

In general, Connecticut Statute promotes (and effectively now requires) non-structural, natural and nature-based projects except where structural alternatives are necessary to protect existing inhabited structures, infrastructure and water dependent uses.

Feasible, less environmentally damaging alternatives to structures are considered to include:

- Moving houses landward from floodwaters and wave action;
- Elevating houses vertically;
- Restoring or creating a dune or vegetated slope between the house and the water to absorb storm waves and protect against erosion; and
- Create a Living Shoreline.

Reasonable mitigation measures and techniques are considered to include: 1) beach nourishment to replace sand supply that may be adversely affected by a seawall or groin; and 2) compensation for hardening one part of a shoreline by removing the equivalent extent of flood and erosion control structures from another part of shoreline.

There are localized opportunities for development of Living Shorelines (including new fringe marsh, vegetated bluffs); however, these opportunities are limited. Due to the shoreline exposure to wind and long fetches, additional wave attenuation (robust rock sills, submerged breakwaters or offshore breakwaters) would be required along with mudline elevation enhancement. Living Shorelines will also modify the recreational use of the beach as well as result in habitat change

Beach Nourishment

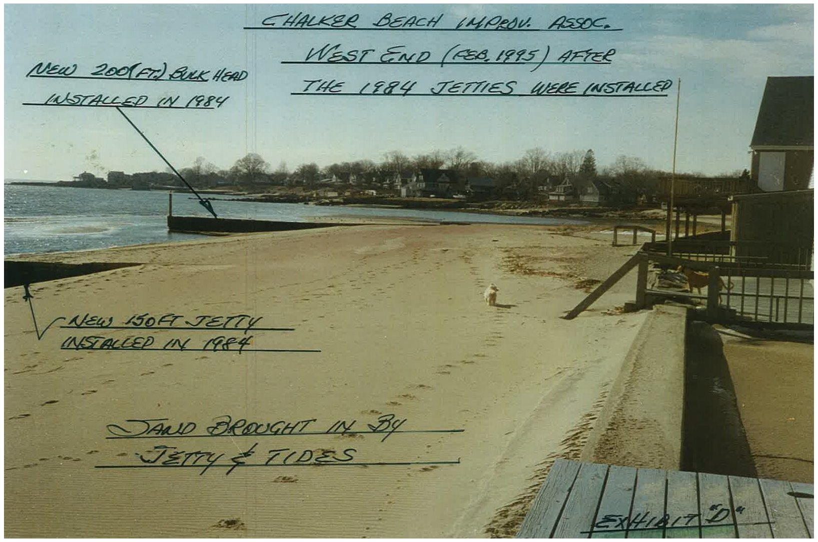
Connecticut does not have an established beach fill program. The U.S. Army Corps of Engineers (USACE) replenishes beaches on a case-by-case basis, mostly with trucked upland sources. Local maintenance dredging projects are also a potential source of sand. While beach nourishment is primarily an activity of the USACE, the State does provide some matching funds including the total cost of flood and erosion control projects benefiting state property, 66% of the cost of projects benefiting municipal property and 33% of the cost of projects benefitting private properties. The State funding for the Flood and Erosion Control program is limited (about $1.5M annually) and not much has gone to beach nourishment). State bonding may also be available for flood and erosion control projects (e.g., the State bonded a $2M beach erosion study and restoration project at Hammonasset Beach State Park using navigation dredge materials from the Housatonic River. The USACE Connecticut Report (current as of September 30, 2017) is attached. Beach nourishment can also be performed in conjunction with local maintenance dredging projects.

Beach Nourishment with Dune Construction

The shoreline extending from Chalker Beach (including Chalker Beach) to just north of Cornfield Point is little over 2 miles in length. Effectively, none of this shoreline has dunes and beach berms are limited. Beach nourishment and dune creation would typically cost on the order of $600 to $700 per linear foot. The cost to replenish the entire shoreline would be on the order of +/-$7.5M to $8.5M; however, beach nourishment projects would be localized and segmented to conform to existing shoreline structures (e.g., the Chalker Beach shoreline). Beach nourishment and dune restoration would be required periodically, since natural sources of sand (littoral drift) to support stable beaches are limited and interrupted by the numerous groins. Sea level rise will increase the rate of erosion and, therefore the demand for beach nourishment. Areas experiencing moderate to severe erosion (e.g., Plum Bank) will likely require periodic beach nourishment. A more detailed shoreline analysis would be required to further define beach nourishment requirements, but replenishment of the order of an average of every 10 years (along with groin maintenance) is not unreasonable for preliminary planning purposes.

Maintenance of Existing Groins, Jetties and Breakwaters

Maintenance of existing groins will help preserve existing beaches. Construction of new groins will not be allowed.



Chalker Beach 1980s Groin Maintenance Program

Example of engineered dune at Indiantown

Land Acquisition

Overview

Managed Retreat is a strategy outlined in the Town's 2015 SLRCAC Report as a potential solution that should be considered by the Town to develop both a near-term and long term climate adaptation strategies. **Attachment 4** identifies several areas with properties that are highly vulnerable to coastal flooding today and will become increasingly more vulnerable to coastal hazards in the future due to sea level rise.

This Study does not identify nor recommend specific areas within the Town for implementation of a Retreat strategy. Building upon the study findings, this section does identify four (4) categories for consideration as opportunities for managed retreat and future land acquisition by the Town. These include:

- Coastal properties located in the VE Zone
- Properties located in areas at risk to future marsh advancement
- Properties located in areas suitable for future levees as flood protection

Property located outside flood hazard zones to accommodate future development and relocation

Coastal Properties Located with the FEMA VE Zone

Based on the Resilience Study risk and vulnerability results, the properties at highest risk to future sea level rise are coastal properties located within the FEMA Coastal High Hazard Zone (Zone VE). The limits of the Coastal VE High Velocity Wave Zone are shown on **Figure 7-5**. The ground surface elevations in the study area ranges from 3 feet NAVD88 to 10 feet NAVD88. The base flood elevations for the VE Zone ranges from 15 feet NAVD88 to 18 feet NAVD88. These properties are exposed to significant flood and waves, resulting in a high probability for damage. They are also located in areas characterized as barrier spit beaches, which are naturally dynamic and subject to erosion. The flood risk of these areas will increase significantly in the future due to sea level rise and it will become increasingly difficult and expensive for property owners to adapt. Property values within these areas may also decrease due to the coastal erosion and flood risk.

The delineated are shown on **Figure 7-5** includes 176 parcels of land located within the VE Zone starting on Route 154 at the bend where Indianola Drive turns into Plum Bank Road, and extending north and west along the coast through Saybrook Manor, Indiantown, and to the Town line in Chalker Beach. Of the 176 parcels, 159 of the parcels include structures with an assessed tax value based on the Tax Assessor's data provided for this study. Single family residential properties make up most of building structures totaling 138 followed by 10 condominiums (all of which located on Shetucket Trail). The remaining 28 properties are a mix of open land without structures (e.g. salt meadow, rear land), two-family, land with outbuildings, land with multiple houses, and non-profit and municipal properties.

Table 7-7 provides a tax analysis of the 176 parcels included in the study area based on data provided by the Town of Old Saybrook. The total assessed tax valuation for the 176 properties is $115,460,200. Based on the Town of Old Saybrook's mill rate of 19.66 - which results in a payment of $19.66 for each $1,000 of taxable property's assessed value - the total estimated annual tax revenue for the Town is $2,269,967. The assessed land value for the 176 parcels - not including the assessed structures valuation - accounts for 67% of the overall assessed value at just over $1.5 million.

The beaches along the shoreline are vulnerable to coastal erosion in the near term that will become increasingly vulnerable to more intensive coastal erosion over the long term. These vulnerabilities will be further compounded by sea level rise that will result in the need for a continuous and ongoing beach nourishment program over the long term as an alternative to a managed retreat. Such a program will increase in cost and the frequency of need for beach nourishment over time that will not be sustainable or feasible over the long term. Below is a breakdown of the location and number of coastal properties by beach community based on the Water Pollution Control Authority (WPCA) district boundaries.

- Plum Bank – 56 properties
- Chalker Beach – 48 properties
- Great Hammock Beach – 26 properties
- Saybrook Manor – 17 properties
- Indiantown – 15 properties

Plum Bank, Chalker Beach and Great Hammock Beach have the highest three number of properties located in the Zone VE.

Figure 7-5: Limits of FEMA Coastal High Velocity (VE) Wave Hazard Zone

Table 7-7: Tax Assessment Properties located in VE Zones (Figure 7-5)

Estimated total assessed value	$115,461,200
Town Mill Rate	$19.66*
Estimated Tax Revenue from delineated area	$2,269,967
Town-wide Property Tax Revenue (2015)	$40,543,368
Percent of Tax Revenue for delineated area	5.6%

*The Town of Old Saybrook's current mill rate is 19.66 which results in the payment of $19.66 for each $1,000 of a taxable property's assessed value. For example, if a house is assessed at $300,000 to determine what the taxes would be take $300,000 and multiply the figure by .01966 and the taxes come out to be $5,898 for the year.

Properties Located in Areas at Risk to Future Marsh Advancement

Several properties in Old Saybrook are located along or near intertidal marshlands. Many of these properties are located within FEMA's Zone AE (i.e. areas with a 1% annual chance of flooding where base flood elevations are provided). While these properties are not as vulnerable as those located in the Zone VE, these properties still have a 26% chance of flooding during the life of 30-year mortgage making these properties the next most vulnerable areas to future coastal flooding. The Nature Conservancy's 2014 study entitled, "A Salt Marsh Advancement Zone Assessment of Old Saybrook, Connecticut" (2014 TNC Study) projects the full extent of marsh advancement by the 2080s to be 1,042 acres, of which 217 acres (21% of the total) are occupied by built structures and associated infrastructure. Based on an evaluation of the results from the Resilience Study's risk and vulnerability assessment results and the 2014 TNC Study, the built structures are expected to provide fewer opportunities for managed retreat than those properties located in the Zone VE outlined above. For additional details of the areas identified for marsh advancement refer to the 2014 TNC Study.

Properties Located in Areas Suitable for Future Levees as Flood Protection

In the future the Town may consider evaluating a levee system as a potential form of flood protection. To construct a FEMA certified levee would likely require the acquisition of some parcels of land in Town that have not been identified as a part of this study. However, for this analysis it is important to note that it is likely that some properties may need to be acquired or easements would need to be put in place to support the development of a levee. The number of properties is expected to be minimal. Identifying the locations and number of properties that may need to be acquired would require an additional feasibility study. The number and locations of properties would largely be dependent on the potential locations where a levee system could be feasibly built. It is recommended that such a study include a benefit-cost analysis for multiple alternative locations to determine whether the cost of the proposed system(s) would result in providing enough flood protection to justify the cost of construction and maintenance.

Land Outside of Flood Zones to Support Future Development

Areas north of I-95 provide land located at higher ground surface elevations that are typically over 20 feet NAVD88, and thus less vulnerable to future coastal flooding hazards. In the long-term, especially if the Town is successful in developing program that results in the acquisition and demolition of numerous properties, it is recommended that the Town identify areas north of I-95 for future development due to the potential decrease in tax revenues. This will assist the Town in maintaining the local tax base and making Old Saybrook a more resilient community.

Conclusions

One of the suitable adaption options supporting a voluntary Managed Retreat strategy for the Town outlined in the Resilience Study is voluntary acquisition and demolition of threatened properties. The voluntary acquisition and/or relocation of these structures will provide the opportunity for enhancement of these beach communities including shoreline habitat and greater public access. Voluntary relocation or voluntary acquisition/demolition of structures located within the Zone VE of the study area is appropriate along the currently-developed portions of the shoreline in the study area. Based on the analysis outlined in this section, it is recommended that the Town 1) continue to conduct resiliency outreach and education to homeowners living in the beach communities based on the neighborhood resiliency workshops conducted for the Resilience Corridor and Chalker, 2) identify specific properties for voluntary acquisition and demolition or relocation through the workshop process and begin to develop FEMA Hazard Mitigation Assistance (HMA) grant applications to assist in the acquisition of properties at greatest risk to the future impacts from coastal flood hazards. Both recommendations are outlined in greater detail below.

Recommendations

1. Resiliency Workshops in the Low Beach Communities

The three beach communities (Plum Bank, Chalker Beach and Great Hammock Beach) with the highest number of coastal properties located in the Zone VE are excellent candidates for conducting future resilience workshops focused on: 1) the current and future coastal flood risks with respect to specific neighborhoods; 2) the general resiliency measures that may be included as a part of a voluntary Managed Retreat strategy including voluntary acquisition and demolition of threatened coastal properties; and 3) the resiliency financial programs (e.g. FEMA HMA grant programs) available to residents and the Town to pursue for acquisition projects. The Town has already begun the process by conducting workshops and developing resiliency measures - as recommend above - for Chalker Beach and a portion of Route 154 that connects Town Center to Saybrook Point (Resilience Corridor). The workshop materials used during these workshops will serve as a template for additional workshops in other vulnerable areas of Town along the shoreline in the future.

2. Identify Specific Properties for Voluntary Acquisition and Demolition and FEMA HMA Grant Application Development

Properties located within the Zone VE will typically increase the competitiveness of such properties for one of FEMA's Hazard Mitigation Assistance (HMA) programs due to the increased risk of coastal flooding making such properties more likely to meet HMA program eligibility requirements. Therefore, properties located in the Zone V or VE should serve as the priority for the Town in the near-term to consider for voluntary acquisition and demolition and location. It will be critical for the Town to coordinate the development of FEMA HMA grant applications with the State Hazard Mitigation Officer (SHMO) at state of Connecticut's Department of Emergency Services and Public Protection. Additional details on FEMA's HMA Grant programs can be found at:

http://www.ct.gov/demhs/cwp/view.asp?a=4062&q=515030

Note that even though coastal properties located in the Zone VE serve as potential candidates for HMA grant funding, that does not guarantee that each of properties will meet FEMA's Hazard Mitigation Assistance (HMA) eligibility requirements independently. This is especially relevant with respect to FEMA's Benefit-Cost Analysis (BCA) requirement. It is recommended that if one (1) property does not meet FEMA's BCA requirement independently, that the Town consider including other properties (or just one more) that when combined as one project result in an overall BCA that is eligible.

Attachment 8: CIRCA Financing Resiliency in Connecticut Fact

Financing Resilience in Connecticut

Current Programs, National Models, and New Opportunities

Becoming resilient to the impacts of climate change and extreme weather in Connecticut has a price. To date, in Connecticut most of the dollars invested in resilient infrastructure have come from federal grants provided in the form of assistance after a declared disaster, but grants alone will not cover the bill. This fact sheet reviews existing resilience financing programs in Connecticut as well as model programs that can be applied in the State. It accompanies a presentation at the Earth Day 2016 symposium *Resilience and the Big Picture*, and a forthcoming publication.[1]

Connecticut Resilience Financing Programs

Shore Up Connecticut. Shore Up Connecticut is a low interest loan program, run by the Housing Development Fund, for homeowners and small businesses in the coastal floodplain to elevate structures and utilities.

Microgrids Grants and Green Bank Financing Program. The Department of Energy and Environmental Protection administers the microgrids grants program. These grants provide funding for energy sources that can operate without the grid. The grants can be paired with financing from the Connecticut Green Bank for additional infrastructure to install the microgrid.

Clean Water Revolving Loan Funds. Loans from the Clean Water Fund provide a low interest loan and grant combination to fund wastewater infrastructure projects. Connecticut's program has provided funding for planning and designing new facilities to operate safely and resiliently under conditions of more frequent and intense storms, flooding, and sea level rise.

Tax Increment Financing (TIF) Districts. TIF districts use increased market value of property and capital improvements that come from public-private partnership investments to a specific geographic area to fund that investment. A TIF district captures the future net economic value increase from the investment through district-level taxes or fees. TIF districts could, in principle, finance neighborhood-scale resilience projects.

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[1] Fact sheet based on article: Rebecca French, Wayne Cobleigh, Jessica LeClair, and Yi Shi. Financing Resilience in Connecticut: Current Programs, National Models, and New Opportunities. *Sea Grant Law & Policy Journal*, *in preparation.*

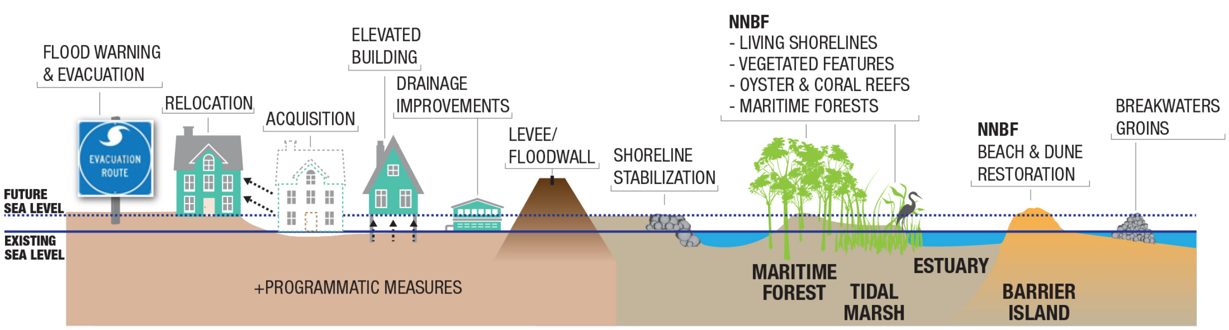
Model Programs for Resilience Financing

Connecticut Green Bank C-PACE and R-PACE Programs and PAR. The Connecticut Commercial Property Assessed Clean Energy (C-PACE) program allows businesses to pay for energy efficiency projects through capital assessed on their tax bill and carried over as a lien on the property, regardless of a change in ownership. This same principle can be applied to residential properties or a Residential-PACE (R-PACE). Using the same principles as C-PACE and R-PACE, Property Assessed Resilience (PAR), captures the increased property value and insurance savings to finance resilience measures for a property.

New Jersey Energy Resilience Bank (ERB). The ERB intends to fund distributed energy resource technologies that can operate in island mode with power blackout start capabilities, both of which allow for operation of critical facilities during extended power outages to the grid. The program is a mix of grants and low interest loans and was capitalized with federal disaster recovery funds from Sandy, utilizing a unique waiver of small business only rules.

Energy Savings Performance Contracts (ESPCs). Owners of properties with large energy usage can hire an Energy Services Company (ESCO) and an Owner's Representative to assist the owner in procuring financing, installation, operation, and maintenance of building retrofits involving onsite energy generation, energy efficiency, and water conservation related capital improvements. The ESCO can access long-term financing methods such as Tax-Exempt Lease Purchase (TELP) commercial loan or bonds for these projects with limited or no up-front costs to the owner. Cash flow to the ESCO from the energy savings pays down the financing over the term of the TELP.

Resilience Bonds. Resilience bonds modify the existing catastrophe bond insurance market to capture the savings from a lowered risk of insurance payouts and then use that value as rebates to invest in resilient infrastructure projects.



Sea level rise and flooding adaptation measures needing federal, state or local funding or long-term financing to be implemented in coastal communities in Long Island Sound. NNBF stands for natural and nature-based features.[2]

[2] Source: ASCE North Atlantic Comprehensive Coastal Study

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