Proactive by Design

Town of Stratford
Coastal Community Resilience Plan

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Prepared for:
Town of Stratford, Connecticut

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1.0 ABOUT THE PLAN

The Town of Stratford Coastal Community Resilience Plan (the Plan) provides the roadmap to make the community more resilient - economically, socially and ecologically - to coastal flooding and the effects of sea level rise. The Plan was made possible through a Community Development Block Grant Disaster Recovery (CDBG-DR) grant.

PLAN PURPOSE

Positioned on the shores of Long Island Sound and the Housatonic River, Stratford is truly a coastal community. It is blessed with coastal resources, including beaches, tidal wetlands and estuaries. It is characterized by water-dependent activities such as swimming and beach-going, nature walks, marinas, yacht clubs, and boat launches. It boasts publicly-accessible open space with broad vistas of the Sound and River.

However, many of Stratford's 51,500 residents and approximately two-thirds of its commercial properties are located in areas where the ground surface elevation is just a few feet above high tide. Hurricane Sandy, which flooded much of the Town in 2012 and resulted in millions of dollars of damage, was only the most recent of many storms that have impacted the Town. As devastating as the flooding was during Hurricane Sandy, the elevation of the flood waters during Sandy was *lower* than the Base Flood Elevations (BFEs) currently predicted by the Federal Emergency Management Agency (FEMA) and considered the minimum standard for flood protection regulations and insurance.

The water levels within Long Island Sound are, unequivocally, rising. More than 50 years of measurements at the National Oceanographic and Atmospheric Administration (NOAA) Bridgeport tide gage indicate that, at the current rate, sea level at Stratford is rising slightly less than 1 foot per century. However, the rate of sea level rise (SLR) is expected to increase – possibly greatly.

The effect of SLR will be to increase the Town's flood risk, including more frequent (and possibly worse) coastal floods than have been experienced to date. This has the potential to significantly impact the Town, its residents, businesses, and natural resources - including impacts to property values, flood insurance costs, taxes, existing and new businesses, population, and beaches and wetlands.

The purpose of the Plan is to:

- Introduce the community to the concept of “risk” as it applies to coastal floods, SLR, and resiliency;
- Characterize coastal flooding in Stratford including tides, storm surge, and waves, now and in the future;
- Identify the Town’s vulnerability to coastal flooding including the consequences of floods;
- Identify strategies, actions, and projects that can be employed to minimize these consequences and create a more resilient Stratford; and
- Introduce coastal resiliency into the Town’s planning process including future revisions of the Town’s Plan of Conservation and Development and Hazard Mitigation Plan.

PLANNING TEAM

The Stratford Coastal Resiliency Plan was developed by the consulting team of GZA GeoEnvironmental, Inc. (GZA), The Cecil Group, and Jamie Caplan Consulting under the direction of the Town Engineer, Mr. John Casey.

The planning process included three public meetings to present findings and solicit public input. Input was also provided by the South Central Regional Council of Governments (SCRCOG), the Connecticut Metropolitan Council of Governments (METROCOG), and Representative Laura Hoydick, 120th District and the following Town departments:

- Engineering Division, Public Works;
- Planning and Zoning;
- Economic Development;
- Conservation Department;
- Police and Fire Departments;
- Office of Community Development;
- Recreation Department;
- Emergency Services; and
- Waterfront and Harbor Management Commission.




Clockwise from top left: Short Beach looking out to Long Island Sound, Main Street / Town Center looking to I-95, Stratford EMS and Fire Station 1, and Beach Drive in the Lordship Neighborhood

TOWN RESILIENCY GOALS

The Town's stated coastal resiliency goals are:

Goal 1: Ensure that the Town continues to be a livable community with future economic opportunity, while supporting Town values;

Goal 2: Make the social, economic, and environmental systems more resilient to coastal flooding and sea level rise;

Goal 3: Support the Town vision presented in the current Plan of Conservation and Development;

Goal 4: Increase the coastal resilience of public infrastructure;

Goal 5: Increase public awareness and understanding of coastal risks and resiliency; and

Goal 6: Provide guidance for future investment, planning, and regulatory change.

READING THE PLAN

Stratford's resiliency planning is not starting from scratch, but building upon the efforts taken to date to address flooding, including the Hazard Mitigation Plan and Plan of Conservation and Development. The Coastal Community Resilience Plan provides recommendations that will be incorporated into future policy and regulatory updates.

Section 2 Approach and Methodology describes the planning methods used. The five steps of coastal resiliency planning are described. This section also introduces the concepts of "risk," "probability," and "risk-informed decision making" and explains how these concepts are used to evaluate the consequences of flooding and the benefits of flood protection.

Section 3 Coastal Flood Hazards describes coastal flooding in Stratford, now and in the future. Basic concepts including tides, storm surge, and waves are presented as well as key terms used by the Federal Emergency Management Agency (FEMA). The effective FEMA Flood Insurance Rate Map (FIRM) is presented. The results of high resolution computer models of tides, storm surges, and waves performed by GZA for the years 2015, 2040, 2065, and 2115 are presented.

Section 4 Vulnerability and Risk discusses the vulnerability to, and consequences of, coastal flooding on the Town's neighborhoods, buildings, natural resources, and public infrastructure both now and in the future.

Section 5 Resiliency Strategies and Projects discusses the three resiliency strategies of Protect, Retreat, and Accommodate and recommends specific coastal resiliency projects.

Section 6 Plan Implementation provides a detailed implementation strategy that includes the steps necessary to implement the Plan including potential funding for future resiliency projects.

RESULTS AT A GLANCE...

COASTAL HAZARD OVERVIEW

Stratford includes large areas of low-lying, developed land south of Interstate 95. Ground surfaces elevations range between Elevations 5 and 9 feet NAVD88. These areas are particularly vulnerable to coastal flooding. Waterways like Ferry Creek and the Marine Basin also provide points of entry for coastal flood waters that progress inland. The contributing factors that most significantly influence coastal flooding today and will continue to influence flooding in the future include the following:

SEA LEVEL RISE

Sea level rise (SLR) will affect future tide elevations as well as the frequency and elevation of coastal storm surge flooding. The Plan utilizes three (3) SLR projections (Low, Intermediate, and High) developed by the United States Army Corps of Engineers (USACE) to predict the range of sea level rise for the years 2015, 2040, 2065, and 2115.

The three projections vary based on different assumptions about greenhouse gas emissions, ice melt, and other factors. However, each of these projections are equally probable. By the year 2065, SLR is projected to range from 0.4 foot to 2.2 feet. By the year 2115, SLR is projected to range from 0.8 foot to 6.2 feet.

TIDES

Except along beaches and near tidal wetlands, the effects of tidal flooding on Stratford are currently minimal. However, unless flood controls are implemented, the Sikorsky Memorial Airport may flood on a daily basis during high tides by the year 2065. Mean High Water (MHW) tidal elevation, assuming the High SLR projection for 2115, is approximately five (5) inches higher than the peak flood observed during Hurricane Sandy and would result in flooding similar to the flooding that occurred during Hurricane Sandy - but on a daily basis.

EXTREME FLOODS

Extreme coastal flooding water levels resulting from storms such as nor'easters, tropical storms, and hurricanes. GZA's flood models, which are based on the results of the USACE's North Atlantic Coast Comprehensive Study (NACCS), predict the coastal flood elevations and inundation limits for the years 2015, 2040, 2065, and 2115. The model results indicate that much of the Town, especially areas located south of Interstate 95, will be significantly flooded during periods of extreme water levels. GZA's flood models also demonstrate how coastal flooding of interior areas originates at specific coastal entry points of Stratford, including:

- The Marine Basin,
- North of the Army Engine Plant Levee,
- Shore Road,
- Ferry and Johnsons Creek,
- Great Meadows,
- Long Beach, and
- South of Short Beach

VULNERABILITY AND RISK

Tables 1.1, 1.2, and 1.3 present flood risk profiles for three SLR time horizons (the years 2040, 2065, and 2115) for neighborhoods, essential and lifeline facilities, hazardous materials facilities, the POCD Employment Growth District, transportation systems, support, high occupancy, and vulnerable populations, and natural resources. An overview of the flood risk of Stratford's neighborhoods and assets and flood protection priority is presented below:

High: indicates a high probability of occurrence in the near term (currently and into the next 25 years) and a significant consequence.

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

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

The priority of each recommended measure was identified based on flood risk levels and extent of losses prevented.

	Town Center		Employment Growth District		South End Neighborhood		Lordship Neighborhood		Historic District and Academy Hill	
	Flood Risk	Priority	Flood Risk	Priority	Flood Risk	Priority	Flood Risk	Priority	Flood Risk	Priority
Current	Low	Low	High	High	High	High	Moderate	Moderate	Moderate	Moderate
2040	Low	Low	High	High	High	High	Moderate	Moderate	Moderate	Moderate
2065	Low	Low	High	High	High	High	Moderate	Moderate	Moderate	Moderate
2115	Low	Low	High	High	High	High	Moderate	Moderate	Moderate	Moderate

Table 1.1 Flood Risk Profiles of PCOD Growth Districts and Sandy Impacted Neighborhoods

	Essential Facilities		Lifeline Facilities: Sanitary Sewer		Lifeline Facilities: Stormwater Management & Tide Gates		Lifeline Facilities: Electricity Transmission		Hazardous Materials Facilities	
	Flood Risk(1)	Priority	Flood Risk	Priority	Flood Risk	Priority	Flood Risk	Priority	Flood Risk	Priority
Current	Low	Low	High	High	High	High	Low	Low	High	High
2040	Low	Low	High	High	High	High	Low	Low	High	High
2065	Low	Low	High	High	High	High	High	High	High	High
2115	Low	Low	High	High	High	High	High	High	High	High

Table 1.2 Flood Risk Profiles of Essential, Lifeline, and Hazardous Materials Facilities

Note:

1. Flood risk is high in localized areas.

	Transportation: Interstate 95 & Amtrak/ Metro-North		Transportation: State and Primary Roads		Support, High Occupancy, and Vulnerable Populations		Natural Resources	
	Flood Risk	Priority	Flood Risk	Priority	Flood Risk	Priority	Flood Risk	Priority
Current	Low	Low	High	High	High	High	High	High
2040	Low	Low	High	High	High	High	High	High
2065	Low	Low	High	High	High	High	High	High
2115	Low	Low	High	High	High	High	High	High

Table 1.3 Flood Risk Profiles of Transportation, Support, High Occupancy, and Vulnerable Populations, and Natural Resources

PROJECTS

Specific flood mitigation projects have been identified, representing the three Resiliency Strategies of Retreat, Accommodate, and Protect. The projects are summarized in the Section 5 Attachment presented at the end of the Plan. A brief overview of the projects by strategy is presented below. Refer to Section 5 for more details on the resiliency projects and strategies.

RETREAT

Retreat has been a successful strategy for the Town in the past with the acquisition/demolition of houses along Pleasure Beach. There is one project recommendation focused on voluntary property acquisition and beach restoration along Shoreline Drive in the Lordship Neighborhood.

PROTECT

The Protection strategy includes a series of flood protection projects that would be located along the shoreline perimeter of the Town to form a nearly continuous flood barrier. These projects would mitigate flooding of coastal areas of the Town as well as interior Town areas, such as the South End neighborhood, that are vulnerable to coastal flooding. At many locations, the proposed flood protection projects will align with greenspaces and greenways currently planned for by the Town.

- Additional flood protection at the Water Pollution Control Facility;
- Construction of the new bridge over Ferry Creek (Broad Street), including raising of the bridge deck elevation, construction of the new culverts and tide gates and raising of the roadway grades to serve (in combination with the existing pump station) as a flood control levee;
- Construction of a series of flood protection measures (levees and flood walls) along the Housatonic Riverfront, from the Water Pollution Control Facility to (and including) the Stratford Army Engine Plant;

- Construction of a flood wall at the north end of Johnsons Creek and Sprague Oil property; and
- Lengthening (and possibly raising) of the seawall/revetment at Long Beach (in combination with the Retreat strategy at Long Beach).

ACCOMMODATE

The Accommodation strategy will be the primary mechanism for flood protection in the near term (and long term, if the protection projects presented above are not constructed). As such, the Town should partner with property owners to apply for FEMA mitigation grants to elevate homes as well as encourage the use of the Connecticut Shore Up home elevation program. The Town should also establish neighborhood zoning regulations and guidance that address elevating properties from a community aesthetic perspective.

Implementing an Accommodation strategy places the direct responsibility (and cost) for building flood protection on the property owner. However, compliance with building code flood regulations (in particular, by elevating homes) will be costly and difficult for many Town property owners to achieve. Accomodation measures include:

- elevation of buildings, structures and infrastructure, including compliance with local, State and federal regulations;
- flood-proofing buildings and structures;
- local use of temporary flood protection measures;
- emergency/flood response plans;
- operation and maintenance of culverts and tide gates;
- operation and maintenance of pump stations;
- dredging of waterways;
- beach nourishment and dune maintenance;
- maintenance of salt marshes (e.g., tidal flow, salinity, depth); and
- post-storm repair and clean-up.

The measures identified above can be implemented at lower incremental costs (relative to the strategies of Retreat and Protect) and, therefore, are easier to implement. However, their net costs will be higher and their efficiency and long term benefits lower than a Protection strategy. The costs of an Accommodate strategy are typically the direct responsibility of the property owner, whereas the costs of Retreat and Protect strategies are typically the responsibility of the municipality, State, and/or federal government.

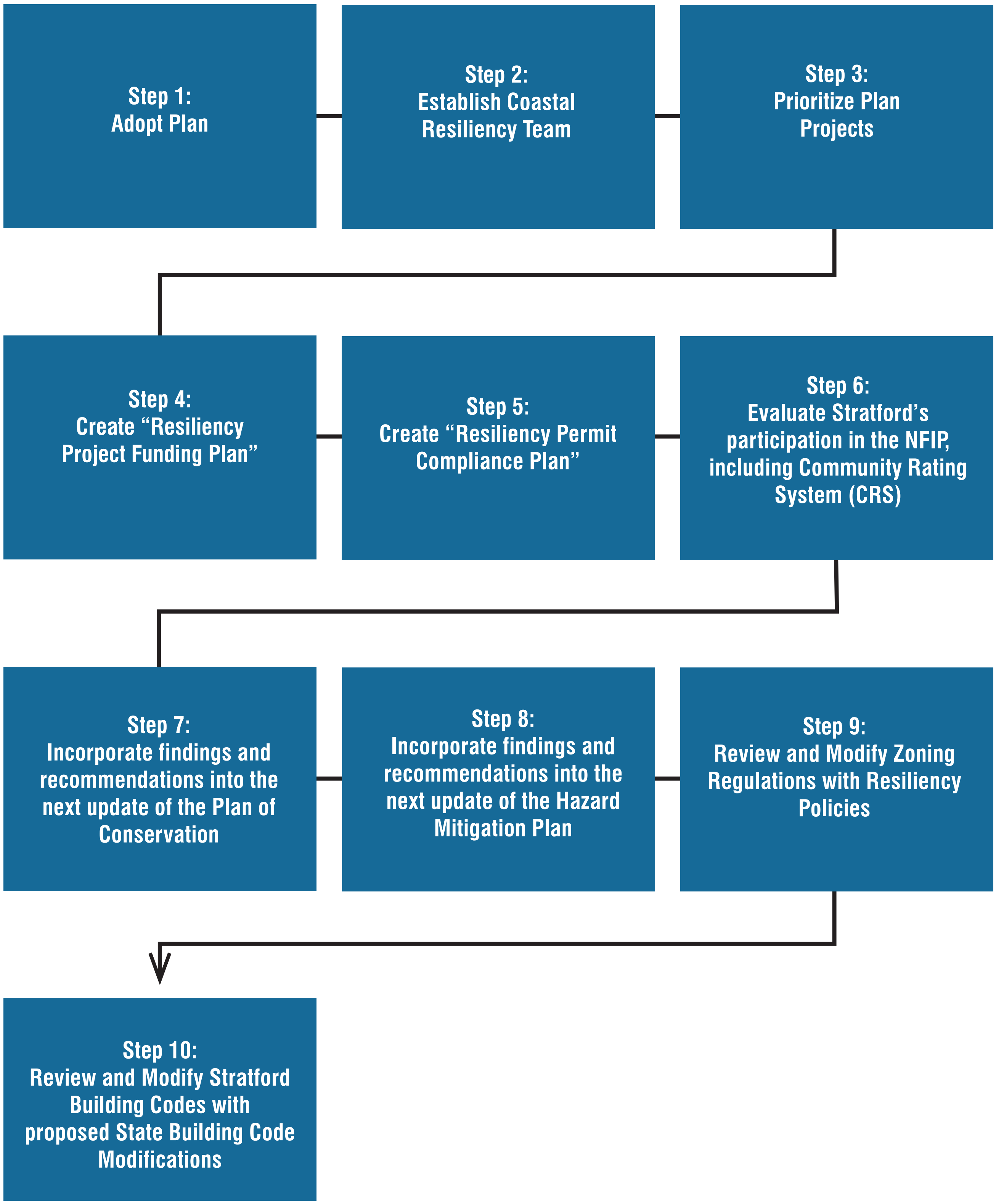


Figure 1.1 Stratford Resiliency Plan Implementation Steps

The Accommodation Strategy also includes flood-proofing, elevating structures, installing temporary flood protection, and developing emergency response/flood plans to protect Sikorsky Airport.

An Accommodation strategy will need to be applied, to a much greater degree, if the projects presented in the Protect and Retreat strategies are not constructed. In particular, buildings experiencing significant damage during future flood events as well as buildings proposed to be "substantially improved" will be required to comply with flood regulations. Compliance will be costly, and could mean that first floor elevations must be raised.

PLAN IMPLEMENTATION

Table 6.1 in Section 6 summarizes the 15 proposed plan implementation actions. Figure 1.1 provides an overview of the recommended steps to assist in the implementation of the Plan.

UNCERTAINTY AND CONSERVATISM

There is no doubt that Stratford is vulnerable to coastal flooding and that the extent and consequences of flooding will increase in the future due to sea level rise.

However, it is important that the reader understand that the prediction of "how much" and "how often" flooding will occur is highly uncertain. For example, there is currently a wide range of sea level rise predictions. Each prediction makes different assumptions about variables such as ice melt, ocean dynamics, and greenhouse gas emissions, which result in different outcomes. There is also uncertainty associated with statistical analysis of tide gage and meteorological data. Computer flood modeling is also subject to uncertainty and error. Areas of significant uncertainty are identified, where important, in the Plan.

Estimating losses due to flooding is also highly uncertain. Therefore, different predictions of flood characteristics can result in significant differences (sometimes orders of magnitude) in predicted losses. GZA has used FEMA's HAZUS-MH Model for estimating Town losses due to flooding and sea level rise.

Regardless of the uncertainty, for for the purpose of resiliency planning, it is acceptable and reasonable to simply acknowledge that uncertainty exists and make conservative assumptions about flood risk that are consistent with the assumptions made by regulatory agencies and/or other organizations engaging in resiliency planning. The Plan makes assumptions and uses methods that are consistent with federal agencies including FEMA and the U.S. Army Corps of Engineers (USACE). To characterize the coastal flood hazards and loss estimation, the Plan relies upon the results of the USACE North Atlantic Coast Comprehensive Study (NACCS), which are more conservative than the current FEMA flood predictions.

PLAN LIMITATIONS

The Plan is intended to be used for municipal planning purposes only. The modeling and other evaluations contained herein were performed in accordance with generally accepted industry standards and rely on historical data and other information obtained from local, state, and federal sources. The Plan is not intended, or suitable, for establishing the flood risk of any specific parcel or property. The information included in the Plan is specific to Stratford and is not to be used by any individual or entity other than the Town for any purpose.

The Plan addresses coastal flooding, including tides, sea level rise, storm surge, waves, and their effects. The Town is vulnerable to other types of flooding such as that due to rivers, precipitation, and stormwater. These other flood types are outside the scope of the Plan and were not evaluated or addressed as part of the planning process. The Plan presents the results of hydrodynamic computer models. These model simulations are limited to coastal flooding. Also, the computer models do not include drainage structures which can influence flood inundation. In particular, the computer models are also based on available topographic data. For these reasons, among others, the model results differ from flood data developed by FEMA and shown on Flood Insurance Rate Maps (FIRMs).

2.0 APPROACH AND METHODOLOGY

WHAT IS RESILIENCY?

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

Coastal resiliency is achieved through a combination of: 1) plans, policies, and regulations and 2) physical measures (such as structural, natural, and nature-based flood protection), that work together to reduce the short and long term effects of flooding and sea level rise (SLR). Resiliency is also achieved through public outreach, education, neighborhood activism, and strong social networks.

PLAN APPROACH

This Plan provides the steps to make the Town more resilient to coastal floods. The Plan approach:

- Uses industry-accepted, sound science about sea level rise and coastal flooding;
- Uses a "risk-based" approach, including defining coastal flood hazards in terms of probability, consistent with methods currently being used by state and federal agencies;
- Uses high resolution, hydrodynamic computer flood modeling to characterize flooding;
- Manages all information using ESRI ArcGIS geographic information system (GIS) software, also used by the Town;
- Identifies resiliency strategies, actions, and projects that are consistent with Stratford's current vision and plans for development.
- Integrates coastal resiliency into existing Town plans, policies, and regulations.

PLAN METHODOLOGY

The preparation of the plan 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 Resiliency Strategies, Actions, and Projects

Step 4: Public and Stakeholder Outreach

Step 5: Identification of Steps to Implement the Plan

STEP 1: CHARACTERIZE THE COASTAL FLOOD HAZARDS

Coastal flood hazards include tides, storm surge, and waves. Stratford's coastal flood hazards 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 Stratford. The FEMA FIS and FIRMs present Stratford's flood hazard as determined by FEMA for purposes of the National Flood Insurance Program (NFIP). The FEMA Base Flood Elevations (BFEs) shown on the FIRMs are also referenced in state and local building codes.

2. Statistical analyses of the NOAA Bridgeport Tide gage historical water level data. The Bridgeport tide gage monitors water level and has an approximately 50-year period of record. Statistical analysis of the tide gage data provides an estimate of the 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 model grid. The USACE has made the information available for public use. The study presents nearshore flood hazard data at a number of locations along the Stratford 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 online for the NOAA Bridgeport tide gage using the USACE "Sea Level Rise Calculator."

5. Computer modeling of storm surge and waves. GZA performed high resolution, numerical hydrodynamic modeling of tides, storm surge, and waves.
6. Flood inundation observed during Hurricane Sandy. Available information about the effects of Hurricane Sandy at Stratford includes photographs, anecdotal information, and documented limits of flood inundation. GZA also simulated Hurricane Sandy flooding using computer modeling.
7. High resolution LiDAR topographic data and NOAA bathymetry were used to develop ground surface elevations nearshore and within the town's boundaries. Shoreline features (such as beaches, wetlands, and man-made structures) were identified.

GZA FLOOD MODELING

GZA modeled the tides, storm surge, and waves along Stratford's coastline 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 of these models are used by federal agencies such as FEMA and the USACE.

GZA developed a high resolution model mesh to represent Stratford's detailed topographic and bathymetric features (Figure 2.1) in the flood models. The model mesh covers all coastal areas in the Town, along Long Island Sound, and the tidal portions of the Housatonic River. The model extends approximately 3 miles offshore into Long Island Sound. The resolution of the model in Stratford 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 extra-tropical (Nor'Easters) and tropical (hurricanes) cyclones, 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's accuracy.

Figure 2.1 GZA High Resolution Computer Model Mesh

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 (2015), flood model simulations were performed for the years 2040, 2065, and 2115 as outlined in Table 2.1.

Year	USACE SLR Scenario	Surge Scenario
2015	No SLR	100-year recurrence interval 500-year recurrence interval Tides
2040, 2065, 2115	High SLR	100-year recurrence interval 500-year recurrence interval Tides
	Intermediate SLR	100-year recurrence interval 500-year recurrence interval Tides
	Low SLR	100-year recurrence interval 500-year recurrence interval Tides

Table 2.1 Stratford Sea Level Rise Scenarios and Time Horizons

METHODOLOGY STEP 2: VULNERABILITY ASSESSMENT

The vulnerability to, and consequences of, coastal flooding on the Town's neighborhoods, buildings, natural resources, and infrastructure, both now and in the future, were evaluated based on the predicted flood limits and depths and the FEMA HAZUZ-MH loss estimation model.

ASSET INVENTORY

The first step of the vulnerability assessment was to create a detailed inventory of Town assets. These assets were categorized using criteria used by federal agencies for hazard management and building codes (Table 2.2).

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 Classes 3 and 4	
Transportation Systems			AASHTO
High Potential Loss Facilities	Not Applicable	Not Applicable	FERC, USACE, NRC
Hazardous Material Facilities	Not Applicable	Flood Design Classes 3 and 4	EPA
Support, High Occupancy and Vulnerable Population Facilities	Occupancy Category III	Flood Design Class 3	

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, and EPA indicate Environmental Protection Agency.

Table 2.2 Stratford Asset Inventory Categories

- **Essential Facilities** are those facilities 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 weather including flooding, 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 lines, 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 Facilities** are those facilities, such as dams, whose failure can result in catastrophic loss of human life. Stratford does not have any High Potential Loss Facilities.
- **Support, High Occupancy, and Vulnerable Facilities** 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** in Stratford include beaches, wetlands, salt marshes, tidal flats, etc.

LOSS ESTIMATION

The second step of the vulnerability assessment was to estimate the losses due to coastal flooding of the Town's assets, now and in the future. The consequences from coastal flooding include damage to buildings and infrastructure, displacement of people, disruption of services, and damages to natural resources.

The FEMA United States Multi-Hazards (HAZUS-MH) software model was used to estimate the consequences of coastal flooding for the Town's buildings and infrastructure (including potential economic losses) as well as the displacement of people. HAZUS-MH is a nationally-applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes.

Economic losses were characterized on an "Average Annualized Loss" basis under each of the time horizons: the years 2015, 2040, and 2065. The results of this analysis were used to predict potential current and future losses and impacts at a census block level.

The impacts of coastal flooding on the Town's natural resources were estimated based on sea level rise, tide, storm inundation, and wave effects.

The estimated losses provide important information for valuing the benefits of future resiliency measures relative to the costs of those measures (i.e. the benefits of flood protection measures include the losses that were prevented by employment of those measures).

RISK LEVEL

Asset vulnerability is characterized by Risk Level:

High: indicates a high probability of occurrence in the near term (currently and into the next 25 years) and a significant consequence.

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

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

METHODOLOGY STEP 3: RESILIENCY STRATEGIES, ACTIONS, AND PROJECTS

A range of coastal resiliency strategies, actions, and projects appropriate for Stratford were evaluated. The strategies, actions, and projects included in the Plan are consistent with those used in other coastal resiliency plans and previously approved for State and federal funding. The USACE's September 2013 publication "Coastal Risk Reduction and Resilience: Using the Full Array of Measures" (CWTS 2013-3) provided guidance for the selection of the strategies, actions, and projects.

The Plan also recommends resiliency strategies, actions, and measures that are consistent with Stratford's Vision as presented in the 2014 Plan of Conservation and Development.

RESILIENCY STRATEGIES

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

Protect: A range of interventions designed to prevent 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 ongoing basis.

RESILIENCY ACTIONS AND PROJECTS

Resiliency actions and projects fall into three categories: 1) Non-Structural; 2) Structural; and 3) Natural and Nature-Based. Plans, Policies, and Regulations that regulate flooding are considered non-structural measures.

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 insuring a structure which is permanently located within the floodplain to land use management and regulations. Examples of non-structural measures (consistent with the USACE National Floodproofing Committee guidance) include:

- Elevating Buildings: Lifting existing structures to an elevation which is equal to or higher than the 1% annual chance flood elevation (and consistent with NFIP and building code requirements).
- Filling Basement with Main Floor Addition: Filling the existing basement without elevating the remainder of the structure (requires that the structure's first floor is located higher than the 1% annual chance flood elevation and consistent with NFIP and building code requirements).
- Relocation: Physically moving the at-risk structure and buying the land on which the structure is located.
- Acquisition: Buying the structure and land. The structures are either demolished or sold to others and relocated. Development sites, if needed, can be part of a proposed project in order to provide locations where displaced residents can build new homes within an established community.
- Wet Floodproofing: In accordance with NFIP and building code regulations, wet floodproofing can be performed under certain circumstances. This involves using water and corrosion resistant construction materials, finishing materials, and utilities while allowing the unoccupied space to flood (e.g., unoccupied parking garages located beneath the 1% annual chance flood elevation).
- Dry Floodproofing: Waterproofing the structure to eliminate water infiltration. Typically, conventionally built structures (i.e., those without structural reinforcement designed to resist hydrostatic and hydrodynamic forces) can only be dry floodproofed up to approximately 3 feet of flood depth. These measures reduce flood risk; however, they are not recognized by the NFIP for any flood insurance premium rate reduction if applied to a residential structure.
- Berms and Floodwalls: Low berms and floodwalls (generally less than 6 feet) and not accredited through the NFIP are considered non-structural measures. These non-structural measures are intended to reduce the

frequency of flooding but not eliminate floodplain management and flood insurance requirements. These measures are generally placed around a single structure or a small group of structures. Their construction cannot result in any increase of the 1% annual chance flood elevation in the adjacent areas.

- Flood Warning System: This non-structural technique relies upon gages and hydrologic computer monitoring to determine the impacts of flooding for areas of potential flood risk. A flood warning system, when properly installed and operated, is able to identify the amount of time available for residents and Town personnel to implement emergency procedures.
- Flood Emergency Preparedness Plans: Local governments, through collaboration with FEMA and the USACE and other federal and state partners, are encouraged to prepare and maintain a Flood Emergency Preparedness Plan (FEPP) that identifies flood hazards, risks and vulnerabilities, mitigation actions, evacuation routes, evacuation and emergency centers, and post-flood recovery processes.
- Land Use Regulations: The basic principles for land use regulations are based on the NFIP and implemented through local and state building codes, which define the minimum standards for floodplain regulation. Local authorities can add additional requirements, beyond those required by the NFIP, such as special Design Flood Elevations (DFEs), overlay zones, etc. through local zoning and building codes.

Structural:

Structural measures are designed to prevent flooding and are consistent with the resiliency strategy of Protection. Specifically, they decrease shoreline erosion and/or reduce coastal risks associated with wave damage and flooding. Flood protection structures include levees, storm surge barrier gates, seawalls, flood walls, revetments, groins, and breakwaters.

The purpose of levees, seawalls, flood walls, and storm surge barrier gates is to prevent flood inundation. Revetments, groins, and breakwaters are typically intended to reduce coastal erosion.

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 “mimic” natural features but are created by human design, engineering, and construction. Nature-based features are impacted by the same physical, biological, geological, and chemical process that effect natural features, and therefore require maintenance to reliably perform. Natural and nature-based features include natural and nourished beaches, natural and constructed sand dunes (including barrier islands), natural and constructed oyster reefs, and natural and constructed marshes and wetlands.

Priority of Resiliency Actions and Measures

The priority of each of the recommended measures was identified based on: 1) the Risk Levels (Low, Moderate, and High) and 2) the extent of losses prevented.

FEMA ACCREDITATION

While each of the resiliency projects presented in the Plan will reduce the Town's flood risk, many may not be accredited by FEMA in their coastal flood mapping and classification of special flood hazard areas (SFHA). The only resiliency measures accredited by FEMA for hazard mapping purposes are levees that are constructed and managed in accordance with 44CFR§65.10. Non-accredited levees may be provisionally considered by FEMA in concert with local authorities. 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 also 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."

Natural primary sand dunes are considered by FEMA during flood mapping. Beach nourishment and constructed dunes may be accredited by FEMA. 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 will be maintained for many years.

METHODOLOGY STEP 4: PUBLIC AND STAKEHOLDER OUTREACH

The Town organized and facilitated a series of three public information meetings and workshops as well as updated the Town's website. The public meetings included presentations to inform the public of the interim plan findings and receive feedback throughout. The planning team gathered and documented input at each public meeting through a survey and question and answer periods. The planning team conducted a survey during the 1st public meeting to document the community's observations of areas of Town impacted by Hurricanes Sandy and Irene as well as areas that will need resiliency improvements in the future.

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

July 14, 2015 – Public Meeting on the Vulnerability and Risk Assessment

November 5, 2015 – Public Meeting on Coastal Adaptation Options

March 3, 2016 – Public Meeting on the Draft Plan

Several additional meetings were held with Town departments (e.g. Planning) to discuss the findings and recommendations and receive Town input.

METHODOLOGY STEP 5: PLAN IMPLEMENTATION

The Plan will be best implemented through incorporation into existing policies, plans, programs, and regulations, and financed principally through available state and federal funding and grant programs. The existing Town plans, programs, and regulations were reviewed in the context of the proposed coastal resiliency strategies, actions, and measures. Available state and federal funding opportunities were also identified.

UNDERSTANDING "RISK"

This plan uses a "risk-based" approach. Specifically, the methodology of **"Risk-Informed Decision Making"** makes decisions that are informed by an understanding of **"Risk."**

"Risk" is defined as:

Hazard Probability x Vulnerability

where:

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, strong winds, and salt spray that often accompany coastal flooding.

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

Vulnerability is the measure of the capacity to resist or recover from the impacts of the hazard, over both the short- and long-term. Vulnerability also considers the consequences of flooding which can include fatalities, injuries, property damage, infrastructure damage, damage to the environment, and interruption of business and services.

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 land on heads. If the coin is flipped multiple times in a row, the chance of getting a heads at least once increases (in ten consecutive flips, there will be nearly a 100% chance that at least one will be heads).

The probability of flooding is characterized in a similar manner. Flood probabilities are described in this plan (and by FEMA and other State and federal agencies) in terms of the “annual chance of occurrence.” The “annual chance of occurrence,” also known as recurrence interval is the probability of experiencing a specific flood in any given year. For example:

- The 1% annual chance flood elevation (also referred to as the 100-year recurrence interval flood) has, in any given year, a 1 in 100 chance of being equaled or exceeded.
- The 0.2% annual chance flood elevation (also referred to as the 500-year recurrence interval flood) has, in any given year, a 1 in 500 chance of being equaled or exceeded.

The chance of experiencing a given flood increases based on the time period of interest. For example, the 1% annual chance flood has a 25% (1 in 4) chance of being equaled or exceeded at least once in 30 years (a typical mortgage).

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 (mean sea level) of Long Island Sound increases in the future due to SLR, the elevation of an equivalent storm surge will be higher than it is today. For example, the 1% annual chance flood today will occur with much greater frequency (say, a 10% annual chance) in the future.

FEMA FLOOD HAZARD ZONES

This plan uses flood terminology similar to 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). A SFHA is defined as the area that will be inundated by a flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the Base Flood or 100-year flood. Moderate flood hazard areas are between the limits of the Base Flood and the 0.2% (or 500-year) flood. Minimal flood hazard areas are areas susceptible to low probability flooding and located outside the limits of the 0.2% (or 500-year) flood.

- **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 within the 1% percent annual chance (base) flood and waves are 1.5 feet or lower in height. Coastal AE zones are within the 1% percent annual chance (base) flood with waves between 1.5 and 3 feet high. These are areas that will be exposed to both flooding, moderate wave forces, and moderate wave effects.
- **VE Zones:** VE flood hazard zones are within the 1% percent annual chance (base) flood and waves are equal to or greater than 3 feet in height. These areas are subject to storm-induced high velocity wave action and significant wave forces.
- **LiMWA:** The Limit of Moderate Wave Action (LiMWA) is the demarcation between waves greater and lower than 1.5 feet high.

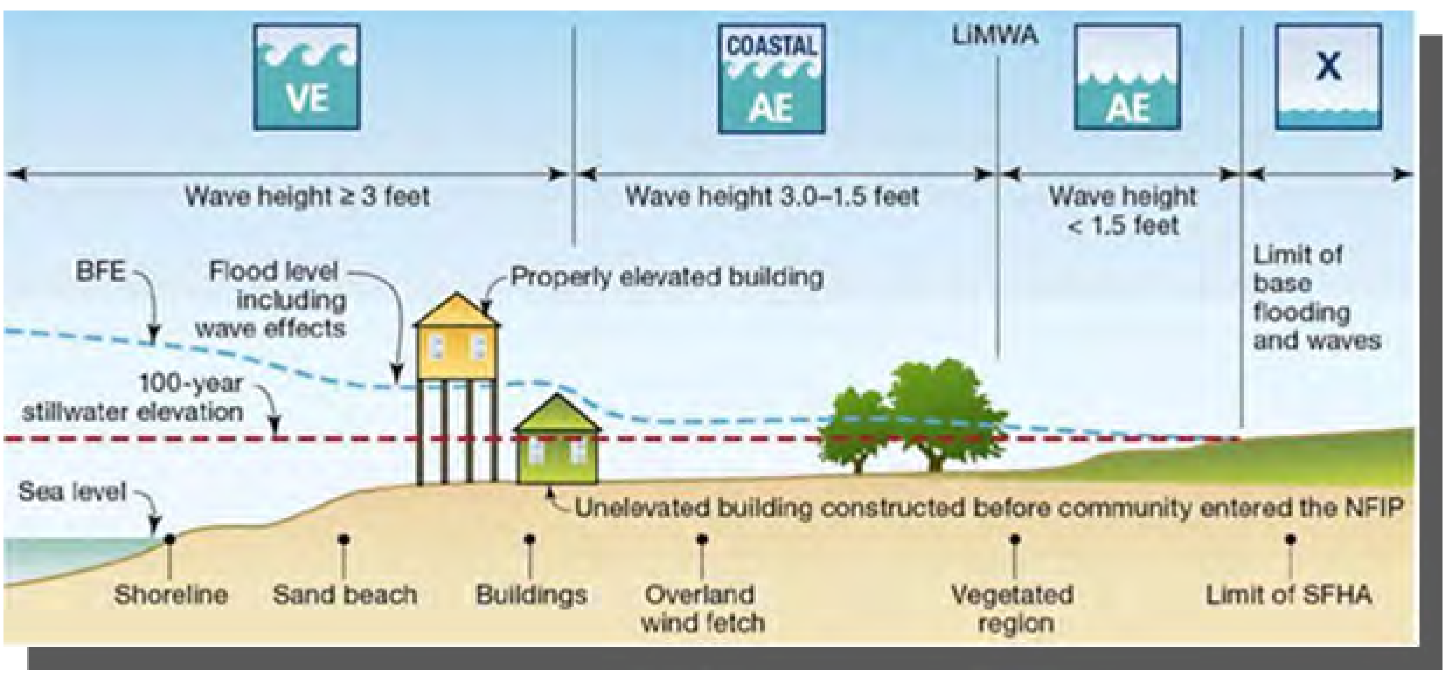


Figure 2.2 FEMA Flood Hazard Zones


EVACUATION ROUTE
ABOVE MEAN SEA LEVEL
19
18
17
16
15
14
13

3.0 COASTAL FLOOD HAZARDS

Section 3.0 describes Stratford's coastal flood hazards, including tides, sea level rise (SLR) and extreme flooding due to storm surge and waves, under current conditions as well as over the next 100 years.

- **Overview:** An overview of Stratford's coastal setting, shoreline features and topography is presented. Each of these set the stage for understanding Stratford's vulnerability to coastal flooding.
- **Tides and Sea Level Rise:** Tides and the future effects of SLR on tidal water levels and tidal flooding is presented.
- **Extreme Water Levels:** GZA's computer simulations of flooding during Hurricane Sandy demonstrate how coastal storm surges cause flooding along Stratford's shoreline and inland areas. The basis for predicting the probability of extreme coastal flooding due to storm surge and waves, both now and in the future.

Flooding in Lordship neighborhood during Hurricane Sandy (Source: ctpost.com)

COASTAL SETTING

Figure 3.1 identifies Stratford's major coastal features.

Location: Stratford is located on a peninsula along the northern shore of Long Island Sound. Stratford is bounded to the south by Long Island Sound, to the east by the Housatonic River and to the west by Bridgeport Harbor.

Characteristics: Stratford 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. Stratford's 14-mile coastline includes shorelines along both Long Island Sound and the Housatonic River.

Beaches: Stratford's southern shoreline, from the entrance to Bridgeport Harbor to the west to Stratford Point to the east, consists of a series of beaches. Moving from west to east, is Long Beach, which along with Bridgeport's Pleasure Beach, forms a barrier beach separating the Sound from the Great Meadows salt marsh and tidal flats. East of Long Beach, along Long Island Sound, is Lordship Beach. Lordship Beach extends to Stratford Point. Short Beach is located north of Stratford Point.

Tidal Wetlands and Marshes: An interconnected network of salt marshes, tidal wetlands, and tidal flats form the Stewart B. McKinney Wildlife Refuge. The Great Meadows Salt Marsh, part of the McKinney Wildlife Refuge, is hydraulically connected to the waters of Long Island Sound by Lewis Gut and Bridgeport Harbor. Due to these hydraulic connections, Great Meadows experiences daily tidal flushing. Great Meadows consists of a series of channels (the deepest of which is Lewis Gut) that drain the tidal flats and wetlands. The Great Meadows salt marsh is also hydraulically connected, via drainage culverts, to the tidal wetlands to its north and east on the other side of Lordship Boulevard and surrounding the Sikorsky Memorial Airport.

Housatonic River: In the vicinity of Stratford, the Housatonic River is a tidal estuary. It connects directly with Long Island Sound and experiences water level fluctuations from both tides and coastal storm surges. The shoreline along the Housatonic River, from south to north, consists of Short Beach, the Marine Basin, and tidal wetlands, flats, and islands. The Marine Basin is a tidal inlet that hydraulically connects the tidal wetlands surrounding Sikorsky Airport with the Housatonic River (via a drainage culvert). As such, these wetlands also experience daily tidal flushing.

Brooks and Creeks: Several brooks and streams discharge into the Housatonic River, including Pumpkin Ground Brook, Raven Stream, and Ferry Creek. Bruce Brook, in the western part of Stratford, discharges into Johnsons Creek (via a drainage culvert) which, in turn, connects to Bridgeport Harbor and Long Island Sound. Ferry Creek, which originates inland, is tidally connected to the Housatonic River.

In total, Stratford's 19.6 square miles consists of 17.6 square miles of land area and 2.3 square miles of water.

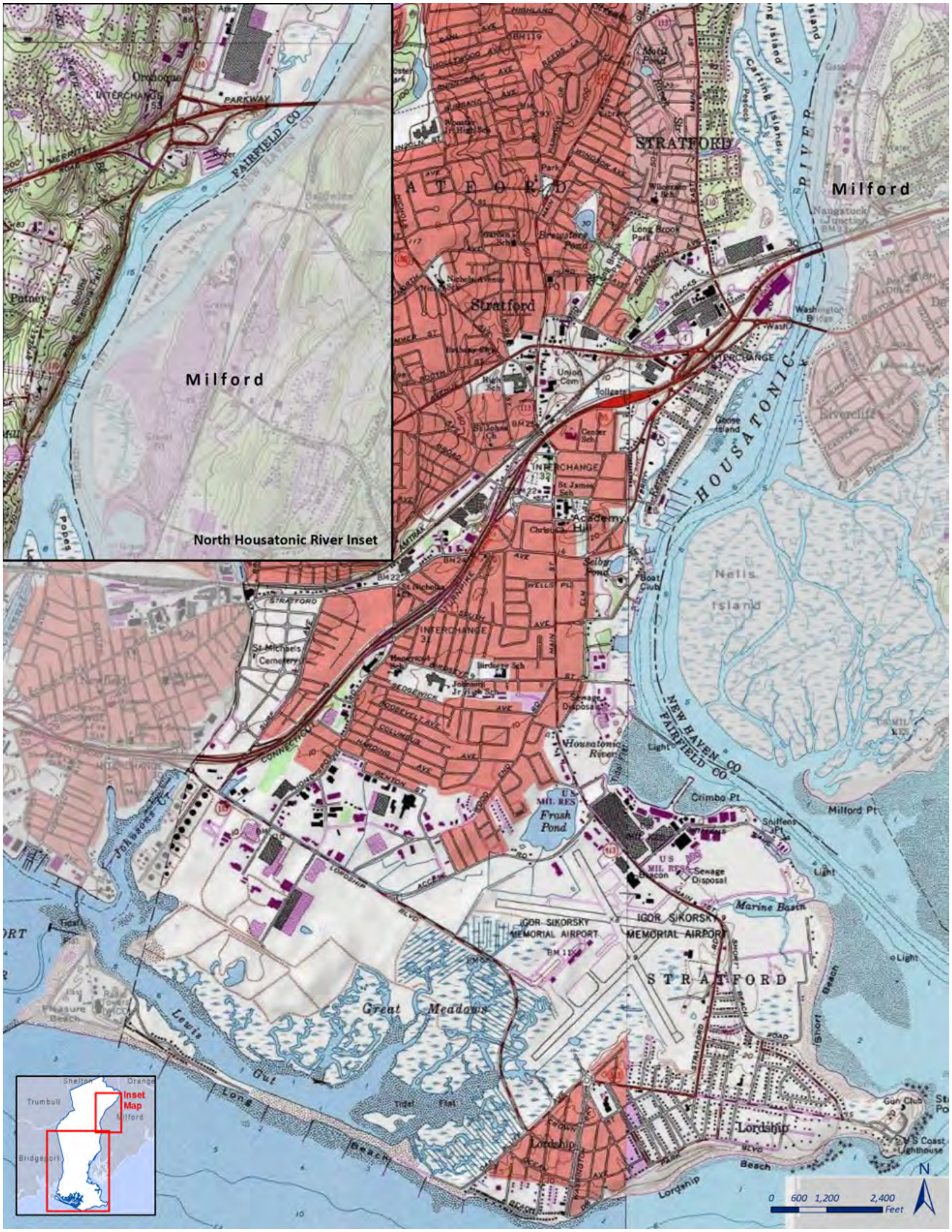


Figure 3.1 USGS Topographic Plan Showing Coastal Setting

SHORELINE FEATURES

Figure 3.2 indicates the shoreline features consistent with classifications developed by the USACE NACCS and identifies the locations of the representative Google Earth™ images shown below.

The Long Island Sound shoreline of Stratford consists of a mix of beaches and dunes, a few bluffs, tidal wetlands and flats, tidal islands (Fowler, Popes, Long, Carting, and Peacock Islands), and man-made structures. The Housatonic River shoreline is characterized by beach, tidal wetlands, flats, and islands with areas of man-made structures. The shoreline geomorphology of Stratford is classified as Glacial Drift and Beaches.

Image 1 (above): Large rock breakwaters are present at the entrance of Bridgeport Harbor (each side). Remnant structures of the old Pleasure Beach Park Bridge are present at the entrance to Lewis Gut and Johnsons Creek.

Image 2 (left): Johnsons Creek is hydraulically connected, via a box culvert with tide gate, to Bruce Brook to the north (on the north side of Lordship Boulevard and Interstate 95). The tide gate is currently not functional, resulting in periodic flooding of the area to the north of Interstate 95

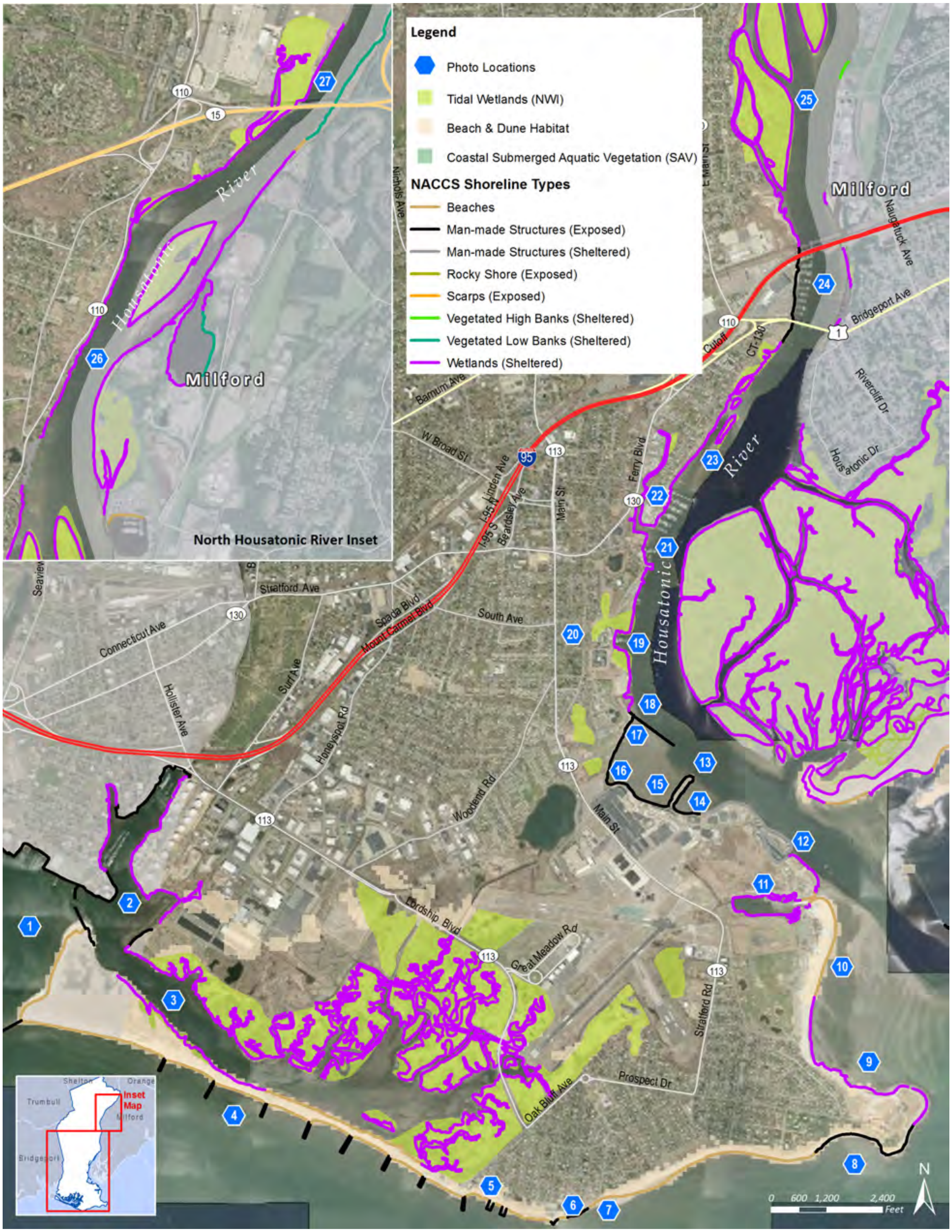


Figure 3.2 Shoreline Features

Image 3: The Great Meadows salt marsh is connected to Long Island Sound via Lewis Gut and separated from the Sound by Long Beach, a barrier beach and dune. It receives both tidal salt water from the Sound and freshwater from several creeks. Great Meadows is an extensive tidal marsh ecosystem and a critical habitat for a diversity of fish, and wildlife, including approximately 270 species of birds. Great Meadows is hydraulically connected to the wetlands surrounding Sikorsky Memorial Airport via a series of culverts beneath Lordship Boulevard. Great Meadows and Long Beach also provide a buffer against coastal flooding of upland areas.

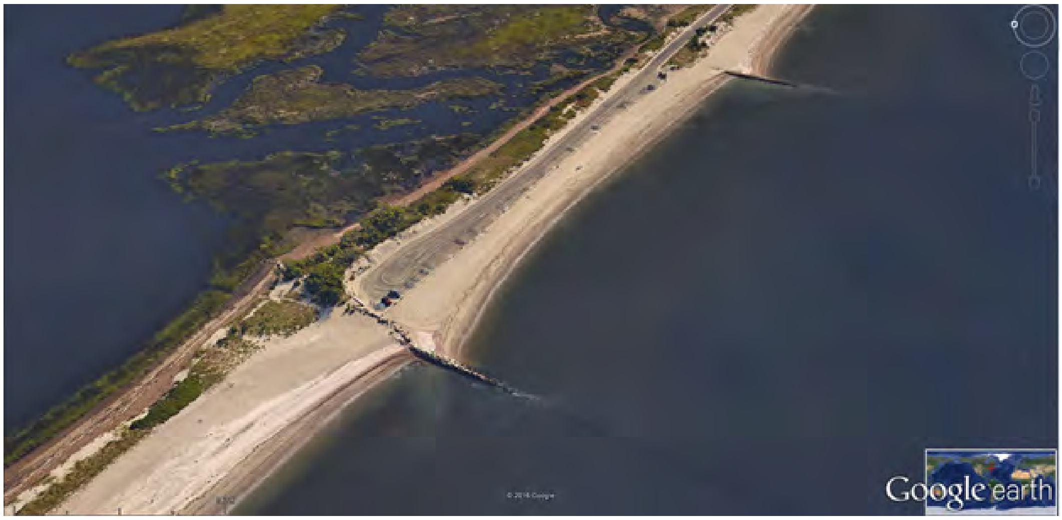


Image 4: Long Beach is Stratford's barrier beach. Eight major and ten minor rock groins are present along Long Beach; these were constructed to prevent erosion and limit the transport of sand due to littoral drift (water currents moving parallel to the beach).

Long Beach is approximately 1.5 miles long. The middle sections of the Beach are maintained as shoreline nesting. The eastern end of the beach is designated as a public beach.

Image 5: A series of houses have been built on Long Beach adjacent to Shoreline Drive. A series of partially submerged rock groins are also present.

Image 6: An approximately 900-foot long stone seawall and quarry stone revetment are present along the southern side of Beach Drive. Detail photo of wall, revetment and beach.

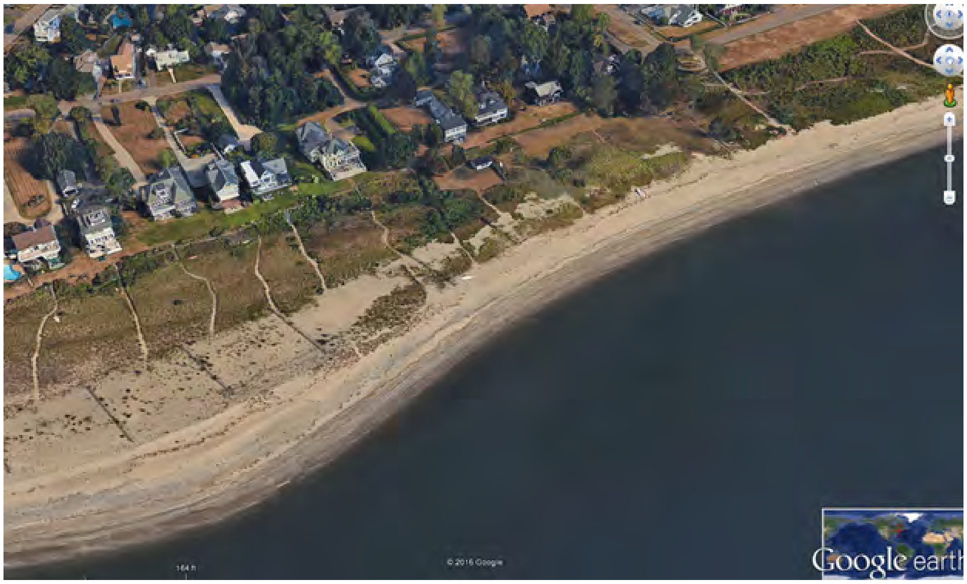


Image 7: Typical representation of beach along Lordship Beach.

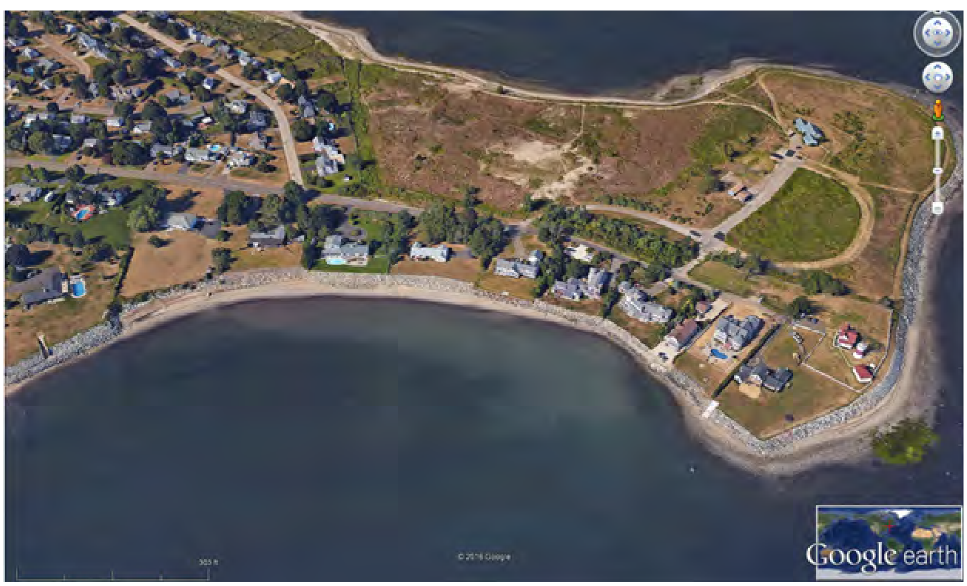


Image 8: Typical representation of quarry stone revetment shore protection along Lordship Beach and Stratford Point.

Image 9: Wetlands and beach and dune area along Stratford Point, south of Short Beach.

In 2011, All Habitat Services, LLC constructed dune reinforcement in this area to stabilize and protect the shoreline from erosion. The reinforced dune stretches across 900 feet of beach at Stratford Point and was constructed with sand-filled geotextile tubes, erosion blankets, a drainage swale and check dams, and planted with 38,000 grass plantings. Hurricane Sandy eroded away the dunes sand cover and plantings, leaving the base of the dune intact. Ref. http://allhabitat.com/project-gallery/stratford-point-dune-restoration-reef-ball-construction/

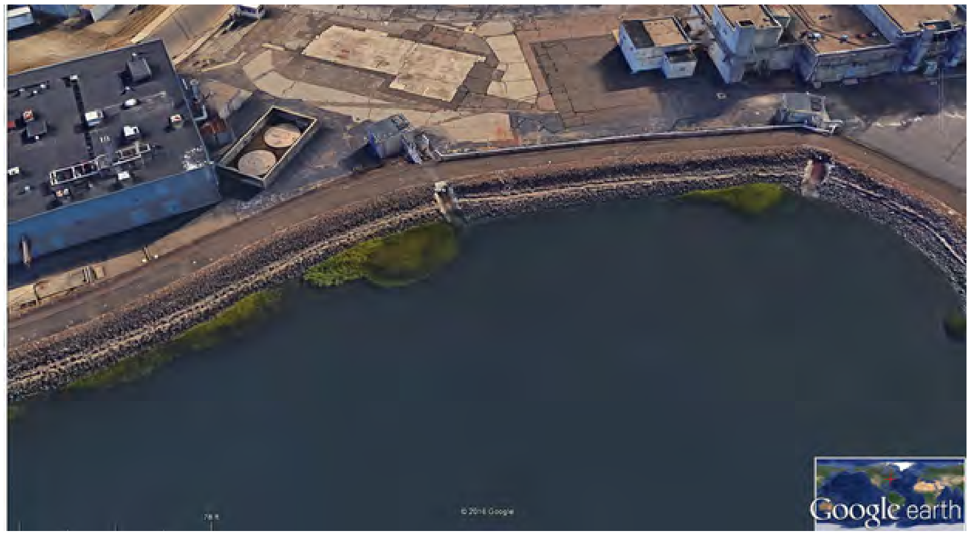
Constructing precast concrete "reef balls" in tidal flat - see location in image above. The "reef balls" were constructed as a shore protection measure and consisted of 40 permeable concrete structures.

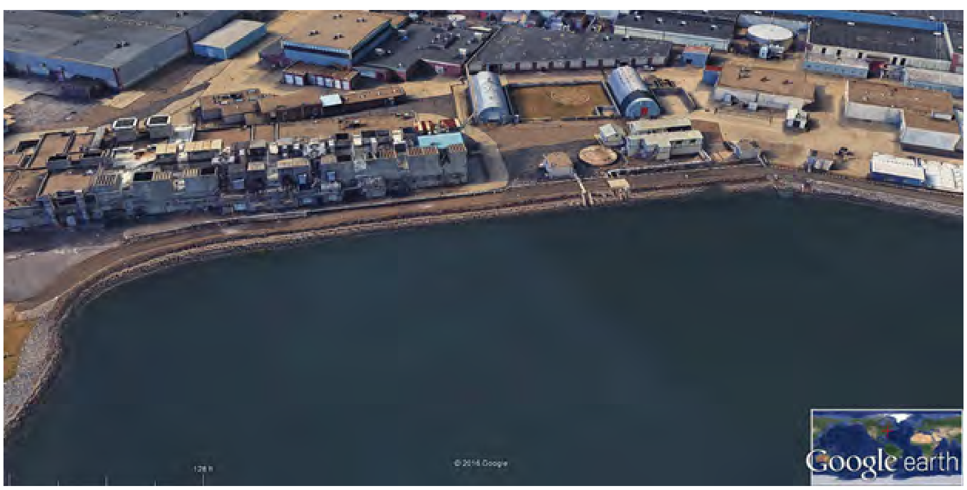
Image 10: Short Beach north of Stratford Point, including the Town recreational facilities, and the Marine Basin and tidal inlet. The tidal inlet is a low-lying area and hydraulically connected to the Housatonic River.

Image 11: Hydraulic connection of the Marine Basin to the tidal wetland areas surrounding the Sikorsky Memorial Airport via culverts constructed beneath the recently reconstructed section of Lordship Boulevard.

Image 12: Sniffens Point and Crimbo Point, located between Short Beach and the Stratford Army Engine Plant, including marina and boat launch ramp.

Image 13: The shoreline in front of the Stratford Army Engine Plant is protected with a levee with a crest elevation of 9 to 10 feet NAVD88 and a rock revetment shoreline protection. An area of sheltered water has been created in front of the Stratford Army Engine Plant by an approximately 1,200-foot long rock breakwater (extending southeast from the wastewater treatment plant) and an approximately 800-foot long, earthen-filled jetty. This area has significantly filled with sediment.





Images 14 and 15: Additional images of the shoreline in front of the Stratford Army Engine Plant. Shoreline is protected with a levee with a crest elevation of 9 to 10 feet NAVD88 and a rock revetment shoreline protection. Ground elevation in areas behind the levee are approximately Elevation 6 to 7 feet NAVD88.

Image 16: Limits of the Stratford Army Engine Plant levee. As shown above, the levee winds around existing parking area. The image also shows the drainage culvert that hydraulically connects Frash Pond to the Housatonic River.

Image 17: Shoreline between the Stratford Army Engine Plant and the Wastewater Treatment Plant. New greenway/bike path traverses parallel to the shoreline.

Image 18: The Stratford Wastewater Treatment Plant, including the plant's discharge canal discharging to the Housatonic River. The plant is partially surrounded with a levee (perimeter roadway) with crest elevation of approximately Elevation 10 feet NAVD88. Image also shows the Birdseye Town Landing and boat ramp.

Image 19: Shoreline between Birdseye and Bonds Dock, including tidal wetlands, marinas and quarry stone revetment. Note wetlands channel discharge from drainage swale at Elm Street - see Image 21 for detail. The Shakespeare Theater and Shelby's Pond is shown in the right half of the image

Image 20: Broad Street Bridge over Ferry Creek. Bridge includes box culvert and tide gate, with pump station to discharge river flow during coastal storms. New bridge currently proposed. Existing bridge deck at approximately Elevation 6 feet NAVD88.

Image 21: Drainage swale and stormwater catch basins at Elm Street, discharging to tidal wetlands and hydraulically connected to the Housatonic River.

Image 22: Broad Street Bridge over Ferry Creek. Bridge includes box culvert and tide gate, with pump station to discharge river flow during coastal storms. New bridge currently proposed. Existing bridge deck at approximately Elevation 6 feet NAVD88.

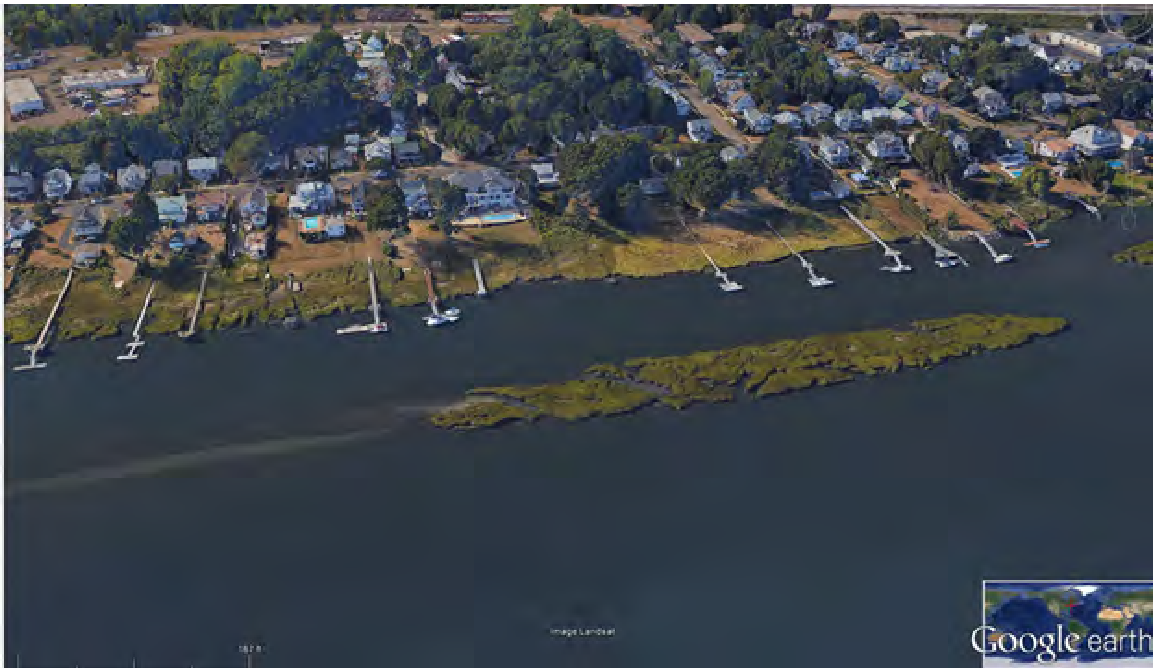


Image 23: Image is representative of shoreline between Brewer's Marina and the Route 1 Bridge. Houses along Housatonic Avenue are located at elevations ranging from Elevation 10 feet to 20 feet NAVD88. Tidal island in foreground.

Image 24: Route 1, Interstate 95 and Amtrak river crossings. Retail center at approximately Elevation 10 feet NAVD88.

Image 25: Long Island and Carting Island tidal islands.

Image 26: Shoreline representative of area along River Road. Houses located at top of embankment, at approximately Elevation 20 to 30 feet NAVD88. Power line crossing at right side of image.

Image 27: Ct. Route 15 Bridge, tidal wetlands, and Sikorsky Aircraft Company. Town walking path/greenway located to the south of the bridge.

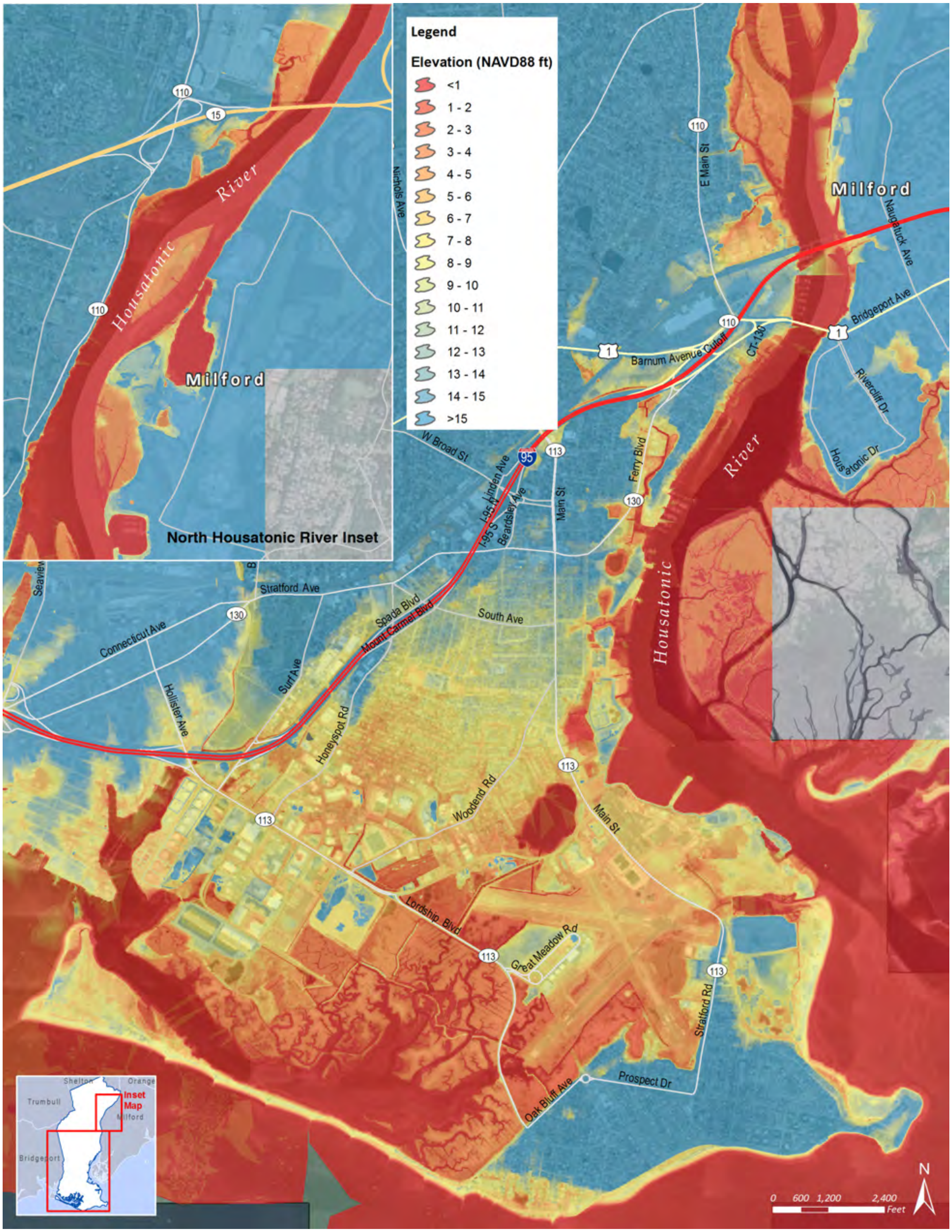


Figure 3.3 Ground Surface Elevation From High Resolution LiDAR Survey

TOPOGRAPHY

One of the single greatest factors that contributes to Stratford's flood vulnerability to tides and storm surge is the ground surface elevation of land areas that are hydraulically connected to the coastal waters of the Housatonic River and Long Island Sound, relative to the River and Sound water elevations. These include low-lying shoreline land areas as well as waterways (streams and brooks) and tidal inlets. These areas provide a point of entry for inland flooding during high tides and coastal storm surges. GZA computer simulations of flooding during Hurricane Sandy, presented later in this section, clearly show how these low lying areas contribute to coastal flooding of the inland areas of Stratford.

Figure 3.3 presents color imagery reflecting high resolution LiDAR topographic data for Stratford. 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 Stratford. All elevations presented in this plan reference NAVD88.

The areas that are vulnerable to coastal flooding are clearly visible, represented by the red and yellow shading. Ground surface elevations within these areas range from Elevation 0 to approximately 8 to 9 feet NAVD88, with most of these areas between Elevations 5 and 9 feet NAVD88. This includes most of the Town's land area to the south of Interstate 95, with the exception of the Town Center, the Lordship neighborhood, and a few localized areas of higher elevation. Areas shaded with blue represent high ground surface elevation.

Figure 3.3 clearly shows how vulnerable much of Stratford to the south of Interstate 95 is to coastal flooding; in particular, coastal floods with water elevations greater than about Elevation 8 feet NAVD88. For comparison, the peak stillwater water elevation in Stratford during Hurricane Sandy was Elevation 9.2 feet NAVD88. Figure 3.3 also shows how waterways like Ferry Creek and the Marine Basin provide points of entry for coastal flood waters to progress inland and how low-lying shoreline areas (such as the barrier beaches and the developed areas along Beach Drive) become directly inundated with coastal flood waters.

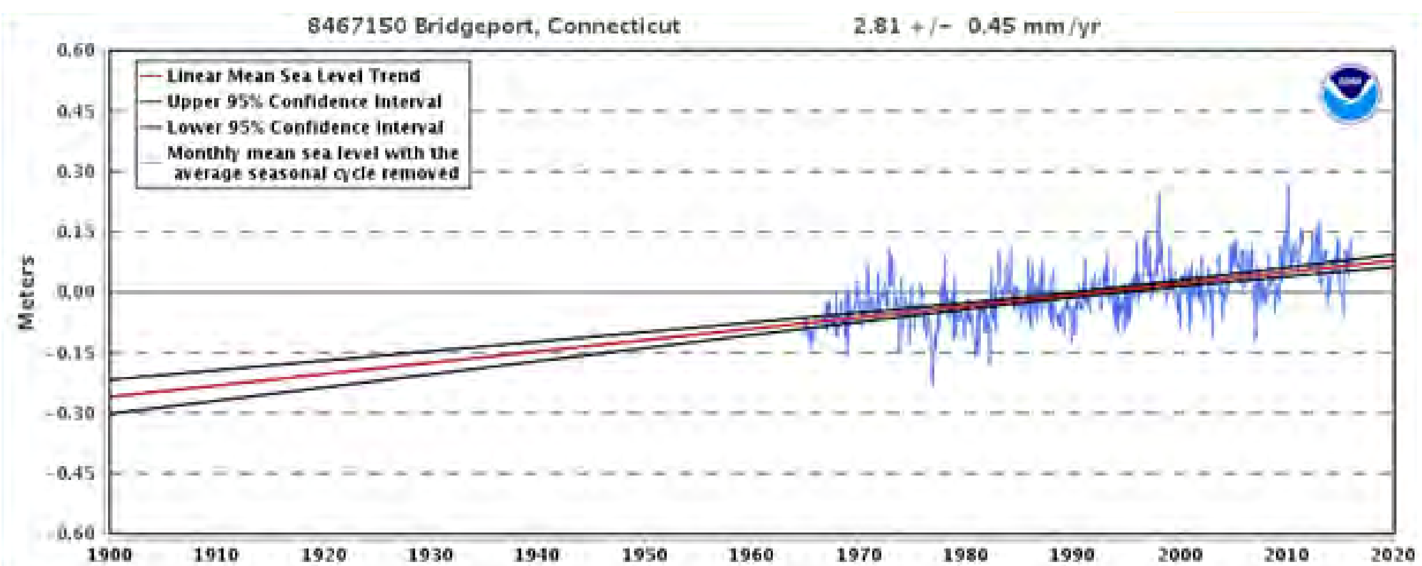
TIDES AND SEA LEVEL RISE

The first step to understanding coastal flooding is to understand tides and the effects of sea level rise. The NOAA tide gage at Bridgeport Harbor (NOAA Station 8467150) provides a detailed record of water levels and tides at Stratford over the last, approximately, 50 years (1964 to 2014). Tides are very long period waves that move through the Earth's oceans in response to astronomical gravitational forces, predominantly the forces exerted by the moon and sun. The tides in Long Island Sound are diurnal, meaning that during each lunar day (24 hours and 50 minutes), there are two high tides and two low tides. The Mean High Water (MHW) represents the average of the two high tides over the "National Tidal Datum Epoch" (the 19 years between 1983 and 2001). Similarly, the Mean Low Water (MLW) indicates the average of the two low tides. The two high tides (and two low tides) are slightly different in height. The Mean Higher High Water (MHHW) is the average of the higher of the two high tides during each tidal day observed over the National Tidal Datum Epoch and the Mean Lower Low Water (MLLW) is the average of the lower of the two low tides over the same time period. Mean Sea Level is the arithmetic mean of all hourly heights over the National Tidal Datum Epoch. The Highest Astronomical Tide (HAT) is the highest predicted tide over the National Tidal Datum Epoch. The mean range of tide (MH) at Stratford, the difference in height between the MHW and the MLW, is 6.74 feet. The current tide elevations, relative to the NAVD88 datum, at Stratford are indicated in Table 3.2.

However, the sea level of Long Island Sound is rising.

RISING SEA LEVELS: The observed sea level trend at the NOAA Bridgeport gage is shown in Figure 3.4. The tide gage data indicate a mean sea level rise trend of 2.81 millimeters (mm) per year (with a 95% confidence interval of +/-0.45 mm per year). Over the most recent 25 years, the data indicates that the mean rate of sea level rise is increasing.

Figure 3.4 NOAA Bridgeport Tide Gage: Observed Sea Level Rise



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 (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.

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 a large number of unknown factors (such as future emissions of greenhouse gases, rate of ice melt, etc.). Therefore, for planning purposes, it is prudent to consider a range of possible sea level rise outcomes. NOAA and the USACE have developed sea level rise projections for use on federal projects in the United States. Using the USACE Sea Level Rise Calculator, the predicted sea level rise at Stratford between the years 2015 and 2115 are shown below (in feet).

Year	NOAA (LOW)	USACE (LOW)	NOAA (INT)	USACE (INT)	NOAA (INT-HIGH)	USACE (HIGH)	NOAA (HIGH)
	All in feet (ft)						
2015	0	0	0	0	0	0	0
2040	0.20	0.20	0.36	0.36	0.71	0.86	1.11
2065	0.40	0.40	0.83	0.83	1.78	2.18	2.86
2115	0.81	0.81	2.11	2.11	4.98	6.22	8.27

Table 3.1 Sea Level Rise Projections at Stratford (using the USACE Sea Level Rise Calculator)

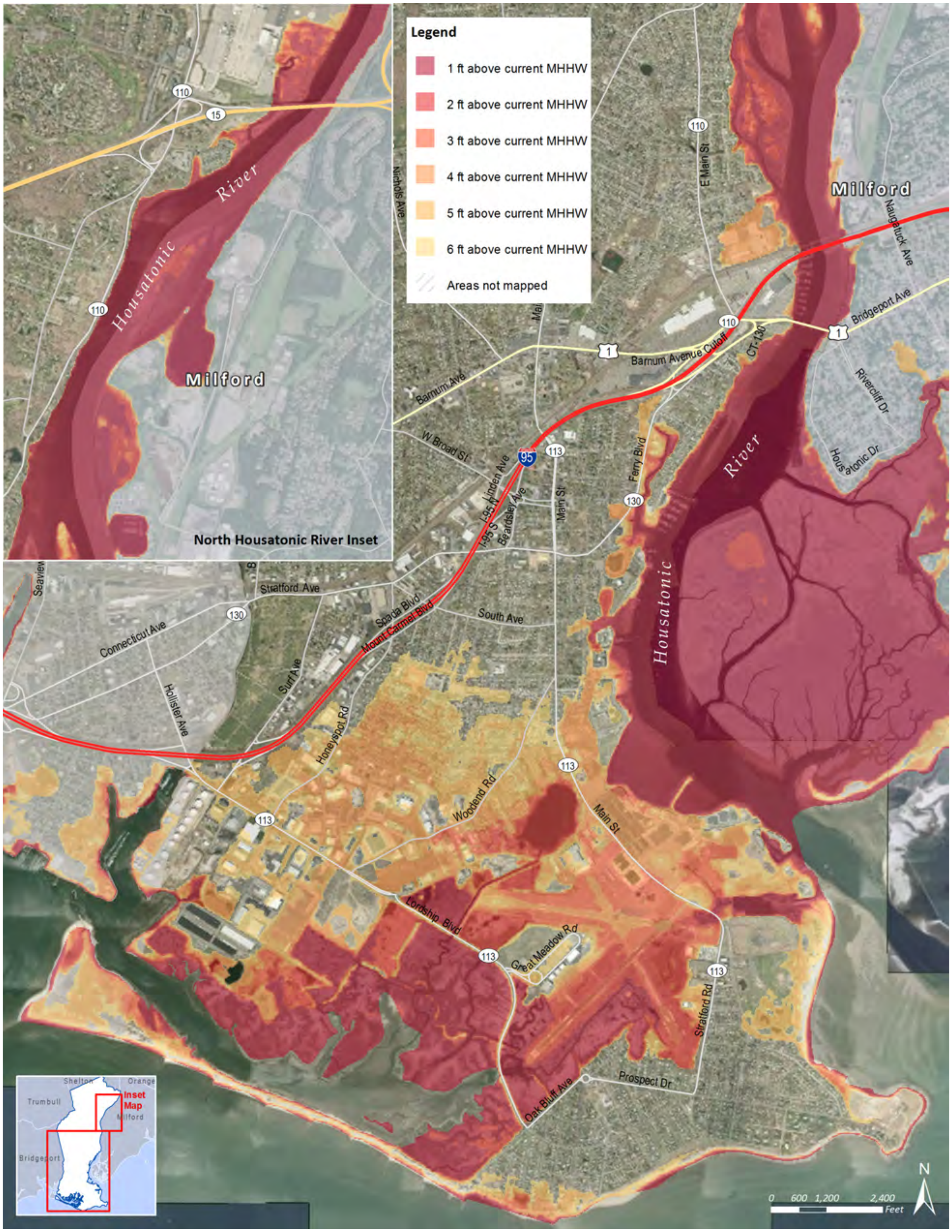


Figure 3.5 Flood Inundation Due to Sea Level Rise (relative to MHHW)

RISING TIDES: Assuming linear superposition of sea level rise on the current tides (a reasonable assumption), the current and predicted changes to the tidal elevations for the years 2040, 2065, and 2115 (in feet, relative to the NAVD88 datum) at Stratford due to sea level rise are presented below in Table 3.2.

	Current 2015	2040			2065			2115		
		High SLR	Int SLR	Low SLR	High SLR	Int SLR	Low SLR	High SLR	Int SLR	Low SLR
Mean Sea Level (MSL)	-0.22	0.64	0.14	-0.02	1.96	0.61	0.18	6	1.89	0.59
Mean High Water (MHW)	3.15	4.01	3.51	3.35	5.33	3.98	3.55	9.37	5.26	3.96
Mean Higher-High Water MHHW)	3.48	4.34	3.84	3.68	5.66	4.31	3.88	9.7	5.59	4.29
Highest Astronomical Tide	4.98	5.62	5.12	5.00	6.94	5.59	5.16	10.98	6.87	5.57
Mean Low Water (MLW)	-3.6	0.74	0.24	0.08	2.06	0.71	0.28	6.1	1.99	0.69
Mean Lower-Low Water MLLW)	-3.84	-2.98	-3.48	-3.64	-1.66	-3.01	-3.44	2.38	-1.73	-3.03

Table 3.2 Current and Projected Tide Elevations (feet, NAVD88 Datum)

Figure 3.5 shows the predicted tidal inundation due to sea level rise, relative to MHHW. Except for areas along the beaches and near tidal wetlands, the effects of tidal flooding on the Town are currently minimal. By the year 2065, there is a moderate likelihood that (without flood controls) the Sikorksy Memorial Airport will flood on a daily basis. The High sea level rise projection for the year 2115 (about 6.22 feet sea level rise; MHHW elevation of 9.7 feet NAVD88) is about 6 inches higher than the peak flood elevation observed during Hurricane Sandy. These conditions would result in flooding throughout the Town similar to that experienced during Sandy, but on a daily basis.

As discussed later in this section, the effects of sea level rise on the frequency and elevation of coastal storm surge flood elevations will be significant.

EXTREME WATER LEVELS

Coastal storm surges at Stratford result from two types of storms: Extra-tropical cyclones (Nor'Easters) and tropical cyclones (Tropical Storms and Hurricanes).

Nor'Easters are relatively common in New England, in particular during the spring, winter, and fall. They are less intense than hurricanes but are large in size and long in duration (sometimes lasting several days), which can cause major 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.

Long Beach West after the 1938 Hurricane (Re. Town of Stratford)

Long Beach after Hurricane Sandy

HISTORIC STORMS FROM HURRICANE '38 TO SUPERSTORM SANDY

"On September 21, the Hurricane of 1938 battered Stratford. After five days of rain, the morning had been changeable, dashes of rain alternating with clearing skies. By early afternoon a solid sheet of rain was falling, whipped by fiercer winds than anyone remembered. By 2:30, WICC announced that a hurricane was on its way. Wind speeds were measured to 121 miles per hour, and gusts to 183. High tides swept over the shoreline and towering waves lashed cottages and roads. Cottages at Short Beach, Lordship, and Long Beach were smashed or swept away. Paul Castelot was drowned attempting to save a boat from drifting onto the jetty in the river, and Charles Krolinowski died of injuries received when part of his roof crashed down on him. Power went out and phones went dead when trees came down on wires. Roads were flooded and for six hours Lordship was cut off from the world. Late in the afternoon, the wind died completely and the sun beamed down from a bright blue sky on an eerie, quiet scene. It was the eye of the storm. As darkness fell, the wind and rain returned, and homes were lighted by oil lamps and candles. Acting town manager Howard Wilcoxson stayed at his desk until midnight directing rescue efforts. The next day, residents looked out on devastation. Fifteen hundred trees were down, and Public Works with WPA crews took five days to clear the streets. Helen and LeRoy Lewis had been swept off their little island in the Thimbles and drowned. Only the week before, Helen Lewis had been nominated secretary of state on the Baldwin ticket. Digging out took weeks. Shoreline trains on the New Haven Road were restored after some days, and power was returned in most of the town. Even without power, the Stratford News was able to use its old hand press to publish the news of the storm. Red Cross chairman Warren Beach asked for donations for hurricane victims, declaring other places were harder hit. Most beach cottages were never restored." (Reference - In Pursuit of Paradise by Lewis Knapp; Town of Stratford)

Hurricanes are relatively rare in New England; hurricanes of high intensity with the tracks and landfalls necessary to cause large floods in Stratford are even rarer. Since hurricane winds circulate in a counterclockwise direction (with the right side of the cyclone having the higher wind speeds), the hurricanes that are most likely to cause the largest storm surges in Stratford are very intense storms that make landfall about 25 to 50 miles to the west of Stratford. The Hurricane of 1938 made landfall between Bridgeport and New Haven with maximum sustained wind speeds of around 100 to 105 kts.

During the last 25 years there have been four significant flood events in Stratford: 1) October 1991 Tropical Storm (Peak Flood Elevation of 7.5 feet NAVD88); 2) December 1992 Nor'Easter (Peak Flood Elevation of 8.2 feet NAVD88); 3) August 2011 Tropical Storm Irene (Peak Flood Elevation of 8.2 feet NAVD88); and 4) Hurricane/Extratropical Storm Sandy (Peak Flood Elevation of 9.2 feet NAVD88).

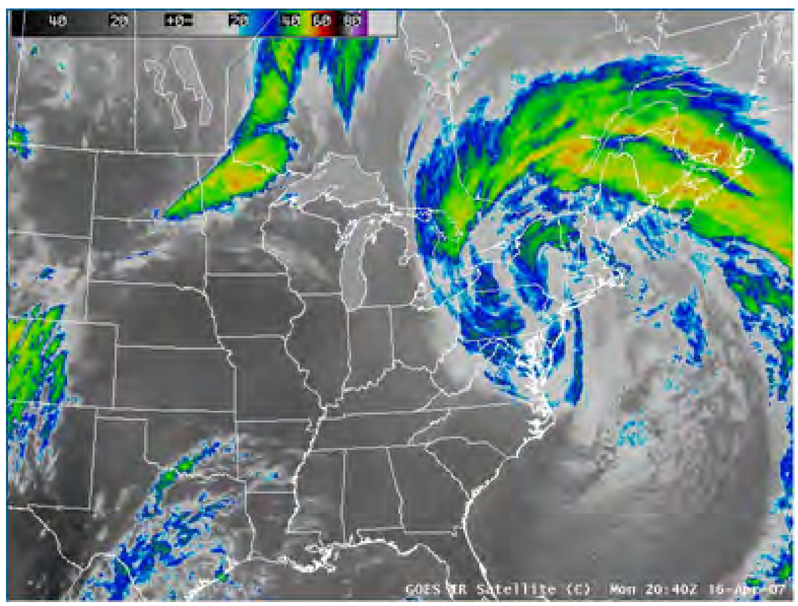


Figure 3.6 NOAA satellite image showing windfield and precipitation during a typical New England Nor'Easter

Hurricane Sandy resulted in the highest flood level in Stratford during the period of record of the NOAA Bridgeport tide gage. Hurricane Sandy was a post-tropical cyclone with an unusual (westerly) track at landfall and an enormous windfield (tropical force winds extending 820 miles from the storm center). Although it made landfall in New Jersey, its large size resulted in high winds along Long Island Sound. The result was to cause a large storm surge within Long Island Sound that "backed-up" from the west end of the Sound to the east.

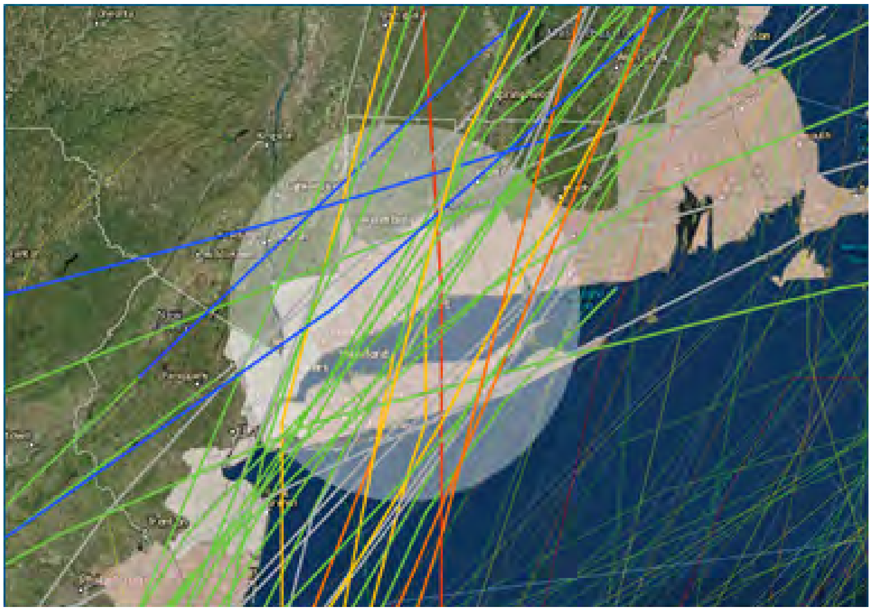


Figure 3.7 - NOAA Storm Tracks for tropical storms and hurricanes near Stratford

Between 1950 and 2015, there were four major hurricane strikes along Long Island: 1) Hurricane Belle (1976; Tropical Storm); 2) Hurricane Gloria (1985; Category 1); 3) Hurricane Donna (1960; Category 2); and 4) Hurricane Carol (1954; Category 1 to 2). There were also several significant hurricanes during the 1800s and early 1900s that made landfall along Long Island, although details about their intensity are limited. As shown in Figure 3.7, there have been about 36 tropical cyclones (including hurricanes and tropical storms) that have tracked within a 50 nautical mile radius of Stratford since the mid-1800s.

No Category 4 hurricanes have been documented. The only documented Category 3 hurricane was the Hurricane of 1938. The storm tide elevation (combined storm surge and tide) was estimated to be about Elevation 12.8 feet MLLW (Elevation 9 feet NAVD88) at Bridgeport.

PREDICTING COASTAL FLOOD PROBABILITY

There are several publically-available sources of information that can be used to predict the flood frequency in Stratford. These include:

1. Statistical analysis of the NOAA Bridgeport Tide Gage.
2. FEMA Flood Insurance Study and Rate Maps.
3. The USACE North Atlantic Coast Comprehensive Study (NACCS).

NOAA BRIDGEPORT TIDE GAGE: Statistical analysis of the NOAA Bridgeport Tide Gage provides an indication of the recurrence interval of flooding based on a 50-year period of record.

FEMA: FEMA has characterized the current flood hazard within Stratford for the purposes of the National Flood Insurance Program (NFIP). Figure 3.7 presents the effective FEMA Flood Insurance Rate Map (FIRM) used to calculate flood insurance rates for Stratford. As indicated on this map, most of the area south of Interstate 95 as well as along the Housatonic shoreline is inundated under the FEMA-predicted coastal 100-year recurrence interval flood (Base Flood).

USACE NACCS: The USACE performed extensive regional flood hazard analyses after Hurricane Sandy (the North Atlantic Coast Comprehensive Study). These analyses utilized statistical analysis, interpretation of meteorological parameters, and numerical computer modeling of storm surge and waves to identify regional flood hazards.

UNCERTAINTY AND FLOOD PROBABILITY: 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 Bridgeport 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 Stratford, 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 the model resolution used by the NACCS is coarse.

Table 3.3 summarizes the predicted flood probabilities and corresponding flood stillwater elevations. The table areas shaded in blue reflect predicted floods greater than or equal to about Elevation 9 (elevations at which Stratford experiences significant coastal flooding that is comparable to Hurricane Sandy).

Figures 3.8 and 3.9 present the results of GZA’s high resolution computer flood modeling of the 100-year and 500-year recurrence interval floods for the years 2015, 2040, 2065, and 2115. Figures 3.8 and 3.9 model results are based on: 1) the USACE NACCS mean flood-frequency data and 2) the USACE Intermediate sea level rise projection (see Table 3.3 for near-shore flood elevations). Note that flooding north of Interstate-95 (I-95) via drainage culverts hydraulically connected to Ferry Creek, and south of I-95 (near Rt. 113) are not indicated in GZA’s simulations and not shown on Figures 3.8 and 3.9.

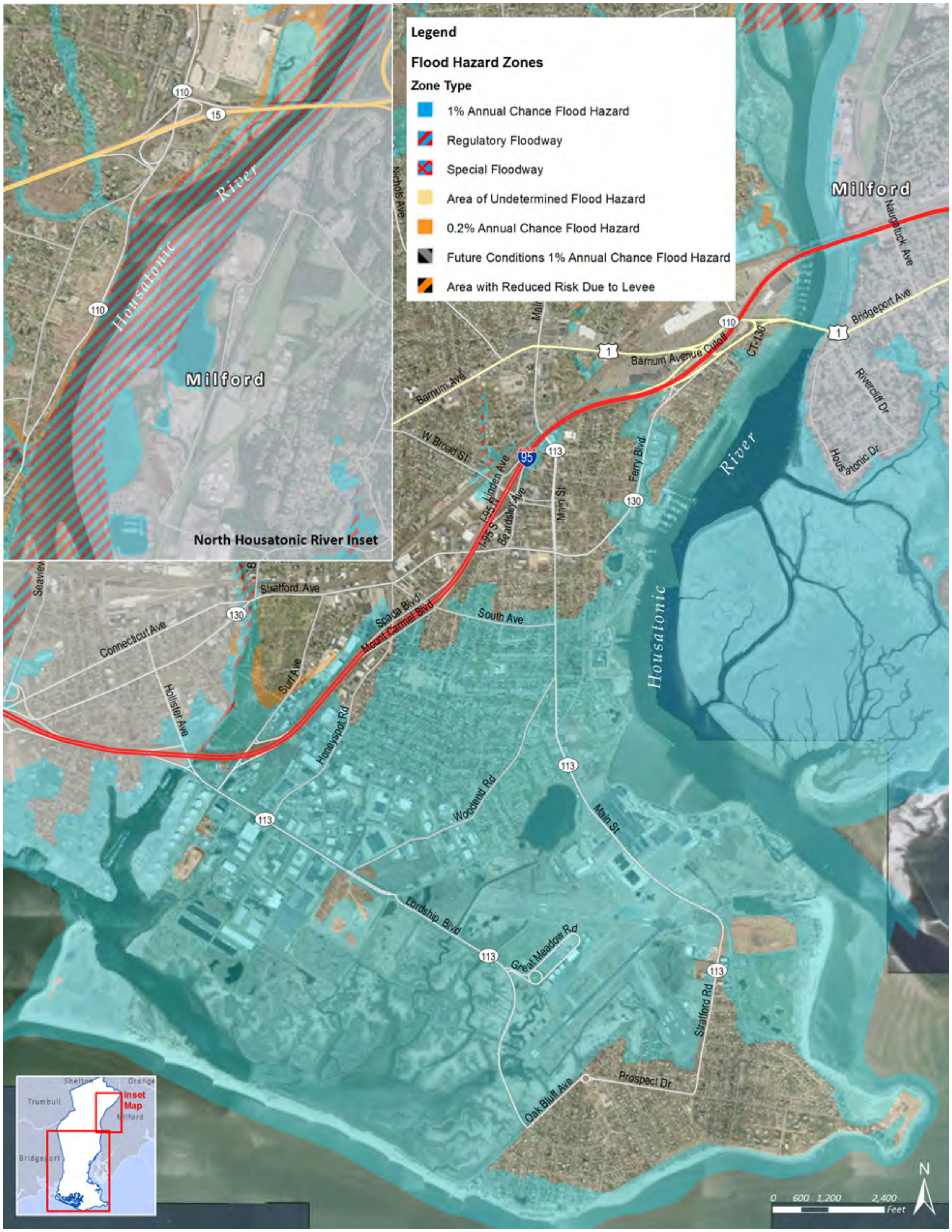


Figure 3.7 Effective FEMA FIRMS Special Flood Hazard Areas

Recurrance Interval	1-yr	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr	1,000-yr
2015:										
NOAA MEAN	5.2	6.2	6.8	7.4	7.8	8.4	9.1	-	-	-
NOAA UB	-	-	-	7.9	8.7	10.0	11.4	-	-	-
NOAA LB	-	-	-	6.9	7.1	7.2	7.9	-	-	-
FEMA	-	-	-	7.7	-	9.2	9.8	-	11.1	-
USACE MEAN	5.8	6.7	8	8.8	9.6	10.7	11.7	13	15	16.4
USACE UB	8.8	9.7	10.9	11.8	12.7	14.1	15.5	16.9	18.8	20.3
USACE LB	2.7	3.7	5.1	5.9	6.5	7.3	7.9	9.1	11.1	12.5
2040:										
USACE MEAN (LOW SLR)	6	6.9	8.2	9	9.8	10.9	11.9	13.2	15.2	16.6
USACE MEAN (INT SLR)	6.2	7.1	8.4	9.16	10.0	11.1	12.1	13.4	15.4	16.8
USACE MEAN (HIGH SLR)	6.7	7.6	8.9	9.66	10.5	11.6	12.6	13.9	15.9	17.3
2065:										
USACE MEAN (LOW SLR)	6.2	7.1	8.4	9.2	10.0	11.1	12.1	13.4	15.4	16.8
USACE MEAN (INT SLR)	6.6	7.5	8.8	9.63	10.4	11.5	12.5	13.8	15.8	17.2
USACE MEAN (HIGH SLR)	8.0	8.98	10.2	10.98	11.8	12.9	13.9	15.2	17.2	18.6
2115:										
USACE MEAN (LOW)	6.6	7.5	8.8	9.6	10.4	11.5	12.5	13.8	15.8	17.2
USACE MEAN (INT SLR)	7.9	8.8	10.1	10.9	11.7	12.8	13.8	15.1	17.1	18.5
USACE MEAN (HIGH SLR)	12.0	12.9	14.2	15.0	15.8	16.9	17.9	18.2	21.2	22.6

Table 3.3 Predicted Stillwater Flood Elevation at Stratford

Notes:

1. Water levels presented above are stillwater elevations (flood levels in the absence of wave effects).
2. FEMA Effective VE Base Flood Elevation ranges between Elevation 13 to 20 feet NAVD88 (including 1.4 to 1.6 feet of wave set-up and waves of 3 feet or greater height).
3. FEMA Effective AE Base Flood Elevation ranges between 12 and 15 feet NAVD88 (including waves up to 3 feet in height).

Figure 3.8 GZA Computer Flood Simulations of the 100-year Recurrence Interval Flood

Figure 3.9 GZA Computer Flood Simulations of the 500-year Recurrence Interval Flood

PREDICTING HOW STRATFORD FLOODS

High resolution numerical flood modeling of Hurricane Sandy, performed by GZA using the ADCIRC model, is presented in the following figures (Figures 3.10 through 3.17). The figures show flood inundation over multiple time intervals during the storm (from the beginning of flooding to the peak flood). The information from this type of computer simulation is very useful for understanding how flooding occurs and, therefore, how and where flood protection projects should be constructed to most effectively prevent or reduce the effects of coastal flooding throughout Stratford.

The model results clearly demonstrate how the coastal flooding in Stratford migrated during Sandy, in particular how inland areas were flooded. As shown on these figures, coastal flood inundation initiates at several specific entrance points as a result of low ground surface elevation and/or hydraulic connection via wetlands and streams.

These areas include:

The Marine Basin: The Marine Basin is a low-lying tidal inlet that is hydraulically connected to the Housatonic River. Flood inundation occurs both via drainage culverts and overland flow. Floodwaters flow to the west, inundating the airport (which has low ground surface elevations on the order of Elevations 4 to 6 feet NAVD88. Airport flooding continues, propagating to the northern, western, and southern limits of the airport property (wetland areas surrounding the airport). Floodwaters also flow to the northwest, eventually inundating the Stratford Army Engine Plant, and to the south flooding parts of Short Beach Park.

North of the Army Engine Plant Levee: The Army Engine Plant is fronted by a levee (crest at Elevation 9 to 10 feet NAVD88). The land area directly north of the levee limits is a low-lying area (+/- Elevation 6 feet NAVD88). Floodwaters entering here propagate to the north, toward the area to the west of the wastewater treatment plant. At this point, the flooding connects with coastal floodwaters entering at Birdseye Street from the Housatonic River, encompassing Frash Pond and continuing to flow to the west toward residential and commercial areas of the South End. Floodwaters from this area also merge with airport flooding, overtopping Access Road.

Shore Road: Housatonic River flooding moves inland via the tidal inlet and wetlands in the vicinity of Shore Road, surrounding Harborview Place, extending to Elm Street and flooding the intersection of Elm Street and Shore Road and surrounding residences, and overtopping Shore Road (at and in the vicinity of the drainage culvert).

Intersection of Stratford Avenue and Lockwood Ave: Housatonic River flooding moves inland over the tidal wetlands at the intersection of Stratford Avenue and Lockwood Avenue, inundating Selby's Pond and surrounding residences.

Ferry Creek: Housatonic River flooding moves inland via Ferry's Creek, south of Broad Street, and overtops Ferry Boulevard. There is a culvert, tide gate, and pump station at the Broad Street Bridge. However, flooding overtops the existing bridge deck elevation, before proceeding along Ferry Creek toward the north. Much of the area between Ferry Boulevard and Ferry Creek becomes inundated. Flooding continues to the north via drainage culverts beneath Ferry Boulevard and East Broadway, extending flood areas to the north of I-95 and near Rt. 113.

Great Meadows: Floodwaters enter Great Meadows from Long Island Sound via the Lewis Gut and the overtopping of Long Beach. As flood elevations within Great Meadows increase, flood inundation occurs within the commercial areas along Metro North and Long Beach Boulevard and overtop portions of Lordship Boulevard. Flooding within Great Meadows also connects with airport flooding via drainage culverts beneath Lordship Boulevard. Great Meadows flooding also inundates the southern portions of Oak Bluffs Avenue.

Johnsons Creek: Flooding from Long Island Sound moves inland via Johnsons Creek, flooding the areas surrounding the waterway. There is a culvert and tide gate at the north end of Johnsons Creek (connecting with Bruce Brook). Flooding initially enters via the culvert (when the tide gate is not operable) and eventually overtops Hollister Avenue and Lordship Boulevard moving northward and eastward. It propagates via the roadway underpasses to area to the north of Interstate 95 and well as into the South End and connects with floodwaters coming in from the east.

Long Beach: Coastal flooding from Long Island Sound directly inundates developed areas along Shoreline Drive and Beach Road.

South of Short Beach: Coastal flooding from the Housatonic River directly inundates the beach/tidal wetlands area between Stratford Point and Short Beach (in the area of the "reef balls").

The conclusions presented above are based on simulations of flooding during Hurricane Sandy, which had a peak stillwater elevation of approximately 9.2 feet NAVD88. More extreme floods will inundate Stratford in a similar way, with the following important difference: as coastal floods exceed approximately Elevation 10 feet NAVD88, there will be direct overtopping of much of the Town's shoreline.

Figure 3.10 GZA Computer Flood Simulations of Hurricane Sandy Time Step 1

Figure 3.11 GZA Computer Flood Simulations of Hurricane Sandy Time Step 2

Figure 3.12 GZA Computer Flood Simulations of Hurricane Sandy Time Step 3

Figure 3.13 GZA Computer Flood Simulations of Hurricane Sandy Time Step 4

Figure 3.14 GZA Computer Flood Simulations of Hurricane Sandy Time Step 5

Figure 3.15 GZA Computer Flood Simulations of Hurricane Sandy Time Step 6

Figure 3.16 GZA Computer Flood Simulations of Hurricane Sandy Time Step 7

Figure 3.17 GZA Computer Flood Simulations of Hurricane Sandy Time Step 8

PREDICTING WAVES

Wind-generated waves also contribute to coastal flooding. Waves can result in significant damage to structures. They can also cause significant damage to wetland vegetation and cause beach erosion. During normal conditions, waves occur only along the shoreline. However, during coastal storm surges, flood water can inundate large areas, and waves can occur within the inundated areas as well. Wave heights greater than 3 feet can result in significant building damage and beach erosion. Wave heights between 1.5 and 3 feet can result in moderate building damage and beach erosion.

Wave heights are a result of the duration that the wind blows on the water surface and the length of unimpeded area (called fetch) that the wind blows over. As waves propagate over land, their height is limited by the water depth (called the depth-limited wave height). In predicting coastal flood risk, FEMA typically assumes that within overland flood-inundated areas the waves are depth-limited. The FEMA FIS characterize the waves for the current, 100-year recurrence interval flood.

GZA performed computer simulations of waves using the wave model SWAN to predict wave heights coinciding with the 100-year and 500-year recurrence interval flood elevations (with the exception of the current 100-year recurrence interval flood) assuming the USACE NACCS mean flood frequency data and the USACE Intermediate sea level rise projection. Predicted wave heights are presented in Figures 3.18 through 3.24.

Tropical Storm Irene Hits Connecticut (Hartford Courant; Photographer Stephen Dunn)

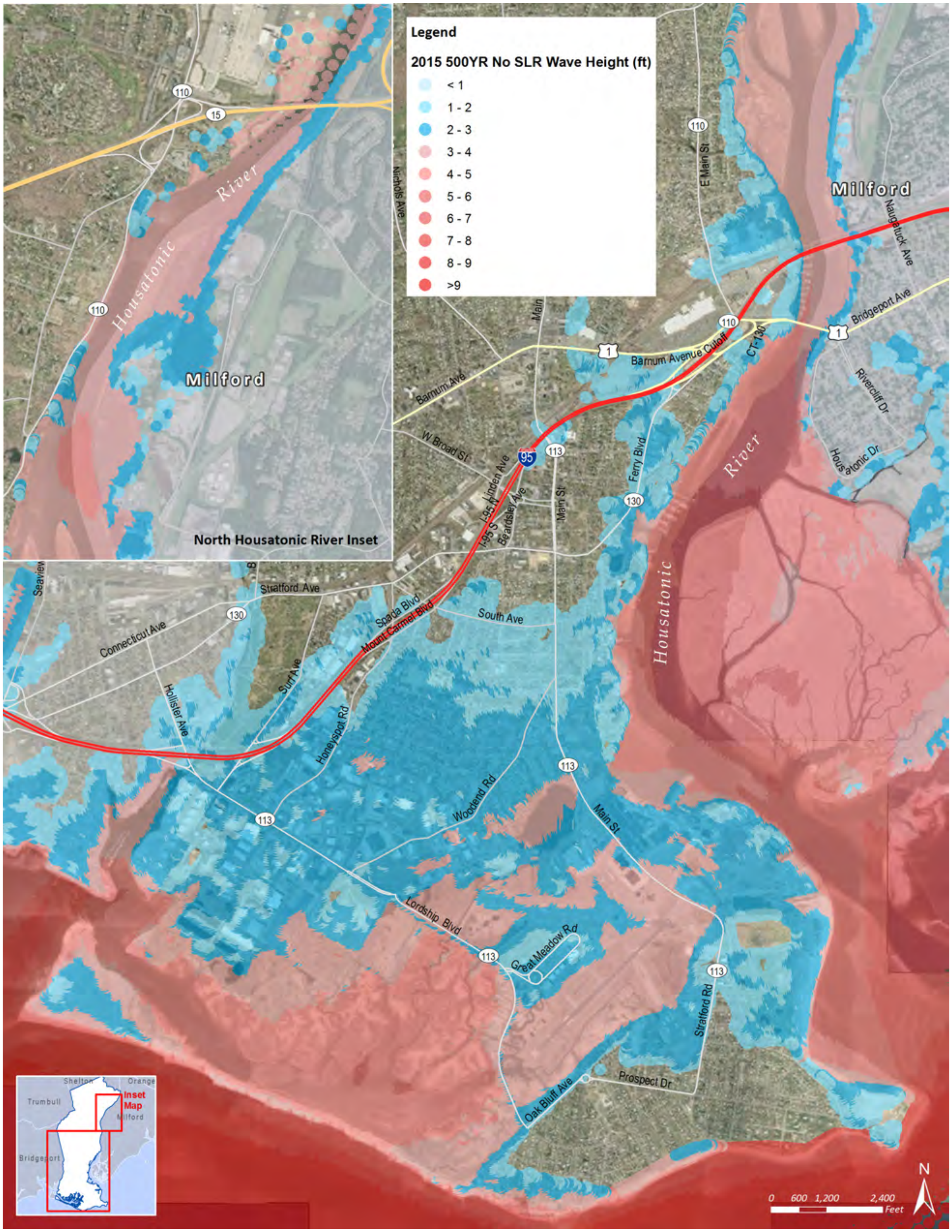


Figure 3.18 GZA Computer Wave Model Year 2015 500-yr Recurrence Interval

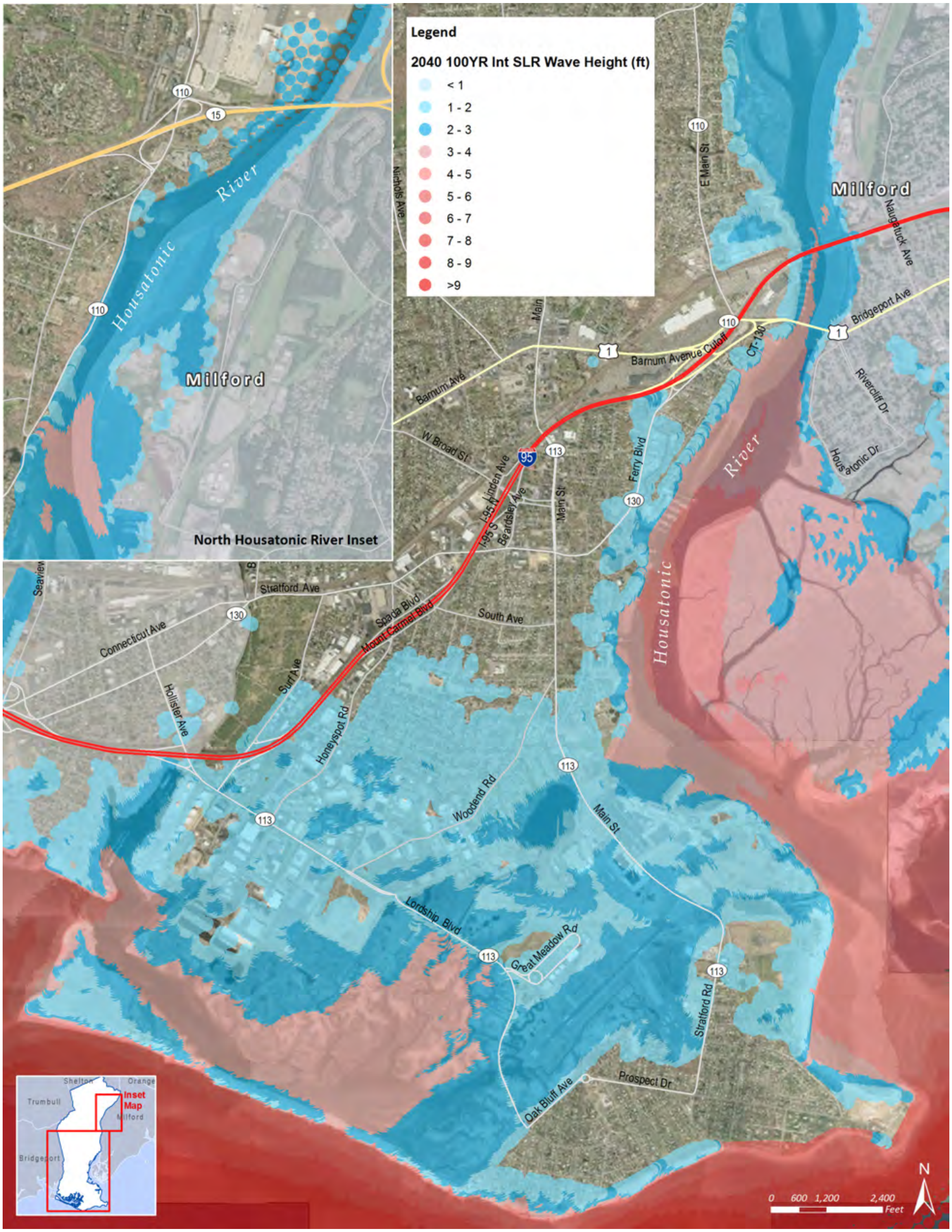


Figure 3.19 GZA Computer Wave Model Year 2040 100-yr Recurrence Interval

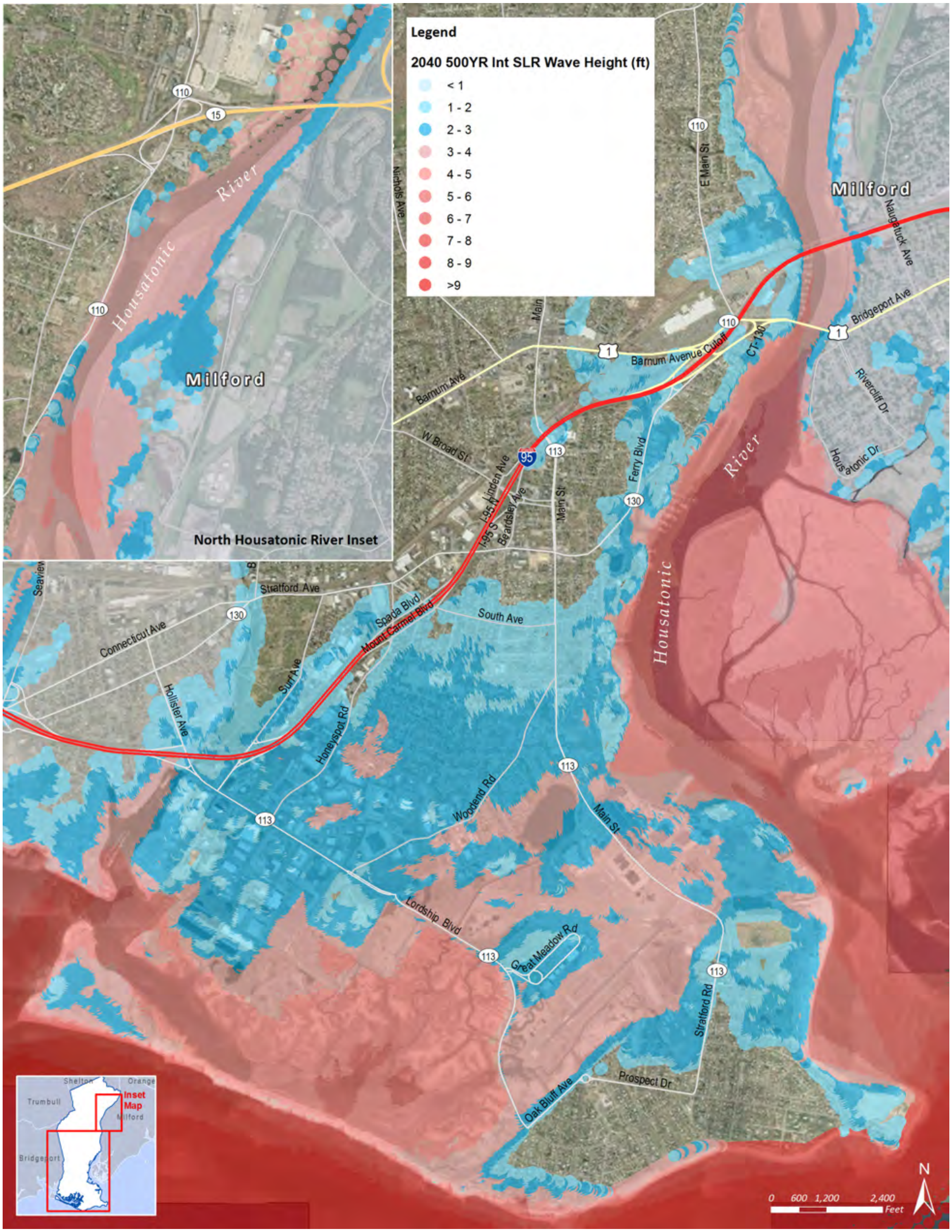


Figure 3.20 GZA Computer Wave Model Year 2040 500-yr Recurrence Interval

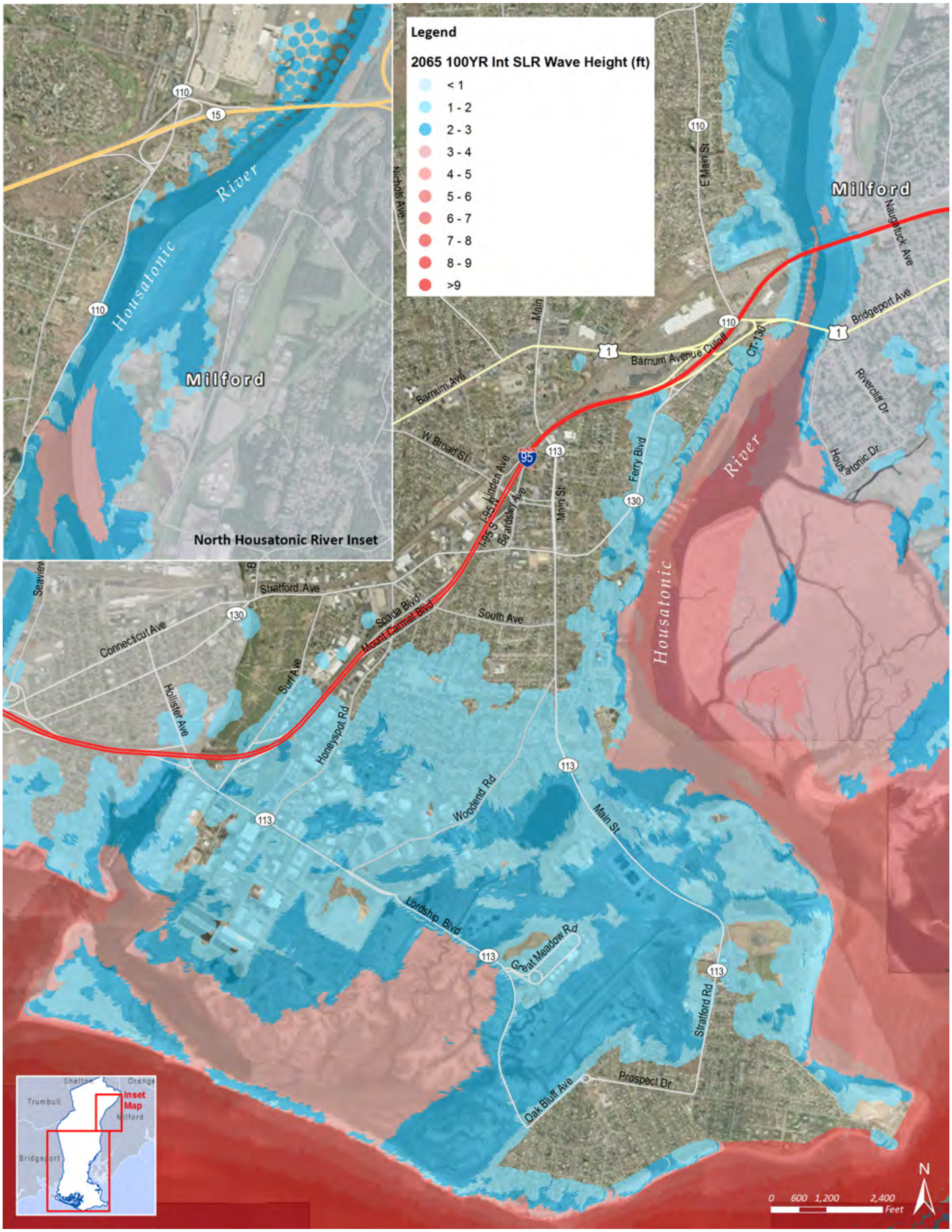


Figure 3.21 GZA Computer Wave Model Year 2065 100-yr Recurrence Interval

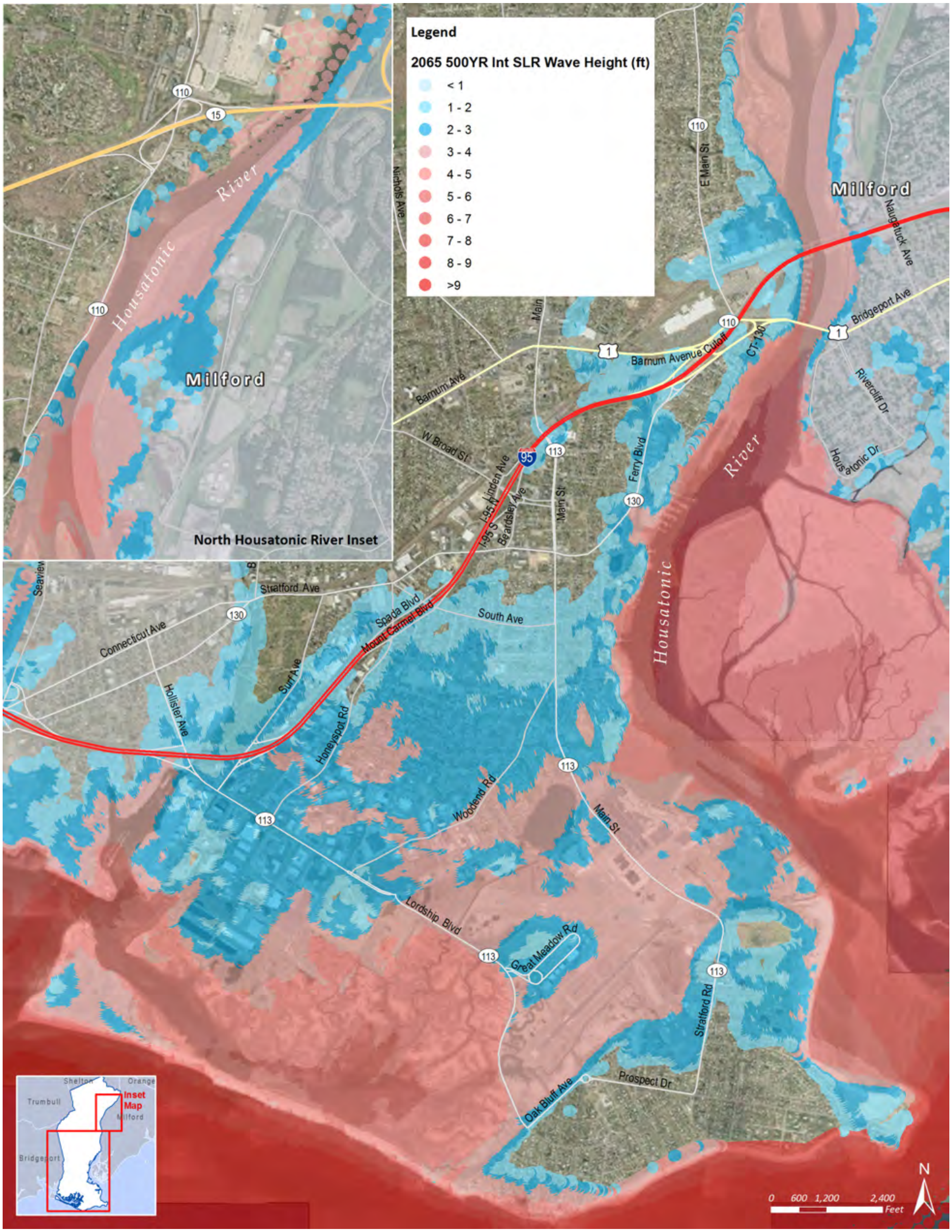


Figure 3.22 GZA Computer Wave Model Year 2065 500-yr Recurrence Interval

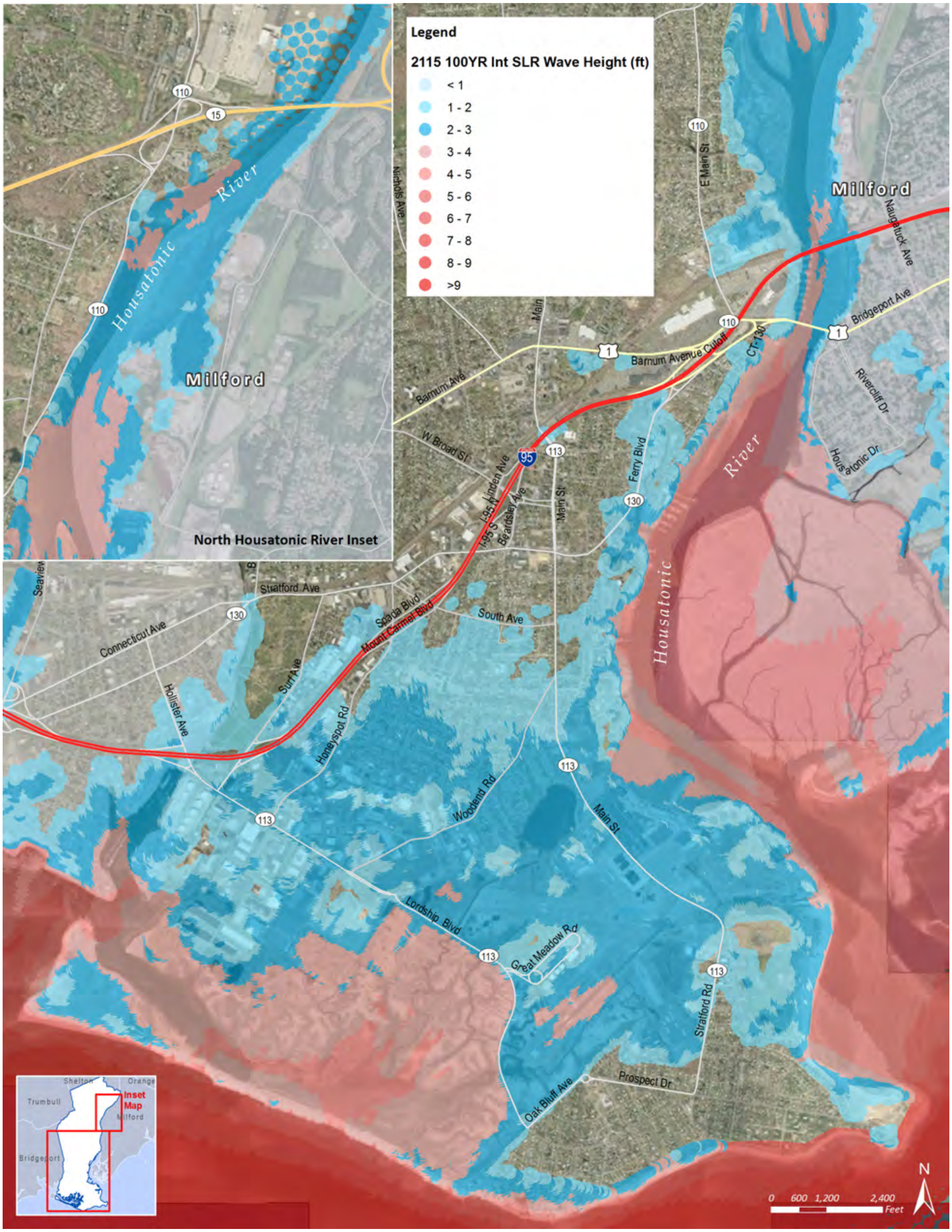


Figure 3.23 GZA Computer Wave Model Year 2115 100-yr Recurrence Interval

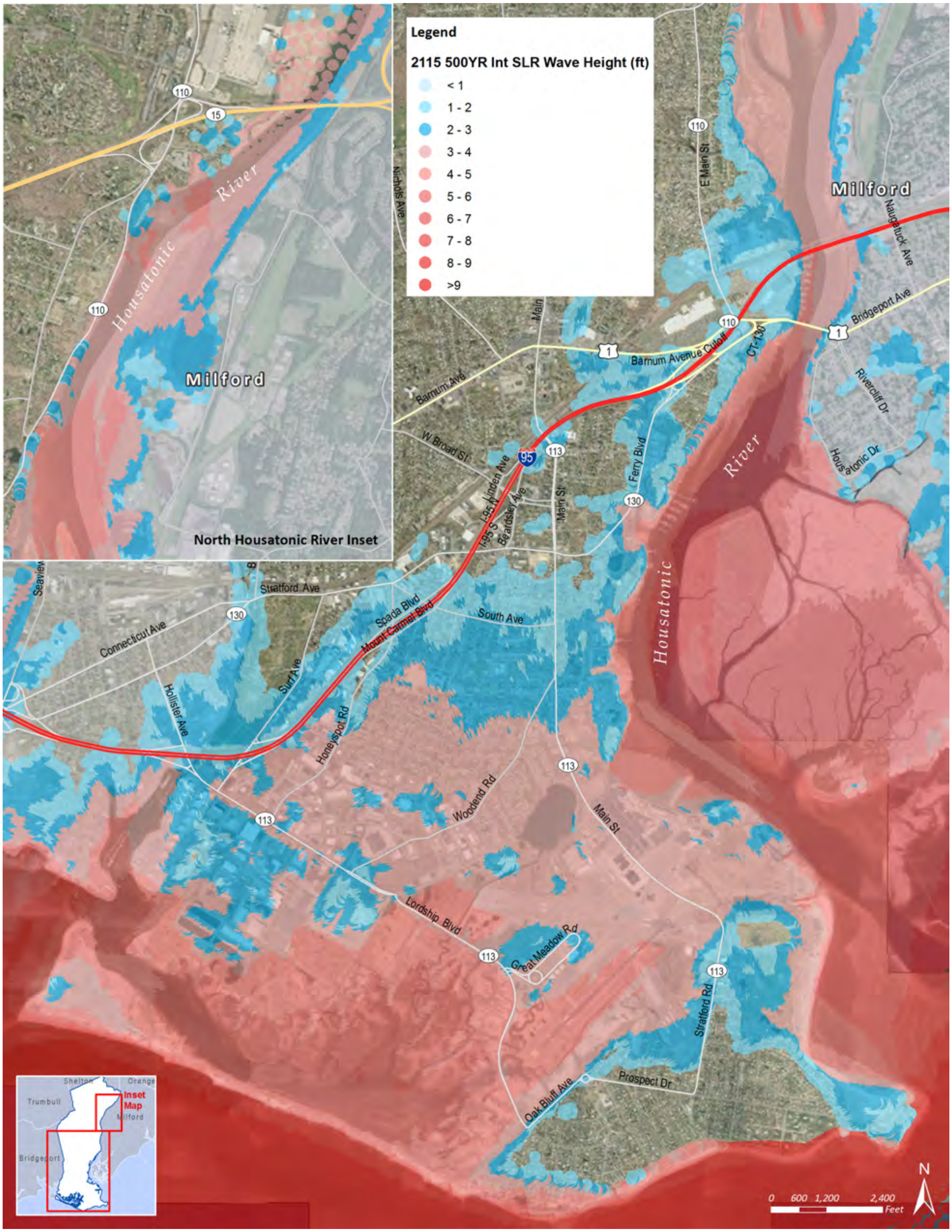


Figure 3.24 GZA Computer Wave Model Year 2115 500-yr Recurrence Interval

4.0 VULNERABILITY AND RISK

Section 3 characterized the coastal flood hazard (tides, storm surge, and waves) within the Town, now and in the future. As demonstrated in Section 3, much of the area south of Interstate 95 is vulnerable to coastal flooding.

This section looks at the Town's risk to these coastal flood hazards; that is, what consequences and effects are predicted to result from coastal flooding now and in the future. This information is important to identify the Town's risk as well as determine the benefit of resiliency actions and projects.

The vulnerability to coastal flooding is characterized in the Plan 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 moderate flood hazard zone; and
- Outside the limits of the 500-year recurrence interval flood are located in a low flood hazard zone.

High flood hazard areas exposed to waves greater than 3 feet in height are located in a "high velocity" zone. Waves of 3 feet and greater height can 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. The risk of building damage within the Limit of Moderate Wave Action is especially high for timber-framed structures, including typical houses.

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

TOWN OVERVIEW

The Town has a land area of about 19 square miles and a population of approximately 51,490 people.

The average age is approximately 43 years. Nearly 8,000 residents are of African American descent, slightly more than 6,500 residents are of Hispanic descent, and more than 1,200 residents are of Asian descent (2009-2013 American Community Survey). More than 9,200 Stratford residents are elderly. Conversely, the size of the younger population (residents 17 years old and younger) is one of the lowest in the region at 10,690 (2009-2013 American Community Survey). There are 20,290 households, representing a population density of about 2,600 people per square mile. Approximately 65% of the households are family households with an average family size of 3.18 people (2009-2013 American Community Survey. The median housing cost is $285,000. The median family income in Stratford is $66,361. More than 15 percent of Stratford households have less than $25,000 in income per year (2009-2013 American Community Survey).

The Town has approximately 21,660 housing units and about 17,380 buildings. More than 80% (16,600 units) of housing is owner-occupied. The median rent for the 3,688 renter-occupied units is $1,133 per month. More than six percent of the housing units are vacant and just shy of one percent of the housing units are in seasonal or recreational (Source: US Census Bureau: 2010 Census and 2009 –2013 American Community Survey).

The vast majority of housing units in Stratford (15,627) were built before 1969. Only 2,599 housing units have been built since 1980. The housing units are largely 1-unit detached and attached; these housing types account for more than 75 percent of the total housing units. Slightly less than eleven percent of housing units are two-unit dwellings and approximately five percent are residential structures containing twenty or more units (2009-2013 American Community Survey). A conservative estimate for the total number of vehicles located at the residential units is 34,958 (2009-2013 American Community Survey). Slightly more than 60 percent of the housing units use natural gas to heat their homes, almost thirty percent use fuel oil or kerosene for heat, and less than seven percent have electric heat (2009-2013 American Community Survey).

TOWN VISION

The 2014 Plan of Conservation and Development (POCD) serves as a guide for future land use and growth through the year 2023, including preserving the natural landscape through a network of greenways that connect neighborhoods as shown in Figure 4.1. There are five distinct planned districts identified in the POCD:

Town Center (TC)

Employment Growth District (EGD)

Housatonic Riverfront

Stratford Greenway Network (SGN)

Environmental and Coastal Preservation (E&CP)

The following presents risk profiles for these planned districts as well as neighborhoods and key Town assets. The risk profiles present the results of GZA computer flood simulations. The flood limits shown here may differ from the effective FEMA Flood Insurance Rate Map (FIRM). The FIRM data (see Figure 3.8) should also be reviewed.

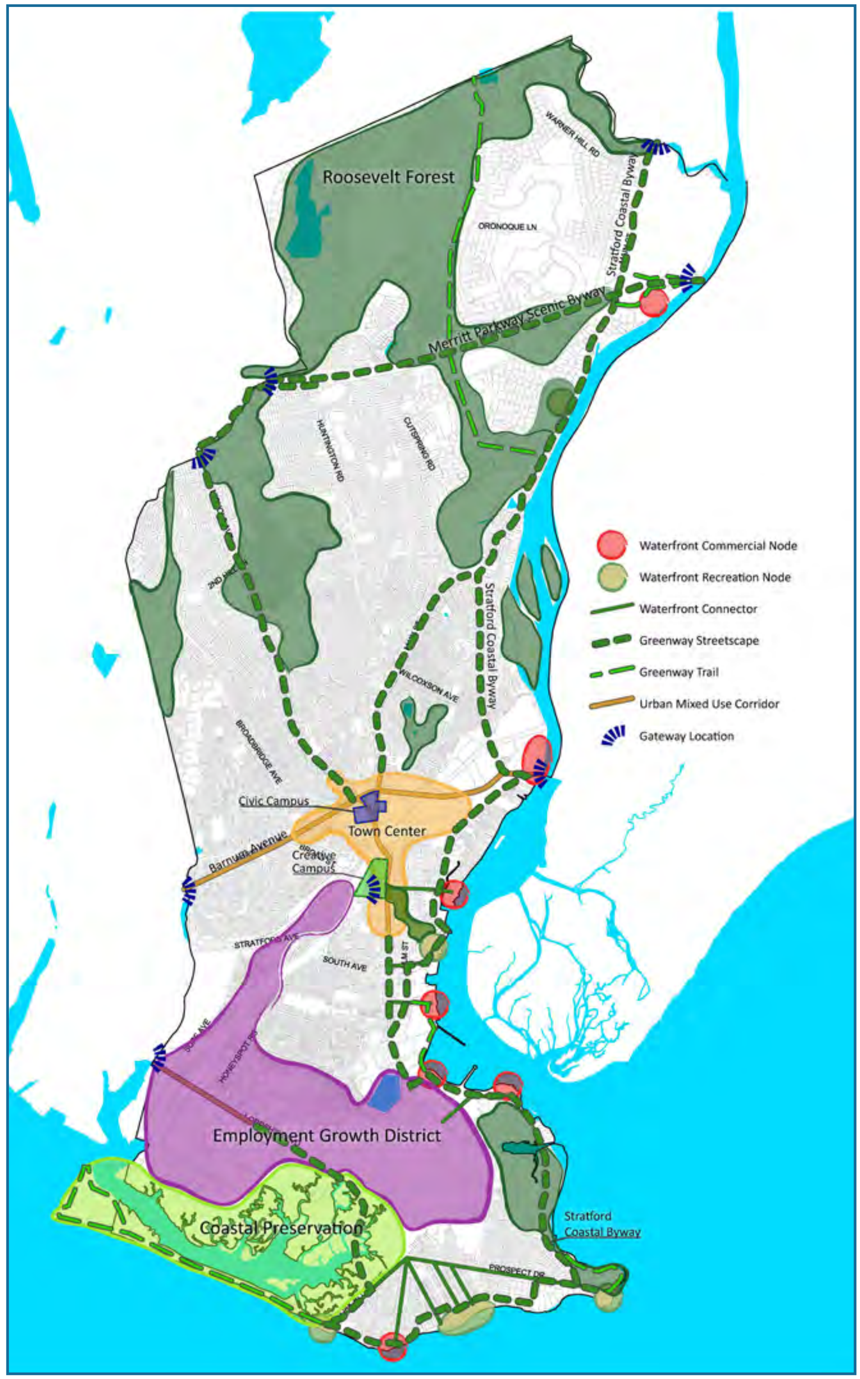


Figure 4.1 Stratford Vision (2014 Plan of Conservation and Development)

COASTAL FLOOD RISK LOSSES

Economic

Disruption of Critical Services

Transportation Disruption

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	LOW	Low
2040	LOW	Low
2065	LOW	Low
2115	LOW	Low

Town Center Flood Risk Profile

The Town Center serves as the urban heart of Stratford and is the home to the Town Hall, Metro-North Transit Station, and a growing commercial and retail center along Main Street. The Stratford POCD envisions building on the recent Transit Oriented Development (TOD) zone with the Town Center serving as the core of commerce for future development, including:

- Civic Campus and Festival Green
- Transit Oriented Development Zone
- Culture and Innovation Campus
- West Broadway Gateway
- Extended Rail Platform
- Rail Platform Parking Structure

The Town Center is located to the north of I-95 and inland from the Housatonic River. Figure 4.2 shows the Town Center relative to the predicted 100-year recurrence interval coastal flood stillwater elevation through the year 2115. Localized areas are within the effective FEMA AE zone. The majority of the Town Center is at high elevation, ranging from Elevations 14 to greater than 30 feet NAVD88, and outside predicted coastal flood zones.

Areas near Ferry Boulevard (along East Broadway) are vulnerable to coastal flooding from storm surge originating at Ferry Creek and overtopping the Broad Street Bridge and roadway. Localized areas north and south of Interstate 95 in the vicinity of Main Street, parallel to Interstate 95 and north of Interstate 95 between California Street and King Street also flood due to a combination of river flooding and coastal flooding (via culverts and underpasses beneath Interstate 95). These areas are located within the effective FEMA FIRM Special Flood Hazard Areas (SFHAs). Risk of loss to the Town Center is expected to be relatively minor.

View of Main Street looking north towards I-95

Figure 4.2 Town Center *(facing page)*


Legend
Town Center
2015 100yr Flood
2040 100yr Flood
2065 100yr Flood
2115 100yr Flood
North Housatonic River Inset
Milford
Housatonic River
Town Center
Barnum Ave
Barnum Avenue Cutoff
Main St
E Main St
Nichols Ave
W Broad St
Linden Ave
Beardsley Ave
Ferry Blvd
CT-130
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
Stratford Ave
Connecticut Ave
Seaview
Hollister Ave
Surf Ave
Spada Blvd
Mount Carmel Blvd
South Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
Shelton
Orange
Trumbull
Milford
Bridgeport
Inset Map
0 600 1,200 2,400 Feet
N

COASTAL FLOOD RISK LOSSES

Transportation Disruption

Disruption of Critical Services

Public Safety

Economic

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

Employment Growth District Flood Risk Profile

The POCD defines the Employment Growth District (EGD) as the mixed use employment corridor along Lordship Boulevard, including Sikorsky Airport, and along Honeyspot Road to Route 95. Table 4.1 presents an overview of the existing development EGD as well as the future development potential for commercial and industrial space and residential units.

	Commercial Space (sf)	Industrial Space (sf)	Residential Units (no. of units)
Existing	858,000	947,000	290
25% Build Out	925,000	4,725,000	610
Full Build Out	3,700,000	18,900,000	2,450

Table 4.1 Existing Development and Development Potential

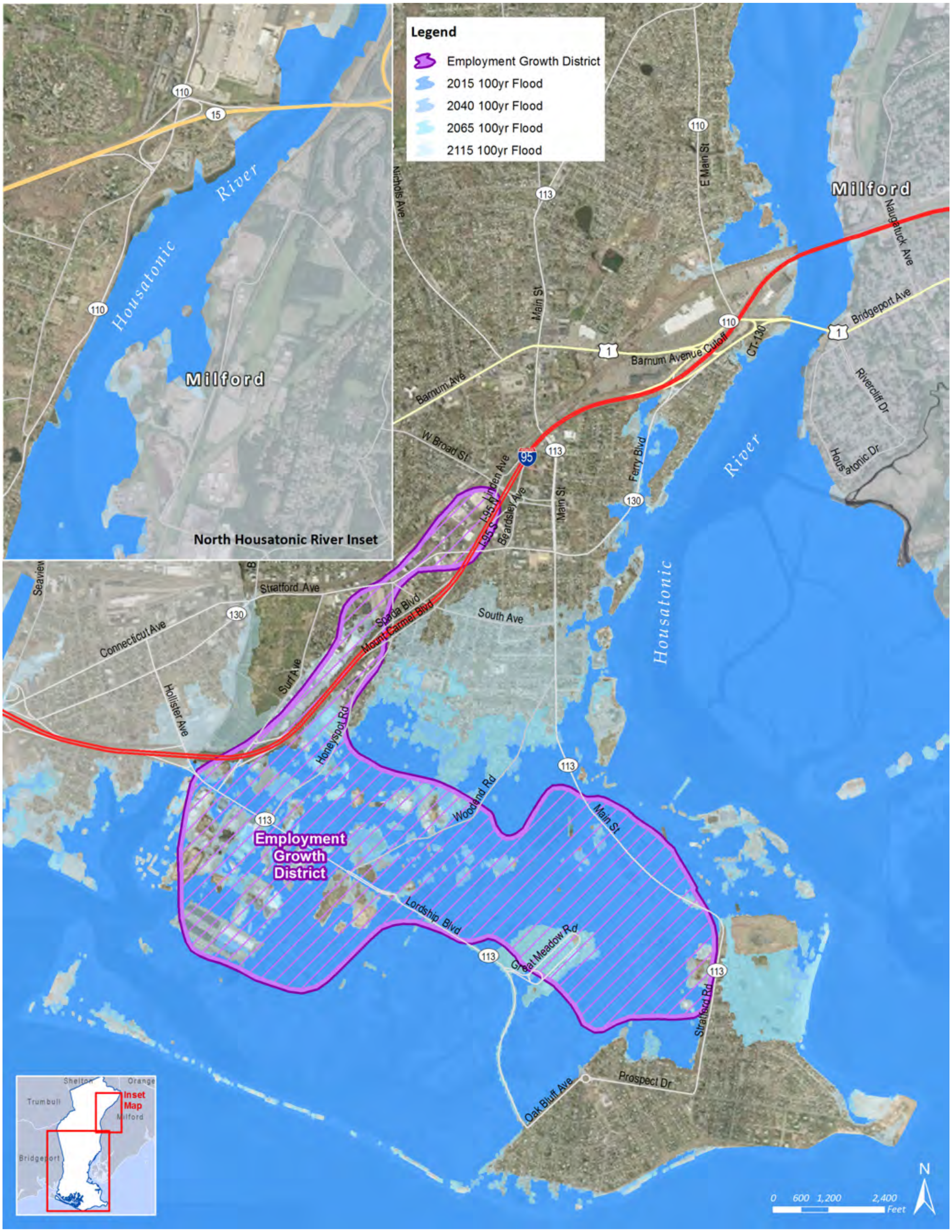
The two key areas outlined in the POCD include are the Lordship Boulevard Employment Growth District and Sikorksy Airport.

Portions of Lordship Boulevard and much of Sikorsky Airport were inundated during Hurricane Sandy. The vulnerability of the EGD was evaluated relative to the current FEMA FIRM Base Flood Elevation and the predicted 100-year recurrence interval coastal floods (stillwater elevation) through the year 2115 (see Figure 4.3). Lordship Boulevard and Sikorsky Airport are highly vulnerable to coastal flooding. Lordship Boulevard and Sikorsky Airport are currently within the effective FEMA Zone AE.

The flood vulnerability is due principally to: 1) flooding from Great Meadows with respect to Lordship Boulevard and 2) floodwaters entering into Sikorsky Airport via the Marine Basin. The effects of coastal flooding will increase due to sea level rise, resulting in increased damage potential especially in consideration of future development along Lordship Boulevard.

Potential losses to the EGD include: 1) direct costs due to existing and future EGD development and content damages; 2) direct costs to aircraft, facilities and content damages at Sikorsky Airport; and 3) indirect costs due to disruption of services. Sikorsky Airport also houses essential facility support such as the police helicopter.

Figure 4.3 Employment Growth District *(facing page)*


Legend
Employment Growth District
2015 100yr Flood
2040 100yr Flood
2065 100yr Flood
2115 100yr Flood
North Housatonic River Inset
Milford
Housatonic River
Employment Growth District
Main St
Lordship Blvd
Great Meadow Rd
Woodland Rd
Honeyspot Rd
Surf Ave
Hollister Ave
Connecticut Ave
Stratford Ave
South Ave
Barnum Ave
Barnum Avenue Cutoff
Bridgeport Ave
Ferry Blvd
Prospect Dr
Oak Bluff Ave
Stratford Rd
Nichols Ave
E Main St
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
W Broad St
Beardsley Ave
Sparta Blvd
Mount Carmel Blvd
Seaview
CT-130
0 600 1,200 2,400 Feet
N
Shelton
Orange
Trumbull
Inset Map
Milford
Bridgeport

Sandy-Impacted Neighborhoods Flood Risk Profile

Stratford is home to many neighborhoods. Three neighborhoods were identified as Sandy-Impacted and vulnerable to future coastal flooding. The vulnerability of the Sandy-Impacted Neighborhoods was evaluated relative to the current FEMA FIRM Base Flood Elevation and the predicted 100-year recurrence interval coastal floods (stillwater elevation) through the year 2115 (see Figure 4.4).

COASTAL FLOOD RISK LOSSES

SOUTH END

The South End is largely residential and includes more than 325 Stratford Housing Authority public housing units (located north of Frash Pond). The entire South End neighborhood is located within the effective FEMA AE Zone. It is low-lying with ground surface elevations ranging from 6 to 10 feet NAVD 88 making the area particularly vulnerable to coastal flooding. The southwest portion of the South End (around Masarik Avenue), which has the lowest neighborhood ground surface elevations, was flooded during Sandy.

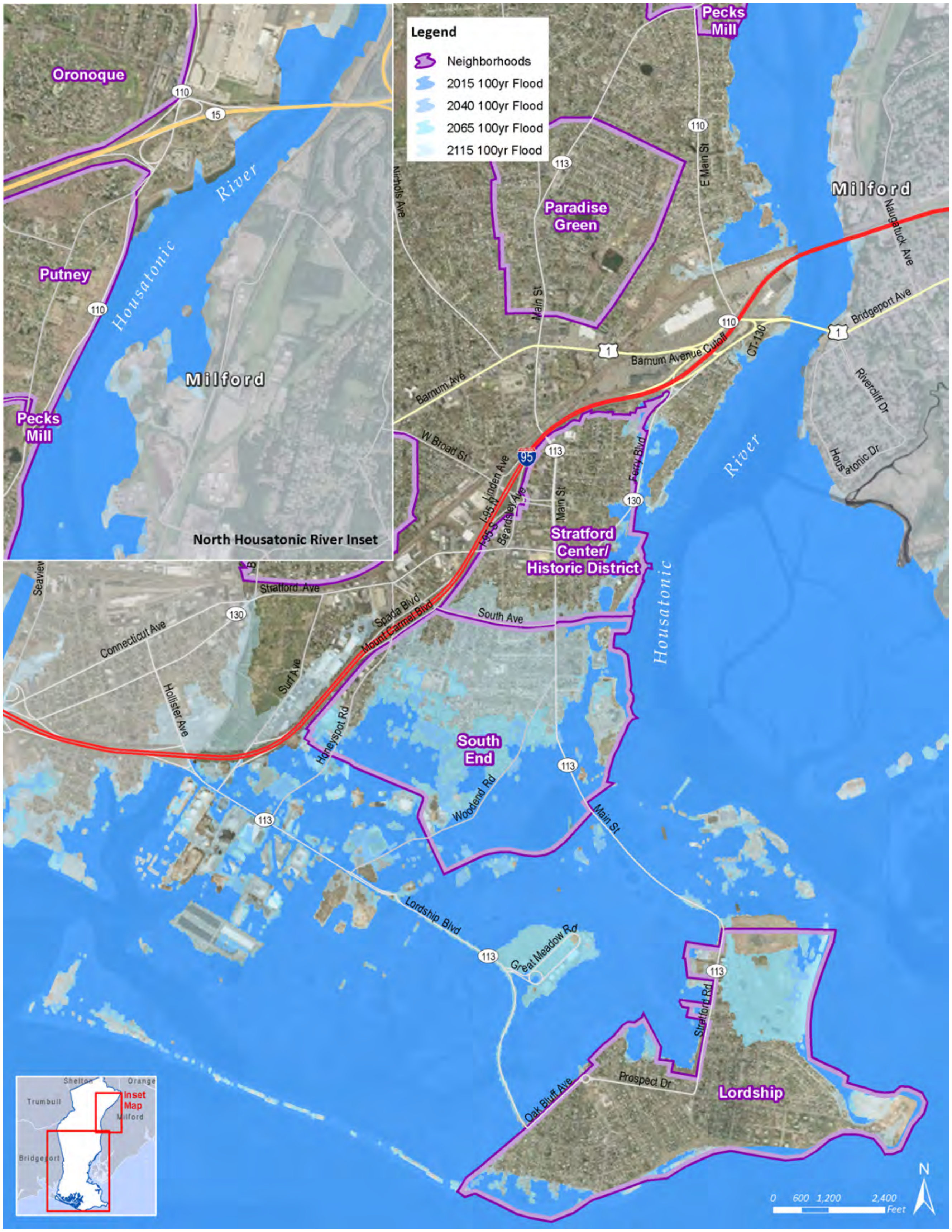
LORDSHIP

Lordship is largely a waterfront residential community separated from the rest of Town by the Great Meadows salt marsh and Sikorsky airport. Most of the homes were built after World War II; infill development has occurred more recently. While most of the Lordship neighborhood is located at high elevation, residences and commercial businesses near the shore are vulnerable to coastal flooding from overtopping of the seawall along Beach Drive and from direct wave action from Long Island Sound. Residences on Long Beach are particularly vulnerable to flooding from direct wave action and are at high risk of repetitive flooding and losses.

STRATFORD CENTER HISTORIC DISTRICT AND ACADEMY HILL

The Stratford Center National Register Historic District (SCHD) is a 300-building historic area to the southeast of I-95 along the Housatonic River. Academy Hill is the central historic residential neighborhood located within the SCHD that is home to many historic homes dating from the late 1600s. In addition, marinas, commercial businesses, residences, and cultural facilities are located within the district. The areas closest to the Housatonic Riverfront (east of Ferry Boulevard), including residences, marinas, and the Stratford Center for the Arts in the SCHD are vulnerable to coastal flooding. The areas along South Avenue are also vulnerable to coastal flooding.

Figure 4.4 Sandy-Impacted Neighborhoods *(facing page)*


Legend
Neighborhoods
2015 100yr Flood
2040 100yr Flood
2065 100yr Flood
2115 100yr Flood
Oronoque
Putney
Pecks Mill
Milford
Housatonic River
North Housatonic River Inset
Paradise Green
Stratford Center/ Historic District
South End
Lordship
Barnum Ave
Barnum Avenue Cutoff
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
E Main St
Main St
Nichols Ave
W Broad St
Linden Ave
Beardsley Ave
Ferry Blvd
Stratford Ave
Connecticut Ave
Hollister Ave
Surf Ave
Spada Blvd
Mount Carmel Blvd
Honeyspot Rd
South Ave
Woodend Rd
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
CT-130
Inset Map
Shelton
Orange
Trumbull
Milford
Bridgeport
0 600 1,200 2,400 Feet
N

Potential losses to the neighborhoods include: 1) direct costs due to residential and commercial structures and content damages; 2) direct costs to vehicles, boats and other recreation vehicles; 3) indirect costs due to disruption of services; and 4) indirect costs associated with delays in emergency response time adversely impacting public safety and health during future hazard events.

SOCIOECONOMIC EFFECTS

The three Sandy-Impacted neighborhoods have significantly different coastal flood risks. The socioeconomic conditions are also significantly different between the three Sandy-Impacted neighborhoods. The South End has the greatest flood risk, today and in the future, due to its vulnerability and predicted economic losses.

Figure 4.5 shows the neighborhood limits relative to the Social Vulnerability Index (SoVi). The SoVi measures the social vulnerability of U.S. counties to environmental hazards. This index synthesizes 29 socioeconomic variables that are predicted to contribute to a reduction in a community's ability to prepare for, respond to, and recover from hazards, including flooding. The data source for Figure 4.5 is the United States Census Bureau.

Figure 4.5 shows SoVi in terms of Low, Medium Low, Medium, Medium High, and High. The three Sandy-Impacted neighborhoods are located in the medium SoVi class; however, it is important to note that the South End has a higher flood vulnerability than the other two neighborhoods.

SOUTH END

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

LORDSHIP*

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	MODERATE	Moderate
2040	MODERATE	Moderate
2065	MODERATE	Moderate
2115	MODERATE	Moderate

HISTORIC DISTRICT AND ACADEMY HILL*

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	MODERATE	Moderate
2040	MODERATE	Moderate
2065	MODERATE	Moderate
2115	HIGH	Moderate

* Flood risk is higher in localized areas

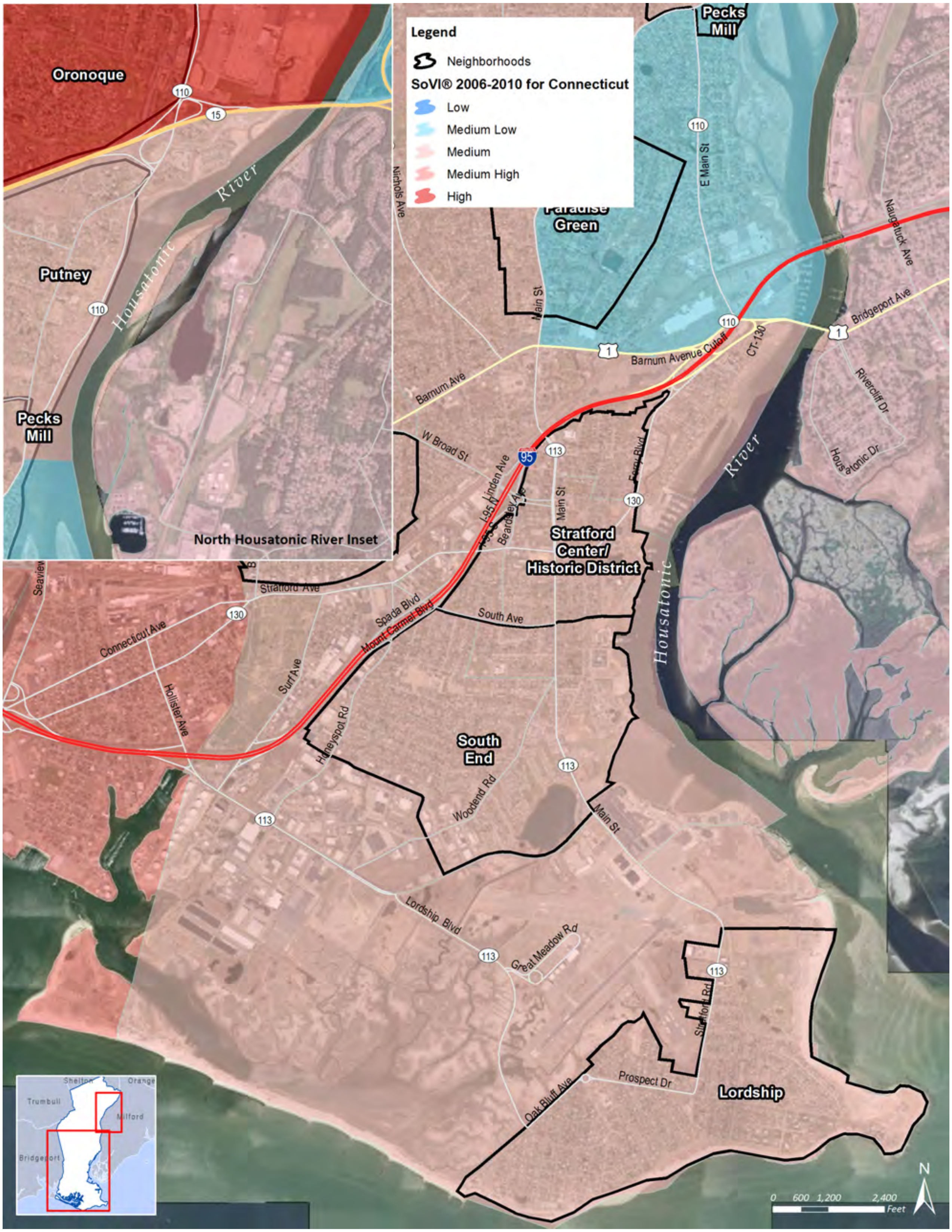


Figure 4.5 Social Vulnerability

Essential Facilities Flood Risk Profile

The Town's Essential Facilities are:

- Four (4) Police Facilities
- Six (6) Fire and Rescue Facilities
- Four (4) Private Healthcare Facilities
- Four (4) Emergency Shelters (Including three schools)
- One (1) Public Works Garage

The main police facility is the Stratford Police Station located at 900 Longbrook Avenue. Ancillary police facilities include the Police Dog Warden, the police boat, and the police helicopter. There are four Town fire stations: Company 1 at 2750 Main Street; Company 2 at 1415 Huntington Road; Company 3 at 20 Prospect Drive; and Company 4 at 200 Oronoque Lane. The Stratford Public Safety Communications Center (SPSCC) is located at Company 1. Emergency Management Services are located at 2712 Main Street. Other fire and rescue services include the fire department boat. No hospitals are located in Stratford. The main hospital (including medivac) servicing the community is Bridgeport Hospital. Private healthcare facilities in Stratford include walk-in care and laboratory services. Three of the schools in Stratford also serve as emergency shelters: Stratford High School, the Harry B. Flood Middle School, and the Frank Scott Bunnell High School. The fourth designated shelter is the Stratford Baldwin Center.

The vulnerability of the Town's Essential Facilities was evaluated relative to the current FEMA FIRM BFE as well as the predicted 500-year recurrence interval coastal floods stillwater elevations through the year 2115 (see Figure 4.6). The primary Essential Facilities for police, fire, and rescue and emergency shelters are located at elevations greater than the projected 500-year recurrence interval flood level. However, there are a number of secondary facilities that are vulnerable to coastal flooding. These facilities are: the police and fire boats; the police helicopter; the Police Dog Warden; the Fire Marine Unit boat; and the Public Works Garage. The Town Garage is potentially vulnerable to coastal flooding starting in 2040. The Town should consider identifying alternate locations for these services during flood emergencies.

In additional to the police, fire, and other municipal services, three private healthcare facilities (including an urgent care provider) are vulnerable to coastal flooding. These three facilities are all located in the Employment Growth District.

COASTAL FLOOD RISK LOSSES

Economic

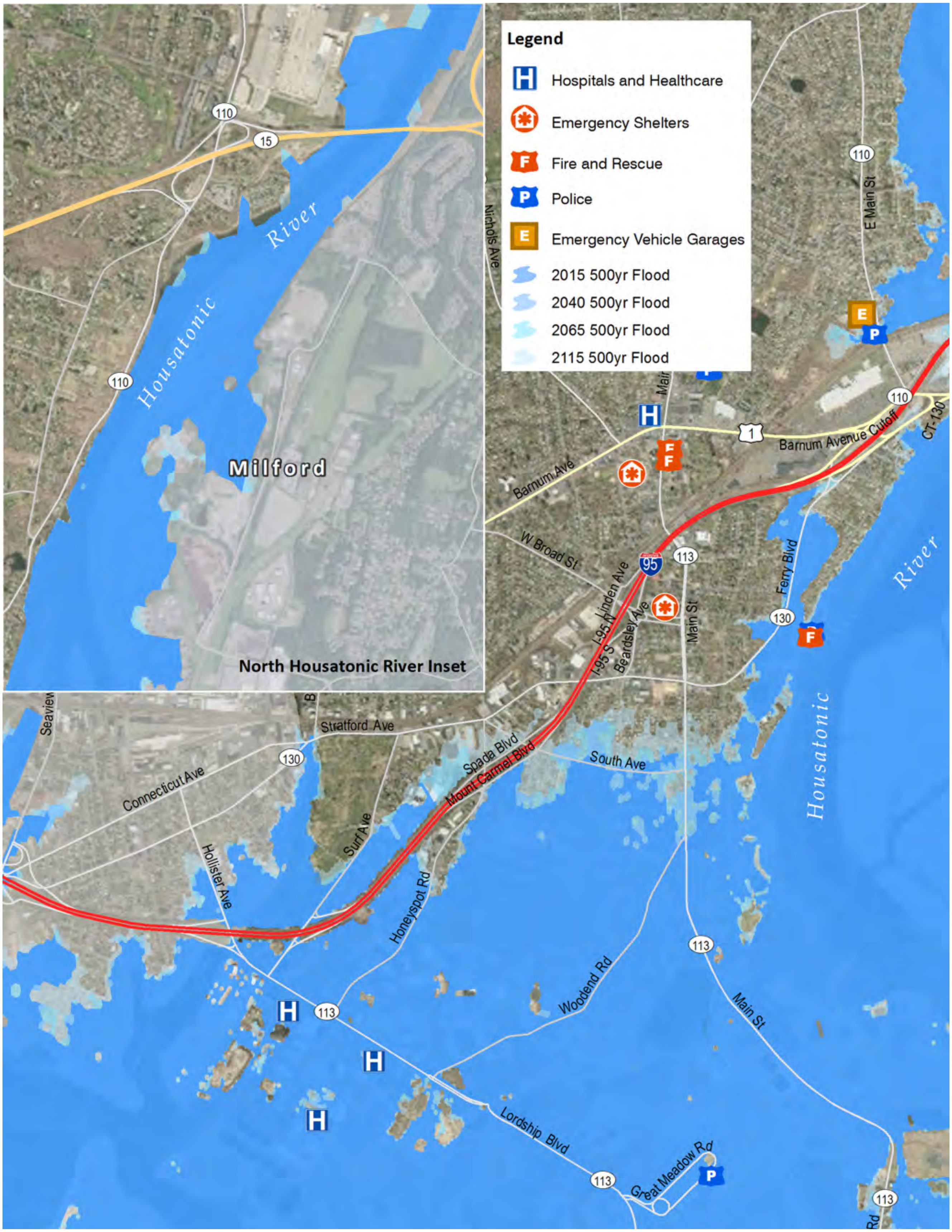
Disruption of Critical Services

Public Safety

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	LOW	Low
2040	LOW	Low
2065	LOW	Low
2115	LOW	Low

Figure 4.6 Essential Facilities *(facing page)*


Legend
Hospitals and Healthcare
Emergency Shelters
Fire and Rescue
Police
Emergency Vehicle Garages
2015 500yr Flood
2040 500yr Flood
2065 500yr Flood
2115 500yr Flood
Housatonic River
Milford
North Housatonic River Inset
Nichols Ave
E Main St
Barnum Ave
Barnum Avenue Cutoff
CT-130
W Broad St
Linden Ave
Beardsley Ave
Main St
Ferry Blvd
Stratford Ave
Connecticut Ave
Seaview
Hollister Ave
Surf Ave
Spada Blvd
Mount Carmel Blvd
South Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
I-95 N
I-95 S

COASTAL FLOOD RISK LOSSES

Disruption of Critical Services

Economic

Loss of Natural Resources

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

Lifeline Facilities: Sanitary Sewer Flood Risk Profile

The majority of Town residents and businesses are serviced by the sanitary sewer system, which includes:

- Stratford Water Pollution Control Facility (WWCF)
- 12 Sanitary Pump Stations
- 170 Miles of Collector Sewers
- 5 Miles of Force Main
- 20 Miles of Trunk Sewers and Interceptors
- 4,500 Manholes
- 20 Brook and Stream Crossings

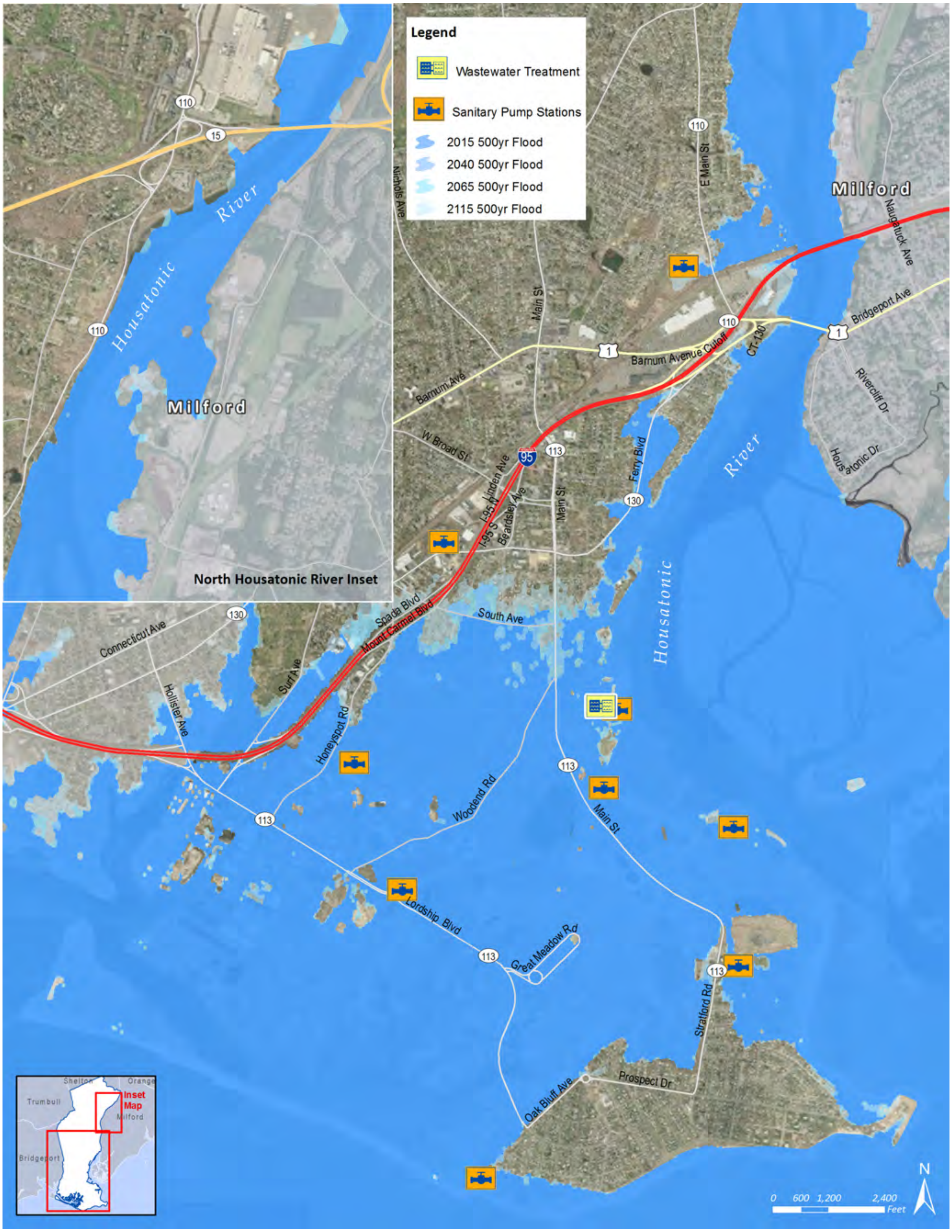
The design flow rate for the Stratford WWCF is 11.5 million gallons of sewage per day (MGD), with average daily flow of 8.5 MGD and a peak flow of 39 MGD. It is operated 24 hours per day, 7 days per week. The processed wastewater is released into the Housatonic River. The WWCF recently underwent a $62M upgrade.

The vulnerability of the Stratford sanitary sewer system was evaluated relative to the current FEMA FIRM BFE and the predicted 500-year recurrence interval coastal floods (stillwater elevation) through the year 2115 (Figure 4.7). The WWCF itself as well as six of the sanitary sewer pump stations are vulnerable to coastal flooding. The WWCF, which abuts the Housatonic River, is partially protected from coastal flooding with an existing levee (levee crest elevation 10 to 11 feet NAVD88) that surrounds approximately 80 percent of the perimeter of the facility. The WWCF's flood vulnerability is principally due to flood elevations exceeding the levee crest elevation and floodwaters entering into the site via low-lying facility entrances and egresses.

The effects of coastal flooding will increase due to sea level rise, resulting in increased damage potential as well as an additional pump station becoming vulnerable. An additional two sanitary pump stations are vulnerable to river flooding (which could occur coincidently with a coastal flood event).

Potential losses to the sanitary system include: 1) direct costs due to facility and content damages; 2) indirect costs due to disruption of services; and 3) direct and indirect costs associated with an uncontrolled effluent release to the Housatonic River. Both the flood hazard vulnerability and hazard consequences are high, resulting in a High Flood Risk and High Project Priority.

Figure 4.7 Lifeline Facilities: Sanitary Sewer *(facing page)*


Legend
Wastewater Treatment
Sanitary Pump Stations
2015 500yr Flood
2040 500yr Flood
2065 500yr Flood
2115 500yr Flood
North Housatonic River Inset
Housatonic River
Milford
Nichols Ave
E Main St
Main St
Naugatuck Ave
Bridgeport Ave
Barnum Avenue Cutoff
CT-130
Barnum Ave
Rivercliff Dr
Housatonic Dr
W Broad St
Linden Ave
Beardsley Ave
Ferry Blvd
Connecticut Ave
Spada Blvd
Mount Carmel Blvd
South Ave
Surf Ave
Hollister Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
Inset Map
Shelton
Orange
Trumbull
Milford
Bridgeport
0 600 1,200 2,400 Feet
N

COASTAL FLOOD RISK LOSSES

Disruption of Critical Services | Loss of Natural Resources | Economic

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

Lifeline Facilities:

Stormwater Management & Tide Gates Flood Risk Profile

STORMWATER MANAGEMENT

Stormwater runoff is managed through a network of catch basins, manholes, underground piping, and several pump stations. The stormwater management system is owned and operated by the Town and currently includes:

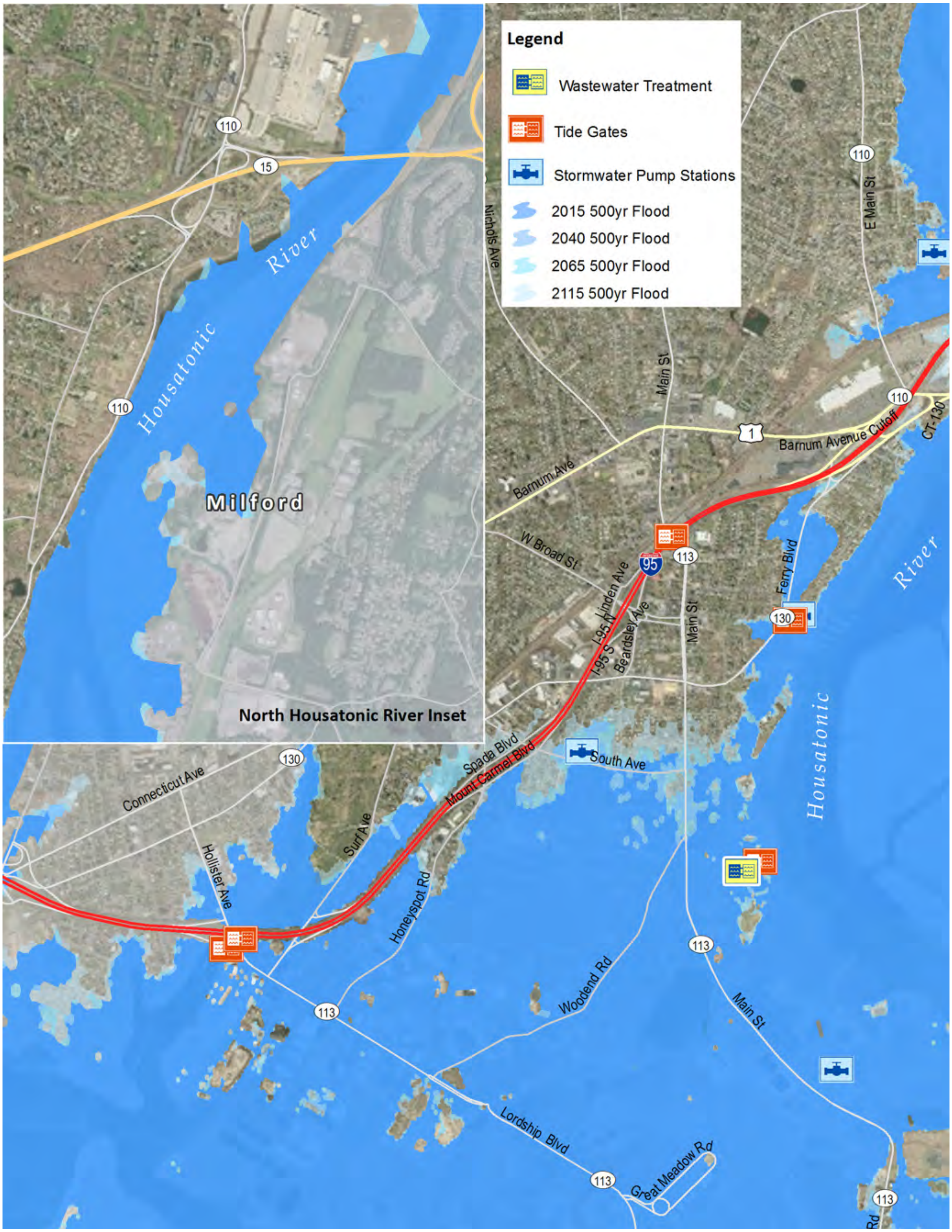
- 3 Stormwater Pump Stations (a fourth is planned for by the Town)
- 5,000 Stormwater Catch Basins
- 4,500 Stormwater Manholes
- Stormwater piping
- Tide Gates

The stormwater piping system discharges via drainage outfalls to the Housatonic River, Long Island Sound, and other local waterways. Outfalls that are constructed without backflow preventers or tide gates will become surcharged during astronomical high tides and coastal flood events. While the stormwater management system is not expected to drain during coastal flood events, it is important that it 1) does not create a source of localized flooding due to surcharged catch basins and manholes and 2) needs to be operable immediately after a 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. Several of the pump stations are also vulnerable to damage during coastal flood events due to the elevation of their equipment.

TIDE GATES

Tide gates are essential to prevent tide waters from backflowing into flood vulnerable areas. There are seven operational tide gates in Stratford that are owned and operated by various entities including the Town and State. The tide gates are critical components to mitigating coastal flooding. However, several of the tide gates are not currently functional. The effectiveness of existing tide gates will also be reduced in the future due to sea level rise (resulting in flood elevations exceeding the tide gate crest elevation.

Figure 4.8 Lifeline Facilities: Stormwater Management and Tide Gates *(facing page)*


Legend
Wastewater Treatment
Tide Gates
Stormwater Pump Stations
2015 500yr Flood
2040 500yr Flood
2065 500yr Flood
2115 500yr Flood
Housatonic River
Milford
North Housatonic River Inset
Barnum Ave
Barnum Avenue Cutoff
W Broad St
Linden Ave
Beardsley Ave
Main St
E Main St
Nichols Ave
Ferry Blvd
South Ave
Spada Blvd
Mount Carmel Blvd
Connecticut Ave
Hollister Ave
Surf Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
CT-130
I-95 N
I-95 S

The locations of the tide gates and pump stations are shown relative to the predicted 500-year recurrence interval coastal flooding stillwater elevation through the year 2115 are shown in Figure 4.8.

The flood vulnerability and risk to the tide gates and stormwater management system is High. Potential losses due to the stormwater management system include 1) direct costs due to infrastructure damages and 2) indirect costs due to property and contents damages from non-functioning pumping stations and tide gates.

Essential Services:
Stratford Emergency Medical Services Building

Lifeline Facilities: Sanitary Sewer
Stratford Water Pollution Control Facility
(Credit: CTPOST)

Lifeline Facilities: Electricity Transmission
Baird Electric Substation (Credit: Google Earth 11/2015)

Hazardous Materials Facilities
Stratford Army Engine Plant
(Credit: Hearst CT News 2013)

Lifeline Facilities:
Electricity Transmission Flood Risk Profile

COASTAL FLOOD RISK LOSSES

Disruption of Critical Services

Public Safety

Economic

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	LOW	Low
2040	LOW	Low
2065	HIGH	High
2115	HIGH	High

Power generation occurs from power plants located outside the Town's limits and is distributed to the Town by the United Illuminating Company (UI), principally via overhead transmission lines and several electricity substations:

- 70+ Above-Ground Transmission Towers
- 3 Electricity Substations
  - Baird
  - Barnum
  - Chestnut

Stratford's major electricity substations are: Baird Substation at 1770 Stratford Avenue, Barnum Substation at the intersection of Barnum Avenue Cutoff and the railway tracks near 725 Barnum Avenue, and Chestnut Substation at Chestnut Street near Sikorsky Airport. Chestnut Substation is a small substation and its vulnerability was not evaluated. The vulnerability of Stratford's electrical substations was evaluated relative to the current FEMA FIRM BFE and the predicted 500-year recurrence interval coastal floods (stillwater elevation) through the year 2115 (Figure 4.9). The Baird electrical substation currently has a Low coastal flood hazard risk, but may be vulnerable to flooding by the year 2065 under the High SLR prediction. The Barnum Substation, located north of I-95, also has a Low coastal flood hazard risk. However, this substation is located just outside of the current FEMA FIRM 500-year return flood zone. The substation is located near the northern reach of Ferry Creek, in an area where the waterway is channeled through a series of drain pipes and culverts beneath I-95, parking lots, and the rail line. Future coastal flooding at this substation is difficult to predict with GZA's flood models; however, it is expected to become susceptible to flooding for the 500-year return period by (or before) the year 2065.

The above-ground transmission towers are not highly vulnerable to flood damage. However, electrical service within Stratford can still be disrupted due to impacts to power generation facilities located outside of the Town.

Potential losses to the electrical substations are: 1) direct costs due to facility and content damages, 2) indirect costs due to disruption of services, and 3) public safety concerns due to the disruption of services.

Figure 4.9 Lifeline Facilities: Electricity Transmission *(facing page)*

Legend
Electric Power Generation
Electric Substation
2015 500yr Flood
2040 500yr Flood
2065 500yr Flood
2115 500yr Flood
North Housatonic River Inset
Housatonic River
Milford
Inset Map
Shelton
Orange
Trumbull
Milford
Bridgeport
Barnum Avenue Cutoff
Barnum Ave
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
W Broad St
Linden Ave
Beardsley Ave
Main St
E Main St
Nichols Ave
Ferry Blvd
CT-130
Stratford Ave
Connecticut Ave
South Ave
Spada Blvd
Mount Carmel Blvd
Surf Ave
Hollister Ave
Seaview
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
0 600 1,200 2,400 Feet
N

Hazardous Materials Facilities Flood Risk Profile

Hazardous waste facilities in Town include thirteen (13) sites identified by the Environmental Protection Agency (EPA) as HazMat Category IV Facilities, including:

- Stratford Army Engine Plant (SAEP)
- Beacon Point Landfill
- Raymark Industries
- Raybestos Memorial Field Parking Area
- Housatonic Boat Club
- Reynolds Aluminum Building Products Company
- Sprague Oil Facility (Bulk Oil Storage Facility)

The vulnerability and risk of each Hazardous Materials Facility was not evaluated as part of this Plan. The locations of the hazardous materials facilities in Stratford is shown relative to the current FEMA FIRM BFE and the predicted 500-year recurrence interval coastal flooding stillwater elevation through the year 2115 in Figure 4.10. Most of the facilities are located within flood hazard zones. Animal shleters were also included becuase these facilites are often repositories for hazardous waste. The SAEP will be the focus of this flood risk profile as presented below.

STRATFORD ARMY ENGINE PLANT

The 2014 POCD envisions the future redevelopment of the SAEP on the Housatonic River as a key mixed use development providing residential and employment opportunities as well as recreational facilities. The existing Army Engine Plant fronts the Housatonic River and is planned to be redeveloped into a mix of commercial, mixed-use, and mid-rise residential properties with connections to the Town's greenway system. The SAEP flood vulnerability is due principally to 1) flood elevations exceeding the levee crest elevation and 2) floodwaters entering into the site from the south via the Marine Basin tidal inlet. The effects of coastal flooding will increase due to sea level rise, resulting in increased damage potential; future development will increase the damage potential and make the area even more vulnerable than it is today.

COASTAL FLOOD RISK LOSSES

Economic | Loss of Natural Resources | Public Safety

SAEP COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

Figure 4.10 Hazardous Materials Facilities *(facing page)*


Legend
HazMat Facilites Cat IV
Animal Shelters
2015 500yr Flood
2040 500yr Flood
2065 500yr Flood
2115 500yr Flood
North Housatonic River Inset
Milford
Housatonic River
Stratford Ave
Connecticut Ave
Hollister Ave
Surf Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
Oak Bluff Ave
Prospect Dr
Stratford Rd
Main St
South Ave
Ferry Blvd
Barnum Ave
Barnum Avenue Cutoff
W Broad St
Nichols Ave
E Main St
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
Linden Ave
Beardsley Ave
Seaview
Feet

COASTAL FLOOD RISK LOSSES

Economic

Transportation Disruption

Public Safety

Transportation Flood Risk Profile

The major transportation systems in Stratford include the primary State and local roadways, Interstate 95, the rail lines, bus facilities, and the public airport. The following list provides an inventory of major transportation assets and infrastructure:

- Interstate 95
- Amtrak Rail Line
- Metro-North Transit Station
- Sikorsky Memorial Airport
- CT Routes 1, 110, 113 (Main Street), and 130 (Stratford Avenue)
- Lordship Boulevard
- Access Roads
- Surf Avenue (ramps to I-95)
- Honeyspot Road (ramps to I-95)
- West Broad Street (ramps to I-95)

The major Stratford transportation systems are shown relative to the current FEMA FIRM BFE and the predicted 500-year recurrence interval coastal flooding stillwater elevation through the year 2115 (Figure 4.11).

INTERSTATE 95

The Interstate 95 roadway itself is at a relatively high elevation and is not vulnerable to coastal flooding. However, many of the I-95 underpasses (Main Street, South Avenue, Honeyspot Road, Metro-North spur, Stagg Street, Surf Avenue, and Hollister Avenue) are predicted to flood during coastal flood events, restricting access and potentially resulting in road damage. Coastal flooding of the Surf Avenue ramps and sections of Honeyspot Road would restrict on and off access to I-95.

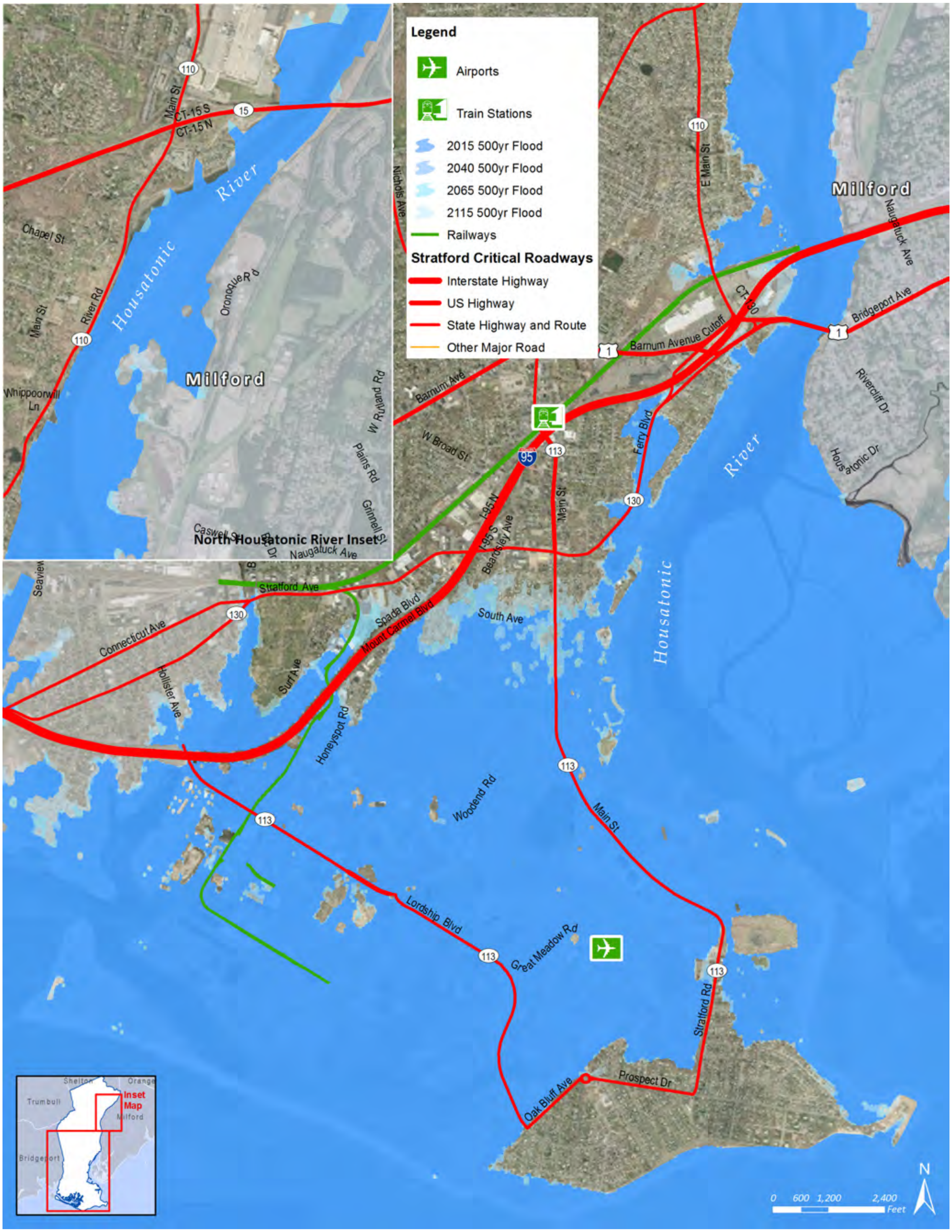
AMTRAK AND METRO-NORTH

The Amtrak Rail lines, including the Metro-North Transit Station, are at a relatively high elevation and are not vulnerable to coastal flooding. The Metro-North spur that extends to the Employment Growth District is highly vulnerable to coastal flooding.

SIKORKSY MEMORIAL AIRPORT

Sikorksy Memorial Airport is a public airport owned by the City of Bridgeport and is therefore not a Stratford Town asset as it is not under Stratford's jurisdiction. The airport is highly vulnerable to coastal flooding, primarily via the Marine Basin tidal inlet and secondarily via Great Meadows.

Figure 4.11 Transportation *(facing page)*



Legend
Airports
Train Stations
2015 500yr Flood
2040 500yr Flood
2065 500yr Flood
2115 500yr Flood
Railways
Stratford Critical Roadways
Interstate Highway
US Highway
State Highway and Route
Other Major Road
North Housatonic River Inset
Housatonic River
Milford
Main St
River Rd
Chapel St
Whippoorwill Ln
CT-15 S
CT-15 N
Oronoque Rd
W Rutland Rd
Plains Rd
Grinnell St
Caswell St
Naugatuck Ave
Nichols Ave
E Main St
Bridgeport Ave
Barnum Avenue Cutoff
Barnum Ave
W Broad St
Ferry Blvd
Rivercliff Dr
Housatonic Dr
I-95 N
I-95 S
Beardsley Ave
Stratford Ave
Connecticut Ave
Hollister Ave
Seaview
Surf Ave
Spada Blvd
Mount Carmel Blvd
South Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
Shelton
Trumbull
Orange
Inset Map
Milford
Bridgeport
0 600 1,200 2,400 Feet
N

CT ROUTES AND PRIMARY LOCAL ROADS

Portions of CT Route 113 along Lordship Boulevard in the Employment Growth District and Stratford Road / Main Street bordering the Sikorsky Airport experienced roadway flooding during Hurricane Sandy. All of the CT routes and primary local roads listed on Page 105 are vulnerable to coastal flooding. The Durham School Services bus lot is located adjacent to the airport in an area that is highly vulnerable to coastal flooding.

The effects of coastal flooding will increase due to sea level rise, resulting in increased damage potential to the airport. Additionally, there will be longer stretches of roadways that will be affected by coastal flooding; this will particularly impact roadways that provide access to the Lordship and South End neighborhoods as well as the Employment Growth District.

Potential losses to the transportation system are: 1) direct costs due to roadways, airport facilities, and content damages, 2) indirect costs due to the disruption of services, and 3) indirect costs associated with delays in emergency response time adversely impacting public safety and health during future hazard events.

INTERSTATE 95 AND AMTRAK / METRO-NORTH

EXCEPT METRO-NORTH SPUR)

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	LOW	Low
2040	LOW	Low
2065	LOW	Low
2115	LOW	Low

SIKORSKY MEMORIAL AIRPORT

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

CT ROUTES AND PRIMARY LOCAL ROADS

COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

Surf Avenue Underpass


Amtrak and Metro-North Rail Lines


Interstate 95

COASTAL FLOOD RISK LOSSES

Transportation Disruption

Economic

Disruption of Critical Services

Support, High Occupancy, and Vulnerable Populations Facilities Flood Risk Profile

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

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

SAEP COASTAL FLOOD RISK HAZARD PROFILE

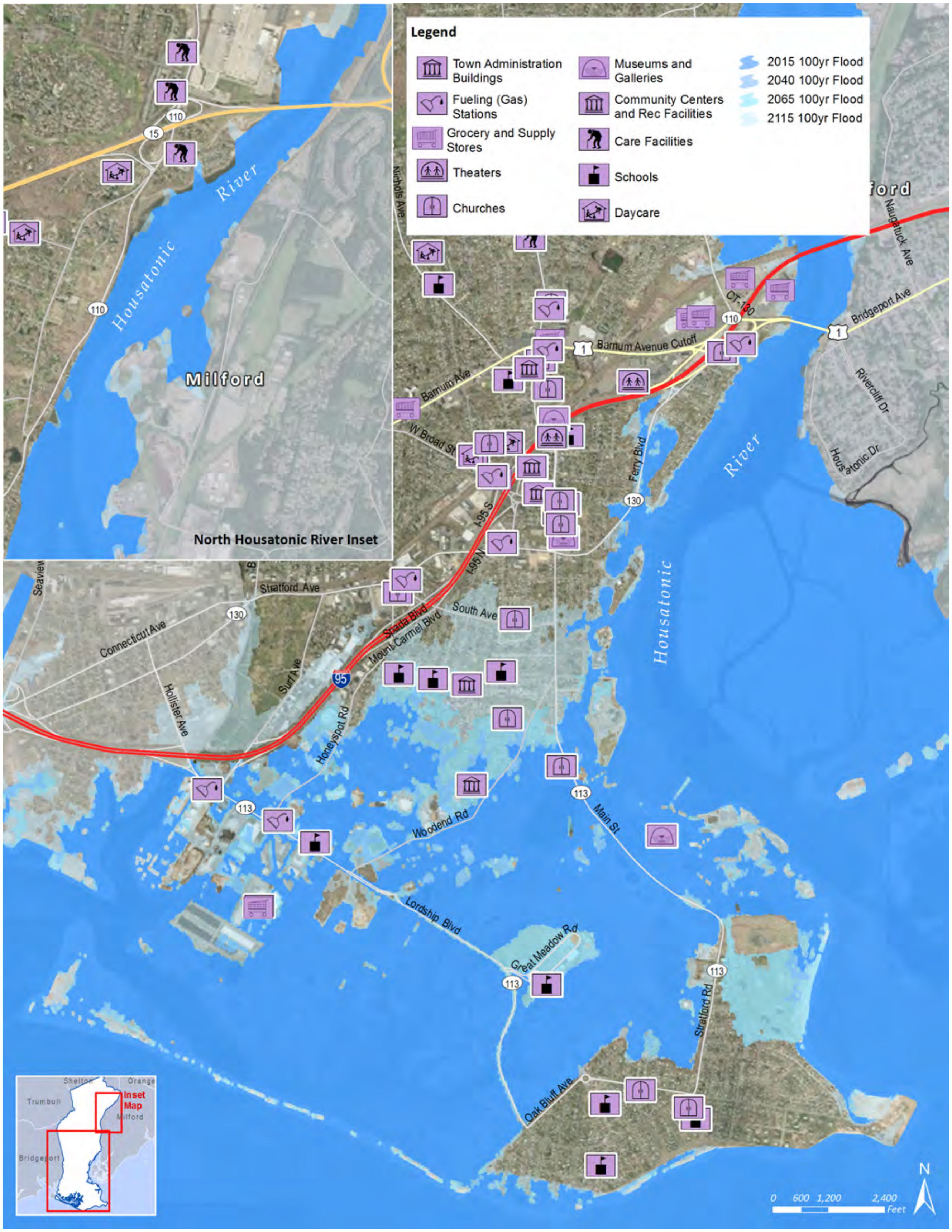
	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

The key SHOVPFs that are at risk to coastal flooding include six (6) schools, three (3) town administration buildings, three (3) religious facilities, two (2) gas stations, and one (1) grocery supply store.

The vulnerability of the Stratford SHOVPFs was evaluated relative to the current FEMA FIRM BFE and the predicted 100-year recurrence interval coastal floods (stillwater elevation) through the year 2115 (see Figure 4.12). A majority of the SHOVPFs in Stratford are located at higher elevations outside predicted coastal flood zones; however, there are fifteen (15) SHOVPFs located at elevations that are below the current FEMA FIRM BFE. These fifteen (15) assets are all in highly vulnerable areas to coastal flooding that include the South End Neighborhood along Lordship Boulevard in the Employment Growth District and at or adjacent to the Sikorsky Municipal Airport.

The flood vulnerability is principally due to:1) flooding from Great Meadows with respect to Lordship Boulevard and 2) floodwaters entering into Sikorksy Airport via low-lying wetlands southeast of the east-facing runway. The effects of coastal flooding will increase due to sea level rise, resulting in increased damage potential to facilities.

Figure 4.12 Support, High Occupancy, and Vulnerable Population Facilities *(facing page)*



Legend
Town Administration Buildings
Fueling (Gas) Stations
Grocery and Supply Stores
Theaters
Churches
Museums and Galleries
Community Centers and Rec Facilities
Care Facilities
Schools
Daycare
2015 100yr Flood
2040 100yr Flood
2065 100yr Flood
2115 100yr Flood
North Housatonic River Inset
Milford
Housatonic River
Barnum Ave
Barnum Avenue Cutoff
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
Ferry Blvd
Nichols Ave
W Broad St
Stratford Ave
Connecticut Ave
Hollister Ave
Surf Ave
South Ave
Mount Carmel Blvd
Honeyspot Rd
Woodend Rd
Main St
Lordship Blvd
Great Meadow Rd
Stratford Rd
Oak Bluff Ave
I-95 S
I-95 N
CT-130
Shelton
Orange
Trumbull
Milford
Bridgeport
Inset Map
0 600 1,200 2,400 Feet
N

COASTAL FLOOD RISK LOSSES

Loss of Natural Resources

Economic

SAEP COASTAL FLOOD RISK HAZARD PROFILE

	Flood Risk	Priority
Current	HIGH	High
2040	HIGH	High
2065	HIGH	High
2115	HIGH	High

Natural Resources Flood Risk Profile

Stratford has exceptional coastal natural resources due, in part, to its proximity to Long Island Sound.

Tidal Wetlands:

- McKinney Wildlife Refuge
- Housatonic Riverfront

Beaches:

- Long Beach
- Short Beach
- Russian Beach
- Lordship Beach

Figure 4.13 shows the Town's natural resources relative to the predicted 100-year recurrence interval coastal flood (stillwater elevation) through the year 2115. A detailed characterization of astronomical tides, sea level rise, and waves is presented in Section 3 of the plan.

NATURAL PROGRESSION DUE TO SEA LEVEL RISE

The natural progression of beaches and tidal wetland systems like Stratford's, subject to sea level rise, would be: 1) migration of the barrier beach (Long Beach) inland into the tidal wetlands (Great Meadows) due to repeated episodic flood inundation, breaching, and rising tides; 2) continued erosion of bluffs and non-barrier beaches; 3) migration inland of wetland habitat; and 4) transformation of tidal wetlands to intertidal mud flats and/or open water. In the absence of man-made structures, over time these conditions will result in a continuing re-alignment of the shoreline and locations of beaches and wetlands.

TIDAL WETLANDS

Tidal wetlands 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. Tidal wetlands are highly susceptible to sea level rise and climate change due to: 1) changes in tidal flow patterns, 2) landward migration of tidal waters, 3) rapid changes to water depth, 4) changes in salinity and water acidity, 5) increased flood vulnerability, and 6) species diversification. Climate change-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

Figure 4.13 Natural Resources *(facing page)*


Legend
Important Bird Areas (Audubon Society)
Tidal Wetlands (NWI)
Tidal Wetlands (CT DEP 1990s)
Beach & Dune Habitat
Coastal Submerged Aquatic Vegetation (SAV)
2015 100yr Flood
2040 100yr Flood
2065 100yr Flood
2115 100yr Flood
North Housatonic River Inset
Housatonic River
Milford
Housatonic River
Milford
Nichols Ave
Barnum Ave
Barnum Avenue Cutoff
CT-130
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
W Broad St
Linden Ave
Beardsley Ave
Main St
Ferry Blvd
Stratford Ave
Connecticut Ave
Seaview
Spada Blvd
Mount Carmel Blvd
South Ave
Surf Ave
Hollister Ave
Honeyspot Rd
Woodend Rd
Main St
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
Shelton
Orange
Trumbull
Inset Map
Milford
Bridgeport
N
0 600 1,200 2,400 Feet

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 wetlands is not fast enough to keep pace with sea level rise, the wetlands convert to open water or tidal flats.

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.

The results presented below are from the study "*Application of SLAMM to Coastal Connecticut, Final Report*" dated January 2015 and prepared by Warren Pinnacle Consulting, Inc. for the New England Interstate Water Pollution Commission. The McKinney Wildlife Refuge, including Great Meadows, is evaluated in the study region's Southwest Coast Watershed. Figure 4.14 shows the low tide current condition. Figure 4.15 shows the low tide condition with 1.7 meters of sea level rise based on the SLAMM predictions for Stratford's tidal marshes. The figures show a significant increase in regularly flooded marsh and a decrease in irregularly flooded marsh corresponding approximately to the High USACE Sea Level Rise predictions.

Transitional salt marsh is shown on the periphery. However, an important feature of the McKinney Wildlife Refuge is that the marsh boundaries are severely constrained by man-made structures and significant lateral migration of the marshes is not possible.

These effects become more pronounced under greater water depths represented by 1.7 meters (lower) sea level rise. According to the study, some tidal flats and open water are predicted, suggesting that the remaining marshes are "on the brink of extensive habitat loss" under high sea level rise scenarios. Continued breaching and loss of Long Beach (a barrier beach) will also result in the eventual loss of the Great Meadows tidal wetlands.

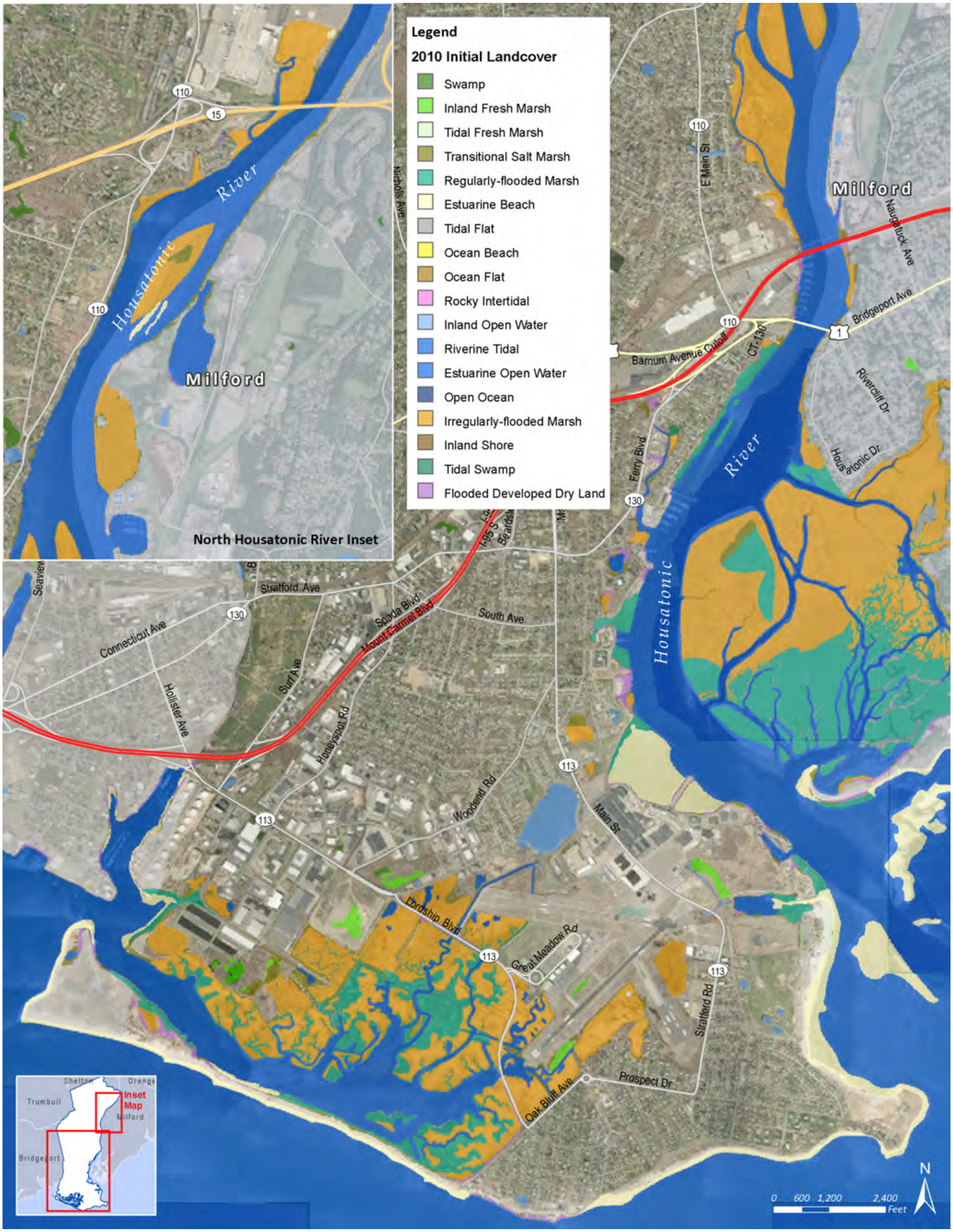
BEACHES

All of Stratford's beaches are exposed to large wind fetches and significant storm wave action.

"Shoreline Erosion Analysis and Recommended Planning Process," Planning Report 29 by the State of Connecticut (1979) provides a detailed evaluation of beach erosion and accretion at Stratford. "Analysis of Shoreline Change in Connecticut" (O'Brien et al; 2014) provides a recent, updated assessment of shoreline erosion and accretion at Stratford.

Stratford is located in a geomorphological region defined as glacial drift and beaches. The shoreline and nearshore areas are characterized by land forms that were glacially deposited and more recently submerged. The future position of the shoreline will be defined by sea level rise, through erosion and deposition of sediment. In addition to water level, sediment erosion

Figure 4.14 SLAMM Model Current Low Tide *(facing page)*



Legend
2010 Initial Landcover
Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Salt Marsh
Regularly-flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Ocean Flat
Rocky Intertidal
Inland Open Water
Riverine Tidal
Estuarine Open Water
Open Ocean
Irregularly-flooded Marsh
Inland Shore
Tidal Swamp
Flooded Developed Dry Land
North Housatonic River Inset
Housatonic River
Milford
Inset Map
Shelton
Orange
Trumbull
Bridgeport
0 600 1,200 2,400 Feet
N

and deposition is a result of water velocity (currents associated with tidal circulation, and more importantly, wave action). Anomalously high tidal currents occur in the Housatonic River (about 1.5 knots at the river mouth). Wave-induced currents are dependent upon regional wind patterns and individual storm events. In general, wind patterns are dominated by low velocity southwest winds in the summer and more intense winds from the northwest during winter. The orientation of the Connecticut shoreline protects from high winds from the north and northwest. High velocity winds occur during tropical cyclones and nor'easters, typically from the northeast and southeast quadrants. The irregular shoreline can cause wave refraction and wave directions may vary locally from that predicted from prevailing wind directions.

Movement of shoreline sediment in the nearshore area by waves, tidal currents, and wave-induced currents is called littoral transport and includes longshore transport (parallel to the shore) and on-shore-offshore transport (perpendicular to the shore). Steeper, larger waves tend to move sediment offshore and smaller waves tend to transport sediment onshore. Longshore transport moves and deposits suspended sediment; the direction of longshore transport is a function of the prevailing wave direction.

A wave analysis for Stratford Point (Connecticut Coastal Area Management Program Planning Report No. 29, dated 1979) showed that over a three year period, the wave record was dominated by waves varying in height up to 4 feet. Waves with heights up to 2 feet occurred 90 percent of the time. Waves greater than 10 feet in height were observed once. The direction of wave approach was dominated by the southerly quadrant with east and southeast approaching waves accounting for the major directions of approach. The configuration of Stratford (as a peninsula) as well as the presence of nearshore shoals creates an environment of relatively high tidal and wave-induced current velocities – conducive to erosion.

The dominant (or net) direction of longshore transport in the vicinity of Stratford (including beaches facing Long island) is westerly and is mostly the result of storm activity with a southeast wind direction. The alignment of Lordship Beach makes it less susceptible to longshore transport, while the alignment of Long Beach makes it more susceptible. The alignment of Short Beach also makes it susceptible to longshore transport to south) in particular due to storm events with northeast and southeast winds.

Numerous groins are present along Long Beach. The Long Beach groins were constructed in the 1950s (along with placement of 600,000 c.y. of sand) in response to breaching of the barrier beach, most likely during the Hurricane of 1938. Groins are designed to inhibit longshore transport but will not prevent future breaching. The vicinity of Stratford (between Norwalk and Milford) is more significantly impacted by the effects of shoreline erosion than other areas of Connecticut. The recent study by O'Brien et al presents shoreline erosion and accretion rates (based on 100-year record). The study indicates the following:

Long term data (1889 – 2006):

Net shoreline movement (negative sign indicates erosion):

Minimum -102.6 meters (m)

Maximum 162.4 m

Average -12.5 m

Average end point rate: -0.1meter/year (m/yr)

Short term data (1889 – 2006):

Net shoreline movement (negative sign indicates erosion):

Minimum -47.4 m

Maximum 50.1 m

Average 5.6 m

Average end point rate: -0.26m/yr

The data further indicate long term end point rates at the beaches:

Long Beach	-0.9m/yr
Lordship Beach	-0.2m/yr
Short Beach	-0.8m/yr

The implication is that on-going erosion of Stratford's beaches should be anticipated. The rates of erosion will likely increase with sea level rise.

The long term effects of sea level rise on the Long Beach barrier beach will be increased erosion and beach migration. The barrier beach erodes from the Long Island Sound side and will either wash overland and remain intact or break up and disappear (leaving open water and a shoreline at the boundary of the Great Meadows tidal marsh. Beach nourishment would modify these effects and the existence of groins along the beach add merit to beach nourishment and dune restoration as beach erosion mitigation measures.

The other Stratford beaches (Lordship and Short Beach) are also expected to experience continued erosion.

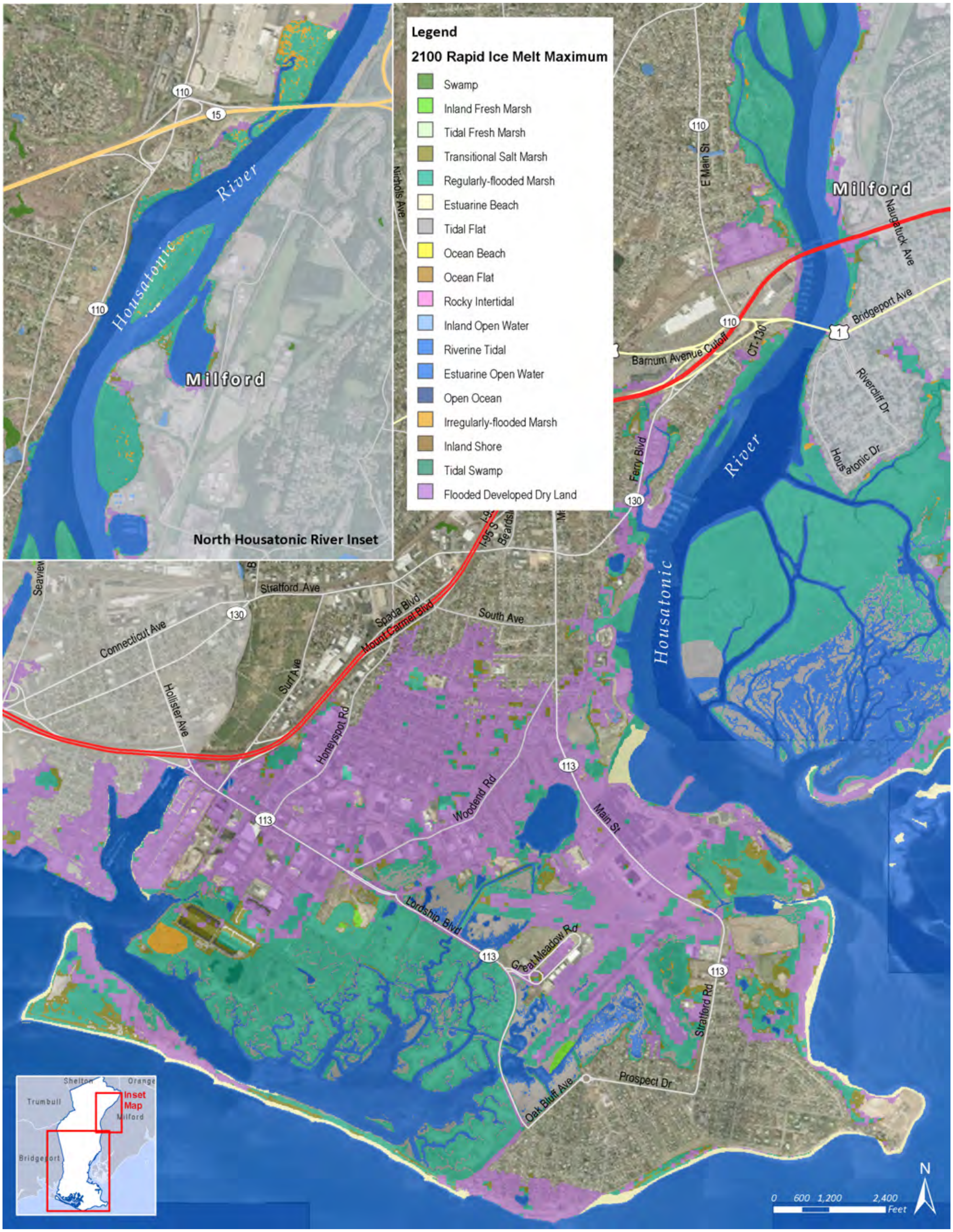

Legend
2100 Rapid Ice Melt Maximum
Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Salt Marsh
Regularly-flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Ocean Flat
Rocky Intertidal
Inland Open Water
Riverine Tidal
Estuarine Open Water
Open Ocean
Irregularly-flooded Marsh
Inland Shore
Tidal Swamp
Flooded Developed Dry Land
North Housatonic River Inset
Housatonic River
Milford
Stratford Ave
Connecticut Ave
Holister Ave
Surf Ave
Honeyspot Rd
Woodend Rd
Main St
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
South Ave
Barnum Avenue Cutoff
Ferry Blvd
Naugatuck Ave
Bridgeport Ave
Rivercliff Dr
Housatonic Dr
E Main St
Nichols Ave
Inset Map
Shelton
Orange
Trumbull
Milford
Bridgeport
0 600 1,200 2,400 Feet
N

Figure 4.15 SLAMM Model Future Low Tide *(facing page)*

VULNERABILITY OF PROPERTIES AND BUSINESSES

Building Losses

As demonstrated during recent years by Hurricanes Irene and Sandy, most of Stratford that is located south of I-95 and along the Housatonic River is vulnerable to coastal flooding. The limits of flood inundation presented on the effective FEMA FIRMs as well as flood models performed by GZA (see Section 3.0) demonstrate that much of the Town is in a coastal high flood hazard zone.

Occupancy	Exposure ($1,000)	Percent of Total
Residential	4,804,160	71.5%
Commercial	1,184,257	17.6%
Industrial	517,257	7.7%
Agricultural	14,010	0.2%
Religious	102,683	1.5%
Government	33,465	.5%
Education	64,294	1%
Total	**6,720,103**	**100%**

Table 4.2 Stratford Building Exposure and Occupancy Type

The effects of coastal flooding on property and business include direct costs due to loss of (or damage to) buildings, equipment, vehicles, building contents, etc. They also include indirect costs due to disruption of business and services (such as power, water, sewer, etc.).

Table 4.2 presents the total building value in Stratford. There are approximately 17,380 buildings in Stratford, with a total building replacement value (excluding contents) of $6.7 billion (in 2010 dollars). Approximately 97% of the buildings (representing about 71.5% of the total replacement value) are residential structures.

Loss estimation using the FEMA HAZUS-MH software provides a good indication of the overall risk to property and business, however it is important to note that these estimations can be overly conservative. Regardless, they are useful for planning, in particular, to demonstrate the potential future effects directly attributable to sea level rise.

The Averaged Annualized Loss (AAL) is the expected loss per year if losses are averaged over many years. FEMA has estimated the total AAL for Fairfield County to be $393.5 million, which represents a per capita AAL within Fairfield County of $429 (Source: FEMA HAZUS Average Annualized

Loss Viewer, 2016). The FEMA Modeling Task Force (MOTF) created this viewer as part of a comprehensive risk management strategy undertaken by the Mitigation Division to better assess and properly mitigate the risks and vulnerabilities associated with flooding. The data were created by FEMA's RiskMAP program using HAZUS.

A HAZUS-MH analysis of building loss in Stratford due to flooding was performed by GZA. Table 4.3 presents the flood event (per discrete recurrence interval) and AAL building losses based on GZA's HAZUS Analysis for the year 2015.

Category	**10 yr**	**25 yr**	**50 yr**	**100 yr**	**500 yr**	**AAL**
	(Shown in Millions of Dollars)					
Residential	$87	$110	$174	$244	$442	
Commercial	$160	$203	$286	$424	$551	
Industrial	$107	$135	$192	$272	$390	
Other	$13	$18	$24	$30	$47	
Total	**$367**	**$465**	**$675**	**$971**	**$1,430**	**$57**

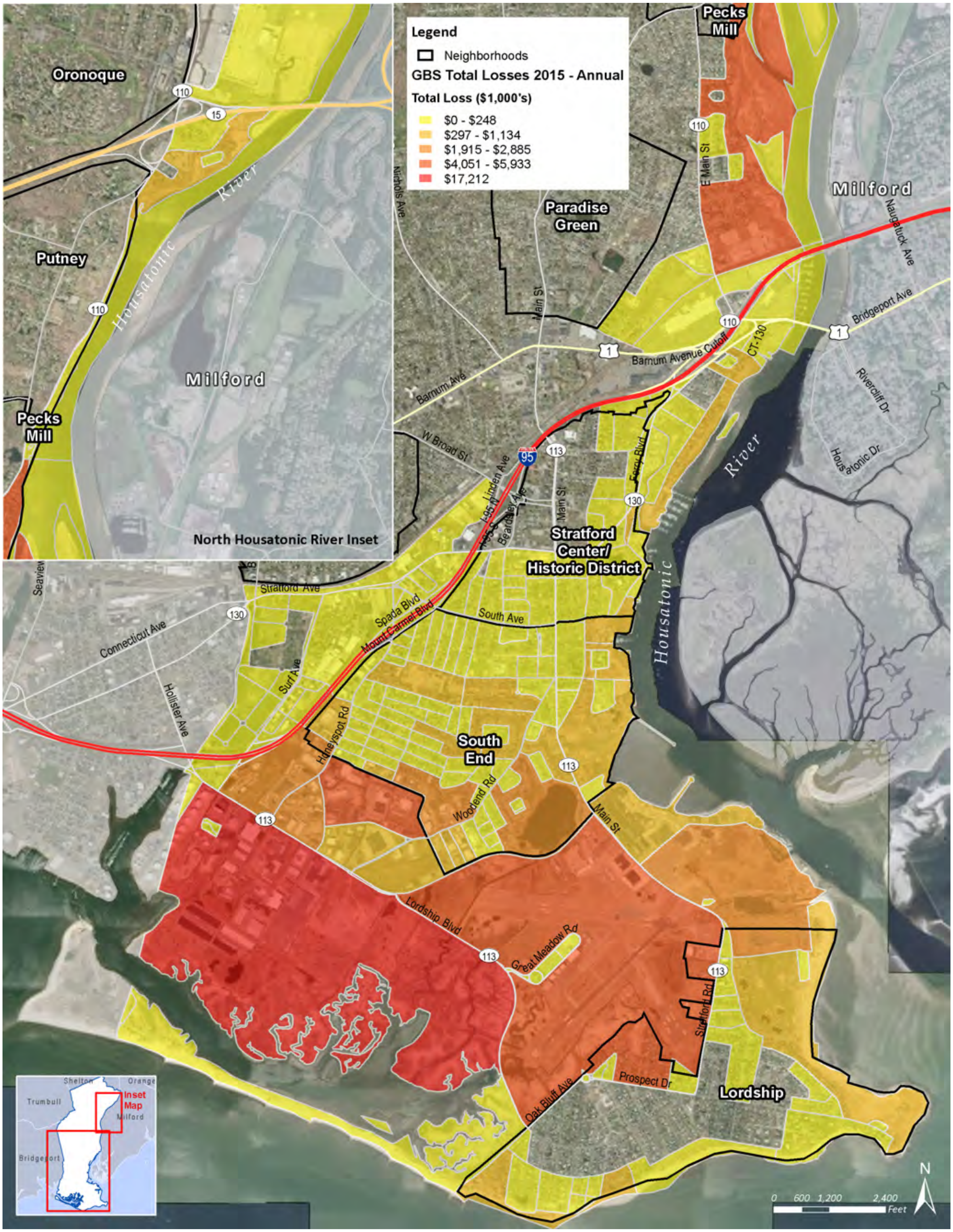
Table 4.3 Estimated Flood-Related Building Losses - Stratford

The current building damage AAL due to coastal flooding, based on FEMA's current flood assessment (FEMA FIRM Maps) is predicted to be approximately $57 million. These costs include building, content, inventory, and business interruption losses. Assuming a Town population of 51,500 people, this translates to a per capita AAL of $1,100. Damage to residential buildings accounts for about 25% of the total loss; privately-owned commercial and industrial buildings bear the majority of the loss. Most of the losses from privately-owned commercial and industrial buildings will occur within the Employment Growth Area. Figure 4.16 shows the geographic distribution (by census block) of the estimated losses for the year 2015.

The AALs will also increase over time due to sea level rise. A 15% increase is expected by the year 2040 ($1,300 per capita) with a total increase of approximately 30% by the year 2065 to $1,400 loss per capita.

The predicted building losses are expected to be significantly greater than the amount currently protected by insurance. The implication is that, over time, there is the potential for the accumulated losses associated with flooding to exceed the capacity of property owners and businesses to respond to these losses, resulting in reduced tax revenue and population loss.

Figure 4.16 2015 Estimated Losses *(facing page)*



Legend
Neighborhoods
GBS Total Losses 2015 - Annual
Total Loss ($1,000's)
$0 - $248
$297 - $1,134
$1,915 - $2,885
$4,051 - $5,933
$17,212
North Housatonic River Inset
Oronoque
Putney
Milford
Pecks Mill
Paradise Green
Stratford Center/ Historic District
South End
Lordship
Housatonic River
Barnum Ave
Barnum Avenue Cutoff
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
W Broad St
Linden Ave
Main St
E Main St
Nichols Ave
Ferry Blvd
Stratford Ave
Connecticut Ave
Hollister Ave
Surf Ave
Spada Blvd
Mount Carmel Blvd
South Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
CT-130
Inset Map
Shelton
Orange
Trumbull
Milford
Bridgeport
0 600 1,200 2,400 Feet
N

Uncertainty: While the loss values presented above include significant uncertainty (HAZUS-MH is very sensitive to flood depth), the estimated losses are predicted to be high and will increase with sea level rise.

VALUE OF FLOOD MITIGATION AND PREVENTION

The value of flood mitigation and prevention is demonstrated by estimating the reduction in AAL for different levels of protection as compared to today (without consideration of sea level rise). Extrapolating over 50 years, the current, unprotected estimated building loss cost is $2.9 billion. The estimated 50-year cost reduces to: $2.3 billion if flood protection up to the 25-year recurrence interval flood elevation is provided, $0.85 billion if protected up to the 100-year recurrence interval flood elevation, and $0.5 billion if protected up to the 500-year recurrence interval elevation. Although highly approximate, this simple analysis demonstrates in terms of prevented losses.

Category	10 yr	25 yr	50 yr	100 yr	500 yr	AAL
Total	0	$465M	$675M	$971M	$1,430M	$46M
Per Capita						$890

Table 4.4 Loss Estimation with Flood Protection, up to 25-year recurrence interval flood elevation

Category	10 yr	25 yr	50 yr	100 yr	500 yr	AAL
Total	0	0	0	$971M	$1,430M	$17M
Per Capita						$330

Table 4.5 Loss Estimation with Flood Protection, up to 100-year recurrence interval flood elevation

Category	10 yr	25 yr	50 yr	100 yr	500 yr	AAL
Total	0	0	0	0M	$1,430M	$9M
Per Capita						$175

Table 4.6 Loss Estimation with Flood Protection, up to 500-year recurrence interval flood elevation


NO PARKING
U.S.
COAST GUARD
PROPERTY

5.0 RESILIENCY STRATEGIES AND PROJECTS

STRATEGIES

Three coastal resiliency strategies are recommended for the Town: Retreat, Protect, and Accommodate.

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 flood waters to prevent flooding of developed areas and prevent erosion and loss of land.

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

The strategies of Retreat and Protect will provide the most effective, long term benefits to the Town. However, each of these strategies requires significant capital investment (for infrastructure), private property acquisition and/or purchase of land easements. Therefore, immediate implementation of these strategies will be challenging and a long term plan to implement them will be required. The strategies of Retreat and Protect also place most of the responsibility for coastal resiliency and flood protection on the Town and less on private property owners.

The strategy of Accommodation is already being implemented within the Town, primarily through compliance with existing local, state, and federal regulations. The responsibility for, and costs of, an Accommodation strategy are borne by both private property owners (e.g., through the implementation and cost of compliance with NFIP and building code regulations and post-storm repair) and the Town (e.g., repair and reconstruction of infrastructure and public resources). However, the costs of an Accommodation strategy may become increasingly difficult to meet, in particular by private property owners, as the frequency of flooding occurs.

An integrated approach using each of these strategies is recommended, as discussed below.

Retreat

Retreat has been a successful strategy for the Town in recent years (e.g., the acquisition and demolition of houses on Pleasure Beach and Long Beach and the return of the beach to a high value, public natural resource). Retreat should be considered by the Town as both a long term strategy (Employment Growth District) and a near-term strategy (Long Beach).

Employment Growth District

The Employment Growth District has been designated as the commercial and light industrial growth area for Stratford. The Stratford Plan of Conservation and Development plans for significant future investment and redevelopment of this area. The District, however, has both a high vulnerability to flooding and the greatest economic building loss potential due to flooding in the Town.

Retreat, rather than redevelopment, is an appropriate long term strategy along the northwest boundaries of the Great Meadows salt marsh, within the limits of the Town's Employment Growth District. It is proposed that revision of the Plan of Conservation and Development be considered relative to the District. An alternative planning approach is to relocate some or all of the Employment Growth District outside of flood-vulnerable areas, and provide an ecological and natural resource zone that would allow advancement of the salt marsh and a Living Shoreline that will provide wave dissipation, flood protection, natural stormwater treatment (using green infrastructure), and public access and greenspace.

Recognizing that complete relocation of the Employment Growth District will not be feasible or practical, a realignment of the limits of the district to allow for an environmental buffer zone and additional public access is recommended. This strategy should be combined with increasing the site grade of future development for maximum effectiveness. As discussed below, perimeter flood protection around the Employment Growth District is also an alternative.

Long Beach

Retreat is an appropriate strategy along the currently-developed portions of Long Beach, where houses are located on the beach. These houses are vulnerable to frequent flooding and high velocity wave action, which will likely result in repetitive loss. The acquisition and removal of these structures will provide the opportunity for enhancing Long Beach. These enhancements include beach nourishment, shoreline habitat, and greater public access.

Protect

The strategy of protection would be implemented through a series of municipal flood protection projects (levees, flood walls, etc.) that will reduce flood risk for most of the Town areas that are currently vulnerable to coastal flooding by providing perimeter flood protection along and near the shoreline. This strategy has been used in many flood-prone areas of the United States (e.g., New Orleans, other proposed Connecticut coastal resiliency projects). There are two goals for Town-wide perimeter flood protection:

1. Provide flood protection during storm events (waves and flood inundation); and

2. Provide recreational and resource value by integrating the flood protection measures with public greenways, greenspace, and other public amenities.

For the most part, the recommended flood protection projects would be coordinated with greenway projects already planned by the Town (2014 POCD and 2008 Greenway Master Plan).

Key to the design of the Protection strategy is a sound understanding of the hydrodynamics of coastal flooding in the Town. As demonstrated by GZA's hydrodynamic flood models, coastal flood inundation (which eventually inundates interior Town areas) initiates at several specific entrance points (as a result of low ground surface elevation and/or hydraulic connection via wetlands and streams). Section 3 presents a detailed discussion of flood inundation processes. Providing flood protection at these areas is key to preventing coastal flood inundation throughout the Town. These principal areas include:

- Ferry Creek at Broad Street;
- The tidal wetland area south of Shore Road;
- At, and in the vicinity of, the Stratford Army Engine Plant;
- The Marine Basin;
- Long Beach;
- Great Meadows; and
- Johnsons Creek.

In brief, the Protection strategy includes (in order of priority):

1. Additional flood protection at the Water Pollution Control Facility.
2. Construction of a new bridge over Ferry Creek (Broad Street), including a raised bridge deck elevation, construction of new culverts and tide gates, and raised roadway grades to serve (in combination with the existing pump station) as a flood control levee. This project is already planned; however, the grade elevations (which will control the amount of flood protection provided) have not been established.
3. Construction of a series of flood protection measures (levees and flood walls) along the Housatonic River, from the Water Pollution Control Facility to (and including) the Army Engine Plant.
4. Construction of permanent and temporary flood protection barriers at the north end of Johnsons Creek and Sprague Oil property

5. Lengthen (and raise) the seawall/revetment at Long Beach (in combination with the Retreat strategy at Long Beach).

6. Construction of flood walls:

   – Along sections of Main Street (adjacent to Sikorsky Airport)

   – Along sections of Lordship Boulevard

   – Along Access Road

   – Along Oak Bluff Avenue

   – Surrounding the perimeter of Employment Growth District adjacent to Great Meadows (in lieu of or in conjunction with a planned retreat in this area), and

   – At Bruce's Brook Drainage Culvert.

The Protection strategy, if fully implemented, would significantly reduce flood risk for most, but not all, of the areas of the Town that are currently vulnerable to coastal flooding.

Selecting the appropriate "level" of flood protection (i.e., "how high would a levee or flood wall be") requires consideration of regulators and technical feasibility, compatibility with other uses, cost, prevented losses, and impact on insurance cost. Conceptual design and a detailed benefit-cost analysis will be required for each of the proposed projects to establish the specific flood protection elevations that are appropriate. Though the specific flood protection elevations need to be defined, the economic losses due to flooding that will be prevented will exceed the cost of these protection measures.

Accommodate

A strategy of Accommodation typically includes:

- Elevating buildings, structures and infrastructure, including to comply with local, state, and federal codes and regulations;
- Flood-proofing buildings and structures;
- Using temporary flood protection measures;
- Emergency/flood response plans;
- Operation and maintenance of culverts and tide gates;
- Operation and maintenance of pump stations;
- Dredging waterways;
- Beach nourishment and dune maintenance;
- Maintenance of salt marshes (e.g., tidal flow, salinity, depth); and
- Post-storm repair and clean-up.

The measures identified above can be implemented at lower incremental costs (relative to the strategies of Retreat and Protect) and are, therefore, easier to implement. However, the net costs of Accommodation will be higher with less efficiency and fewer long term benefits.

It is recommended that the strategy of Accommodation continue to be used throughout the Town in the near term and as a permanent strategy for certain applications. These ongoing actions include:

1. Operations and maintenance of culverts, tide gates, and pump stations;
2. Flood protection of pump stations and electrical substations;
3. Flood-proofing, elevation of structures, temporary flood protection and emergency response/flood plans to protect Sikorsky Airport;
4. Dredging of waterways (including coordination with the USACE 2015 Dredging Plan for Long Island Sound);
5. Beach nourishment and dune maintenance; and
6. Maintenance of salt marshes.

SUMMARY OF RESILIENCY PROJECTS

The Section 5 Attachment presents a summary and conceptual details of the proposed Town resiliency projects. Approximate “order of magnitude” cost estimates are presented. Note that detailed, site-specific cost estimates have not been developed at this time.

The priority of the projects (High, Moderate, and Low) are also presented. The projects are prioritized based on consideration of flood risk level, benefit (i.e., prevented loss), and near-term versus long-term risk.

Table 5.2 presents additional resiliency projects that have been proposed by the Southern Connecticut Regional Council of Government (SRCOG). The project details presented in the Section 5 Attachment are intended to present a concept. Modifications to the project concepts are expected.

Proposed projects fall into four types: Non-Structural, Structural, Natural, and Nature-Based Features. These classifications are consistent with federal guidance (FEMA, USACE). Natural, nature-based, non-structural, and structural are terms used to describe the full array of measures that can be employed to support coastal resilience and risk reduction (consistent with policies and programs implemented by the U.S. Army Corps of Engineers). See Section 2 for detailed descriptions.

GREENWAY CONNECTIONS

The 2008 Stratford Greenway Master Plan presents a Town-wide vision for a greenway system starting at Stratford Point in the south end of Town and ending in Roosevelt Forrest in the north. The Stratford Greenway includes connections to and along the Housatonic River, Long Beach and the Merritt Parkway to the north. The greenway system established eight (8) sections that includes various types of existing pathways (i.e. Off-road, Shared-use Trail and On-road, Bicycle Routes) as well as proposed pathways for each section to create a unified greenway system.

Many of the existing and proposed greenway pathways provide opportunities to integrate future resiliency projects into the greenway system that can improve connectivity in sections near and along Long Island Sound and the Housatonic River. An overview of how the Town-wide Perimeter Flood Protection projects tie into the proposed Stratford Greenway project is presented below.

SECTION 1: STRATFORD POINT TO SHORT BEACH

Overview: Section 1 is a 1.16 miles long section of multi-use trail connecting Stratford Point to the Marine Basin. It is envisioned that this section of greenway will constructed as close to the Housatonic waterfront as possible with a large portion of the trail running through the short beach park. Two of the proposed coastal resilience projects could support improved connectivity in Section 1 of the greenway system as outlined below.

Short Beach Nourishment will assist in maintaining access to the Off-road, Shared-use trail with improved connectivity to Stratford Point to the south and the land adjacent to the Marine Basin to the North.

Airport Flood Wall can be combined with the development of the proposed pathway extensions on Section 1 along Main Street (Rte. 113).

SECTION 2: STRATFORD POINT TO LONG BEACH

Overview: Section 2 of the greenway system includes over 4 miles of multi-use, boardwalk and bicycle routes that will provide connections from Stratford Point to Long Beach. This section begins with a walkway from Short Beach connecting with bicycle routes along Riverdale Drive, Prospect Street and Oak Bluff Avenue, and then connecting to an off-road trail along Long Beach. Four of the proposed coastal resilience projects could support improved connectivity in Section 2 of the greenway system as outlined below.

Long Beach Nourishment will support the sustainability of the off-road, Shared-use Trail that is envisioned in the form of a future boardwalk extending along Long Beach with connections to Pleasure Beach in Bridgeport.

Oak Bluff Avenue Flood Wall will support maintaining access to the On-road, Bicycle route along Oak Bluff Avenue, while also providing flood protection to residences, and maintaining access to emergency response during future coastal storms.

Shoreline Drive Retreat and Protect will support maintaining access to an alternative On-road, Bicycle route connecting W. Beach Drive to the Lordship Beach area.

Beach Drive and Jefferson Street Seawall Improvement will maintain access to the On-road, Bicycle route on Beach Drive that will provide connectivity to Washington and Jefferson Streets to the existing bicycle routes.

SECTION 3: SHORT BEACH TO BIRDSEYE STREET BOAT LAUNCH

Overview: Section 3 is a 1.56 mile multi-use trail that provides the greatest access to the Housatonic waterfront. The vision for this section extends from Short Beach Park through the Stratford Army Engine Plant (SAEP) property, the Hunter Haven parcel and the Water Pollution Control Facility (WPCF), and finally connecting to Birdseye Dock. It is envisioned that the trail would provide a 10-foot paved trail that includes one future crossing over the mouth of the Marine Basin. Three of the proposed coastal resilience projects could support improved connectivity in Section 3 of the greenway system as outlined below.

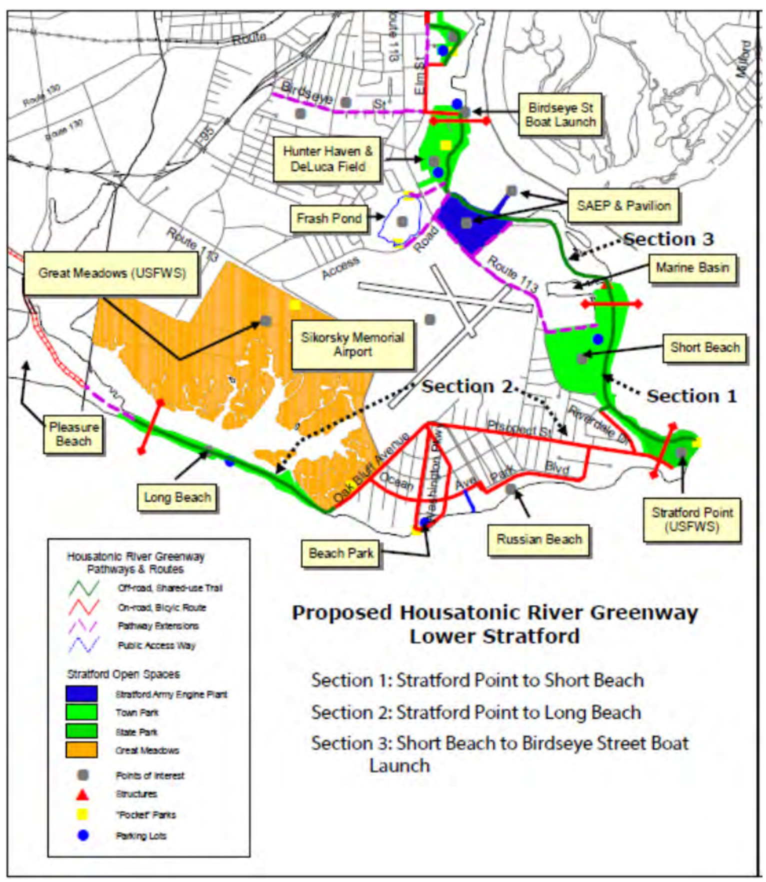


Figure 5.1
Proposed Housatonic River Greenway Lower Stratford
(Image ref. Town of Stratford 2008)

Stratford Army Engine Plant Redevelopment berm elevation increase can be designed to include the improvement of the off-road, shared use trail as a joint project that will connect with the proposed planted revetment with earth berm to the north and trail to the south.

Park Path/Greenway planted revetment with earth berm will provide an opportunity to build the greenway connection between the SAEP and the Water Pollution Control Facility (WPCF).

WPCF flood protection will assist in maintaining access to the Off-road, Shared-use trail providing connectivity to the Birdseye St. to the north and greenway trail to the south.

6.0 PLAN IMPLEMENTATION

Resiliency actions will be best implemented by incorporating them into existing Town policies, plans, programs, and regulations. Section 6 discusses the ten (10) steps to assist the Town with Plan implementation including the creation of a Town Coastal Resiliency Team and a Flood and Erosion Control Board. Section 6 also presents fifteen Plans, Policies, and Programs (PPR) Actions designed to support implementation of the Plan.

Table 6.4 summarizes the proposed Plan implementation actions. Table 6.5 summarizes the recommended future plans and studies.

STEPS TO IMPLEMENT THE STRATFORD RESILIENCY PLAN

The steps toward implementation of the Stratford Resiliency Plan are:

Step 1: Adopt Plan

Step 2: Establish Coastal Resiliency Team

Step 3: Prioritize proposed Plan projects

Step 4: Create "Resiliency Project Funding Plan"

Step 5: Create "Resiliency Permit Compliance Plan"

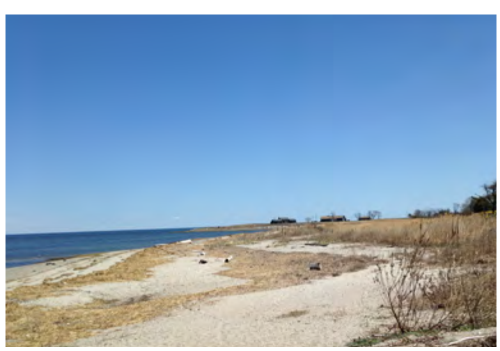
Step 6: Evaluate the Town's participation in the National Flood Insurance Program (NFIP)

Step 7: Incorporate the Plan findings and recommendations into the next revision of the Plan of Conservation and Development (POCD)

Step 8: Incorporate the Plan findings and recommendations into the next revision of the METRO-COG Hazard Mitigation Plan

Step 9: Review and modify the Stratford Zoning Regulations

Step 10: Review and modify the Stratford Building Codes to be consistent with proposed modifications to the State Building Code



TOWN COASTAL RESILIENCY TEAM AND FLOOD AND EROSION CONTROL BOARD

Action PPR 1 is to establish a *Town Coastal Resiliency Management Team*, headed up by the *Town Coastal Resilience Lead*. The goals of the Team will be to: 1) lead the implementation of the Plan; 2) lead integration of coastal resiliency into all Town plans, policies, programs and regulations; and 3) consult with key Town stakeholders (such as Police and Fire, Stratford Housing Authority, etc.). It may be appropriate that the Team may consist of departmental leads, as outlined in Table 6.1:

Title	Department
Emergency Management Director	Emergency Medical Service
Planning and Zoning Administrator	Planning and Zoning
Economic Development Director	Economic Development
Town Engineer	Department of Public Works
Building Official	Office of the Building Official
Conservation Administrator	Conservation Department
Health Director	Health
Community Services Administrator	Community Services

Table 6.1 Coastal Resilience Management Team Proposed Membership

Action PPR 2 is to designate or establish a *Flood and Erosion Control Board* to be eligible for funding under the State Flood and Erosion Control Board (FECB) Program. Per the Program guidance, an ordinance should be promulgated to adopt CSG Sections 25-84 through 25-94, thereby establishing the board. Though a municipality can choose to create a new board to serve as the FECB, an existing board, such as the Town Council, may be designated as the FECB.

PLANS, POLICIES, AND PROGRAMS

The remaining actions address specific plans, policies, and programs. Figure 6.1 presents existing and relevant federal, State, and Town plans, policies and programs. Each of these include components that will be impacted by sea level rise, coastal flooding and climate change. Several of these also have existing provisions for sea level rise, coastal flooding, and climate change.

NATIONAL FLOOD INSURANCE PROGRAM

The Town is a participating community in the National Flood Insurance Program (NFIP). This 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). As of July 2015, there are 2,191 flood policies in the Town; though Stratford has more than 2,000 policies, it is important to note that the number of policies in the Town is low relative to the number of buildings located within FEMA Special Flood Hazard Areas (SFHAs) and vulnerable to flooding. There have been 742 claims have been paid since 1978, totaling approximately $10.8M. The average premium for properties located within a FEMA SFHA is $1,500 (total premium costs are on the order of $3.3M). These claims do not include additional federal spending in Connecticut on Hazard Mitigation Grants ($18M) and Community Development Block Grants ($94M), which are open to owners who do not have flood insurance. In addition, the Biggert-Waters Flood Insurance Reform Act of 2012, which was temporally rescinded, will (if implemented) significantly increase the average cost of premiums in the Town. The effect of climate change, which will result in more properties being included in future FEMA FIRMs (and to greater flood depths), will also increase future insurance costs.

As a participating community, the Federal government makes flood insurance available throughout the Town. Without participation in the NFIP:

- No resident would be able to purchase a 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 HUD, EPA, and 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 FHA, VA, and others.

Figure 6.1 Stratford Coastal Resiliency Policy and Planning Framework

POLICIES, PLANS, AND PROGRAMS

- National Flood Insurance Program
- Plan of Conservation and Development
- Housatonic River Greenway Project
- Hazard Mitigation Plan
- Harbor Management Plan

Town coastal floodplain areas are classified on the FEMA FIRMS as SFHAs ranging from VE (waves equal to or greater than three feet) to AE (waves less than 3 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 differently than those constructed after issuance of the FIRM.

The FIRMS are periodically updated by FEMA; however, they are based on the level of risk that exists at that time and do not consider future changes to risk (for example, due to climate change). Climate change is likely to have significant impacts on the NFIP; SFHAs are predicted to increase in the future.

Three implementation actions are recommended related to the Town's participation in the NFIP: 1) Letter of Map Revision and Letter of Map Amendment opportunities; 2) Repetitive Loss Analysis; and 3) Community Rating System.

Letter of Map Revision (LOMR) and Letter of Map Amendment (LOMA): Although the Town is highly vulnerable to coastal flooding and the FEMA FIRM correctly maps much of the Town as a SFHA, analyses performed by GZA as part of the Plan development indicate that the flood elevations and wave heights predicted by FEMA may be high relative to the actual current risk (due to the methodologies used by FEMA to predict coastal flooding, in particular wave setup). If so, a reduction in risk (and premium costs) is possible. Newer, higher resolution topographic data is also now available for the Town. The new topographic data indicates that changes to the effective FEMA FIRMs based solely on elevation may be warranted. A Letter of Map Amendment (LOMA) is the mechanism for modifying the FIRMs based on ground surface elevation. LOMRs and LOMAs are the process to modify an effective FEMA FIRM.

Action PPR 3 is to perform a feasibility study to evaluate the potential for, benefits of, and likelihood of success of a LOMR for the Town coastal flood areas. If warranted based on the feasibility study, application for the LOMR/LOMA are recommended.

Community Rating System: The NFIP's Community Rating System (CRS) is a voluntary incentive program that encourages development of floodplain management activities that go beyond the minimum NFIP requirements. Credit points for CRS floodplain management activities determine a community's CRS Class. Credit points are assigned to each of 19 activities, organized under 4 main categories: Public Information, Mapping and Regulation, Flood Damage Reduction, and Flood Preparedness. Based on the total number of points earned, the CRS assigns one of ten classes. The Town does not currently utilize the CRS (Stratford is currently classified Class 10);

the CRS program provides the Town with an opportunity to reduce the flood insurance premiums of its residents from 5% to 45%, and to make the Town more resilient. An assessment by METRO-COG in 2014 indicates potential annual average savings for the Town ranging from about $110,240 (Class 9) to about $992,100 (Class 1) in reduced insurance premium costs. The Town is already performing several CSR-eligible activities. Several of the Stratford Resiliency Plan actions, if implemented, would also be eligible CSR activities.

Action PPR 4 is for the Town to evaluate eligibility in the CRS, including the following:

1. Identify all of the existing Town programs and policies that are consistent with CRS activities and the associated points;
2. Identify proposed resiliency actions that are consistent with CRS activities and the associated points;
3. Evaluate property eligibility (e.g., pre- and post-FIRM properties, elevated properties with V zones, etc.);
4. Identify costs of program application and administration and perform benefit-cost analysis; and
5. Apply for program (if warranted).

Repetitive Loss Area Analysis: Several CRS activities are related to reducing losses within "repetitive loss areas." A repetitive loss (RL) property is any insurable building for which 2 or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978. Certain repetitive loss properties are characterized as Severe Repetitive Loss Properties, which has special implications relative to flood insurance costs. Nationwide, repetitive loss properties represent only about 1.5% of all policies, but 15% to 20% of claims payouts. The goal of the NFIP is to actively reduce the flood risk (and costs) associated with repetitive loss properties. Communities that enforce stricter regulations can benefit by receiving a reduced rate for all policy holders through the CSR. There is also a Repetitive Flood Claims Grant program that provides funding to reduce or eliminate the long term risk of flood damage to structures insured under the NFIP. There are currently 76 repetitive loss properties located in the Town, representing 240 losses and about $4.0M in building payments. This number will increase in the future due to climate change, in particular for properties located within or near SFHA V zones.

Action PPR 5 proposes that the Town perform a Repetitive Loss Area Analysis (RLAA). As a community with more than 10 repetitive loss properties, the Town activities should include identification of repetitive loss properties (including map preparation showing areas), an analysis of the flood risk, annual outreach to repetitive loss property owners, preparation of a floodplain management plan and/or the RLAA. The RLAA involves a close examination and mitigation assessment for an area with a high number of repetitive loss properties. There is a National Flood Mitigation Data Collection Tool that allows communities to collect/data on the repetitive loss properties and submit updates directly to FEMA. (Note that all RLAA activities need to conform to the Federal Privacy Act of 1974.) The RLAA will support future Town and property owner resiliency and mitigation activities, including acquiring, relocating and/or flood mitigation of the repetitive loss properties.

PLAN OF CONSERVATION AND DEVELOPMENT AND HOUSATONIC RIVER GREENWAY PROGRAM

A goal of the plan is to present actions that are consistent with and supportive of the Town's vision for the future as stated in the POCD and the Housatonic River Greenway Program, in particular:

- A Greenway Community (e.g. Connections from Long Beach to Sikorsky Aircraft along the waterfront);
- Preserving Important Landscapes (e.g. Great Meadows, Long Island Sound, and Housatonic Shorelines);
- Culture & Innovation Campus (includes the Baldwin Senior Center, Stratford Library, Sterling and Perry Houses);
- Stratford Town Center (e.g. Enhanced Transit Center);
- Housatonic Riverfront;
- Employment Growth District; and
- Stratford Army Engine Plant.

Action PPR 6 is to integrate the findings and actions of the Stratford Resiliency Plan into the 2023 edition of the POCD. In particular, the flood hazards projected for the future should be a major consideration in planning for, and investing in, planned development projects such as the Employment Growth District which are located in flood hazard areas. The predicted flood hazards should also be re-evaluated at that time (7 years from now) including conforming to sea level rise projections that are projected at that time.

HAZARD MITIGATION PLAN

Stratford is one of six municipalities included in the GBRC's 2014 Multi-jurisdictional Natural Hazard Mitigation Plan Update (2014 Plan). The 2014 Plan is authorized under the federal Disaster Mitigation Act (DMA) of 2000. The DMA requires that municipalities and States develop and adopt mitigation plans to become eligible for FEMA's Hazard Mitigation Assistance (HMA) and Disaster Recovery Programs. These programs are critical to assisting

Stratford in providing funding opportunities to make Stratford more resilient before and to recover more quickly from the next coastal storm resulting in a federal disaster declaration. The second half of this Section provides an overview of the HMA Grant Programs available to Stratford.

The 2014 Plan identified thirty-five town owned vulnerabilities and assets in Table 4.11 Risk Matrix with respect to coastal flooding, inland and riverine flooding, winter storms, and wind. The 2014 Plan also included several recommended mitigation strategies to address the future impacts from coastal flooding that included a cost-benefit review of the identified mitigation strategies and actions using FEMA STAPLE+E. The Stratford Resiliency Plan incorporates many of the strategies and mitigation actions presented in Table 4.12 Action Matrix of the 2014 Hazard Mitigation Plan.

The 2014 State Hazard Mitigation Plan (State Plan) establishes the hazard mitigation strategy for the State and also addresses climate change. As stated in the State Plan, extreme weather events have already become more frequent over the past 50 years and this trend is expected to continue into the future. The State Plan includes three resiliency and climate change 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.
- 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 Update affirmed the following three mitigation goals for Connecticut:

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

These goals and strategies establish the mitigation priorities for the State. Stratford submittals for FEMA Hazard Mitigation Assistance (HMA) grant applications should be for projects that are consistent with the State's mitigation priorities.

Figure 6.2 Stratford Regulatory Framework

REGULATIONS

- Presidential Executive Orders
- Coastal Zone Management Act (CZA)
- National Flood Insurance Program Regulations
- Federal and State Permits
- Federal Coastal Barriers Act
- State Building Codes
- Town Codes
- Town Zoning Regulations

Action PPR 7 is to integrate the findings and actions of the Plan into the 2019 METRO-COG Hazard Mitigation Plan Update. Also, the Hazard Mitigation Plan Update should consider the flood hazard information presented in this Stratford Resiliency Plan relative to flood hazards to account for flood risk in terms of annual exceedance probabilities and future sea level rise.

REGULATIONS

Action PPR 8 is to review and modify applicable sections of the Town regulations, including the Town codes and zoning regulations, to reflect coastal resiliency and flood mitigation. Figure 6.2 presents the regulatory framework for the Town. Town, State, and federal regulations affect activities, including development, within the Town's coastal areas. The Town is empowered to make modifications to Town codes and regulations. Effectively, all federal and State regulations have been modified (or are in the process of being modified) to include requirements that address climate change, sea level rise, and enhanced flood mitigation.

EXECUTIVE ORDERS 11988, 13690, AND 13653

Executive Orders related to resiliency, flood mitigation, and climate change provide requirements for agencies, programs, and projects receiving federal investment. There are also several other executive orders that address sustainability and greenhouse gas emissions. The key orders relative to resiliency and flood mitigation include:

Executive Order 11988 (1977, Amended in 2015), Floodplain Management, addresses long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practical alternative. This executive order led to federal regulation of floodplains (National Flood Insurance Program Regulations).

Executive Order 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 American communities to strengthen their resilience to climate change. This executive order 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 develop adaptation plans. Each of these federal plans (e.g., Federal Highway Administration) impact future design guidelines and standards for Federal projects.

Executive Order 13690 (2015), Establishing a Federal Flood Risk Management Standard (FFRM) and a Process for Further Soliciting and Considering Stakeholder Input, was issued in January, 2015 and 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. This order also amended Executive Order 11988. The new standards give agencies the flexibility to select one of three approaches for establishing the flood elevation and hazard area they use in siting, design, and construction. They can:

Use data and methods informed by best-available, actionable climate science;

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

Build to the 500-year (0.2% annual chance) flood elevation.

COASTAL ZONE MANAGEMENT ACT (CMA)

The Coastal Zone Management Act 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. Connecticut's Coastal Management Program is administered by the Department of Energy and Environmental Protection (DEEP) Office of Long Island Sound Programs (OLISP) and is approved by NOAA under the federal Coastal Zone Management Act.

Under the Connecticut Coastal Management Act (CCMA), enacted in 1980, the Program ensures balanced growth along the coast, restores coastal habitat, improves public access, protects water-dependent uses, public trust waters and submerged lands, promotes harbor management, and facilitates research. The Program also regulates work in tidal, coastal and navigable waters, and tidal wetlands under the CCMA (Section 22a-90 through 22a-112 of the Connecticut General Statutes), the Structures Dredging and Fill statutes (Section 22a-359 through 22a-363f) and the Tidal Wetlands Act (Section 22a-28 through 22a-35). Development of the shoreline is regulated at the local level through municipal planning and the zoning boards and commissions under the policies of the CCMA, with technical assistance and oversight provided by Program staff. The Stratford Zoning Commission administers the program at the local level through the coastal site plan review process. Figure 6.3 on the following page presents the land area in Stratford within the CCMA jurisdiction (coastal boundary). Coastal site plan reviews are required for certain projects or activities located within the coastal boundary if the activity or use is located landward of the mean high water mark (coastal jurisdiction line, a fixed elevation for each coastal town). The coastal jurisdiction lines for the Town are:

- Long Island Sound – Elevation 4.8 feet NAVD88
- Housatonic River – Elevation 5 feet NAVD88

Changes to the CCMA in 2012 (through Public Act 12-101) launched new initiatives that are focused on sea level rise and revisions to shoreline protection and shoreline protection regulatory procedures. Sea level rise is now part of the CCMA's general goals and policies for coastal planning; in particular, consideration of the potential impacts from sea level rise, coastal flooding, and erosion patterns on coastal development. The CCMA defines sea level rise 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 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 setback 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, in order to encourage natural

Figure 6.3 Limits of Coastal Zone Management in Stratford
(facing page, Image Ref. CT DEEP)

Legend
Coastal Boundary
North Housatonic River Inset
Milford
Housatonic River
Inset Map
Shelton
Orange
Trumbull
Milford
Bridgeport
Barnum Ave
Barnum Avenue Cutoff
Bridgeport Ave
E Main St
Main St
Nichols Ave
W Broad St
Linden Ave
Beardsley Ave
Ferry Blvd
CT-130
Naugatuck Ave
Rivercliff Dr
Housatonic Dr
Stratford Ave
Connecticut Ave
Hollister Ave
Surf Ave
Spada Blvd
Mount Carmel Blvd
South Ave
Honeyspot Rd
Woodend Rd
Lordship Blvd
Great Meadow Rd
Stratford Rd
Prospect Dr
Oak Bluff Ave
Seaview
0 600 1,200 2,400
Feet
N

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.

STATE AND FEDERAL PERMITS

Several State and federal permits regulate future coastal resiliency projects as well as how the Town implements maintenance of key infrastructure, such as tide gates, required for flood mitigation and response.

Action PPR 9 is for the Town to review their permit status for all State and federal permits relative to supporting activities related to coastal resiliency and flood mitigation. The goal is to have a comprehensive permit compliance process that supports coastal resiliency and efficient and effective flood mitigation. This action also includes meetings between the Town and the CT DEEP Office of the Ombudsman to review the Town’s permit process, issues, and opportunities to make implementation more efficient in support of coastal resiliency.

Stormwater Permits

Removal of sediment from stormwater structures such as catch basins, particle separators, and tide gates are covered under the Town’s MS4 General Stormwater Permit; however, sediments that have been dispersed away from stormwater outfalls may not be covered under this permit. In such cases, the dredging-related permits below would apply.

Coastal Activities

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.

Dredging

Dredging of Town coastal waterbodies such as the Housatonic River, Yellow Mill Channel, Johnsons Creek, and Ferry Creek requires federal and State permits (see list below). The permit details depend on: location (coastal or inland); volume of dredge material; physical and chemical characteristics of the sediment; sediment disposal location, and proximity to regulated resources.

- U.S. Army Corps of Engineers (USACE) Section 404 Permit
- USACE Section 10 Permit
- Connecticut Department of Energy & Environmental Protection (DEEP) Office of Long Island Sound Programs (OLISP) Structures and Dredging Permit or Certificate of Permission (COP)
- DEEP OLISP Coastal Zone Consistency Review
- DEEP Section 401 Water Quality Certification
- Local Inland Wetlands and Watercourses Permit (inland waters only)

Dredged 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 which exempt projects from certain permitting requirements and can result in a favorable and streamlined permitting process, depending on the complexity of the project.

Action PPR 10 involves future coordination with the USACE relative to proposed future dredging projects and reuse of dredge materials as "ecological restoration" projects under the USACE and DEEP OLISP permit programs.

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 Stratford, the Great Meadows and Long Beach West). Figure 6.4 shows the coastal areas in Stratford that are part of the Coastal Barrier Resource System (CBRS). The CBRA limits, but does not completely prohibit development within the CBRS. There are also restrictions under the CBRA that affect funding of future resiliency projects.

This Plan recommends that the Town continue to preserve and potentially grow this vital natural resource over the short and long term.

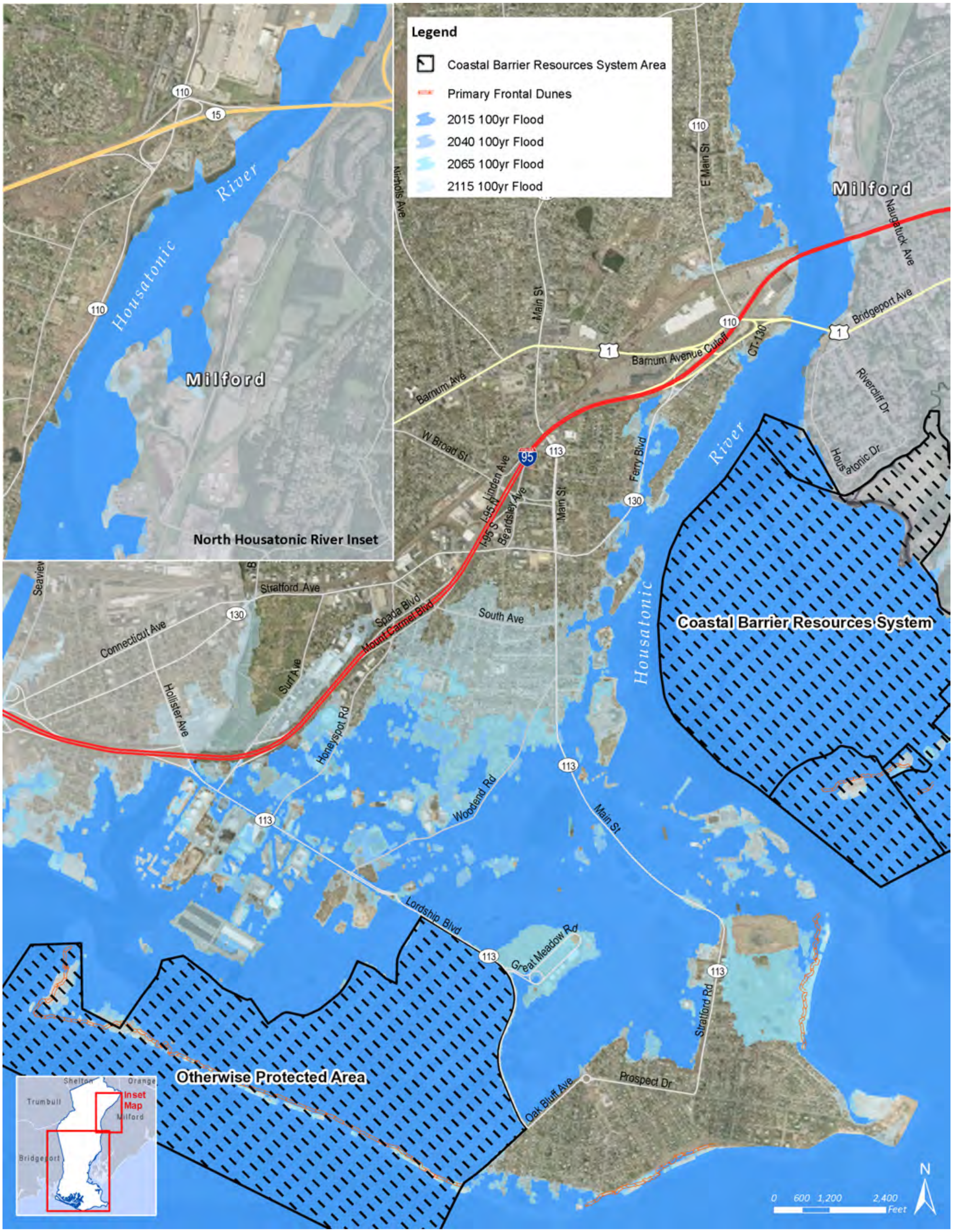
Building Codes

Construction within the Town is subject to the requirements of the State and local building codes.

Action PPR 11 involves review of the effective building codes relative to resiliency and climate change. In particular, this includes consideration of: 1) adopting flood standards presented in ASCE 24-14 (which are more conservative than current Town standards and will likely be incorporated in the next revision of the State Building Code), 2) establishment of a Design Flood Elevation (DFE) that is higher than the Base Flood Elevation (BFE) presented on the effective FEMA FIRMs, and 3) monitoring the efforts taken in response to Governor Malloy's Executive Order No. 53 dated April 22, 2016, effective immediately, to make changes to the State Building Code to increase a structures resiliency to wind and flood hazards.

The Office of the Building Official is responsible for the enforcement of all construction and building codes in the Town. The Town uses the Connecticut State Building Code. The effective State Building Code includes the 2009 International Building Code, the State Building Code Connecticut Supplement, and 2013 Amendments.

Figure 6.4 Limits of Coastal Barrier Resources in Stratford
(facing page)



Legend
Coastal Barrier Resources System Area
Primary Frontal Dunes
2015 100yr Flood
2040 100yr Flood
2065 100yr Flood
2115 100yr Flood
North Housatonic River Inset
Housatonic River
Milford
Coastal Barrier Resources System
Otherwise Protected Area
Inset Map
Barnum Avenue Cutoff
Stratford Ave
Connecticut Ave
South Ave
Lordship Blvd
Great Meadow Rd
Oak Bluff Ave
Prospect Dr
Stratford Rd
Main St
Woodend Rd
Honeyspot Rd
Hollister Ave
Surf Ave
Main St
Ferry Blvd
Bridgeport Ave
Naugatuck Ave
Rivercliff Dr
0 600 1,200 2,400 Feet
N

The State Building Code also incorporates by reference ASCE 7 (Minimum Design Loads for Buildings and Other Structures) and ASCE 24 (Flood Resistant Design and Construction), which contain most of the requirements related to flood regulations. The State also uses the 2009 International Residential Code for regulation of residential structures.

The Connecticut State Building Codes support and are consistent with the federal NFIP regulations (44CFR Parts 59 and 60). The State is scheduled to update the State Building Codes in 2016; and significantly due to the Governor's Executive Order No. 53, this code update may incorporate the current version of ASCE24-14 (which has substantive changes to flood regulations) and more wind resistant roofing construction methods.

Chapter 102 of the Code of Stratford serves as the local floodplain ordinance. The purpose of Chapter 102 (§ 102-3. Purpose) 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:

- Protect human life and health;
- Minimize expenditure of public money for costly flood control projects;
- Minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;
- Minimize prolonged business interruptions;
- Minimize damage to public facilities and utilities, such as water and gas mains, electric, telephone and sewer lines, and streets and bridges located in the Special Flood Hazard Area (SFHA);
- Help maintain a stable tax base by providing for the sound use and development of areas of special flood hazard so as to minimize future flood-blight areas;
- Ensure that potential buyers are notified that property is in an area of special flood hazard; and
- Ensure that those who occupy the areas of special flood hazard assume responsibility for their actions.

Stratford's flood design requirements are consistent with NFIP's minimum requirements for construction in flood hazard areas. Relevant and key features related to design and construction requirements for new buildings and structures, and substantial improvements in flood hazard areas based on Chapter 102-18 are presented in Table 6.2.

	Special Flood Hazard Area (SFHA)	Elevation Requirement
Minimum Elevation of Lowest Floor (including basement)	Zone AE	BFE or Above
Minimum Elevation of Bottom of Lowest Horizontal Structural Member	Coastal High Hazard Areas (Zone VE)	BFE + 1 Feet

Table 6.2 Chapter 102 Design and Construction Requirements in Flood Hazard Areas

AE Zone standards

As outlined in Chapter §102-18B new construction and substantial improvement of any commercial, industrial, or other nonresidential structure shall have either the lowest floor, including basement, elevated to at least the base flood elevation (BFE) or, together with attendant utility and sanitary facilities, shall:

- Be floodproofed to the base flood level so the structure is watertight with walls substantially impermeable to the passage of water.
- Have 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 standards of this subsection are satisfied; such certifications shall be provided to the official as set forth in §102-12C.

Coastal High-Hazard area (VE Zones) standards

As outlined in Chapter §102-19, within VE Zones, electrical, plumbing, machinery, or other utility equipment that services the structure must be elevated to or above the BFE and cannot be located below the structure. Any service equipment that must be located below the BFE must be flood-proofed to prevent water from entering during flood conditions.

The effective State Building Code elevation requirements for new construction and substantial improvement in AE and VE zones are consistent with those outlined above and the additional AE and VE standards outlined in the Chapter 102 Flood Damage Prevention section. 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.

Zoning Regulations

Action PPR 12 includes detailed review and modification of the Town's zoning regulations to incorporate coastal resiliency, flood mitigation, and climate change standards.

The Planning and Zoning Office has the primary responsibility for managing land use, including administering the Zoning Regulations. The zoning regulations are included as Chapter 220a in the Code of Stratford Connecticut. The zoning regulations most relevant for the integration of coastal resiliency and climate change provisions are Sections 3, 7, 8, and 10.

Section 3 General Requirements: Integrate coastal resiliency and climate change provisions into several of the general requirements:

3.1.1 Coastal Area Management Regulations: This section includes regulations to: a) assure that development within the coastal area of Stratford is accomplished in a manner consistent with the goals of the Connecticut Coastal Area Management Act (CCMA) and with the goals and policies of the Town of Stratford Zoning Commission and b) promote and encourage public access to and use of the waters of Long Island Sound, Housatonic River, and other similar marine and tidal waters as identified in Chapter 444 of the Connecticut General Statutes. 2012 changes to the CCMA require that, at a minimum, sea level rise consistent with that observed over the historical record be addressed in design of shoreline flood and erosion control structures. More conservative assumptions of sea level rise is encouraged in the CCMA. The rate of sea level rise is predicted to increase; therefore, it is recommended that the zoning recommendations define a more conservative sea level rise projection (in concert with the other METRO-COG communities).

3.1.2 Erosion and Sediment Control: This section includes regulations that conform with, and adhere to, the requirements and public policy as set forth in Public Act 83-388. 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 presented in detail below. Section 3.1.2 can be modified to encourage the use of natural and nature-based features.

3.14 Waterbody, Watercourse, Wetland, and Coastal Resource Protection: This section requires that no new building construction that increases building area, including minor additions to existing buildings or detached accessory buildings, such as garages and sheds and no pools, tennis courts, driveways, parking areas, terraces, other impervious surfaces or alteration of existing contours shall be permitted within 50 feet of the mean high water line of any waterbody or watercourse or within 50 feet of any freshwater inland wetland as defined in Chapter 440 of the Connecticut General Statutes except for direct water dependent/public access structures and uses as defined by the Connecticut Coastal Management Act and when consistent with coastal management policies. The location of the mean high water line will increase in the future due to sea level rise. Modifications to the 50-foot setback should be considered for coastal waterbodies to account for these changes. Also, building elevation standards should be updated.

3.28 Wireless Telecommunications Facilities: Flood mitigation standards should be considered for these structures (consistent with ASCE 24-14) due to their importance for flood and hazard response.

Section 7.10 Transit-Oriented Development Overlay District: Section 4 of the Plan presented the potential future impacts to various sea level rise scenarios on the flood risk of this area. This district is also particularly relevant to the future vision in the 2014 POCD. The addition of specific flood and climate change guidelines (e.g. DFE) should be considered.

Section 8 Water Front Business Districts: The purpose is to preserve and enhance water dependent uses where appropriate and encourage development which is compatible with the coastal resource characteristics. All uses must be heard as special cases and are subject to a coastal site plan review. This zoning requirement will apply to future impacts along Long Beach and extending inland to waterfront business districts along the Housatonic River including recreational and park areas. The addition of specific flood and climate change guidelines (e.g. DFE) should be considered.

Section 10 – Coastal & Light Industrial: The intent and purpose of this regulation is to place stricter limitations on development and use of land in those areas to preserve and protect sensitive coastal resources while reducing hazards to life and property as outlined in the Connecticut Coastal Area Management Act. The Stratford Army Engine Plant (SAEP), Bond's Dock, and the Employment Growth District are critical areas for future development considerations as noted in the 2014 POCD and are located within a coastal industrial district. The addition of specific flood and climate change guidelines (e.g. DFE) should be considered.

FUNDING MECHANISMS

Funding of resiliency projects is a key component of the implementation of the Plan. Disaster recovery and climate change adaptation projects in Connecticut are primarily funded through federal grant programs. There are also State funding programs in Connecticut that can used to finance resiliency. Funding resiliency through the Town's Capital Budget general funds and municipal bonds are also options.

Action PPR 13 involves the development of a comprehensive funding plan that addresses identification of appropriate funding mechanisms, grant applications, and grant administration for the proposed Town resiliency projects (Section 5). The goals are to: 1) apply for grants for funds available now; 2) plan for next year's funding allocations; 3) position the Town to respond quickly with grant applications associated with future Presidential declarations; and 4) evaluate other funding mechanisms such as bonds.

The following describes applicable grant and financing opportunities.

FEMA HAZARD MITIGATION ASSISTANCE GRANT PROGRAMS

Several of the proposed resiliency projects and actions are eligible activities for funding under FEMA Hazard Mitigation Assistance Grants.

Pre-Disaster Mitigation (PDM)

The purpose of PDM is to reduce the overall risk to communities and structures from future hazard events including coastal flooding, while also assisting communities in recovering more quickly from future natural disasters. PDM funds mitigation planning and project grants designed to reduce future losses in advance of potential disaster. Funding for PDM and FMA is appropriated by Congress annually and awarded on a nationally competitive basis. Some of the proposed resiliency projects and actions are eligible activities for funding under PDM.

Flood Mitigation Assistance (FMA)

The purpose of the FMA program is to reduce or eliminate insurance claims under the National Flood Insurance Program (NFIP). FMA provides funding to States, Territories, federally-recognized tribes, and local communities for projects that reduce or eliminate long-term risk of flood damage to structures insured under the NFIP. FMA funding is available for flood hazard mitigation projects, plan development, and management costs. Funding for PDM and FMA is appropriated by Congress annually and awarded on a nationally competitive basis.

Hazard Mitigation Grant Program (HMGP)

FEMA's HMGP provides funding to municipalities, states, COGs, and other eligible applicants to help communities implement hazard mitigation measures following a Presidential major disaster declaration. The most recent disaster declaration in Connecticut was announced on April 8, 2015 - Connecticut Severe Winter Storm and Snowstorm (DR-4213). A declaration typically opens up a host of disaster recovery and mitigation programs to assist states in recovering from and mitigating the future impacts from all natural hazards.

The funding for FEMA's HMGP is 15% of the total assessed damages for a given disaster for states that meet FEMA's standard Mitigation Plan requirements, which applies to the state of Connecticut. The HMGP application period is open for one year from the disaster declaration date.

Table 6.3 presents an overview of the eligible activities for each HMA program.

Eligible Activities	HMGP	PDM	FMA
Property Acquisition and Structure Demolition	X	X	X
Property Acquisition and Structure Relocation	X	X	X
Structure Elevation	X	X	X
Mitigation Reconstruction			X
Dry Floodproofing of Historic Residential Structures	X	X	X
Dry Floodproofing of Non-Residential Structures	X	X	X
Minor Localized Flood Reduction Projects	X	X	X
Hazard Mitigation Planning	X	X	X

Table 6.3 FEMA HMA Eligible Mitigation Activities

All three HMA programs are managed by the Connecticut Department of Emergency Services and Public Protection (DESPP) with support from Department of Energy and Environmental Protection (DEEP). There is currently a backlog of potentially eligible project applications for future HMA funding cycles. However, the DESPP advised the Town to develop and rank an itemized list of resiliency and mitigation projects that will assist in pursuing HMA grant funding when the state accepts new grant applications. Based on this guidance

Action PPR 14 involves the preparation of a FEMA Pre-disaster and Post-disaster recovery plan before the next disaster that itemizes and ranks a list of projects the Town is looking to fund. This recovery plan should also include brief project summaries of projects to increase Stratford's likelihood to pursue, and potentially receive, PDM, FMA, and HMGP funding.

There are currently no open disasters in Connecticut under HMGP. The application period for the Fiscal Year (FY) 2016 PDM and FMA grant programs is March 15 - June 15, 2016. The application process for PDM and FMA is conducted through an online application process using FEMA's eGrants system.

HUD DISASTER RECOVERY AND RESILIENCY GRANTS

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

Similar to FEMA's HMGP, HUD provides disaster recovery grants to help municipalities like Stratford and the State recover from Presidentially-declared disasters, especially in low-income areas. The goal of these grants is to rebuild the impacted areas and provide critical funding to start the recovery process. The CDBG-DR program allows for the funding of a wide range of recovery activities including planning activities that aide communities and neighborhoods that may otherwise not recover because of a lack of resources. In response to Hurricane Sandy, the State received approximately $159 million in funding from the HUD CDBG-DR program. Funds from this program supported the development of this resiliency plan and can assist Stratford in the future in funding recovery programs dedicated to owner-occupied housing, multi-family housing, infrastructure, planning, small business express, and planning.

EXP/Hurricane Sandy Business Disaster Relief Program

The EXP/Hurricane Sandy Business Relief Program provides grants to Connecticut's small businesses adversely impacted by Hurricane Sandy with $4 million dollars in available funding for matching grants. The goal of the program is to maintain job growth and economic revitalization of small business eligible counties. Eligible applicants include small businesses meeting the following criteria:

- Employ not more than 100 employees.
- Small businesses with operations in the following Connecticut areas
  - Fairfield County,
  - New Haven County,
  - Middlesex County
  - New London County, and
  - Mashantucket Pequot Indian Reservation
- Registered to conduct business for not less than twelve months as of October 29, 2012, and
- In good standing with all state agencies and with the payment of all state taxes.

Matching Grants may be used for:

- Ongoing or new training,
- Working capital,
- Acquisition or purchase of machinery and equipment,
- Construction or leasehold improvements,
- Relocation within state, or
- Other authorized business expense approved by the Commissioner of DECD and consistent with 24 Code of Federal Regulations (CFR) part 570.3 -570.203.

The DEEP Commissioner prioritized funding awards for matching grants based upon job retention and use of funds. These funds can assist eligible small businesses in Stratford through assistance designed to help businesses maintain and grow during the post disaster recovery process.

HUD National Disaster Resilience Competition (NDRC)

HUD opened the National Disaster Resilience Competition (NDRC) in partnership with the Rockefeller Foundation with $1 billion dollars in funding for areas affected by natural disasters in 2011, 2012, and 2013. The State of Connecticut was successful in winning a NDRC award from HUD totaling more than $54 million. HUD funding will support a pilot project in Bridgeport that is a part of the Connecticut Connections Coastal Resilience Plan. The Connecticut Connections Coastal Resilience Plan is focused on reconnecting and protecting economically-isolated coastal neighborhoods through investments in mixed green and gray infrastructure that protect against flooding while strengthening connectivity to existing transportation nodes. In addition, the funding supports Connecticut's efforts to bring these resiliency approaches to other at-risk communities along the I-95 corridor by contributing to planning efforts, including economic and climate modeling.

US ARMY CORPS OF ENGINEERS SECTION 103 AND OTHER FUNDING AUTHORITIES

Under Section 103 of the 1962 River and Harbor Act, the US Army Corps of Engineers (USACE) can study, design, and construct small coastal storm damage reduction projects in partnership with non-Federal government agencies including the Town of Stratford. $5,000,000 is the maximum Federal cost for planning, design, and construction of a single project. The USACE must determine that each project is economically justified through a cost-effectiveness evaluation; environmentally sound per the National Environmental Policy Act (NEPA); and technically feasible. Hurricane and storm damage reduction projects are not limited to any particular type of improvement and can include structural activities such as beach nourishment and non-structural ones including floodproofing.

Some of the resiliency recommendations and actions presented in this plan are candidates for consideration by the USACE under Section 103. The first step in the process is requesting the USACE to perform a feasibility study under Section 103 Hurricane and Storm Damage Protection. The feasibility study is 100% federally funded up to $100,000.

Action PPR 15 Involves submitting a letter to the USACE requesting the USACE perform a feasibility study under Section 103 Hurricane and Storm Damage Protection to evaluate proposed actions included in this resiliency plan.

Section 103 falls under the USACE's Continuing Authorities Program (CAP) that also includes seven more authorized programs. These programs also serve as potential opportunities for Stratford that may assist in the planning, design and implementation of resiliency projects and actions that meet the criteria for each program as outlined by the USACE including:

- *Section 14 Emergency Streambank and Shoreline Protection* authorizes the USACE to construct emergency shoreline and streambank protection works to protect public facilities, such as bridges, roads, public buildings, sewage treatment plants, water wells, and non-profit public facilities, such as churches, hospitals, and schools.
- *Section 107 Small Navigation Project Study* authorizes the USACE to improve navigation including dredging of channels, anchorage areas, and turning basins and construction of breakwaters, jetties and groins, through a partnership with non-Federal government sponsor such as cities, counties, special chartered authorities (such as port authorities), or units of state government.
- *Section 204 Ecosystem Restoration in Connection with Dredging* authorizes the USACE to plan, design and build projects to protect, restore and create aquatic and ecologically related habitats in connection with dredging of authorized Federal navigation projects. Often these projects involve the beneficial use of dredged material from navigation channels to improve or create wetlands or water bird nesting habitats.
- *Section 205 Flood Damage Reduction Projects* authorizes the USACE to study, design, and construct small flood control projects in partnership with non-Federal government agencies, including Stratford. Projects are not limited to any particular type of improvement. Examples of

flood control projects include a levee and channel modifications with a maximum of $10 million for one project that would first require a feasibility study.

- *Section 206 Aquatic Ecosystem Restoration Projects* authorizes the USACE to plan, design, and build projects to restore aquatic ecosystems for fish and wildlife. Examples of projects completed in New England include eelgrass restoration, salt marsh and salt pond restoration, freshwater wetland restoration, anadromous fish passage and dam removal, river restoration, and nesting bird island restoration.
- *Section 208 Clearing and Snagging Projects of the 1954 Flood Control Act* authorizes the USACE to conduct clearing, snagging, or channel excavation, and limited embankment construction can be provided by using the materials from the cleaning operation. The first step in the process is requesting the USACE to perform a feasibility study to determine USACE interest in viability of the project. The maximum federal cost for a project is $500,000 that can be used for project related costs for planning, engineering, construction, and supervision and administration.
- *Section 1135 Environmental Restoration of the Water Resources Development Act of 1986* authorizes the USACE to plan, design, and build modifications to existing Corps projects, or areas degraded by Corps projects, to restore aquatic habitats for fish and wildlife. Examples of projects completed in New England include salt marsh and salt pond restoration, estuary restoration, freshwater wetland restoration, anadromous fish passage, and river restoration. The Federal cost is limited to $10 million for one project. The project must be in the public interest and be cost effective.

NOAA REGIONAL COASTAL RESILIENCE GRANT PROGRAM

The NOAA Regional Coastal Resilience Grant program will support regional approaches to undertake activities that build resilience of coastal regions, communities, and economic sectors to the negative impacts from extreme weather events, climate hazards, and changing ocean conditions. It will support planning or implementing actions that mitigate the impacts of environmental drivers on overall resilience, including economic and environmental resilience. Funded projects will result in improved information for decision makers and actions that reduce risk, accelerate recovery, and promote adaptation to changing social, economic, and environmental conditions. This would serve as a good funding source for Stratford to pursue with other coastal municipalities in Connecticut.

$4M was available in program funding during FY2015 to provide four to eight grants nationwide ranging in value from $500k to $1M. It is anticipated that Congress will authorize future funding with similar funding levels. The NOAA program provides Stratford with an opportunity to work regionally with neighboring communities such as Milford and Bridgeport as well as METRO-COG.

NATURAL RESOURCES CONSERVATION SERVICES (NRCS)

The NRCS is the US Department of Agriculture's (USDA) leading agency providing voluntary technical and financial assistance to conservation districts, private land-owners, tribal governments, and other organizations to help sustainability manage, conserve, and improve natural resources at the local level. Two financial programs that offer funding support in response to natural hazards as outlined below.

Emergency Watershed Protection Program (EWP)

Congress established the Emergency Watershed Protection Program (EWP) to assist public and private landowners in response to emergencies resulting from natural hazards including coastal flooding and storms. The mission of the EWP Program is to assist people and conserve natural resources by reducing the future impacts to public safety and property caused by floods, coastal storms, and other natural hazards. The NRCS is the managing agency for the EWP Program that includes two focus areas: EWP-Recovery and EWP-Floodplain Easement (FPE).

EWP-Recovery provides recovery assistance to public and private landowners as a result of a natural disaster that requires a 25% local match with the NRCS providing a 75% match for the construction cost for emergency measures. EWP-FPE provides assistance to privately-owned lands or lands owned by a local or state government that have been damaged by flooding at least once within the previous calendar year or have been subject to flood damage at least twice within the previous ten (10) years.

Watershed and Flood Prevention Operations (WFPO) Program

The Watershed and Flood Prevention Act of 1954 authorizes the NRCS to provide technical and financial assistance to states, local, and tribal governments (project sponsors) for the planning and implementation of approved watershed plans. The NRCS works with local sponsors to protect and restor watersheds from damage caused by erosion, floodwater, and sediment to conserve and develop water and land resources and to solve natural resource and related economic problems on a watershed basis. In Connecticut, the project sponsor for watershed projects is the Connecticut Department of Environmental Protection (CT DEP). The CT DEP provides assistance for the implementation of measures outlined in approved plans and is focusing their efforts on reducing flood damages. Eight projects have been completed through the WFPO Program and four projects are under development at this time in Connecticut.

Northeast Regional Ocean Council (NROC)

NROC was established in 2005 by the Governors of New England (i.e. Connecticut, Massachusetts, New Hampshire, Rhode Island, and Vermont) as a state and federal partnership. The purpose of the NROC is to facilitate development of coordinated and collaborative responses to coastal and ocean management issues that benefit from regional solutions. The NROC provides training and small grant programs designed to improve regional resilience and response to impacts of coastal hazards and climate change that can assist Stratford in collaborating with the METROCOG and neighboring communities.

HIMES BILL - USACE FEASIBILITY STUDY

Representative Jim Himes from Connecticut's 4th District secured $300K as the first installment of the federal government's share of financing for a feasibility study to be performed by the USACE, which will encompass both Fairfield and New Haven Counties. The study will be conducted over a three-year period, with the estimated $3 million cost shared evenly between the federal government and a non-federal partner. It is important to note that the non-federal partner for this effort has yet to be identified.

In recent press release, Col. Christopher Barron, Commander of the USACE New England District said that USACE will reach out to communities in Fairfield and New Haven Counties to participate in this effort. This plan recommends that the Town coordinate with the USACE New England District to demonstrate the Town of Stratford's strong interest in participation in future outreach conducted by the USACE project team.

CONNECTICUT INSTITUTE OF RESILIENCY AND CLIMATE ADAPTATION (CIRCA) GRANT PROGRAMS

Municipal Resilience Grant Program

Up to $100,000 total funds were available for this grant program. Stratford is eligible to submit proposals for initiatives that advance resilience, including the creation of conceptual design, construction (demonstration projects or other) of structures, or the design of practices and policies that increase their resilience to climate change and severe weather. The second round of funding for this grant program closed on April 15, 2016.

Project proposals should develop knowledge or experience that is transferable to multiple locations in Connecticut and have well-defined and measurable goals. It is preferred that projects be implemented in no more than an 18-month time frame. Preference will also be given to those projects that leverage multiple funding sources and that involve collaboration with CIRCA to address at least one of the following priority areas:

- *Priority Area 1:* Develop and deploy natural science, engineering, legal, financial, and policy best practices for climate resilience;
- *Priority Area 2:* Undertake or oversee pilot projects designed to improve resilience and sustainability of the natural and built environment along Connecticut's coast and inland waterways;
- *Priority Area 3:* Foster resilient actions and sustainable communities – particularly along the Connecticut coastline and inland waterways – that can adapt to the impacts and hazards of climate change; and
- *Priority Area 4:* Reduce the loss of life and property, natural system and ecological damage, and social disruption from high impact events.

The CIRCA Executive Steering committee will weigh the following factors in their decision process:

- The extent to which a project makes a community more resilient to climate change and extreme weather;
- Develop knowledge or experience that is transferable to multiple locations in Connecticut;
- Involve collaboration with CIRCA to address at least one of the priority areas outlined above (numbered 1-4);
- Have well-defined and measurable goals;
- Be completed in an 18-month timescale;
- Leverage multiple funding sources; and
- Emphasize implementation.

CIRCA is open to using the entire funding on one project, but funded five smaller projects during the first round of funding in the Fall of 2015.

CIRCA's Matching Funds Grant Program

CIRCA's Matching Funds Program also makes up to $100,000 of matching funds available. The most recent deadline was May 15, 2016. Stratford is eligible to pursue matching funds for projects that address CIRCA's mission. The first condition of award for successful applications is that a proposed project must have a commitment of primary funding within 6 months of the CIRCA award announcement or have received a waiver from the CIRCA Executive Steering Committee. CIRCA Matching Funds will provide up to 25% of the primary funder's contribution (with the exception of municipal or State of Connecticut funds) to enhance the likely success of project proposals. Proposals are required to leverage independent funding awarded through a competitive process.

This grant program looks to fund project proposals that develop knowledge and/or experience that is transferable to multiple locations in Connecticut with well-defined and measurable goals. CIRCA gives preference those proposals that involve collaboration with CIRCA to address at least one of the following priority areas:

- *Priority Area 1:* Improve scientific understanding of the changing climate system and its local and regional impacts on coastal and inland floodplain communities;
- *Priority Area 2:* Develop and deploy natural science, engineering, legal, financial, and policy best practices for climate resilience;
- *Priority Area 3:* Undertake or oversee pilot projects designed to improve resilience and sustainability of the natural and built environment along Connecticut's coast and inland waterways;
- *Priority Area 4:* Create a climate literate public that understands its vulnerabilities to a changing climate and which uses that knowledge to make scientifically informed, environmentally sound decisions;
- *Priority Area 5:* Foster resilient actions and sustainable communities – particularly along the Connecticut coastline and inland waterways – that can adapt to the impacts and hazards of climate change; and
- *Priority Area 6:* Reduce the loss of life and property, natural system and ecological damage, and social disruption from high-impact events.

On April 18, 2016 CIRCA released a Fact Sheet, *Financing Resilience in Connecticut - Current Programs, National Models, and New Opportunities,* on CIRCA's website. This Fact Sheet summarizes several of the funding programs summarized here as well as new finance models yet to be implemented in Connecticut including Property Assessed Resiliency and Resilience Bonds. See the Section 6 Attachment for the Fact Sheet.

CONNECTICUT FLOOD AND EROSION CONTROL PROGRAM

The State Flood and Erosion Control Board (FECB) Program provides state financial assistance to municipalities that have an active Flood and Erosion Control Board for preventing potential hazards due to flooding, stream bank erosion, or beach erosion. Funding is provided on a priority basis. Private Dam owners or private property owners are not eligible, but tax districts may be considered municipalities for the purpose of FECB funding. The municipality must own (or have a long-term lease) of the property at which the funded project is located. CGS Sections 25-84 through 25-98 enable municipal acquisition of private property for flood control, erosion control, non-structural flood or erosion control mitigation measures, and the repair of municipally owned or leased dams when such structures will provide a benefit to the community.

SHORE UP CONNECTICUT

Shore Up CT is a State-funded low interest loan program for homeowners and small businesses in the coastal floodplain to elevate structures and utilities. Additional retrofitting for flood protection and wind proofing activities can also be financed. Loans of $100,000 to $300,000 are available for eligible properties. Criteria to determine eligibility include:

- Primary and secondary single family homes or 1-4 unit owner-occupied rentals. Owners must live in the property at least 14 days per year.
- Businesses with fewer than 100 employees and in good standing with all state agencies.
- Subject to coastal flooding and located in either Zone VE or Zone AE in coastline communities as defined by the Federal Emergency Management Agency (FEMA) and NFIP.
- Must be up-to-date with all local, state, and federal taxes.

ADDITIONAL FUNDING OPPORTUNITIES

There are also funds available through other funding programs that are not explicitly related to flood protection but can be support an integrated funding plan. These include:

Microgrid Grants and Green Bank Financing Program

The CT DEEP administers the microgrid grants program. These grants fund energy sources that can operate without the grid and can be paired with financing programs from the Connecticut Green Bank to pay for infrastructure and generation capabilities to build a microgrid.

Clean Water Revolving Loan Funds

Revolving loans from the Clean Water Fund provide a low interest loan and grant combination to funding wastewater infrastructure projects. Connecticut's program provides funding for planning and designing new and upgraded facilities to operate safely and resiliently under conditions of more frequent and intense storms, flooding, and sea level rise.

Tax Increment Financing (TIF) Districts

Tax Increment Financing (TIF) is a value capture instrument; that is, a way to borrow against future tax revenues. A local TIF District uses future value created for private owners and developers in the area through government investment in the District to finance initial investment. The value is captured by the government by levying district-level taxes or fees on the private owners or developers. The State recently passed legislation (Public Act 15-57) allowing TIF Districts to be used by municipalities.

State of Connecticut Transportation Capital Infrastructure Program

Connecticut transportation funding such as the Transportation Investment Generating Economic Recovery, or TIGER Discretionary Grant program (which includes federal funds from U.S. DOT or Federal Highway Administration), is a potential source of funding for resiliency projects that have a transportation component. This includes typical State-owned transportation systems (roads, bridges, rail, and bus) but also includes pedestrian trail corridors (including along the Housatonic River in Stratford). 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.

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 are a version of catastrophe bond insurance that capture the savings from a lowered risk of payout and then use that value as rebates to invest in resilient infrastructure projects.

Federal Highway Administration; Planning, Environment, and Realty

The Federal Highway Administration (FHWA) announced a 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.

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.

It is anticipated that two to four applied research projects (pilots) will be selected and receive $50,000 to $100,000 each. The funds 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. Proposals were due June 1, 2016.

ADDITIONAL EXISTING RESOURCES AND RELEVANT PUBLICATIONS

The Nature Conservancy Salt Marsh Advancement Zone Assessment of Stratford, Connecticut

In 2014, the Nature Conservancy (TNC) completed a salt marsh advancement assessment for Stratford to assist with the future planning of natural resources for risk reduction and to improve future resiliency of the Town shoreline with respect to sea-level rise. This report will assist Stratford in better understanding and informing the Town with respect to future marsh advancement locations, current land-use of those locations, and which parcels are critical to making the natural resources along the shoreline more sustainable for the community in the future. The analysis presented in the report extends out to 2080 as the advancement of salt marsh will be slow, but unavoidable. It is expected that by 2080, the total extent of salt marsh advancement will encompass 2,383.5 acres, of which 1,105.4 acres are currently occupied by built structures, infrastructure, and land that is not suitable for marsh advancement at present. The report provides further details that outline the parcels of land that are currently not protected and will provide Stratford with key data for making future land use decisions that can assist the Town in becoming more resilient to the future impacts of sea-level rise.

Stratford Community Resilience Building Workshop Summary of Findings Report

In 2013, Stratford partnered with TNC and the Greater Bridgeport Regional Council of Governments (GBRC) to increase awareness of risks tied to natural hazards as well as to assess the strengths and vulnerabilities in Town and across the Region. The ultimate goal of this initiative was to cultivate discussion among community stakeholders and decision makers, assist in expanding community awareness, and to plan for adaptation and mitigation action priorities. The partnership conducted a series of presentations and public meetings that concluded with a capstone Hazards and Community Resilience Workshop in October 2013.

The report findings identified coastal flooding as one of the top hazards, identified vulnerable areas and current strengths in Town, and provided a series of recommendations generated from the workshop. The vulnerable areas / assets identified include the South End and Lordship Neighborhoods, Water Pollution Control Facility (WPCF), Lordship Boulevard, Main Street, Stratford Avenue, Long and Short Beaches, Baldwin Senior Center, and buildings south of Stratford Avenue. These findings are consistent with this Plan. Some of the recommendations identified as highest priorities that this Plan also addresses are:

- Conduct an investigation to examine implications of various flooding scenarios on facilities and identify appropriate and feasible responses;
- For the sixteen (16) pump stations, assess and scope the feasibility of hardening facilities, particularly the six (6) or seven (7) pump stations currently subjected to flooding; and
- For the South End, reassess existing and future risks to employment growth areas identified in the Stratford Plan of Conservation and Development.

The Connecticut Coastal Design Project

TNC initiated and led the Connecticut Coastal Design Project (CCDP) in 2014. This project culminated in a two-phase approach with the intent of creating an ongoing dialogue among coastal engineers, regulatory agencies, academia, and natural resource managers to assist with the cultivation of natural infrastructure projects that make coastal communities more ecologically, socially, and economically resilient. Phase 1 captured critical input from coastal engineers, designers, and natural regulatory agents that were actively involved in ongoing coastal projects through a series of interviews. The results from Phase 1 provided a summary of the interviews that created the baseline framework for understanding the obstacles and opportunities for developing the best conditions for implementing future natural infrastructure projects. In addition, the Phase 1 results assisted in providing a structure and focus for conducting Phase 2, which was the first CCDP workshop.

The purpose of the CCDP report was to accurately document the productive discussions and agreements resulting from the June 11, 2014 CCDP workshop. The workshop resulted in a common and agreed upon list of priority actions that included specific tasks, timeframe, and responsibilities based on a series of group exercises that were designed to overcome the obstacles outlined in Phase 1 and assist in furthering natural infrastructure projects. Some of the actions identified included: Develop Leadership, Develop Technical Design Document, Best Management Practices / Project Catalogue, "How-To" Permitting Guidance, Availability of Native Plantings, and Public Outreach and Education.

2014 Analysis of Shoreline Change in Connecticut

The goal of the 2014 Analysis of Shoreline Change in Connecticut (2014 ASCC) was to conduct a GIS time series using maps of the Connecticut shoreline from different time periods between 1880 and 2006 that would provide a high-level, quantitative data set presenting the shoreline trends in Connecticut on a statewide, regional, and local level. The 2014 ASCC presented long-term rates of shoreline change from 1880-2006 and short-term rates from 1983-2006.

2015 Long Island Sound Resource Comprehensive Conservation and Management Plan

Congress authorized the Environmental Protection Agency (EPA) in 1985 to research, monitor, and assess the health of the Long Island Sound ecosystem. The strengthening of the Clean Water Act in 1987 by Congress creating the National Estuary Program (Section 320). Section 320 authorized the EPA in collaboration with the states of New York and Connecticut to develop the Comprehensive Conservation and Management Plan (CCMP) for protecting and improving the health of Long Island Sound. In March of 1988, to assist in supporting the development of the CCMP, the EPA and States of Connecticut and New York established the Long Island Sound Study (LISS), which is, in effect, a Management Conference that has participation from federal, state, interstate, and local agencies as well as universities, environmental groups, industry, and the public. The LISS includes several committees and work groups that were instrumental in drafting the CCMP that was approved in 1994 by the States of Connecticut and New York.

The LISS continues to advance the environmental commitments and management priorities in protecting Long Island Sound through action agreements in the 1990s, 2000s, and 2011. Additionally, LISS partners have implemented actions from the 1994 CCMP each year, thus making Long Island Sound waters cleaner and coastal habitats more robust which also better engaging the public. In 2014, LISS completed a study that evaluated the framework and accomplishments of the 1994 CCMP that informed the development an approval of the 2015 CCMP that provides the vision for the next 20 years.

Table 6.4 Resiliency Implementation Matrix

Legend

Strategy: Protect = P, Accommodate = A, Retreat = R

Priority: High=H, Medium=M, Low=L

Project Type: Structural = S, Non-Structural = N-S, Natural and Nature-Based = NNB

Action	Strategy	Project Type	Responsibility	Priority
Policies, Plans, and Regulations				
PPR 1: Establish a Town Coastal Resiliency Team and identify the Town Resiliency Program Leader. The purpose of the team is to ensure integration of coastal resiliency and climate change into future Town policies, plans, and projects.	A	N-S	• Conservation Department and Commission • Public Works • Planning and Zoning • Economic Development • Health • Community Services • Building Official	H
PPR 2: Identify or establish a Flood and Erosion Control Board (FECB), making Stratford eligible for the State Flood and Erosion Control Board funding program. Per the Program Guidance, an ordinance should be promulgated to adopt CSG Sections 25-84 through 25-94, thereby establishing the board. The FECB may be an existing board such as the Town Council.	A	N-S	• Town Council	H
PPR 3: Perform a feasibility study to evaluate the potential for revising the coastal portions of the FEMA Flood Insurance Rate Map (FIRM), with particular focus on wave set-up. Apply for a FEMA Letter of Map Revision (LOMR) for Stratford coastal areas, as applicable.	A	N-S	• Town Council • Economic Development • Conservation Department and Commission • Public Works	H
PPR 4: Participate in FEMA Community Rating System (CRS). Apply for a Level 9 status with FEMA. This will require designating a staff member to manage the CRS program for the Town.	A	N-S	• Conservation Department • Public Works • Planning and Zoning	H
PPR 5: Perform a RLAA to identify impact to Town NFIP insurance rate due to repetitive loss and support Town and property owner resiliency and mitigation activities, including acquiring, relocating and/or flood mitigation of repetitive loss properties.	A	N-S	• Town Council • Economic Development • Conservation Department and Commission • Public Works • Planning and Zoning	H

Action	Strategy	Project Type	Responsibility	Priority
PPR 6: Integrate recommendations of Stratford Coastal Resilience Plan into the 2023 Plan of Conservation and Development.	A	N-S	• Economic Development • Conservation Department and Commission • Public Works • Planning and Zoning	M
PPR 7: Integrate Stratford Coastal Resilience Plan recommendations into the 2019 Mitigation Plan Update.	A	N-S	• Economic Development • Conservation Department and Commission • Public Works • Planning and Zoning	M
PPR 8: Review and modify applicable sections of the Town regulations, including Town codes and zoning regulations, to reflect coastal resiliency and flood mitigation goals. Adopt zoning regulations to reflect coastal resiliency and climate change: 1) Design Flood Elevations (DFEs) and 2) Overlay Zones. Additional resiliency requirements should include: 1) new conditions for issuing development permits in flood vulnerable areas (i.e., DFEs for buildings, roadways and utilities) and 2) revise rebuilding restrictions for structures that are substantially damaged (FEMA's threshold uses the 50% rule to govern rebuilding) to include the following approaches: a) rebuilding limitations and b) rebuilding prohibition. At a minimum, these regulations should apply to the Stratford Army Engine Plant.	A	N-S	• Conservation Department and Commission • Public Works • Planning and Zoning	M
PPR 9: Develop a permit, maintenance, and operations plan for stormwater structures, including tide gates and culverts, that addresses 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	• Conservation Department and Commission • Public Works	H

Table 6.4 Resiliency Implementation Matrix (continued)

Action	Strategy	Project Type	Responsibility	Priority
PPR 10: Coordinate with USACE relative to proposed, future dredge projects, and re-use of dredged materials for Town beach nourishment and salt marsh maintenance and restoration projects. These projects can be permitted as "ecological restoration" projects under the USACE and DEEP OLISP permit programs which exempt projects from certain permitting requirements and can result in a favorable and streamlined permitting process, depending on the complexity of the project. http://www.nae.usace.army.mil/Missions/ProjectsTopics/LongIslandSoundDMMP.aspx	A	N-S	• Conservation Department and Commission • Public Works • Harbor Management Commission	M
PPR 11: Adopt ASCE 24-14 standards for construction within flood areas as a special purposes ordinance. (To be incorporated by reference in future Connecticut State Building Code revisions - proposed Fall 2016).	A	N-S	• Public Works • Planning and Zoning • Building Official	H
PPR 12: Modify local floodplain regulations to comply with Executive Order 11988 Update - Federal Flood Risk Management Standard (FFRMS) - for all projects on real federal property, federal financed or assisted and/or federal activities and programs affecting land use.	A	N-S	• Town Council • Economic Development • Conservation Department and Commission • Public Works • Waterfront and Harbor Management • Building Official	M
PPR 13: 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	• Conservation Department and Commission • Public Works • Planning and Zoning	H
PPR 14: 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). The application period for the Fiscal Year (FY) 2016 PDM and FMA grant programs is March 15 - June 15, 2016.	A	N-S	• Public Works	H

Action	Strategy	Project Type	Responsibility	Priority
PPR 15: Request USACE to perform a feasibility study under Section 103 Hurricane and Storm Damage Protection to evaluate proposed projects included in the Stratford Coastal Resilience Plan for future funding. The feasibility study is 100% federally funded up to $100,000. Requests for assistance should be in the form of a letter describing the location and nature of the problem and requesting assistance under the program. The request should be submitted by a state or local government agency to Mr. John Kennelly, Chief, Planning Branch, U.S. Army Corps of Engineers, New England District, 696 Virginia Road, Concord, MA 01742-2751. For more information, call Chris Hatfield of the Special Studies Section at 978-318-8520.	A	N-S	• Public Works	H

Table 6.5 Plans and Studies

Plans and Studies	Responsibility
Develop and Implement Flood Response Plan: Sanitary Pump Stations. Emergency/Flood Response Plan with implementation of temporary and/or permanent flood protection measures, including a storage facility for temporary flood protection.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Develop and Implement Flood Response Plan: Stormwater Pump Stations. Emergency/Flood Response Plan with implementation of temporary and/or permanent flood protection measures, including storage facility for temporary flood protection.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Perform a quantitative study to determine which manhole covers within the existing or new flood zones to waterproof to prevent inundation of flood waters into the sanitary sewer system. This study should consider current and predicted future flood inundation limits. Secure funding for this project.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Coordinate and conduct meetings with United Illuminating Company (UI) to discuss the: 1) protection of the electrical substations and 2) reliability of electrical service during flood events.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Coordinate and conduct meetings with Sprague Oil to discuss protection of the facility during flood events and potential easement for Town flood protection project.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Develop Emergency Response Plan to maintain the functionality of the Birdseye boat docks and ramp under flooded conditions to ensure continued use during disasters.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Public Works Garage and Fueling Station: Emergency Response Plan with use of temporary flood protection measures. Note – Flood mitigation at Ashcroft Inc. (see above) may also mitigate flood hazard at public works facility.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Sikorsky Airport Emergency Response Plan; use of temporary flood protection around buildings; assume runways flood. (Airport is the responsibility of Bridgeport).	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management

Plans and Studies	Responsibility
Develop a comprehensive Beach Management Plan for Long Beach, including design, beach nourishment, survey, maintenance, and documentation.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Develop a comprehensive Beach Management Plan for Lordship Beach, including design, beach nourishment, survey, maintenance, and documentation.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Develop a comprehensive Beach Management Plan for Short Beach, including design of beach nourishment, survey, maintenance, and documentation.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Plan to Support Concrete Reef-Ball Project. Planning meeting to discuss wave and surge simulation data, including hydrodynamic loads on existing Reef Balls. Evaluate future placement locations.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management
Evaluate erosion along Lordship Beach. Assess erosion protection alternatives and perform conceptual design and cost-benefit analysis. Alternatives include: structural revetment, beach nourishment and/or hybrid planted and geosynthetic erosion protection.	• Conservation Department and Commission • Public Works • Planning and Zoning Waterfront and Harbor Management

SECTION 5 ATTACHMENT
Stratford Resilience Plan Projects

SECTION 5.0 ATTACHMENT

This attachment to the Plan presents the proposed resiliency projects. The objectives of these projects is to provide protection form coastal flooding to nearly the entire Town. The projects, in their totality, provide protection along the coastal Town perimeter where the ground surface elevation is relatively low and highly vulnerable to coastal flooding. Most of these projects will work to support and combine with proposed Town bike paths and greenways. Project details are attached. A summary of the projects, indicating approximate project costs and priorities is also attached.

Project highlights are shown in the figure, below.

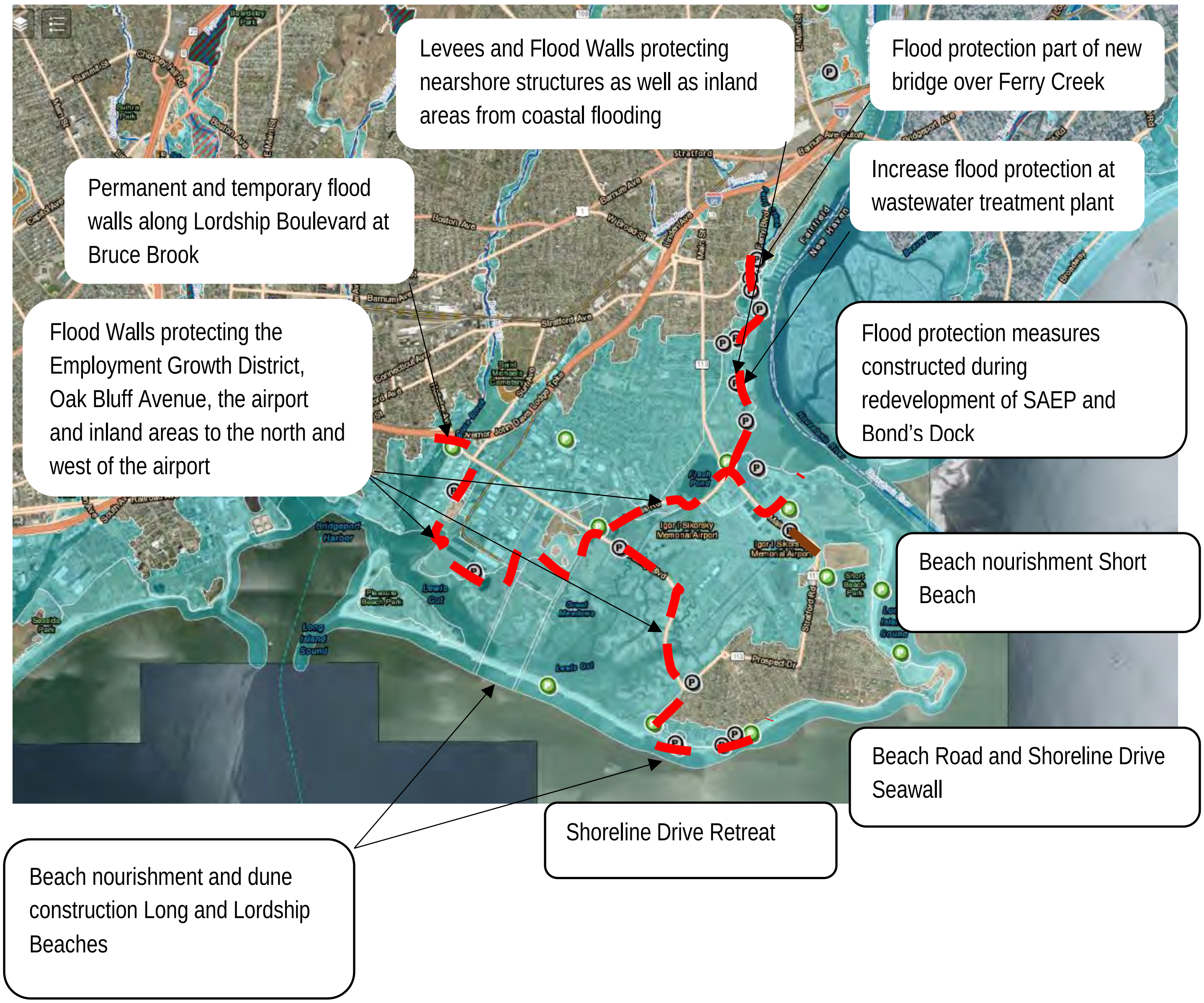


Table 5.1 Project Matrix

Legend

- Strategy: Protection = P, Accommodate = A, Retreat = R
- Priority: High=H, Moderate=M, Low=L
- Project Type: Structural = S, Non-Structural = N-S, Natural and Nature-Based = NNB

Town Coastal Resiliency Projects

Project	Strategy	Project Type	Responsibility	Approximate Cost	Priority
Town-Wide Perimeter Flood Protection:			-		
Ashcroft Inc. Project includes permanent flood levee. Also Emergency Response Plan and Temporary Flood Protection. On private property. Project part of Town-wide perimeter flood protection.	P	S;N-S	- Conservation Department and Commission - Public Works - Planning and Zoning	$1,900,000	M
Replacement of Structure No. 138-005 Broad Street Over Ferry Creek. This project involves replacement of the existing bridge/culvert and raising existing roadway profile at intersection of Ferry Boulevard and Broad Street. Flood hazard due to inundation at bridge results in significant flooding of upland areas along Ferry Creek. Part of Town-wide perimeter flood protection.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$4,000,000	M
Ferry Boulevard Flood Protection (south of Broad Street). Ferry Boulevard flood wall. This project extends the flood protection from the Broad Street intersection and involves constructing a permanent flood wall along Ferry Boulevard south of Broad Street to Lockwood. Project part of Town-wide perimeter flood protection.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$2,000,000	M
Lockwood Avenue Flood Protection (south of Broad Street). This project extends the flood protection from Ferry Boulevard and involves constructing a permanent flood wall along Lockwood Avenue. Project part of Town-wide perimeter flood protection.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$1,500,000	M
Stratford Avenue Flood Protection (south of Broad Street); Berm/levee. This project extends the flood protection from Lockwood Avenue and involves constructing an earthen berm partially along Stratford Avenue and partially on a privately-owned parcel. Project part of Town-wide perimeter flood protection.	P	S, NNB	- Conservation Department and Commission - Public Works - Planning and Zoning	$350,000	M

TABLE 5.1 PROJECT MATRIX

Town Coastal Resiliency Projects					
Shore Road and Bond's Dock. Increase roadway elevation and grade elevation of Bond's Dock, with new marine bulkheads. This project would be integrated with the proposed redevelopment of Bond's Dock and serve as part of Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$2,500,000 (only includes cost of road elevation)	L
Shore Road. Increase roadway elevation. New culvert. This project involves elevating the existing road grade, installing a new culvert and constructing sections of retaining walls to create the new road grade. Part of Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$2,500,000	M
Shore Road and Elm Street Tidal Wetlands Flood Berm. Vegetated revetment/berm flood protection around tidal wetlands. Includes installation of tide gate at the Elm Street storm drain. Part of Town-wide perimeter flood protection system.	P	S;NNB	- Conservation Department and Commission - Public Works - Planning and Zoning	$11,000,000	L
Birdseye Flood Berm/Planted Revetment. Part of Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$8,500,000	L
Water Pollution Control Facility (WPCF). This project involves constructing increasing the flood protection along the existing levee surrounding the plant and utilizing temporary flood gates at entrances and exits and additional stormwater management controls. Project also involves temporary or permanent flood protection of sanitary pump stations, including development of emergency response plans.	P, A	S; N-S	- Public Works - Water Pollution Control Authority	$8,500,000	H
Park Path/Greenway Planted Revetment. This project involves constructing a shoreline revetment with low berm, connecting to the existing SAEP levee. Part of Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$7,000,000	H
Stratford Army Engine Plant. Increase flood protection elevation of existing levee. Also elevate site grades during future construction (redevelopment of the Stratford Army Engine Plant [SAEP]). Coordinate with site remediation, possibly using elevated site grades as containment for contaminated soil and dredge spoil. Part of Town-wide perimeter protection system.	P,A	S;N-S	- Conservation Department and Commission - Public Works - Planning and Zoning	$3,500,000	H

Table 5.1 Project Matrix

Town Coastal Resiliency Projects					
Landfill Berm. Project involves construction of a earth berm/levee adjacent to Main Street along Main Road to SAEP. Part of Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$1,500,000	H
Beach Drive and Jefferson Street. Extension of seawall along Jefferson Street. Increase existing Sea Wall Elevation. This project involves increasing the elevation of the existing sea wall. Part of Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning - Waterfront and Harbor Management	$1,100,000	M
Shoreline Drive. Acquisition and demolition of Shoreline Drive properties. Retreat Along Shoreline Drive. This project involves acquisition and demolition of houses along Shoreline Drive. Extension of seawall at Washington Parkway. This project involves extending the sea wall adjacent to the newly formed beach and dune area. This project would be integrated with the proposed Town Greenway system and serve as part of Town-wide perimeter flood protection system.	R, P	N-S, S	- Conservation Department and Commission - Public Works - Planning and Zoning - Waterfront and Harbor Management	$21,500,000	M
Oak Bluff Avenue Flood Wall. Construct a permanent flood wall along Oak Bluffs to Lordship Boulevard. Part of a Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$5,000,000	L
Lordship Boulevard Flood Wall. This project involves construction of permanent flood walls along the west side of Lordship Boulevard. Part of Town-wide perimeter flood protection system.	P	S	- Conservation Department and Commission - Public Works - Planning and Zoning	$16,250,000	M
Employment Growth District. This project involves constructing a vegetated berm (or flood wall) along the southern and eastern perimeter of the industrial/commercial areas of the Employment Growth District, connecting to Lordship Boulevard flood wall. Part of Town-wide perimeter flood protection system.	P	S,NNB	- Conservation Department and Commission - Public Works - Planning and Zoning	$28,750,000	H
Bruce Brook Culvert. This project involves a combination of permanent flood wall and temporary flood barriers. Includes a new stormwater pump station.	P,A	S, N-S	- Conservation Department and Commission - Public Works - Planning and Zoning	$3,250,000	H

Table 5.1 Project Matrix

Town Coastal Resiliency Projects					
Local Flood Protection:			-		
All Existing Property: Compliance with Local and State Flood Regulations. Responsibility of the property owner.	A	N-S	-	-	-
Erosion protection east of Diane Terrace (located N. of I-95 just East of Housatonic near Carting Island). Responsibility of the property owner.	A	S	- Conservation Department and Commission - Public Works - Planning and Zoning Waterfront and Harbor Management	-	M
All Water-Dependent Users (e.g., Marinas). 1) Emergency Response Plan; 2) temporary flood protection; and/or 3) permanent flood protection using flood wall. Consideration of sea level rise for future pier and piling construction. Responsibility of the property owner.	A	N-S	- Waterfront and Harbor Management	-	H
Flood proof structures and construct drainage improvements in the vicinity of Masarik Avenue, Benton Street and Harding Avenue (required if Town-wide perimeter protection not employed).	A	N-S	- Conservation Department and Commission - Public Works - Planning and Zoning	-	M
Beach Nourishment and Dune Restoration:			-		
Long Beach nourishment and dune restoration.	A	N-S	- Conservation Department and Commission - Public Works - Planning and Zoning - Waterfront and Harbor Management	$7,250,000	M
Lordship Beach nourishment and dune restoration.	A	N-S	- Conservation Department and Commission - Public Works - Planning and Zoning - Waterfront and Harbor Management	$23,000,000	M

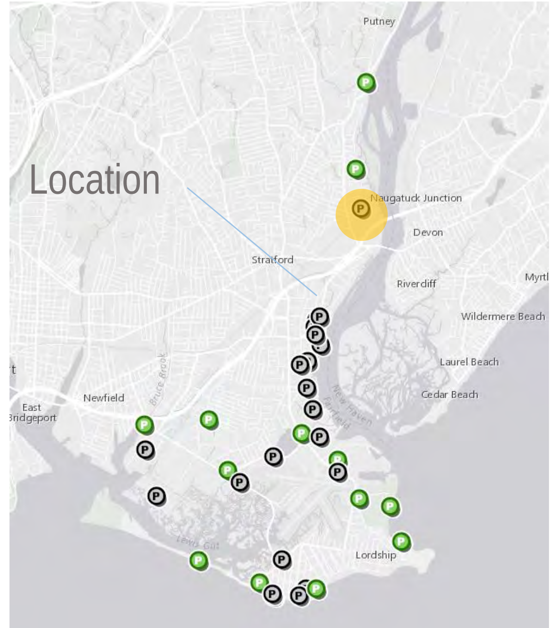
Future Town Development Projects:					
Large, new Town Development projects (i.e., projects presented in the POCD). Comply with local, State and federal flood regulations. For large area sited development, elevate site grades during future construction. Develop and use special development Design Flood Elevation (DFE) to reflect sea level rise.	A	N-S	- Conservation Department and Commission - Public Works - Planning and Zoning - Economic Development	-	

Estimated Cost Summary of Town Resiliency Projects:

Estimated Construction Cost:	$181,853,400
Engineering, Design and Permitting (15%):	$ 27,278,010
Contingency (10%):	$ 20,913,141
Total Estimated Cost:	$230,000,000

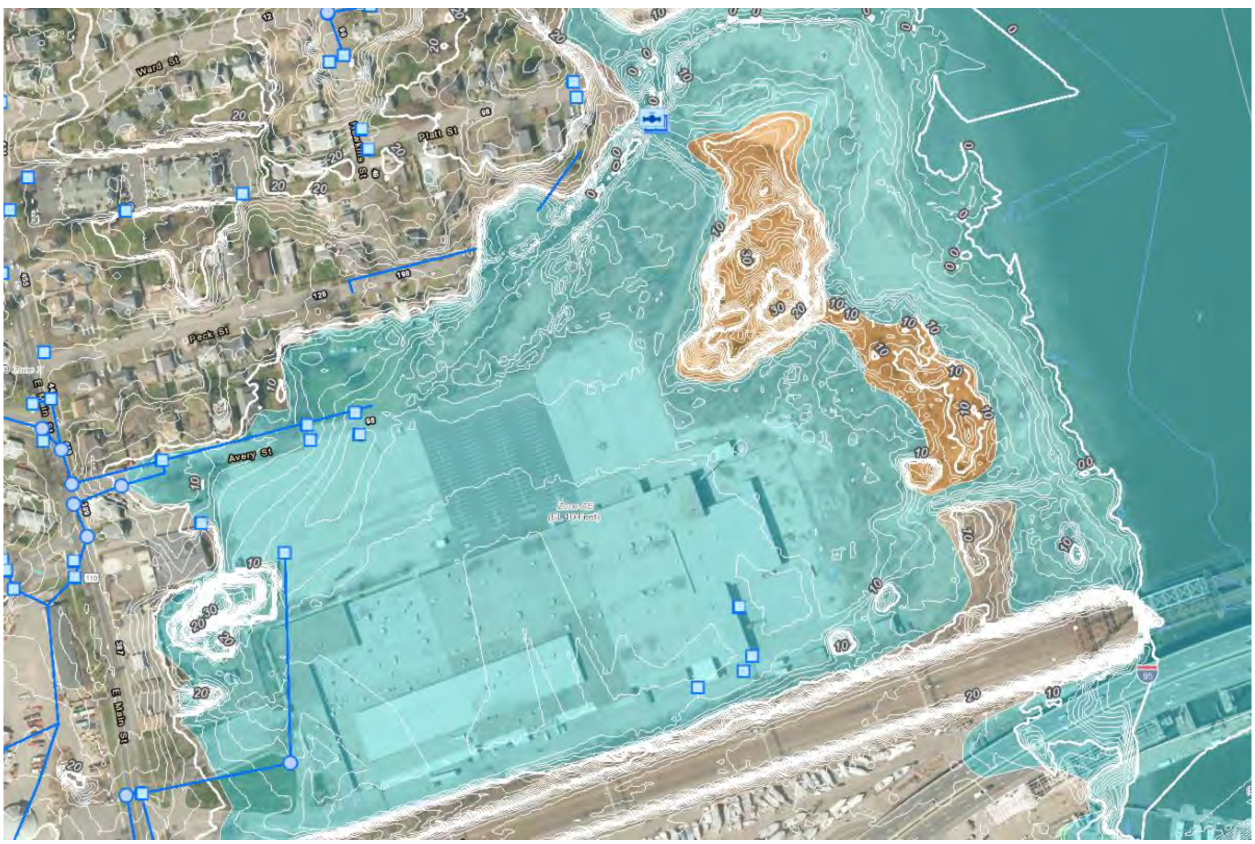
Note: The costs presented above are highly approximate, “order-of-magnitude” costs. These are presented for the purpose of comparing different projects and estimating the approximate, overall cost of flood protection. These costs do not represent detailed, site-specific itemized costs and should be considered accordingly.

Project Location:	Ashcroft, Inc.
Strategy:	Protect
Project Type:	Flood Protection Berm
Risk Profile:	FEMA FIRM Zone AE Base Flood Elevation: 10 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.1 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-2 feet 2065: +/-2 feet



Project Location

FEMA FIRM:



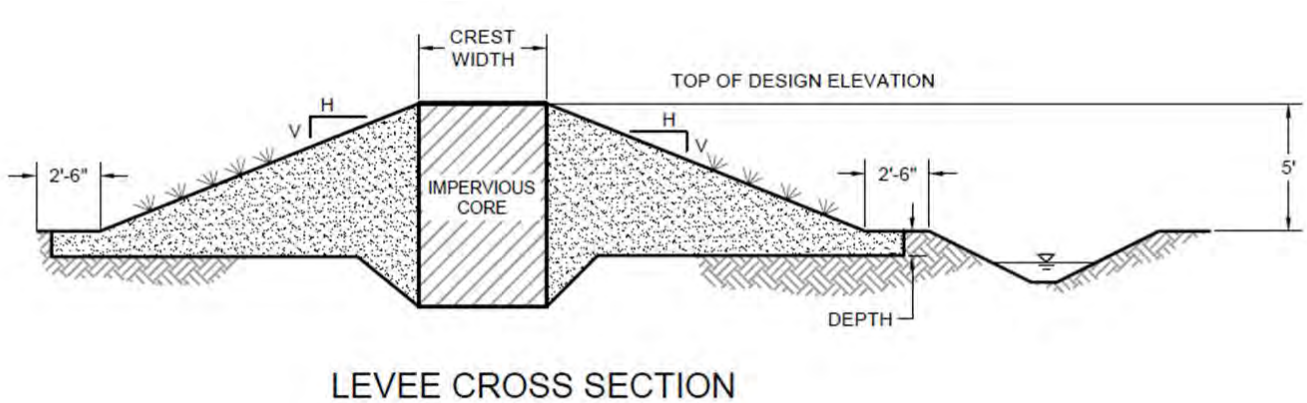
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The locations of the existing flood gate and stormwater pump station are also shown.

Project Objective: The objective of this project is to provide coastal flood protection of the Ashcroft, Inc. facility, as well as the adjacent East Main Street intersection and the Department of Public Works facility. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 13 feet NAVD88).

Preliminary Project Concepts: The project concept is to construct an earthen berm/flood levee. There are several approaches relative to berm construction. One approach, shown below, is to construct the berm immediately adjacent to the developed portion of the property. The estimated berm length is +/- 2,000 feet. The second approach is to utilize the existing topographically high areas, slightly elevating and connecting these areas. The second approach will involve more clearing and grubbing. However, if extended far enough to the north the berm/levee will also provide coastal flood protection to the residences located to the north of the property. Additional project features (to be confirmed during conceptual and final design) may include: 1) a drainage culvert; and 2) modifications to the existing tide gate and pump station.

Preliminary Project Concept: Alternative berm/levee location.

Preliminary Project Concept: Typical berm/levee section.



Project Location: New Broad Street Bridge

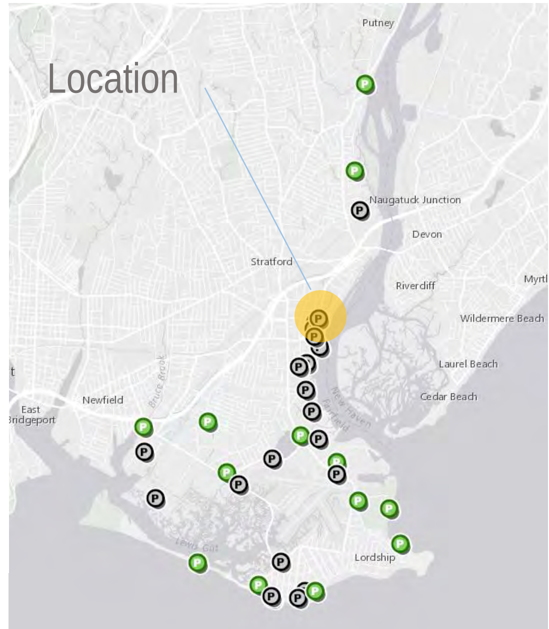
Strategy: Protect

Project Type: Bridge replacement with elevated bridge deck, culvert and elevated roadway profile

Risk Profile: FEMA FIRM Zone AE
Base Flood Elevation: 13 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.1 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-2 feet
2065: +/-2 feet



Project Location

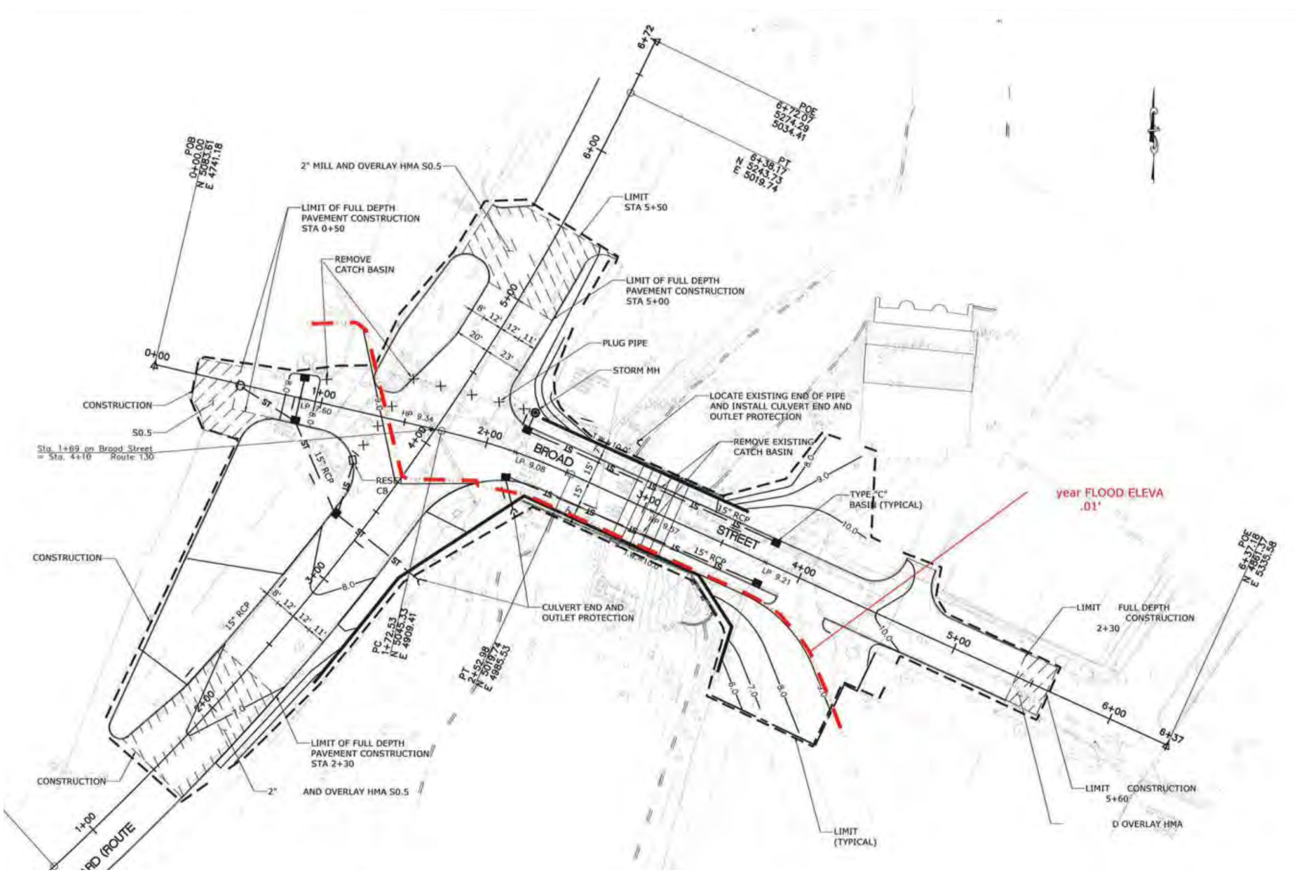
FEMA FIRM:

This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The locations of the existing tide gate and stormwater pump station are also shown.

Project Objective: Bridge replacement is already proposed by the Town. The objective of this project is to elevate the bridge deck and adjacent roadway to (in conjunction with the existing pump station and a new culvert/tide gate) to provide coastal flood protection to areas to the north of the bridge (including flooding of pipes and culverts located beneath East Broadway Street and Interstate 95). This project is part of the proposed Town-wide perimeter protection system. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88).

Preliminary Project Concepts: The project concept is to construct an elevated bridge deck and roadway. There are several approaches relative to bridge design, which can include a combination of flood wall and bridge deck.

Preliminary Project Concept: Bridge Replacement Grading and Site Plan (by others)



Project Location: Ferry Boulevard

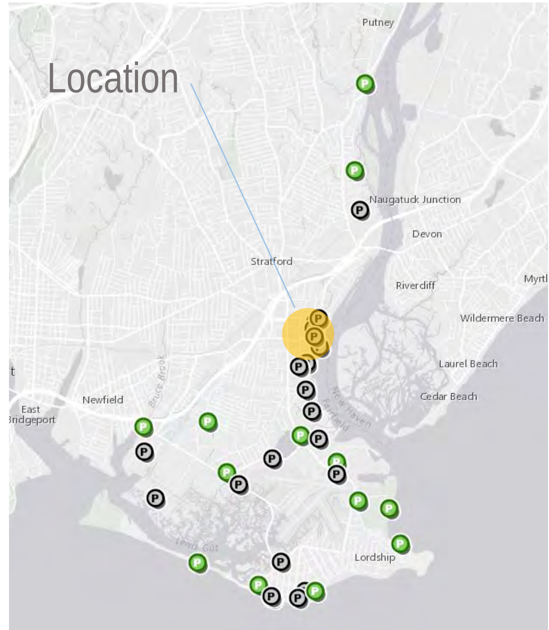
Strategy: Protect

Project Type: Elevated Road with Flood Wall

Risk Profile: FEMA FIRM Zone AE
Base Flood Elevation: 13 feet NAVD88

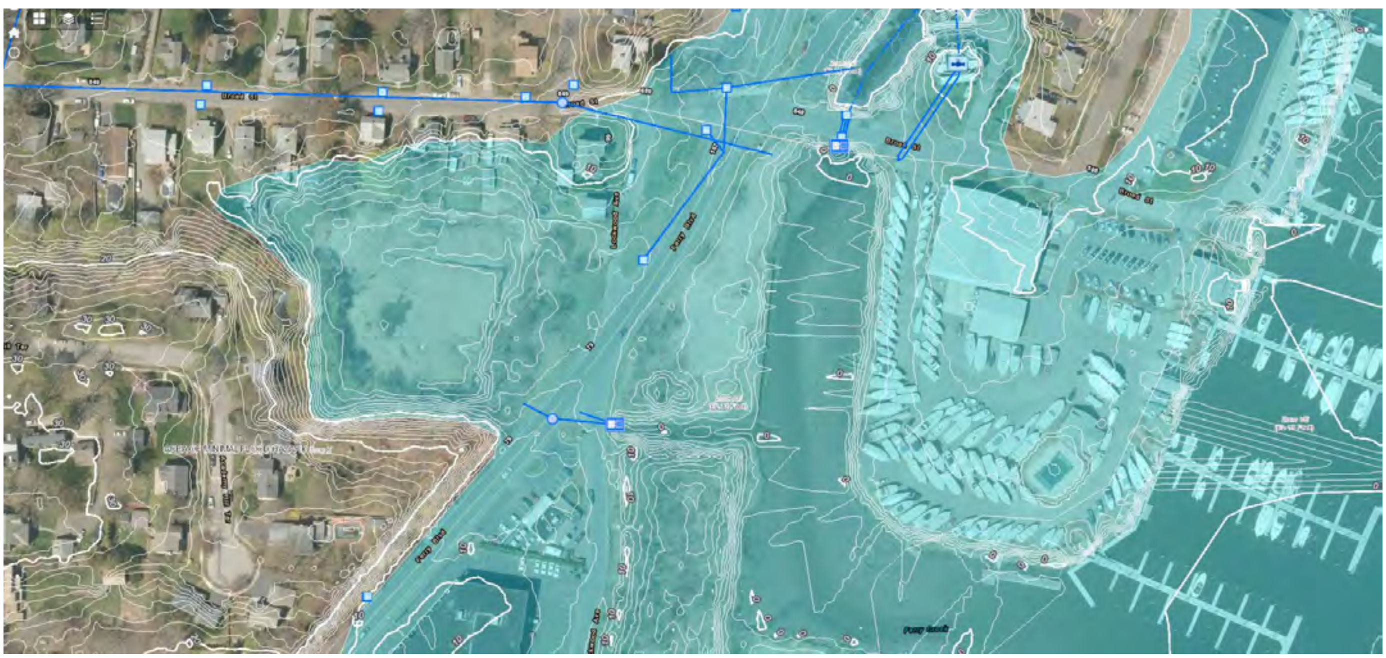
Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.1 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-2 feet
2065: +/-2.5 feet



Project Location

FEMA FIRM:



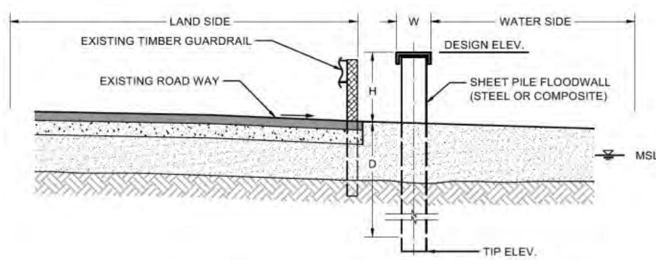
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The locations of the existing tide gates and stormwater pump station are also shown.

Project Objective: The objective of this project is to provide coastal flood protection of Ferry Boulevard and areas to the west of Ferry Boulevard. This project is part of the proposed Town-wide perimeter protection system. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88).

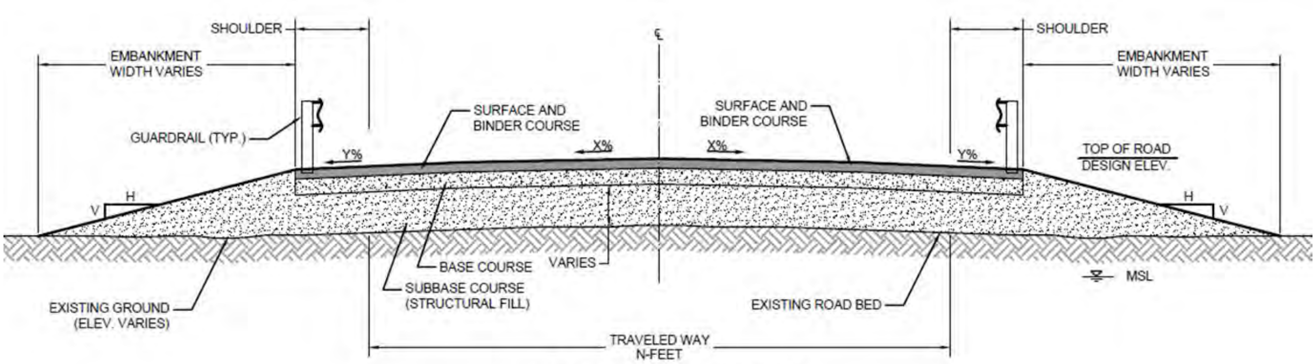
Preliminary Project Concepts: The project concept is to construct a combination elevated roadway and roadway flood wall. There are several approaches relative to project design and construction. The estimated project length is +/- 400 feet. The details of the project, including flood wall type and requirements (e.g., vinyl sheet pile versus concrete T-wall), are highly dependent upon the elevation of flood protection selected as well as aesthetic considerations (e.g., street views). For example, raising the road grade from the existing elevation 6 feet NAVD88 to Elevation 9 feet NAVD88 would require a flood wall height of 7 feet to achieve FEMA accreditation. Additional project features include stormwater management.

Preliminary Project Concept: Project Location.

Preliminary Project Concept: Project Example Details

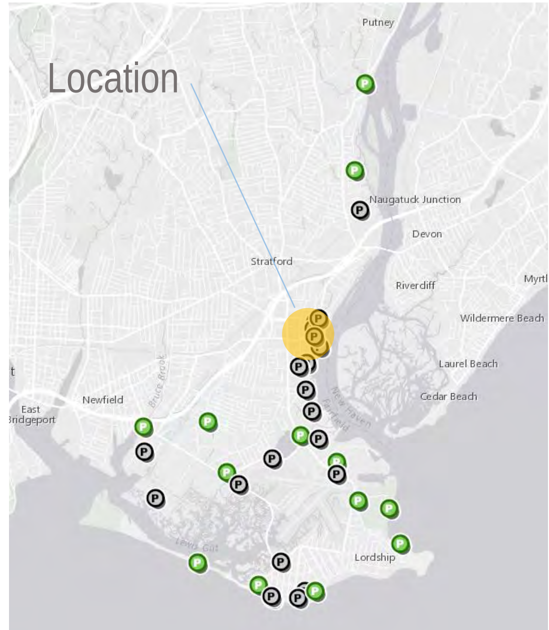


ROAD SIDE SHEET PILE FLOODWALL - CONCEPTUAL



RAISED ROAD WAY

Project Location:	Lockwood Avenue
Strategy:	Protect
Project Type:	Flood Wall
Risk Profile:	FEMA FIRM Zone AE Base Flood Elevation: 13 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.1 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1 foot 2065: +/-1.5 feet



Project Location

FEMA FIRM:

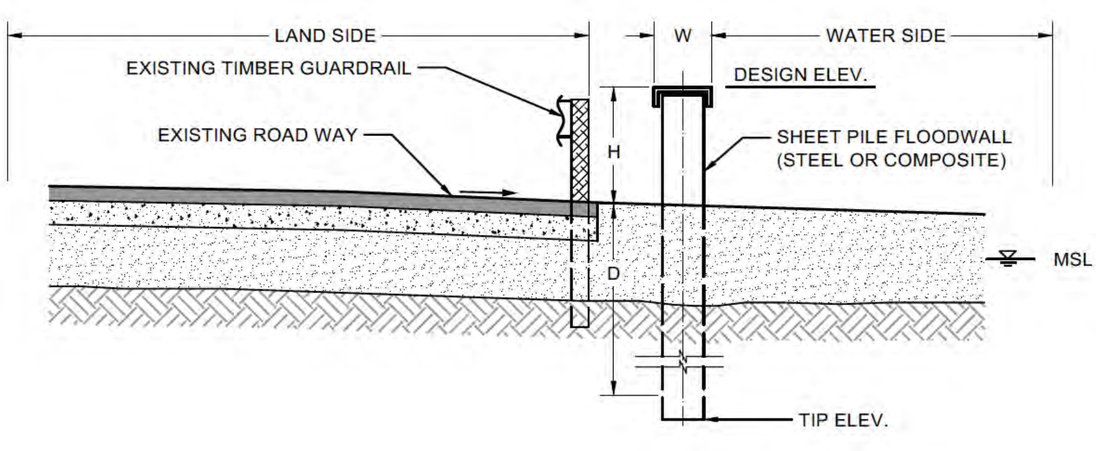
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The locations of the existing tide gate is also shown.

Project Objective: The objective of this project is to provide coastal flood protection of Lockwood Avenue and areas to the west of Lockwood Avenue. This project is part of the proposed Town-wide perimeter protection system. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88).

Preliminary Project Concepts: The project concept is to construct a combination elevated roadway and roadway flood wall. There are several approaches relative to project design and construction. The estimated project length is +/- 600 feet. The details of the project, including flood wall type and requirements (e.g., vinyl sheet pile versus concrete T-wall), are highly dependent upon the elevation of flood protection selected as well as aesthetic considerations (e.g., street views). For example, a flood wall height of 8 to 9 feet to achieve FEMA accreditation. Additional project features include stormwater management.

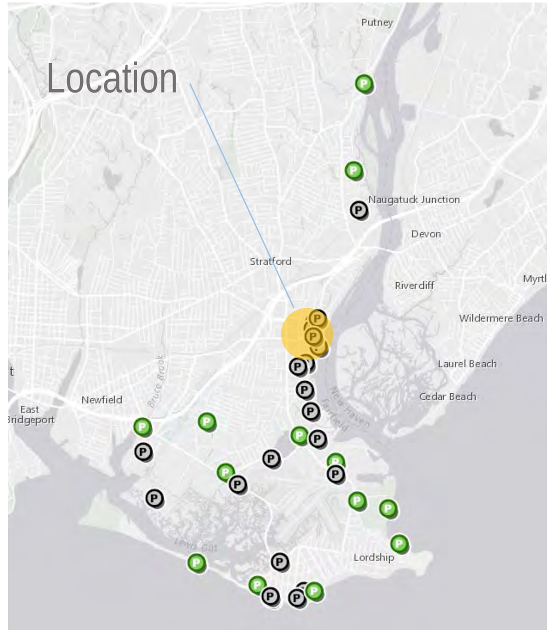
Preliminary Project Concept: Project Location.

Preliminary Project Concept: Project Example Detail



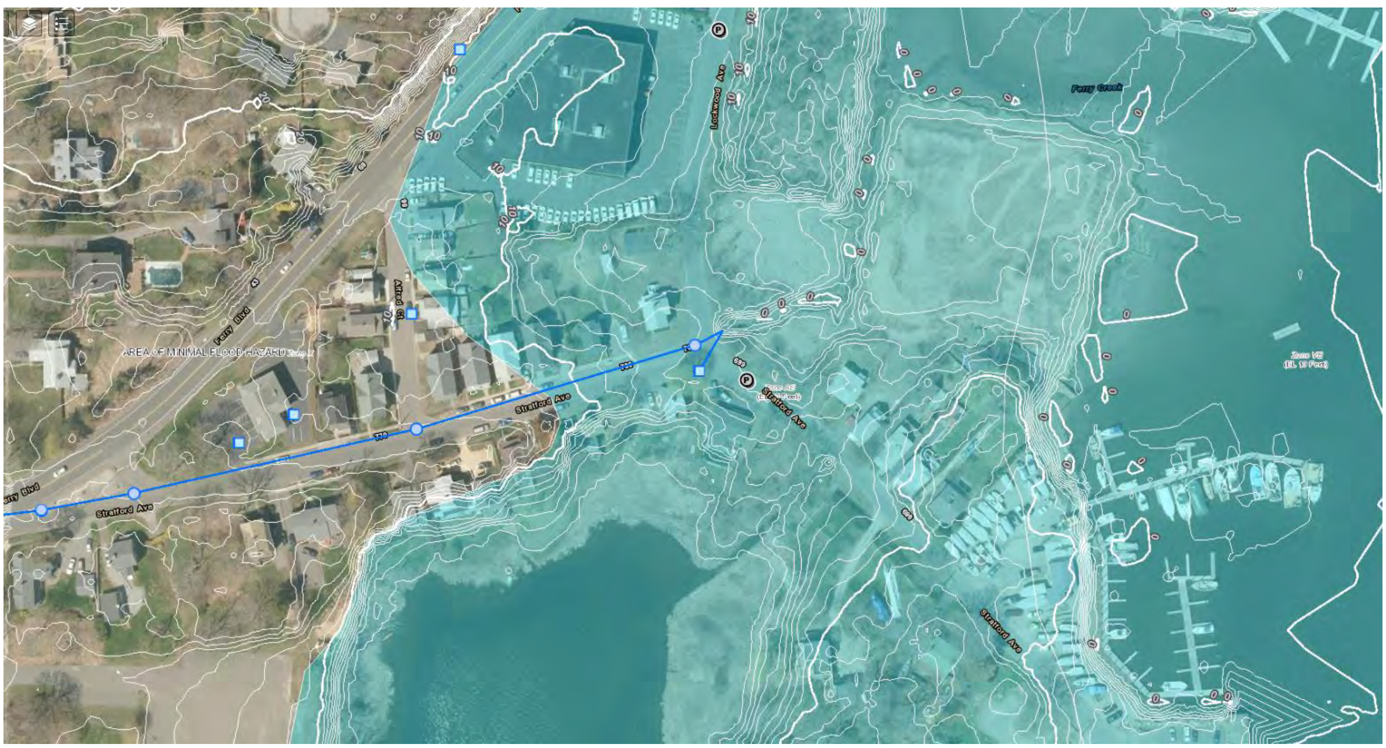
ROAD SIDE SHEET PILE FLOODWALL - CONCEPTUAL

Project Location:	Stratford Avenue Levee
Strategy:	Protect
Project Type:	Earth Berm
Existing Grades:	El. 4 to 12 feet NAVD88
Risk Profile:	FEMA FIRM Zone AE Base Flood Elevation: 13 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.1 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1.5 to 3 feet 2065: +/-1.5 to 3 feet



Project Location

FEMA FIRM:



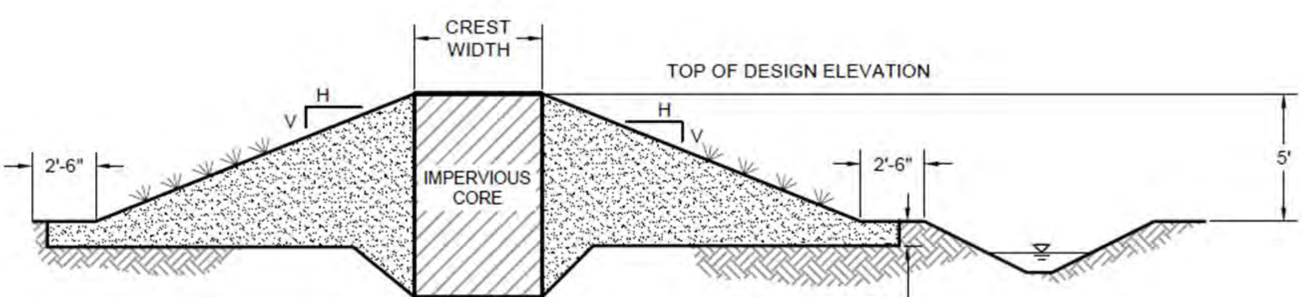
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection, connecting with the flood protection along Lockwood Avenue. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88).

Preliminary Project Concepts: The project concept is to construct an earthen berm levee. The levee will connect with the Lockwood Avenue flood protection. There are several approaches relative to project design and construction. Protecting to levee crest El. 12 feet NAVD 88 can be performed with the levee limits shown below, which at the easternmost location tie into the existing site grade at Elevation 12 feet NAVD88. The estimated project length is +/- 350 feet. Additional flood protection can be provided by also constructing a flood wall section along the east side of the existing houses. Localized flood protection, using a combination of permanent measures (elevated revetment or sheetpile bulkhead) and deployable temporary measures is recommended to extend the flood protection to the adjacent marina.

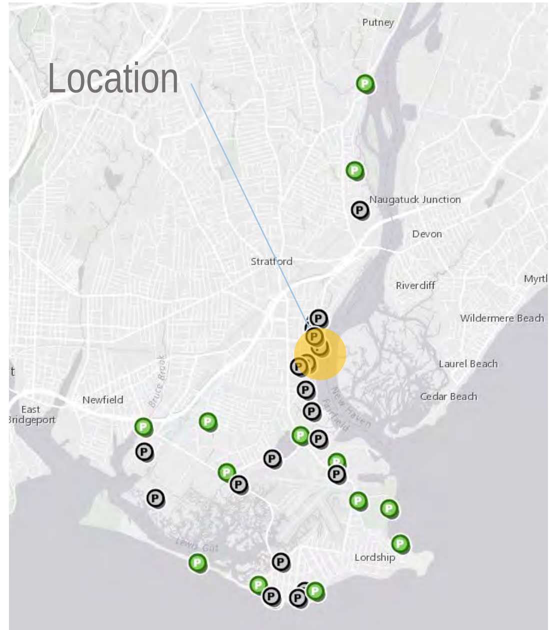
Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



LEVEE CROSS SECTION

Project Location:	Bond's Dock Redevelopment
Strategy:	Protect
Project Type:	Elevated Rod and Bond's Dock; Marine Bulkheads
Existing Grades:	El. 3 to 9 feet NAVD88
Risk Profile:	FEMA FIRM Zone VE Base Flood Elevation: 13 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.1 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/- 3.5 to 4.5 feet 2065: +/-3.5 to 4.5 feet



Project Location

FEMA FIRM:

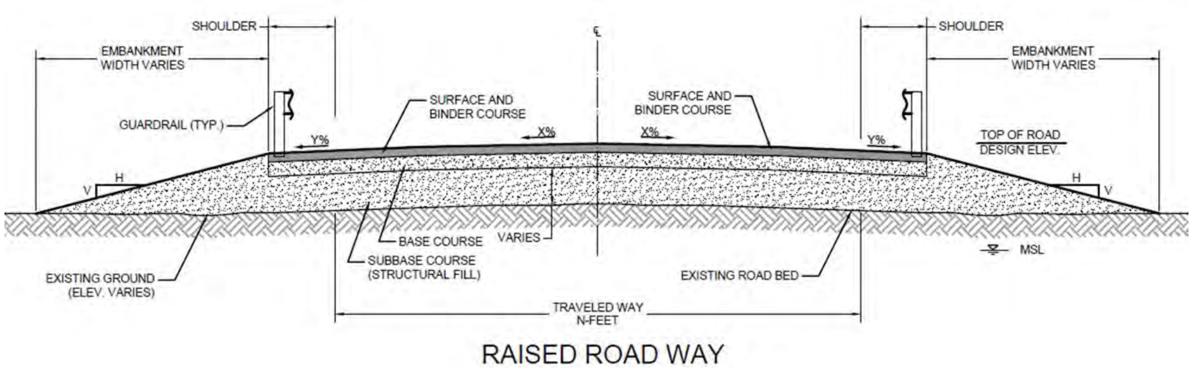
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection. This project will require significant redevelopment of the area. Redevelopment of Bond's Dock is included in the Town's Plan of Conservation and Development. Flood protection should be a key redevelopment design consideration. The specific elevation of flood protection should be determined during conceptual and final design. To qualify for a modification to the FEMA FIRM, the grade elevation of the entire area would need to be increased to at least above the effective FEMA BFE (currently Elevation 13 feet NAVD88).

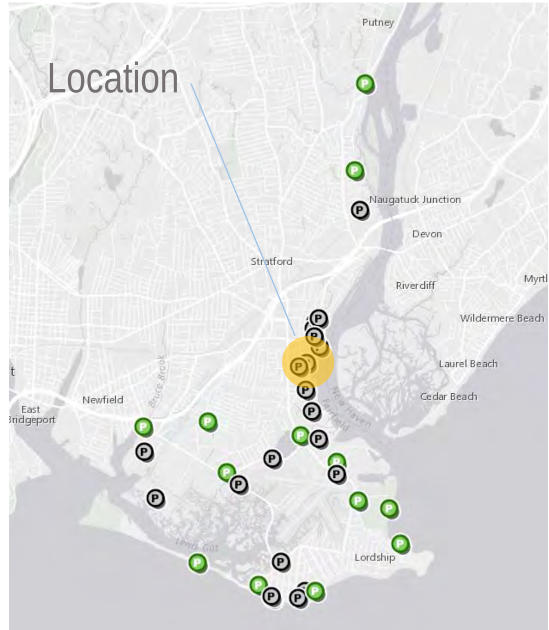
Preliminary Project Concepts: The project concept is to increase the grade elevation of the road and dock area and to provide wave protection along the perimeter. There are several approaches relative to project design and construction. A preliminary concept is to construct new marine bulkheads and increasing the adjacent dock and road grades.

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



Project Location:	Shore Road Levee
Strategy:	Protect
Project Type:	Elevated Road; New Culvert; Retaining wall
Existing Grades:	El. 6 to 9 feet NAVD88
Risk Profile:	FEMA FIRM Zone AE Base Flood Elevation: 11 to 13 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.1 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1 to 4 feet 2065: +/-1 to 4 feet



Project Location

FEMA FIRM:

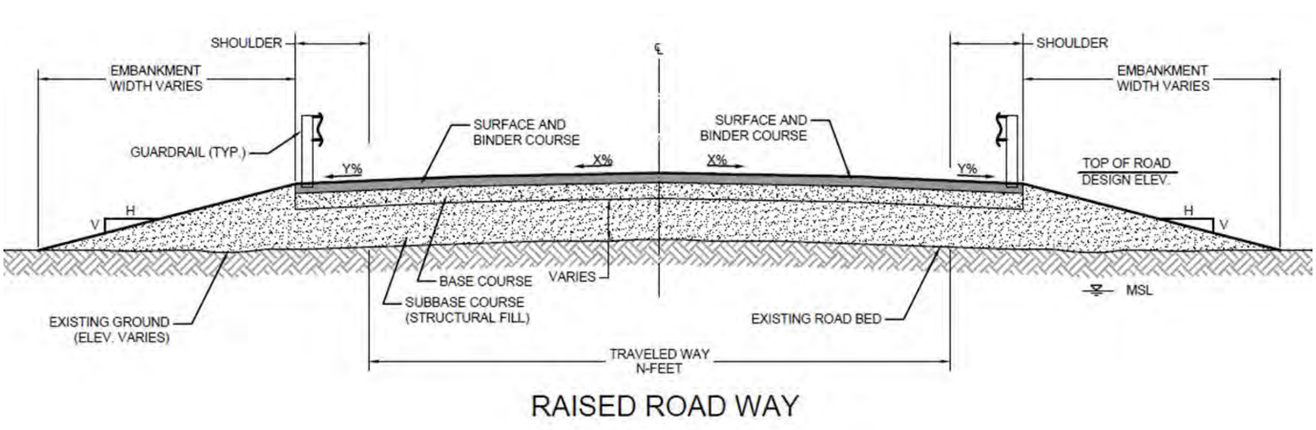
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The existing tide gate is also shown.

Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection, connecting with the flood protection at Bond's Dock. The specific elevation of flood protection should be determined during conceptual and final design. The project can also be combined with the proposed bike path. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88). To qualify for a modification to the FEMA FIRM, the grade elevation of the area would need to be increased to above Elevation 13 feet NAVD88.

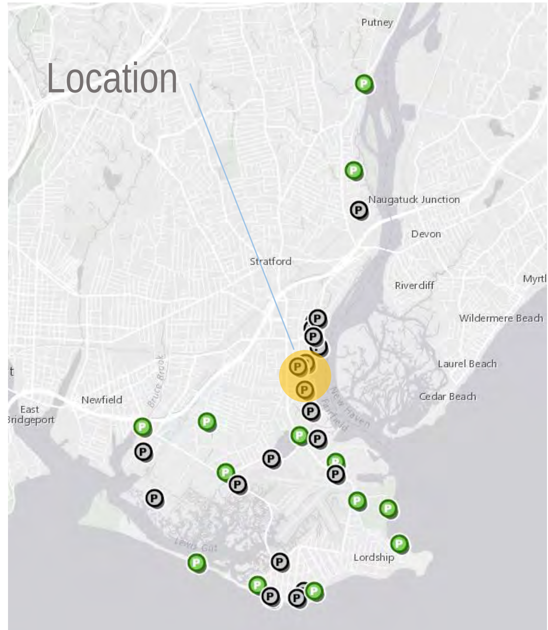
Preliminary Project Concepts: The project concept is to construct an elevated roadway. Alternatively, the proposed bike path along Shore Road could be constructed as an elevated section adjacent to the road. The project length is approximately 1,500 feet. The project is a low priority since the adjacent (Shakespeare Theater) property grades are high (Elevation 13 feet NAVD88). The Housatonic Boat Club remains highly vulnerable to coastal flooding. The project also includes a replacement of the existing culvert and tide gate to accommodate the change in road elevation.

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



Project Location:	Tidal Wetlands Levee and Living Shoreline
Strategy:	Protect
Existing Grades:	El. +/- 7 feet NAVD88
Project Type:	Earth Berm/Planted Revetment/Elm Street Tide Gate
Risk Profile:	FEMA FIRM Zone AE Base Flood Elevation: 13 to 14 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.0 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1 to 3.5 feet 2065: +/-1 to 3.5 feet



Project Location

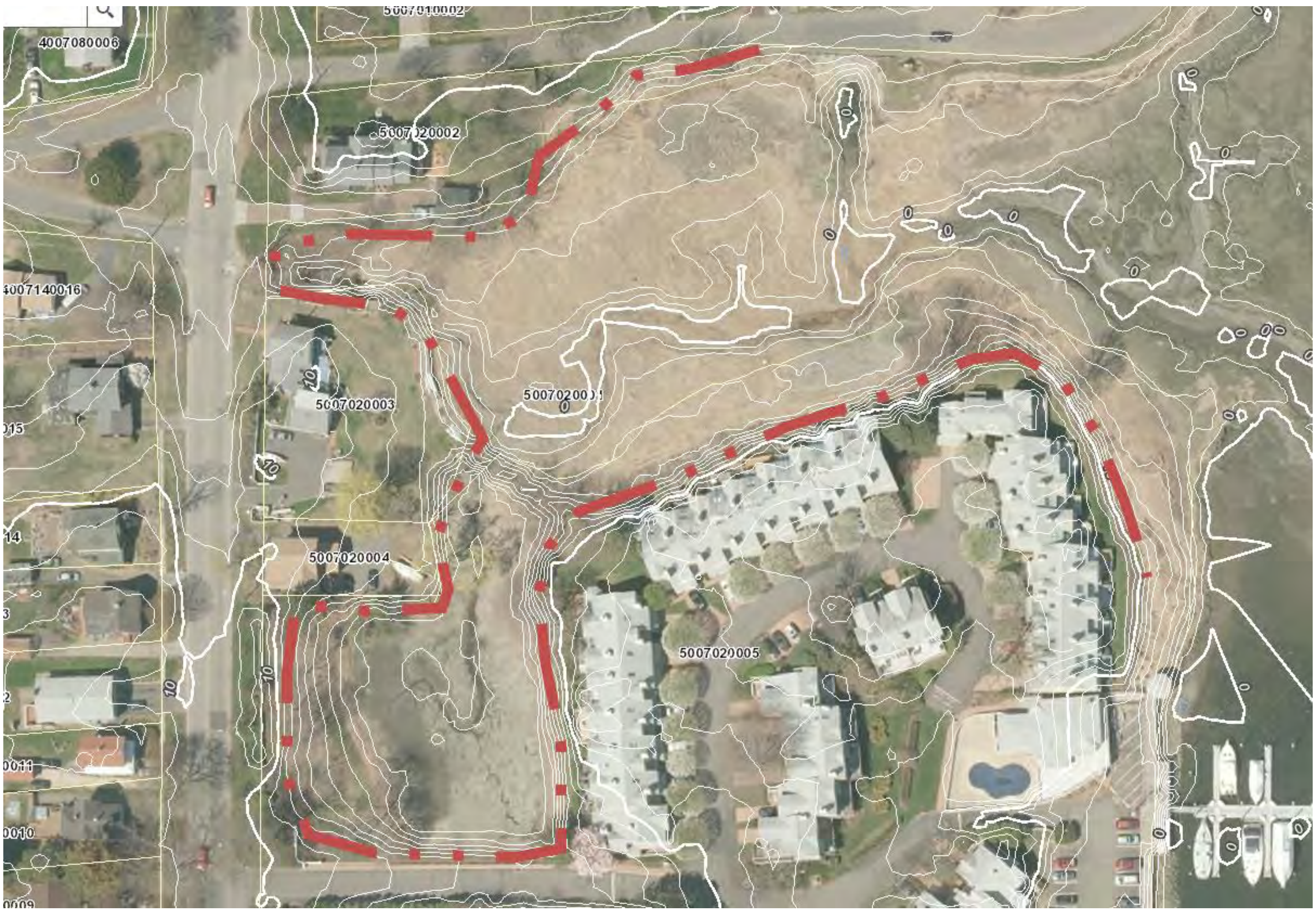
FEMA FIRM:

This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The existing tide gate is also shown.

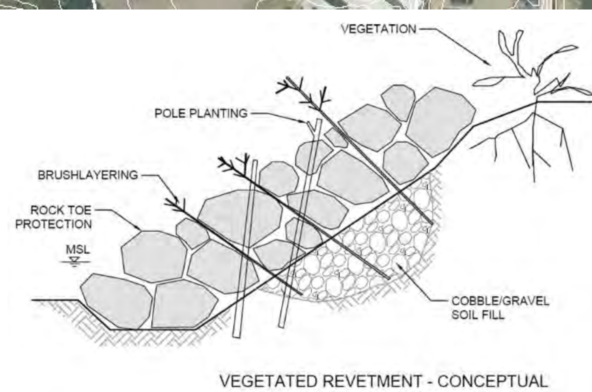
Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection, connecting with the flood protection along Shore Road. The specific elevation of flood protection should be determined during conceptual and final design. The berm could be enhanced to be constructed to include a segment of the proposed bike path (which is currently proposed along Shore Road and Elm Street. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 to 17 feet NAVD88).

Preliminary Project Concepts: The project concept is to construct a planted revetment/earth berm/levee around the tide marsh perimeter. There is an existing revetment along the eastern portion of the marsh. The estimated project length is +/- 2,000 feet. The concept is to create flood protection through use of the earth berm, while providing a "living shoreline" perimeter through the use of a planted revetment. The project also includes a tide gate at the Elm Street storm drain outfall

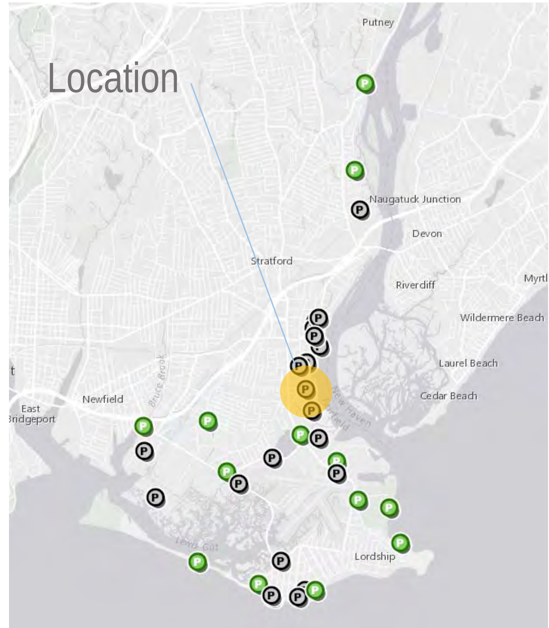
Preliminary Project Concept: Project Location



Preliminary Project Concept: Project Example Detail



Project Location:	Birdseye Levee and Living Shoreline
Strategy:	Protect
Existing Grades:	El. +/- 7 feet NAVD88
Project Type:	Earth Levee/Planted Revetment
Risk Profile:	FEMA FIRM Zone VE/AE Base Flood Elevation: 13 to 14 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.1 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1 to 3 feet 2065: +/-1 to 3.5 feet



Project Location

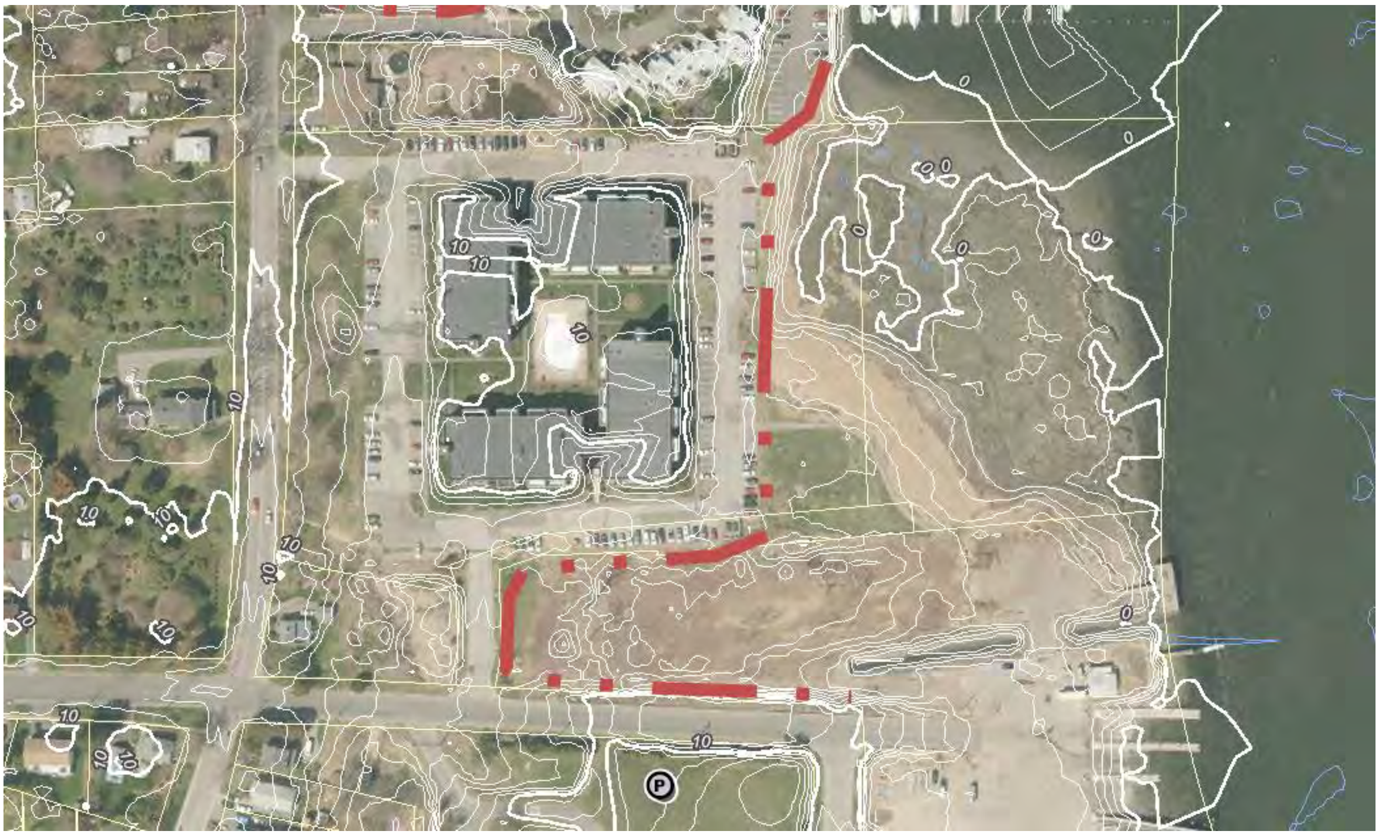
FEMA FIRM:

This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

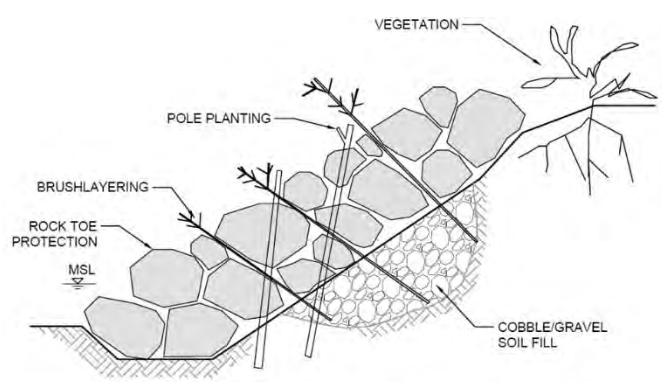
Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection, connecting with the flood protection along the tidal wetlands to the north. In addition to flood protection, the project will also provide shoreline erosion protection. The berm could be enhanced to be constructed to include a segment of the proposed bike path (which is currently proposed along Shore Road and Elm Street). The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 to 17 feet NAVD88).

Preliminary Project Concepts: The project concept is to construct a planted revetment/earth berm/levee around the coastal shoreline and adjacent to the Birdseye boat landing area. Alternative alignments (to that shown here) will meet the project objectives. The estimated project length is +/- 1,500 feet. The concept is to create flood protection through use of the earth berm, while providing a "living shoreline" perimeter through the use of a planted revetment.

Preliminary Project Concept: Project Location



Preliminary Project Concept: Project Example Detail



VEGETATED REVETMENT - CONCEPTUAL

Project Location: Wastewater Treatment Plant

Strategy: Protect

Project Type: Flood Protection Berm Enhancement

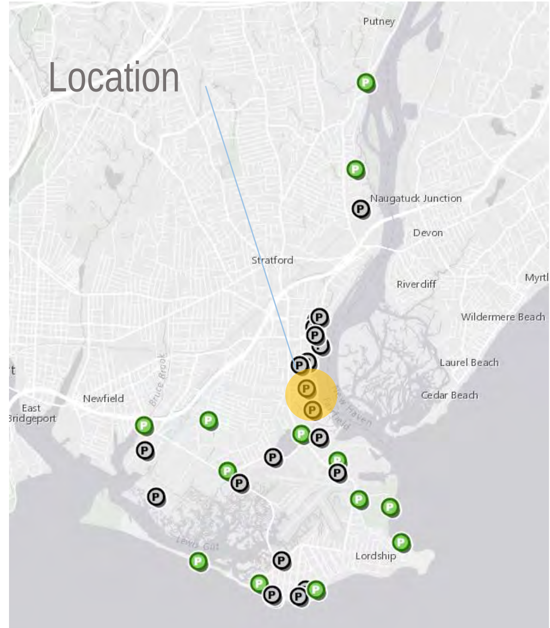
Risk Profile: FEMA FIRM Zone AE
Base Flood Elevation: 14 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.0 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-1.5 to 3 feet
2065: +/-2 to 3.5 feet

Predicted 500-year Stillwater Floods:
2015: 14.2 NAVD88
2040: 14.6 NAVD88 (Int. SLR)
2065: 15.0 NAVD88 (Int. SLR)

Predicted 500-year Wave Heights:
2015: +/-3.0 to 4.5 feet
2040: +/-3.5 to 4.5 feet
2065: +/-3.5 to 5 feet



Project Location

FEMA FIRM:

This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The location of the existing flood gate is also shown.

Project Objective: The wastewater treatment plant currently has substantial flood protection in the form of an existing flood protection berm. The existing berm has crest elevations ranging from:

North Side (Birdseye Street): Elevation 5 (at entrance) to 11 feet NAVD88 (between entrance and Beacon Point Road intersection)

East Side (Beacon Point Road): Elevation 11 (Birdseye Street and Beacon Point Road intersection) to 13 feet NAVD88

South Side: Elevations 10 to 12 feet NAVD88. However, to the south of the plant (within the park) the grades over most of the southern plant boundary are higher, at about Elevations 12 to 14 feet NAVD88.

West Side: Elevations 9 (north end) to 12 feet NAVD88 (south end).

Most of the interior site areas (located within the flood berm) are at a relatively low elevation (Elevations 7 to 8 feet NAVD88). Coastal floods (less than Elevation 11) will enter into (and inundate) the site via the low elevation areas (including the Birdseye Street entrance and along the low elevation area on the west side). Floods of higher elevation will overtop the existing flood berm on all sides.

The objective of this project is to enhance the existing flood protection of the facility. The specific elevation of flood protection should be determined based on a benefit–cost analysis during conceptual and final design. Per ASCE24-14 based on use, the facility meets the description of Flood Design Class 3. Based on estimated wave heights, the facility is expected to be located within a coastal A zone. Per ASCE24-14, for Flood Design Class 3 facilities the minimum elevation of the bottom of the lowest supporting horizontal structural member of the lowest floor (an indication of flood protection goals) is the base flood elevation + 2 feet (or currently, Elevation 16 feet NAVD88). To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88). To account for sea level rise in the future, the assumed berm/wall elevation would be higher.

Preliminary Project Concepts: Several flood protection approaches have been considered. These approaches included: 1) use of deployable, temporary flood protection measures around individual structures; 2) use of deployable, temporary flood protection measures around perimeter areas; and 3) permanent flood protection structures around the site perimeter to enhance the existing flood protection berm. A fourth option is temporary or permanent flood protection structures around the site perimeter and use of deployable temporary flood protection (i.e., flood gates) at site entrances and exits. A fifth option would also include increasing the grade along several areas of the perimeter road/berm.

Several structures can be used to enhance the existing flood protection berm and increase the flood protection elevation, including:

1. Steel sheetpile
2. Vinyl sheetpile
3. Concrete T-wall

These structures would be constructed within the existing berm along the edge of the roadway. The selection of the structure type (including both deployable temporary and permanent perimeter flood walls) depends upon the following issues: 1) cost; 2) constructability (considering the presence of existing underground structures); 3) the required height/wall elevation; 4) settlement due to the presence of compressible, organic soils; 5) aesthetic and design considerations; 6) impacts to adjacent wetlands; 7) stormwater management requirements; and 8) effects on odor/area air flow.

Constructing to a flood wall elevation of 17 feet NAVD88 would require a flood wall ranging from about 4 feet to 12 feet above existing grade (typically around 6 to 7 feet). The site perimeter is approximately 2,500 feet in length.

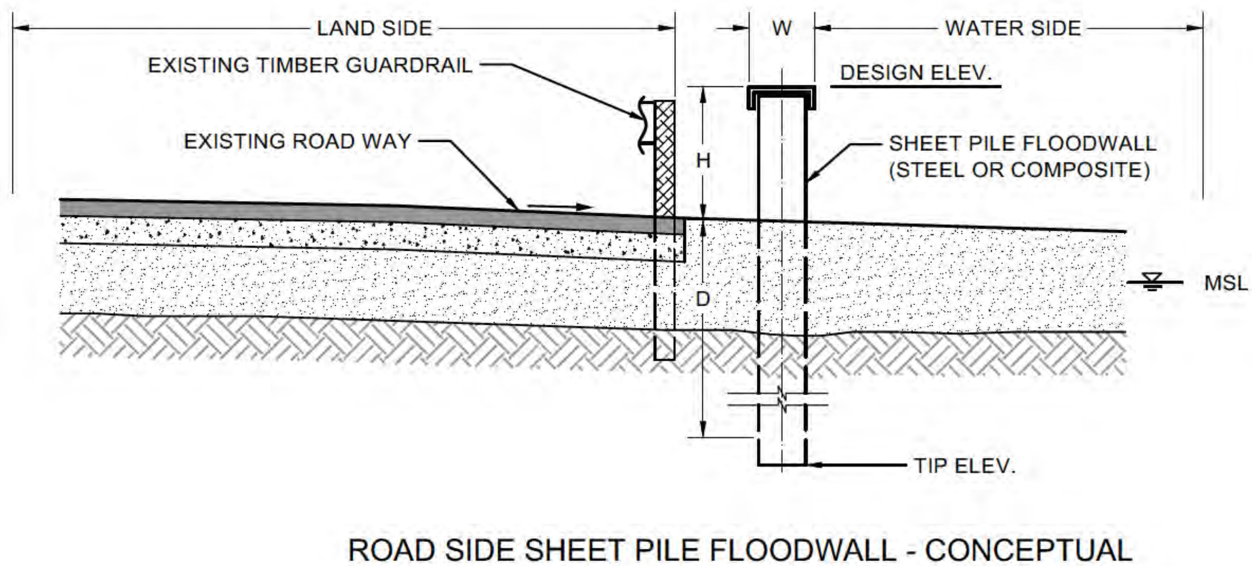
For preliminary planning purposes, the following project concept is proposed. This concept should be re-evaluated during conceptual and final design based on a benefit-cost analysis and detailed consideration of the issues identified above.

1. Relocate Birdseye Street entrance to existing berm; raise berm to match high point along Birdseye Street (Elevation 12 feet NAVD88).

2. Increase perimeter road grades (or adjacent berms) to a minimum of Elevation 12 feet NAVD88.
3. Enhance the existing flood berm flood protection by constructing a permanent flood wall (or deployable, temporary flood wall) to increase the berm crest elevation (preliminarily, assume Elevation 17 feet NAVD88), using steel sheeting, vinyl sheeting or concrete T-wall (permanent) or aluminum stop logs (temporary) (to be selected during conceptual and final design).
4. Utilize deployable, temporary flood gates at plant entrances and exits.
5. Improve stormwater management structures as required to manage stormwater discharge and system surcharging during flood coastal events.

Preliminary Project Concept: Enhanced Perimeter Protection Location

Preliminary Project Concept: Typical berm/wall section.



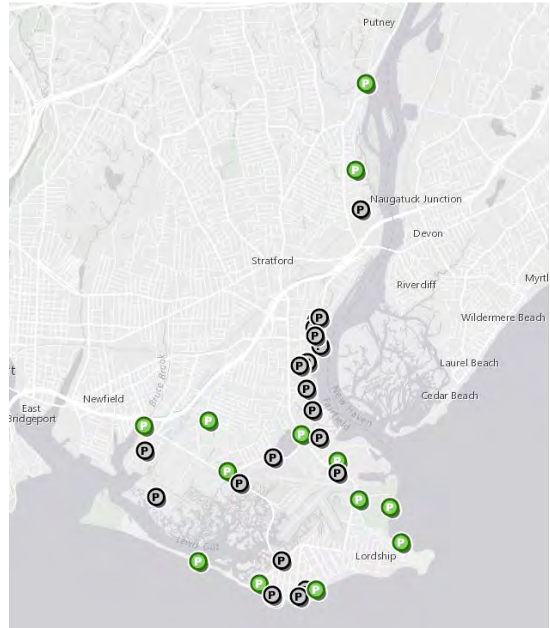
Project Location: Wastewater Treatment: Sanitary Pump Stations; Sanitary Drain Manholes

Strategy: Protect

Project Type: Varies

Risk Profile: FEMA FIRM Zone AE
Base Flood Elevation: typ. 12 to 14 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: varies
2065: varies



Project Location – Multiple Sites (not shown)

FEMA FIRM:

This figure indicates the effective FEMA FIRM limits of inundation relative to the sanitary pump stations. The locations of the existing flood gates are also shown.

Project Objective: The wastewater treatment system utilizes 12 sanitary pump stations. Based on the effective FEMA FIRM, in addition to the Wastewater Treatment Plant, six of the pump stations are vulnerable to coastal flooding. An additional pump station may become vulnerable to coastal flooding in the future du to sea level rise. An additional two sanitary pump stations are vulnerable to river flooding.

The project objectives relative to the sanitary pump stations are to: 1) perform a comprehensive vulnerability determination of each of the pump stations; 2) provide flood protection. Per ASCE24-14, based on use the pump stations meet the description of Flood Design Class 3. Per ASCE24-14, for Flood Design Class 3 facilities the minimum elevation of the bottom of the lowest supporting horizontal structural member of the lowest floor (an indication of flood protection goals) is the base flood elevation + 2 feet.

There are also a large number of sanitary line manholes. The project objective is to minimize stormwater infiltration into the system by waterproofing the manhole covers. A Town study is underway, as part of a separate effort, to evaluate manhole flood protection vulnerability and flood mitigation measures.

Preliminary Project Concepts: The pump stations are located within enclosed buildings. A detailed vulnerability analysis will be required to establish the appropriate flood sanitary pump station flood protection. For preliminary planning purposes it is assumed that flood mitigation measures will include one or both of the following:

1. Elevation of existing key equipment such as batteries, electrical, etc. that are not already floodproofed.
2. Use of deployable, temporary flood protection measures.

Project Location: Park Path Greenway Levee and Revetment

Strategy: Protect

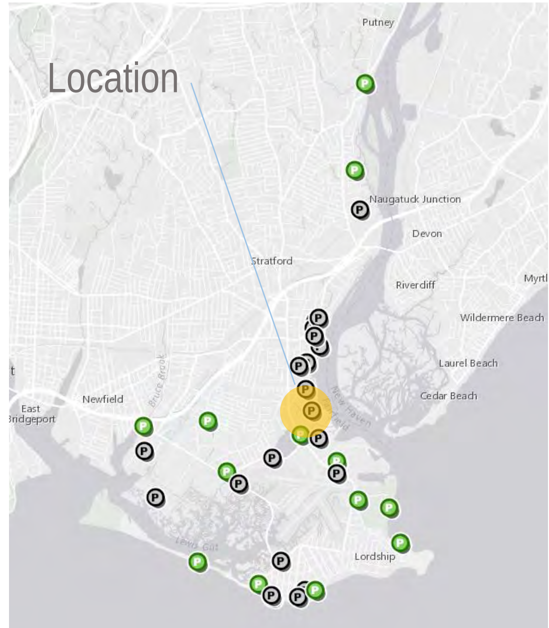
Existing Grades: El. +/- 7 feet NAVD88

Project Type: Earth Berm/Planted Revetment

Risk Profile: FEMA FIRM Zone VE/AE
Base Flood Elevation: 13 to 14 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.1 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-1 to 4 feet
2065: +/-1 to 4 feet



Project Location

FEMA FIRM:

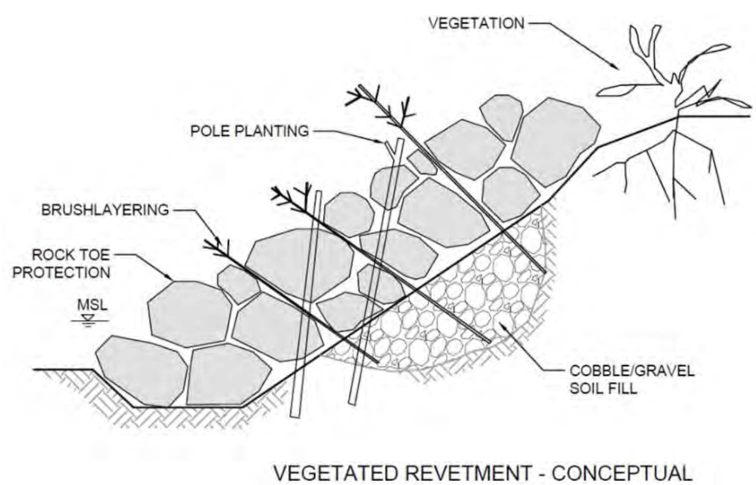
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection, connecting with the flood protection at the wastewater treatment plant. The levee/planted revetment will also provide shoreline erosion protection with components of a "living shoreline". The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88).

Preliminary Project Concepts: The project concept is to construct a planted revetment/earth berm/levee around the coastal shoreline. In addition to flood and shoreline protection, the project will include elements to blend into the existing living shoreline. The estimated project length is +/- 1,250 feet. The most significant portion of the levee (relative to coastal flood protection) is the section between the end of the constructed greenway and the existing levee to the south. This project is a high priority since this is a location where coastal flooding can enter and move inland to inundate interior areas of the Town.

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



Project Location: Stratford Army Engine Plant Redevelopment

Strategy: Protect

Existing Grades: El. +/- 10 feet NAVD88 (exist. levee)

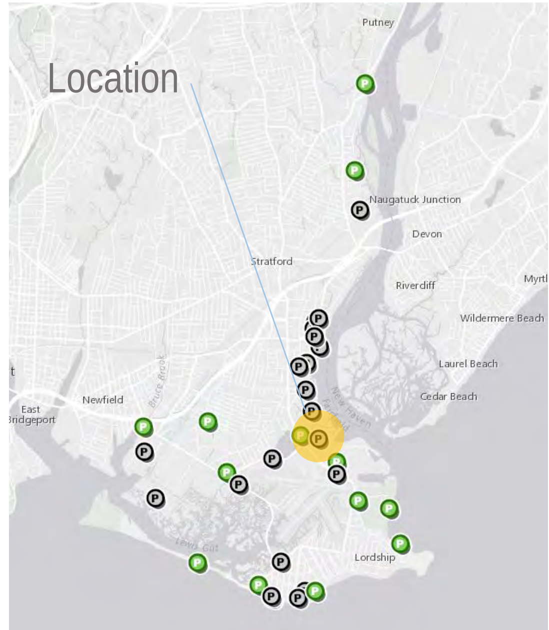
El. +/- 6 to 7 feet NAVD88 (upland area behind levee)

Project Type: Elevate Site Grades; Increase Existing Levee Crest Elevation

Risk Profile: FEMA FIRM Zone VE/AE
Base Flood Elevation: 13 to 14 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.1 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-1 to 3 feet
2065: +/-1 to 3 feet



Project Location

FEMA FIRM:

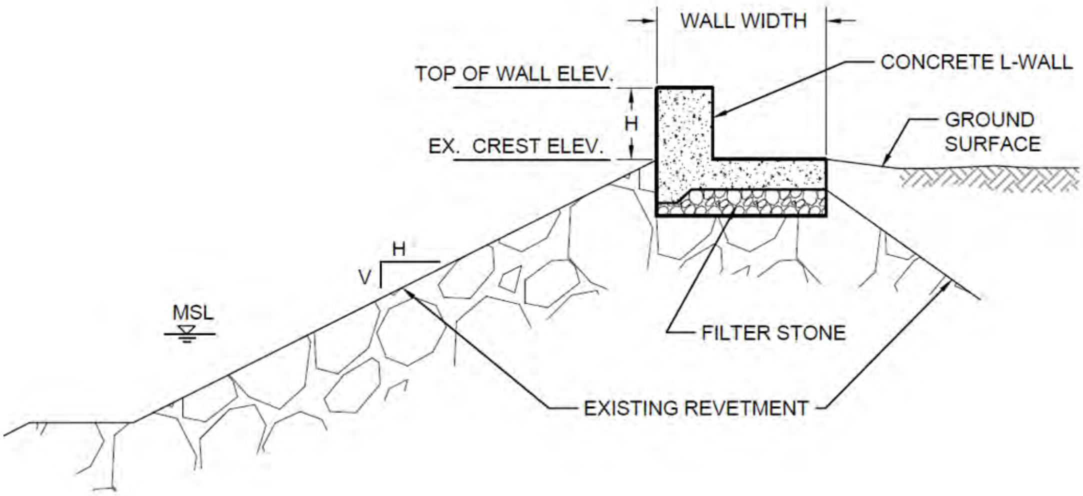
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection, connecting with the flood protection levee to the north. The redevelopment of the Stratford Army Engine Plant (SAEP) is currently planned for by the Town. The redevelopment of this property will require significant flood protection measures to comply with the State building code flood regulations (ASCE24-14, incorporated by reference). Dependent upon the proposed future property use (and based on the effective FEMA FIRM), new structures will be required to have the minimum elevation of the top of the lowest floor (including basements) equal to 1 to 2 feet above base flood elevation (currently Elevations 15 to 16 feet NAVD88 – about 8 to 10 feet above existing grade). Given the large land area of this development as well as environmental considerations, it can be assumed that regulatory compliance will be achieved during redevelopment by increasing site grades (i.e., filling the site). Alternatively, regulatory compliance could be achieved through: 1) construction of a certified levee; or 2) using the ground level for parking. The property has an existing levee (with a crest elevation at about Elevation 10 feet NAVD88) that was constructed for the SAEP and which can be enhanced to provide additional flood protection. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88). It is important for the Town (to achieve perimeter Town-wide flood protection) that the redevelopment of this property be designed to achieve the flood protection goals of this Plan. It is also important to note that flood modeling performed by GZA indicates that this site can flood during coastal flood events not only from flooding overtopping the existing levee, but also from flooding inundating the area from the south (entering at the Marine Basin). This project can be integrated with a public-access greenway or bike path.

Preliminary Project Concepts: As noted above, the project objective is to continue the Town-wide perimeter flood protection within the limits of the SAEP property. This can be performed through elevating the site grades and/ or elevating the existing levee crest elevation. Ideally, the Town will assure that the property is redeveloped in a manner consistent with the objectives of this Plan. The preliminary project concept show here is to elevate the crest elevation of the existing levee using a concrete T-wall section. The estimated project length is +/-2,500 feet. This project is a high priority since this is a location where coastal flooding can enter and move inland to inundate interior areas of the Town.

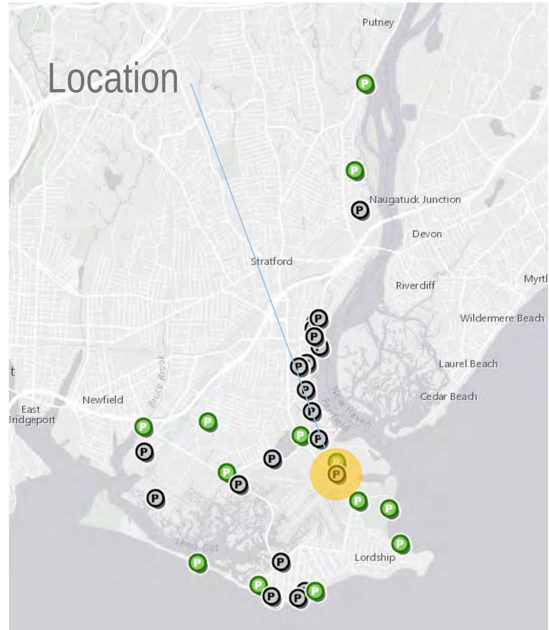
Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



FLOOD WALL ON EXISTING REVETMENT - CROSS SECTION

Project Location:	Airport Flood Wall; Tide gates
Strategy:	Protect
Project Type:	Flood Wall
Existing Grades:	El. 4 to 9 feet NAVD88
Risk Profile:	FEMA FIRM Zone AE Base Flood Elevation: 14 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.0 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1.5 to 2.5 feet 2065: +/-1.5 to 2.5 feet



Project Location

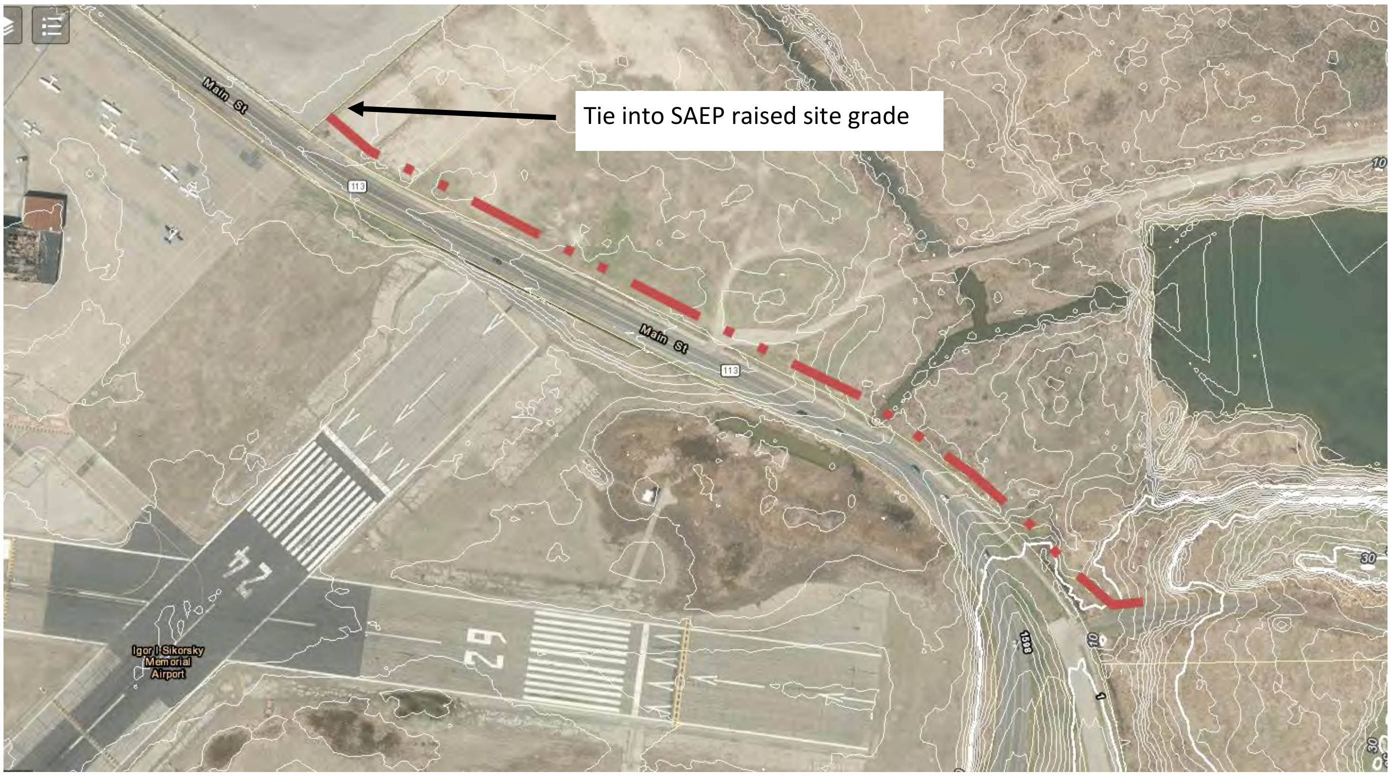
FEMA FIRM:

This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. Note that the aerial photographic image shown above does not reflect the recent improvements to the roadway and drainage structures (including a roadway re-alignment).

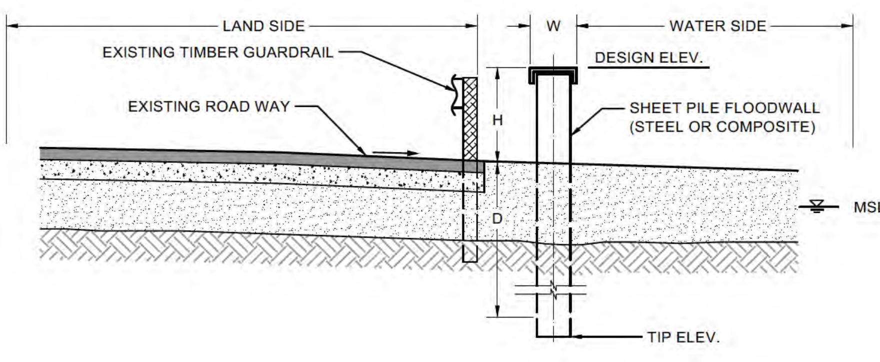
Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection, connecting with the flood protection to the north at the SAEP. Coastal flood protection within this area is a high priority because: 1) it is the principal source of flooding of the airport; and 2) flooding entering at this area (i.e., the Marine Basin) progresses to the SAEP and other inland areas. There are several challenges to constructing flood protection here, including: 1) presence of wetlands; 2) the recent roadway reconstruction including drainage culverts constructed to maintain normal water flow to the tidal wetlands surrounding the airport; and 3) structure height constraints due to the adjacent airport runways. Although these challenges exist, the benefits of providing flood protection here are significant. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88). Due to the site constraints, construction of the wall to achieve FEMA levee accreditation may not be feasible. However, any level of additional flood protection (e.g., protecting to predicted stillwater flood elevations) here will result in significant loss prevention. With sea level rise, this area is predicted to flood frequently in the future (e.g., 2 to 5 year recurrence interval floods). This project can be integrated with a public-access greenway or bike path.

Preliminary Project Concepts: The project concept is to construct a floodwall that connects to the flood protection to the north (e.g., elevated SAEP site grade) and existing high grades to the south (the landfill or high area between Stratford Road and Short Beach), as part of the Town-wide perimeter flood protection. Several wall alignments are feasible (tying the wall into either the landfill or the median area between Stratford Avenue and Short Beach Road. The estimated project length is +/- 1,500 feet. An alternative to this project is to allow flooding of the airport and protect from coastal flood inundation of inland Town areas along Access Road. Other project components include tide gates at the existing drainage structures.

Preliminary Project Concept: Project Location

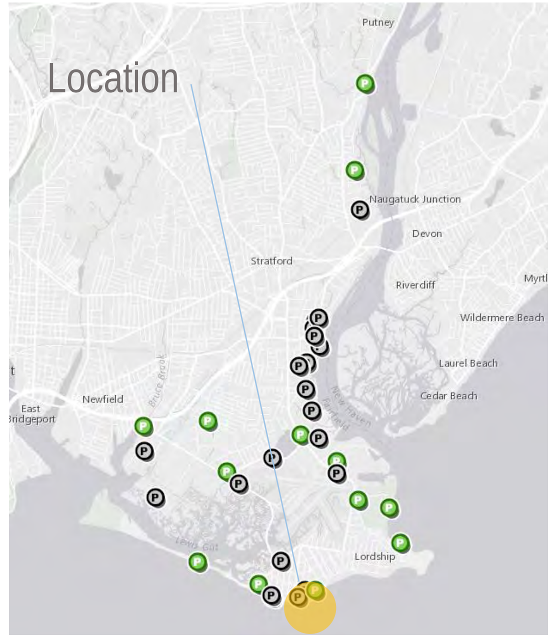


Preliminary Project Concept: Project Example Detail



ROAD SIDE SHEET PILE FLOODWALL - CONCEPTUAL

Project Location:	Beach Drive Flood Wall
Strategy:	Protect
Project Type:	Flood Wall
Existing Grades:	El. 7 to 8 feet NAVD88 +/- El. 10 feet NAVD88 (top of exist. seawall)
Risk Profile:	FEMA FIRM Zone VE Base Flood Elevation: 14 feet NAVD88 FEMA FIRM Zone AE (north of Beach Road) Base Flood Elevation: 11 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.0 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-5 to 6.5 feet 2065: +/-5 to 6.5 feet



Project Location

FEMA FIRM:

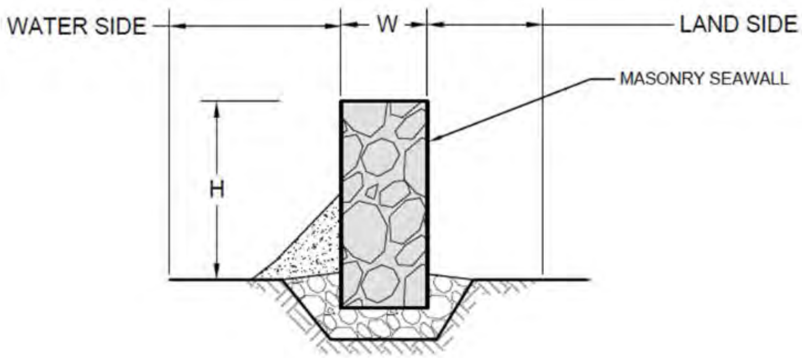
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

Project Objective: The objective of this project is to continue the Town-wide perimeter coastal flood protection. As observed during Hurricane Sandy, Beach Road is directly exposed to Long Island Sound waves and storm surge. The existing seawall/revetment provided some flood protection (mostly from wave action) during Hurricane Sandy. Its effectiveness in providing protection from flood inundation is limited since flood waters can enter around the ends of the wall. This project, which includes extending the wall and possibly increasing the wall protection elevation, will only be effective in conjunction with the other, adjacent, seawall project proposed in the Plan (next project). The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard is 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88).

Preliminary Project Concepts: The project concept is to: 1) extend the floodwall along Jefferson Street (to protect against flooding around the east end of the wall); and 2) increase the elevation of flood protection provided by the wall. The estimated project length is +/- 1,100 feet. A significant, permanent increase in the wall height is not desirable since it would eliminate the view. An alternative approach would be to modify the wall to support use of temporary, deployable flood protection panels (on top of the wall) to increase flood protection during extreme flood events. Temporary flood gates would also be required to protect wall openings, and sand bags (or equivalent) would be required to block wall drains. Engineering evaluation of the capacity of the wall to resist increased hydrostatic, hydrodynamic and wave loads is also required.

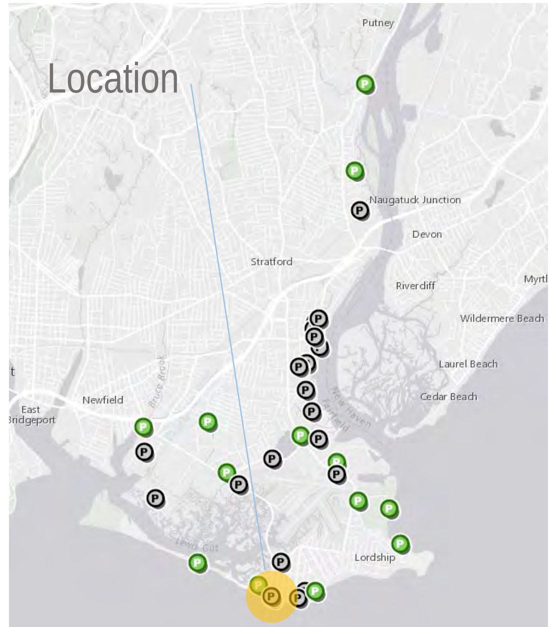
Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



MASONRY SEAWALL

Project Location:	Shoreline Drive Flood Wall
Strategy:	Retreat and Protect
Project Type:	Flood Wall
Existing Grades:	El. 3 to 8 feet NAVD88
Risk Profile:	FEMA FIRM Zone VE Base Flood Elevation: 14 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.0 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-3 to 6.5 feet 2065: +/-3.5 to 6.5 feet



Project Location

FEMA FIRM:

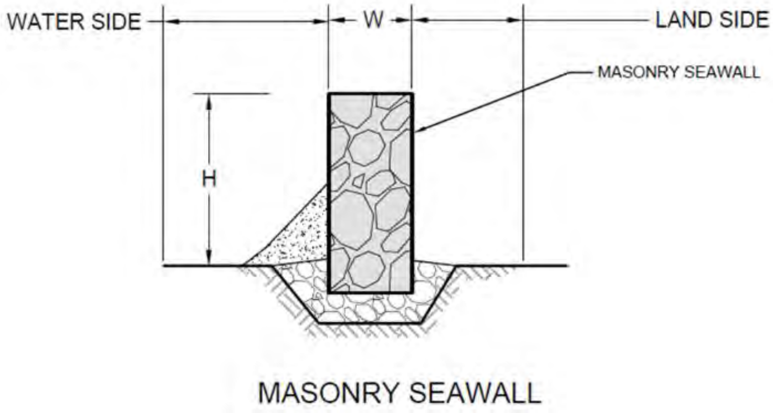
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The stormwater tide gate and pump station are also shown.

Project Objective: The objectives of this project are to: 1) continue the Town-wide perimeter coastal flood protection; 2) eliminate repetitive losses associated with existing structures that are highly vulnerable to waves and storm surge; and 3) enhance the natural resource benefit of the Town's beaches (in particular, gaining a continuous beach front from Long Beach to Lordship Beach). As observed during Hurricane Sandy, Shoreline Drive and the existing structures along Shoreline Drive are directly exposed to Long Island Sound waves and storm surge. In conjunction with nourishment of the existing beaches, this project would provide both significant flood protection and natural resource and recreational benefits. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard of the seawall would be 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88).

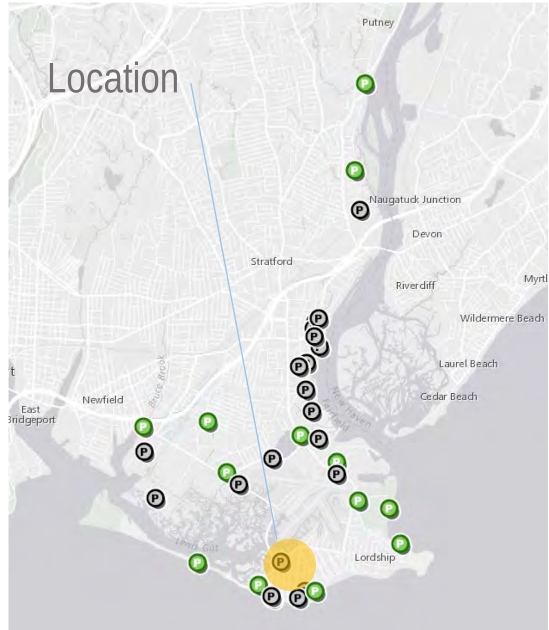
Preliminary Project Concepts: This project includes both retreat and protection components. Retreat includes the acquisition of 33 existing homes located to the south of Shoreline Drive and the return of that area to beach. Protection includes construction of a seawall and revetment that extends from the existing seawall along Beach Drive to Oak Bluff Avenue. The estimated project length is +/- 2,400 feet. A high wall height is not desirable since it would eliminate the view. An alternative approach would be to construct the wall to support use of temporary, deployable flood protection panels (on top of the wall) to increase flood protection during extreme flood events. Temporary flood gates would also be required to protect wall openings, and sand bags (or equivalent) would be required to block wall drains.

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



Project Location:	Oak Bluff Avenue Flood Wall
Strategy:	Protect
Project Type:	Flood Wall
Existing Grades:	El. 7 to 14 feet NAVD88
Risk Profile:	FEMA FIRM Zone VE Base Flood Elevation: 14 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.0 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1 to 2.5 feet 2065: +/-1 to 3 feet



Project Location

FEMA FIRM:

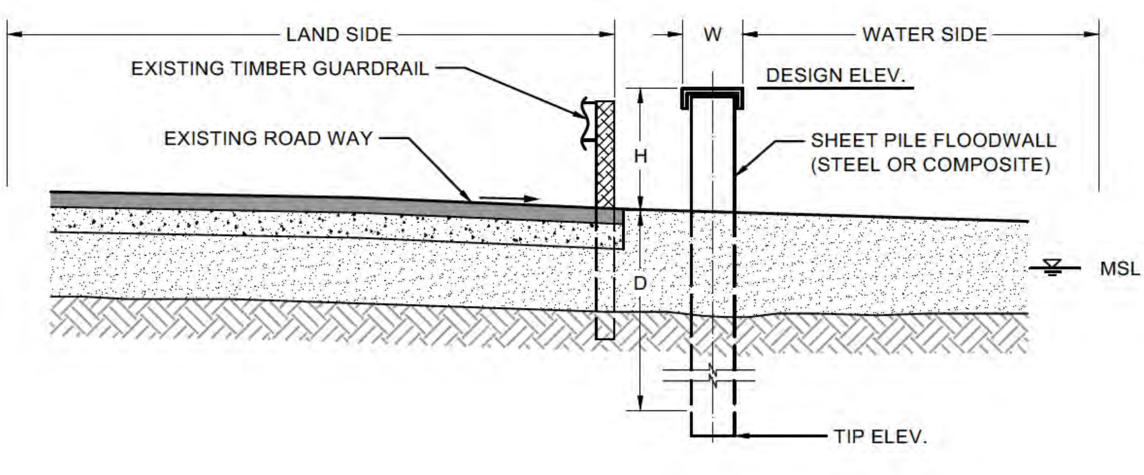
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

Project Objective: The objectives of this project are to continue the Town-wide perimeter coastal flood protection, including protection of Oak Bluff Avenue and areas to the east of Oak Bluff Avenue. This area is vulnerable to coastal flooding from the adjacent Great Meadows salt marsh. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard of the seawall would be 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88).

Preliminary Project Concepts: Protection includes construction of a floodwall adjacent to Oak Bluff Avenue, extending from the proposed Shoreline Drive seawall to Lordship Boulevard. The project can be integrated with bike paths and greenways. The estimated project length is +/- 2,000 feet.

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



ROAD SIDE SHEET PILE FLOODWALL - CONCEPTUAL

Project Location: Lordship Boulevard Flood Wall

Strategy: Protect

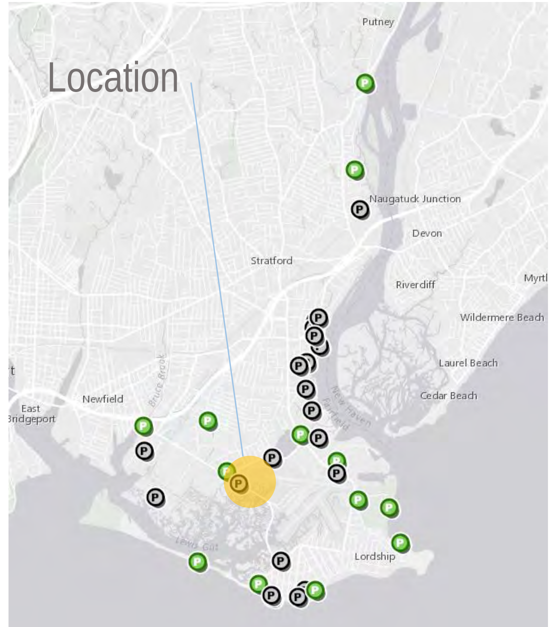
Project Type: Flood Wall

Existing Grades: El. +/-9 feet NAVD88

Risk Profile: FEMA FIRM Zone VE
Base Flood Elevation: 14 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.0 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-2 to 3 feet
2065: +/-2 to 3 feet



Project Location

FEMA FIRM:

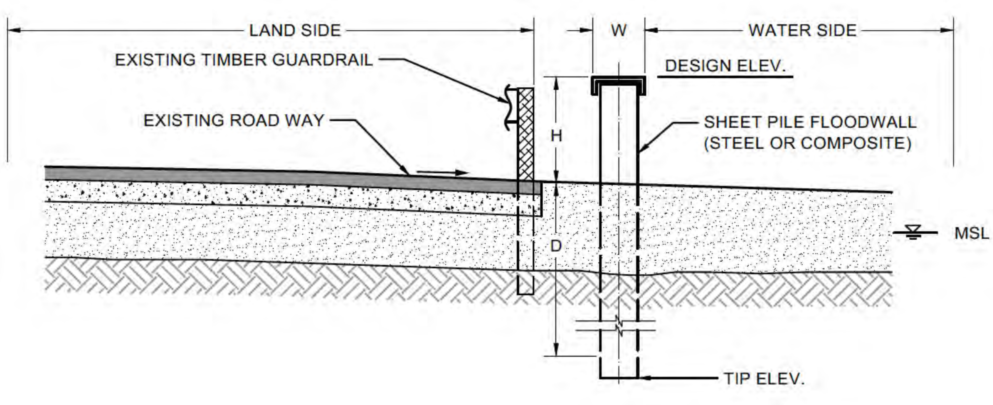
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins are also indicated.

Project Objective: The objectives of this project are to continue the Town-wide perimeter coastal flood protection, including protection of Lordship Boulevard and partial protection of the airport. This area is vulnerable to coastal flooding from the adjacent Great Meadows salt marsh. If the Airport Flood Wall project is not constructed (and the airport is allowed to flood this Lordship Boulevard Flood Wall project can be eliminated. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard of the seawall would be 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88).

Preliminary Project Concepts: Protection includes construction of a floodwall adjacent to the roadway. The estimated project length is +/- 6,500 feet (13,000 both sides of roadway).

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



ROAD SIDE SHEET PILE FLOODWALL - CONCEPTUAL

Project Location: Access Road Flood Wall

Strategy: Protect

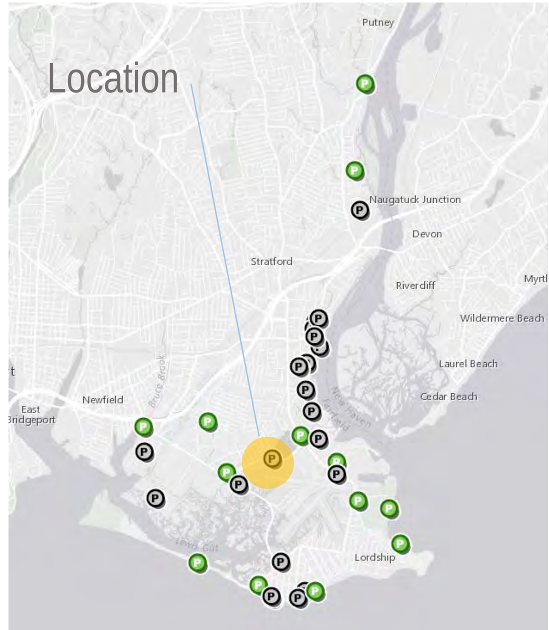
Project Type: Flood Wall

Existing Grades: El. +/-6 to 7 feet NAVD88

Risk Profile: FEMA FIRM Zone AE
Base Flood Elevation: 13 to 14 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.0 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-1 to 2.5 feet
2065: +/-1.5 to 3 feet



Project Location

FEMA FIRM:

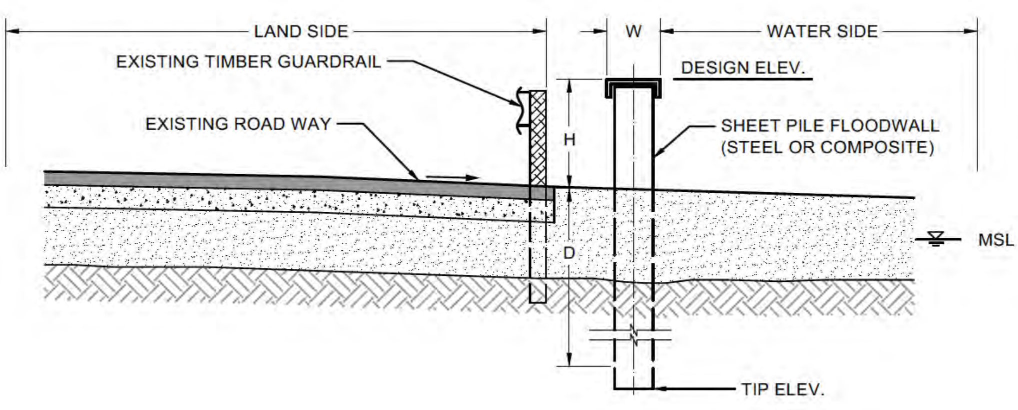
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

Project Objective: The objectives of this project are to continue the Town-wide perimeter coastal flood protection, including protection of areas to the west of Access Road. This area is vulnerable to coastal flooding from the adjacent Great Meadows salt marsh as well as flooding of the airport. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard of the seawall would be 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 17 feet NAVD88).

Preliminary Project Concepts: Protection includes construction of a floodwall adjacent to the roadway. The project can be integrated with bike paths and greenways. The estimated project length is +/- 6,500 feet (13,000 both sides of roadway).

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



ROAD SIDE SHEET PILE FLOODWALL - CONCEPTUAL

Project Location: Employment Growth District Flood Wall

Strategy: Protect

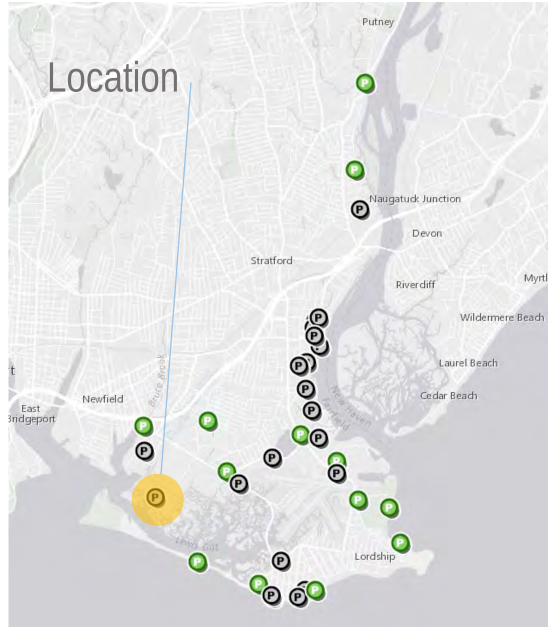
Project Type: Flood Wall (Alt. Vegetated Revetment with Levee) (Alt. Increase Site Grades)

Existing Grades: El. +/-7 to 10 feet NAVD88

Risk Profile: FEMA FIRM Zone AE
Base Flood Elevation: 12 to 13 feet NAVD88

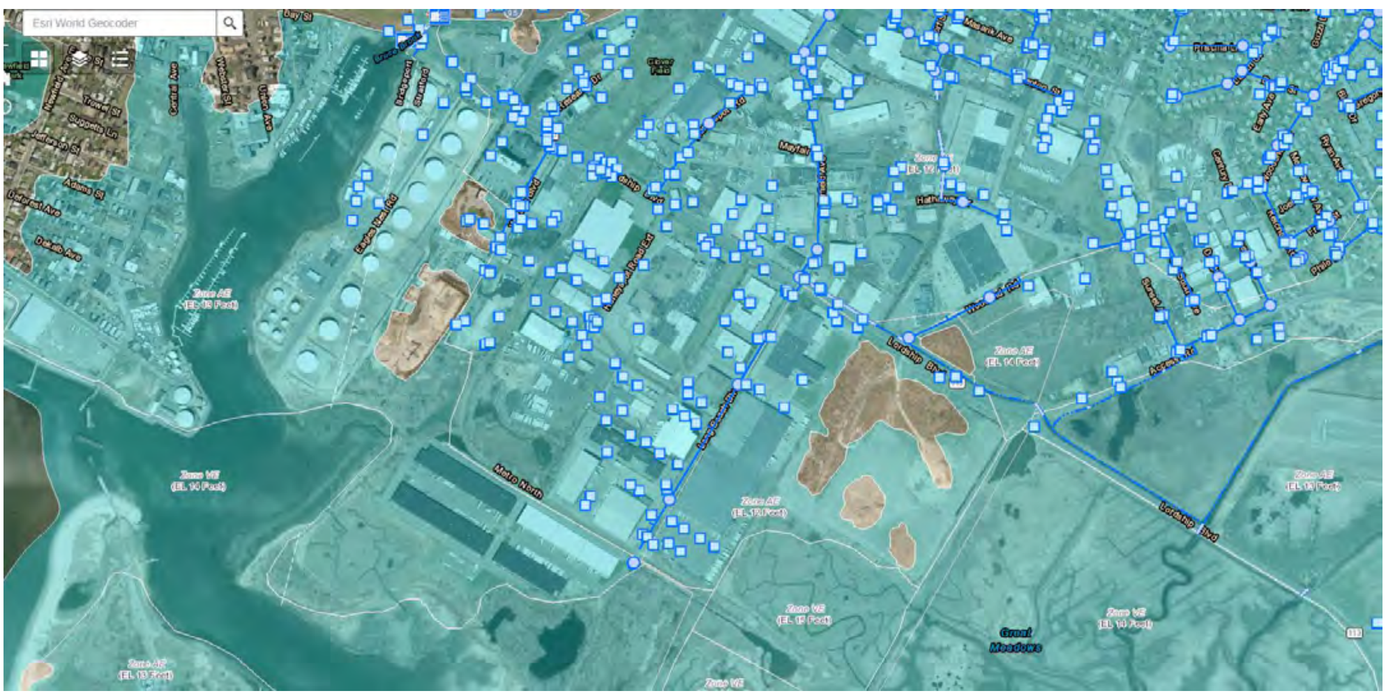
Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.0 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-1.5 to 3 feet
2065: +/-1.5 to 3 feet



Project Location

FEMA FIRM:



This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated.

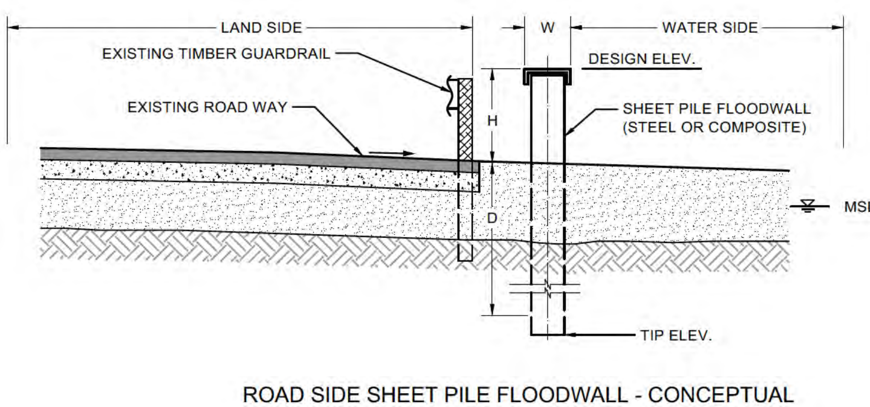
Project Objective: The objectives of this project are to continue the Town-wide perimeter coastal flood protection, including protection of the Employment Growth District (EGD). The existing EGD buildings are located within flood hazard zones and represent a significant financial loss potential. This area is vulnerable to coastal flooding from the adjacent Great Meadows salt marsh. The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard of the seawall would be 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88). To qualify for a modification to the FEMA FIRM, the grade elevation of the entire area would need to be increased to at least above the effective FEMA BFE (currently Elevations 12 to 13 feet NAVD88).

Preliminary Project Concepts: Protection includes construction of a perimeter floodwall. The flood protection should be coordinated with flood protection at the adjacent Sprague Oil bulk terminal. The estimated project length is +/- 11,500 feet.

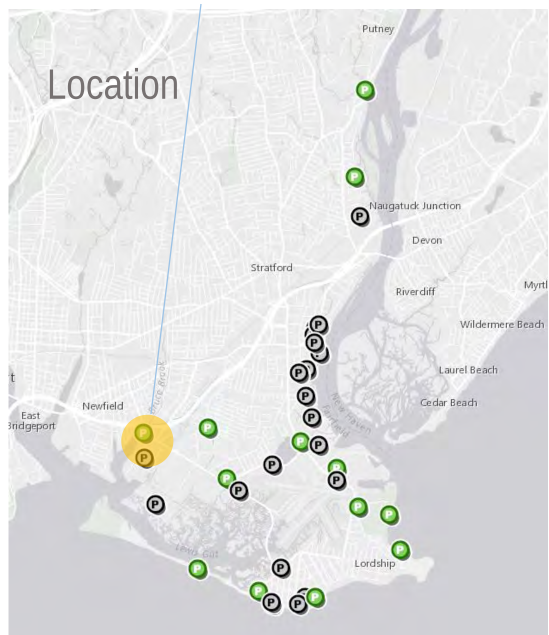
An alternate to a perimeter flood wall is a vegetated revetment and levee that would surround the boundary of Great Meadows. This alternative, although more expensive, can be integrated with bike paths and greenways. This area is proposed for redevelopment per the Plan of Conservation and Development. Another alternative is to increase the site grade elevations and building lower floor elevations during redevelopment of the existing properties.

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail

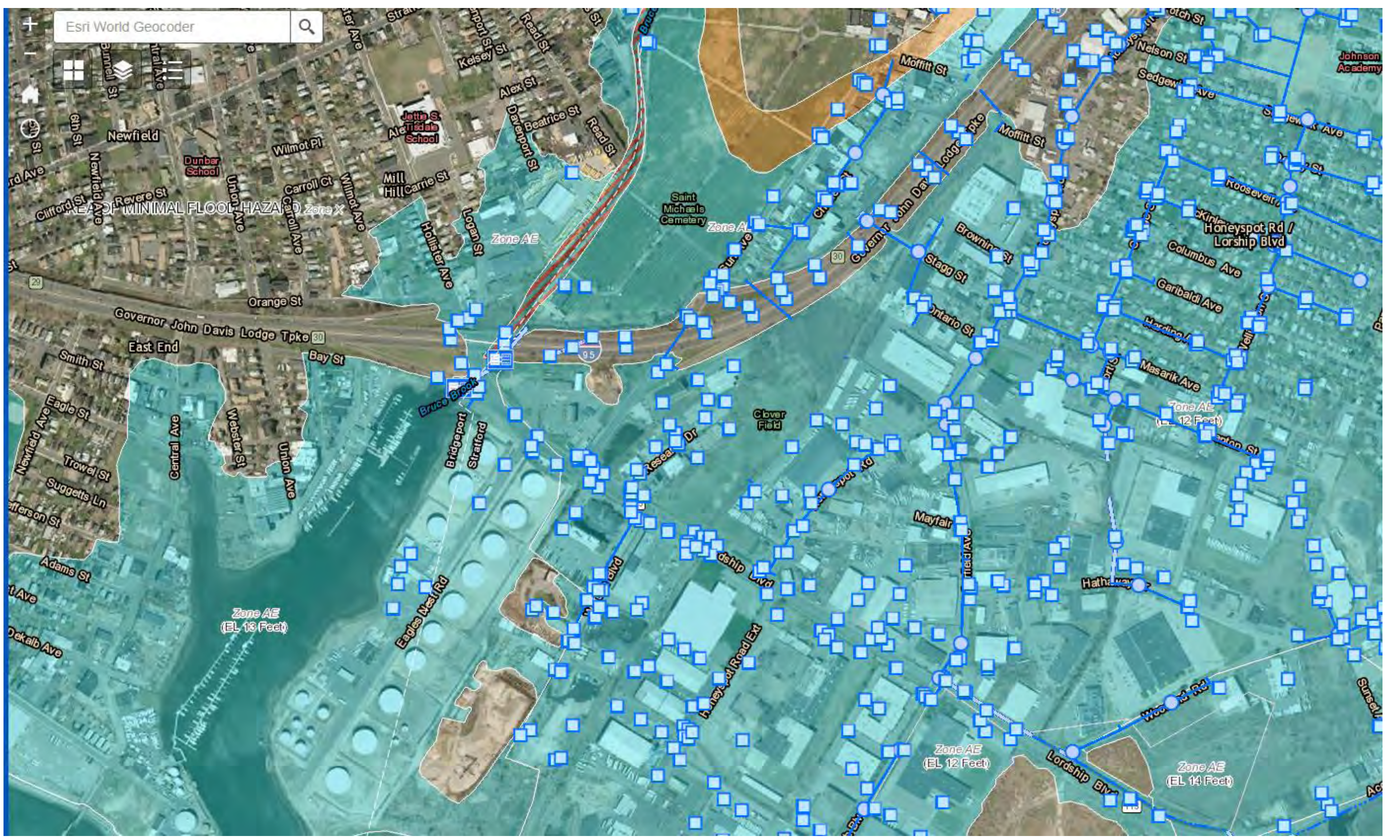


Project Location:	Bruce Brook Culvert
Strategy:	Accommodate and Protect
Project Type:	Flood Wall; Temporary (Deployable) Flood Walls; Stormwater Pump Station
Existing Grades:	El. +/-7 to 10 feet NAVD88
Risk Profile:	FEMA FIRM Zone AE Base Flood Elevation: 12 to 13 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.0 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-1.5 to 2.5 feet 2065: +/-1.5 to 2.5 feet



Project Location

FEMA FIRM:

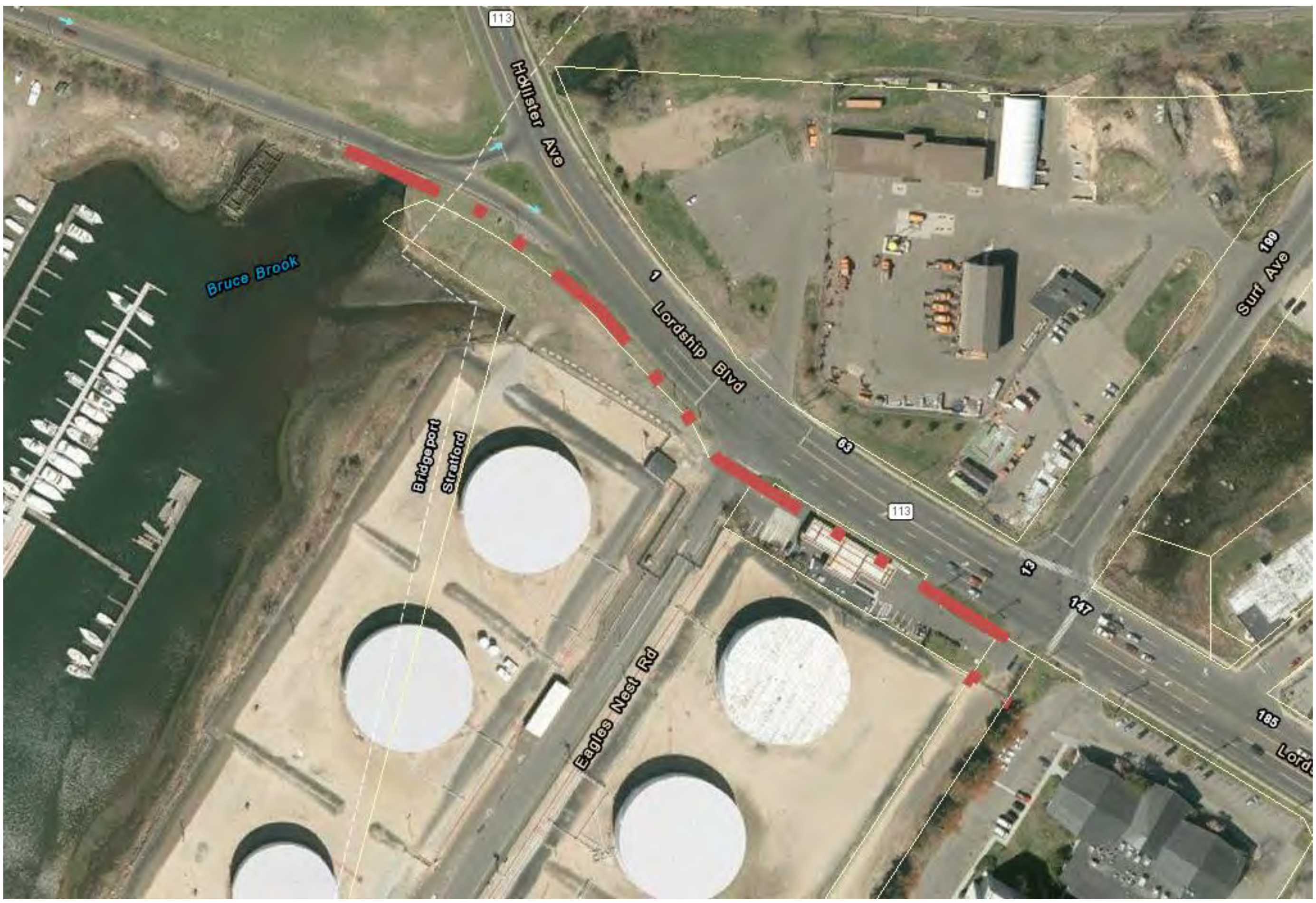


This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins and area ground surface elevations also indicated. The existing tide gates are also shown.

Project Objective: The objectives of this project are to continue the Town-wide perimeter coastal flood protection, including protection of the Employment Growth District (EGD), the interstate 95 underpasses, the State DPW facility, and portions of the South End neighborhood. This area is vulnerable to coastal flooding from Bruce Brook (within the culvert - if the tide gate is not functional - and overtopping Lordship Boulevard). The specific elevation of flood protection should be determined during conceptual and final design. To qualify as FEMA-accredited levee, the minimum freeboard of the seawall would be 3 feet above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 16 feet NAVD88).

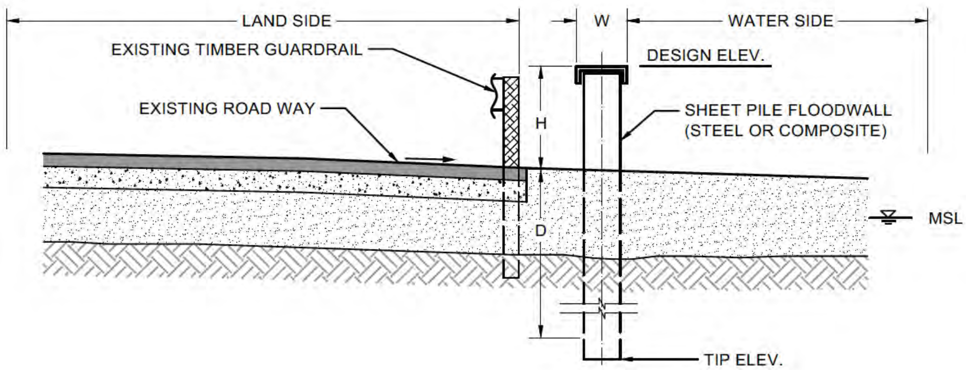
Preliminary Project Concepts: This flood source area is difficult to provide flood protection for due to limited access. Flood protection components include: 1) functional tide gates; and 2) permanent or temporary (deployable) flood protection along Lordship Boulevard (connecting to high ground surface elevations to the west and the EGD flood wall to the east. The flood protection can be integrate with flood protection for the Sprague Oil bulk terminal. Coordinating with Sprague Oil for flood protection will likely result in a more efficient approach. The project length is about 1,100 feet.

Preliminary Project Concept: Project Location



Preliminary Project Concept: Project Example Detail

Example details include both permanent flood walls and temporary (deployable) flood protection:



ROAD SIDE SHEET PILE FLOODWALL - CONCEPTUAL

Project Location: Lordship Beach Nourishment

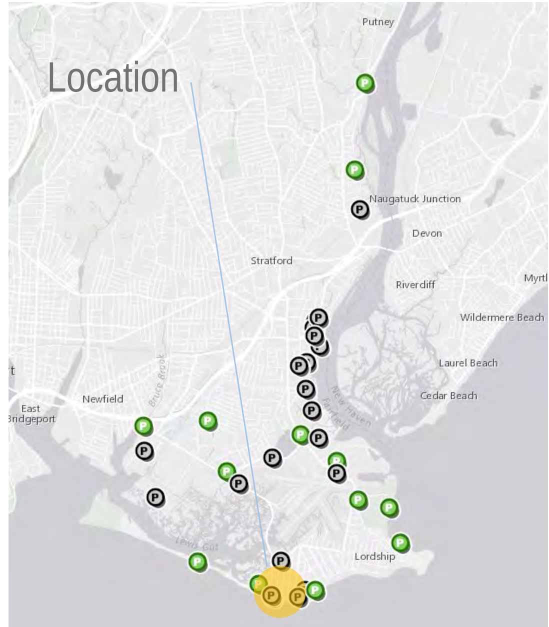
Strategy: Accommodate and Protect

Project Type: Beach Nourishment and Dune Maintenance

Risk Profile: FEMA FIRM Zone VE
Base Flood Elevation: 14 feet NAVD88

Predicted 100-year Stillwater Floods:
2040: 11.6 NAVD88 (Int. SLR)
2065: 12.0 NAVD88 (Int. SLR)

Predicted 100-year Wave Heights:
2040: +/-3 to 6.5 feet
2065: +/-3.5 to 6.5 feet



Project Location

FEMA FIRM:

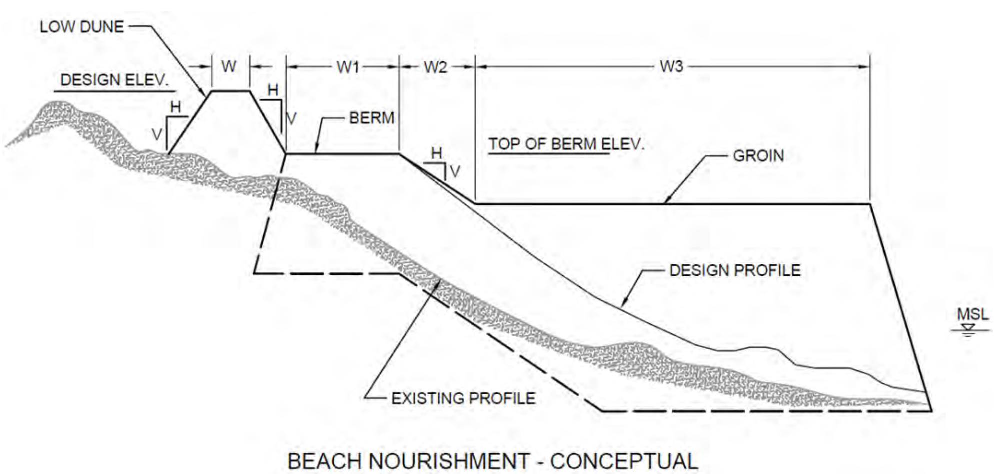
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing storm drains, manholes and catch basins are also indicated. Existing beach groins are also shown.

Project Objective: The objectives of this project are to increase the lateral extent of the beach and create a beach and dune morphology, providing additional flood protection due to waves as well as enhanced natural resource and recreational value to the Town.

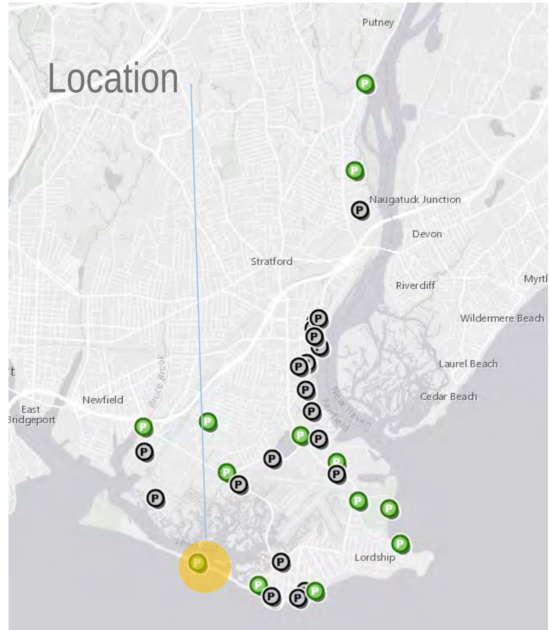
Preliminary Project Concepts: The project is includes beach nourishment and dune construction. The proposed beach length project limits are approximately 2,400 feet and the proposed additional beach width is about 100 feet. The dune crest elevation should be above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 14 feet NAVD88).

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



Project Location:	Long Beach Nourishment
Strategy:	Accommodate and Protect
Project Type:	Beach Nourishment and Dune Maintenance
Risk Profile:	FEMA FIRM Zone VE Base Flood Elevation: 14 feet NAVD88 Predicted 100-year Stillwater Floods: 2040: 11.6 NAVD88 (Int. SLR) 2065: 12.0 NAVD88 (Int. SLR) Predicted 100-year Wave Heights: 2040: +/-5 to 7 feet 2065: +/-5 to 7 feet



Project Location

FEMA FIRM:

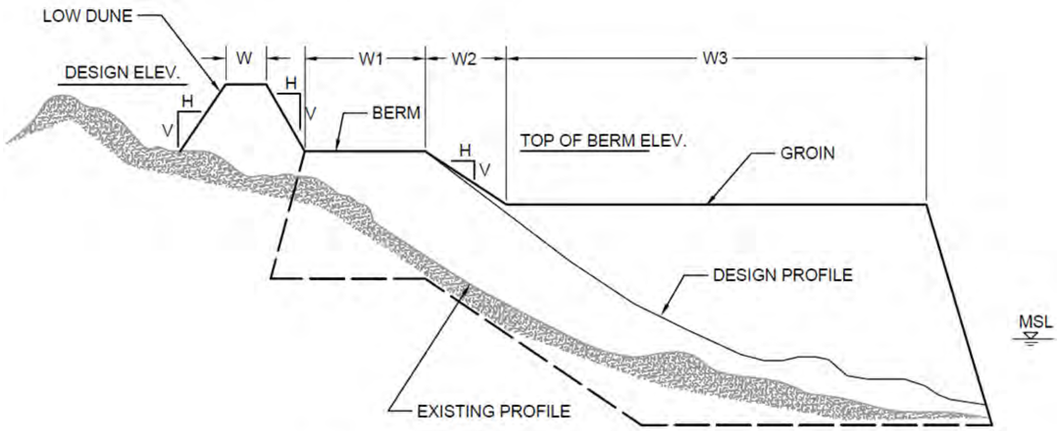
This figure indicates the effective FEMA FIRM limits of inundation and Base Flood Elevation. Existing tide gates and stormwater pump stations are also indicated. Existing beach groins are also shown.

Project Objective: The objectives of this project are to increase the lateral extent of the beach and create a beach and dune morphology, providing additional flood protection due to waves as well as enhanced natural resource and recreational value to the Town.

Preliminary Project Concepts: The project is includes beach nourishment and dune construction. The proposed beach length project limits are approximately 7,600 feet and the proposed additional beach width is about 300 feet. The dune crest elevation should be above the FEMA FIRM Base Flood Elevation (or, currently, Elevation 14 feet NAVD88).

Preliminary Project Concept: Project Location

Preliminary Project Concept: Project Example Detail



BEACH NOURISHMENT - CONCEPTUAL

SECTION 6 ATTACHMENT
CIRCA FINANCING RESILIENCY IN CONNECTICUT FACTSHEET

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.

[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.*

April 19, 2016

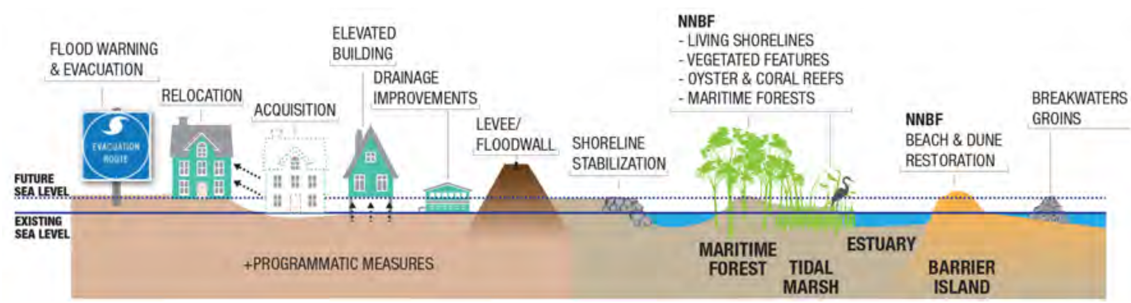
Model Programs for Resilience Financing

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

April 19, 2016

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Acknowledgments:

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Daniel C. Stapleton, P.E. is a Senior Principal and Senior Vice-President of GZA and a leader of GZA's Water Services group. He is currently directing GZA project teams in assessing the flood vulnerability of communities and critical infrastructure throughout the United States. Dan served as the Principal-in-Charge for developing the Community Coastal Resilience (CCR) Plan in Stratford, CT and Old Saybrook, CT, and a Long Wharf Flood Protection Study in New Haven, CT, working in collaboration with these communities, and respective Regional Council of Governments. Dan is a registered engineer in the State of Connecticut, and a recognized expert in flood and geo-hazard characterization, hazard vulnerability assessment, adaptation planning and design and coastal resiliency.

Dan has over 30 years of experience and advanced degrees in geology, geotechnical and civil engineering, and ocean engineering. Dan is a regular speaker on climate change, effects on critical infrastructure and the application of "Risk-Informed Decision Making", and has addressed municipalities, industry groups and the Army Corps of Engineers around the United States on this issue. Dan has also recently become a member of key ASCE subcommittees that form the ASCE Infrastructure Resilience Division-Civil Infrastructure and Lifeline Systems Committee.

Samuel J. Bell is a Senior Hazard Mitigation Specialist and Planner at GZA GeoEnvironmental, Inc. (GZA). In this role Sam is responsible for assisting GZA's clients with natural hazard mitigation and resiliency planning, flood vulnerability and risk assessments, emergency response planning, and community education and outreach. Sam has extensive experience providing technical assistance to States and municipalities throughout the United States on mitigation and disaster resiliency projects designed to protect critical facilities, public and private infrastructure, and residences in coastal and riverine environments. Sam served as the Project Manager leading the development of the Stratford CCR Plan. He is currently assisting the Town of Old Saybrook, CT develop a similar Coastal Community Resilience Study, and is assisting the City of New Haven in the development of flood protection strategies for Long Wharf in New Haven, CT including natural and nature-based solutions, permanent flood mitigation and temporary deployable flood response solutions.

Prior to joining GZA, Sam worked for the Federal Emergency Management Agency (FEMA) and was responsible for FEMA mitigation and disaster resiliency technical assistance to coastal communities throughout New England. Sam administered grants designed to protect critical facilities, public and private infrastructure, natural resources, and historic districts in coastal and riverine environments. Sam has a Bachelor of Environmental Design in Planning from the University of Colorado-Boulder and a Master of Arts in Urban and Environmental Policy and Planning from Tufts University.

GZA GeoEnvironmental, Inc.