Attachment 7: Comprehensive Flood Mitigation Study

This attachment presents the findings of the *Comprehensive Mitigations Items Feasibility Study* and looks at the feasibility of flood mitigation alternatives for key Town assets. **Attachment 4** presents a detailed evaluation of the vulnerability and risk of these assets.

- Roads and Bridges;
- Essential Facilities;
- Commercial and Industrial Districts;
- Historical Properties; and
- Natural Resources.

Of all the Town's assets, the most significant coastal flood risk is the Town's roadway system. The Town's roadway system, which includes both municipal and state roads, is highly vulnerable to coastal flooding. Almost all of the Town's roads servicing areas located to the south of I-95 flood during extreme coastal flood events and a portion of the Town's roads now flood frequently (every year or so). These sections of roadway (generally defined by the limits of the current 2-year recurrence interval flood, will become chronically flooded in the future (around 2040 to 2050) as a result of sea level rise.

Roadway flooding disrupts the use of the roads, isolates neighborhoods, affects the Town's capability to evacuate and provide emergency services and results in roadway damage. As such, it represents a major liability to the Town.

Sanitary wastewater treatment is also significant issue relative to shallow groundwater and frequent coastal flooding. The Town established a Decentralized Wastewater Management District (WWMD) in August, 2009 and adopted: 1) WWMD boundaries that include approximately 1900 lots located within 15 neighborhood areas; and 2) Upgrade Program Standards for on-site septic system improvements. GZA evaluated the coastal flood risk and presented relevant information via a separate memorandum to the Town for use in the "Old Saybrook Wastewater Pollution Control Authority [WPCA]) Study".

The Town's stormwater management system will also be affected by future flooding and sea level rise. At this time, there is inadequate information about the system details to perform a detailed assessment of these impacts. Stormwater management improvements are not included in this Study.

The coastal flood risk to the Town's Lifeline Facilities, including Electricity, Natural Gas, Water and Communication and Sewer, is relatively low (except sanitary waste water management, discussed above). The electrical substation located at Elm Street is vulnerable to coastal flood station. The substation is the responsibility of Eversource.

Roads, Bridges and Culverts

The Town is served by two major limited access highways, Interstate 95 and Route 9, as well as major arterials such as U.S. Route 1, CT Route 154 and Route 166. The Town also has a network of smaller roads that provide access throughout town and serve act as collectors for the major arterials and highways. The Town is also served by several bus routes of the 9 Town Transit District, as well as a train station which offers a stop on both Amtrak's Northeast Regional service and the Shore Line East Railroad. The Town's piers. Dock and marinas, while not formerly part of the Town's transportation system, are available to provide water access and egress.

An overview of the roadways, bridges and culverts, by jurisdiction, is presented below and is followed by a detailed list of each road and bridge included for analysis for this evaluation. This section of the report supports the goal of the Town's updated Natural Hazard Risk Management Plan to evaluate flood risk to roads.

Roads

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

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

Municipal roads make up approximately 88 miles of total roadway within Old Saybrook.

Table 7-1 summarizes the length of roadway impacted under different coastal flood scenarios. **Attachment 4** presents a detailed vulnerability assessment.

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

Table 7-1: Summary of Impacted Roads Due to Coastal Flooding

Bridges

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

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

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

Three (3) Amtrak Rail bridges:

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

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

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

Eight (8) Town bridges:

- Great Hammock Road Bridge over Back River
- Ingham Hill Road Bridge over Amtrak
- Nehantic Trail Bridge over Hagar Creek
- Plum Bank Road Bridge over Plum Bank Creek
- School House Road Bridge over Amtrak
- Sequassen Avenue Bridge over tidal creek
- Spencer Plain Rd Bridge over I-95
- Spencer Plain Road Bridge over Amtrak

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

Table 7-2: Summary of Bridges Inundated during the 100-year recurrence interval Coastal Flood

Eight (8) bridges have bridge decks that will be inundated and exposed to wave action during the 2016 100-year return period flood (see **Table 1-4**). Three (3) of the bridges are along the South Cove Causeway. **Figure 1-16** shows the location of the bridges relative to the 100-yr return period flood. Amtrak and I-95 bridge decks are not flooded during the 2016 100-year return period flood.

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

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

Table 7-3: Summary of Roadway Culverts Inundated during 100-year Return Period Coastal Flood

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

TRANSPORTATION INFRASTRUCTURE FLOOD MITIGATION CONSIDERATIONS

There are several considerations relative to identifying Old Saybrook's transportation system flood mitigation priorities and alternatives, including:

- Effects of Nuisance Flooding (i.e., Chronic Flood Inundation) versus Extreme Flood Events
- Emergency Response Capabilities
- Storm Evacuation Requirements
- Transportation Infrastructure Damage
- Technical Feasibility
- Cost

Nuisance Flooding

Nuisance flooding generally describes areas which are regularly flooded, including due to tides during "sunny sky" conditions. The term "chronic flood inundation" applies a specific quantitative guideline for nuisance flooding - specifically 26 times per year. Chronic flood inundation has significant implications relative to roadway use limitations and associated negative impacts to businesses and residents. **Figure 7-1** provides a reasonable representation of roadway sections that have a high probability of being flooded today and will be chronically flooded by about the year 2050. As shown on **Table 7-1**, about 3 miles of Town roads and 3 miles of State roads are impacted under this scenario.

Emergency Response

Populated Town areas and neighborhoods become isolated during coastal flooding due to road inundation and flood depths along both primary and secondary roadway can be significant. This impacts the ability of people to leave during the flood event as well as limits the Town's emergency response capabilities. The more limited the Town's emergency response capability becomes, the greater the requirement for, and frequency of evacuation, becomes. Another consideration is the capability of the Town's emergency response equipment relative to passaging flooded roads. Cars cannot, typically, passage greater than six inches (<1 foot) of water depth and heavy, high clearance 4 wheel drive vehicles cannot typically passage more than 24 inches (2 feet) water depth. As the flood depth increases to these depths, the vehicles speeds will reduce dramatically. The presence of high velocity water flow (such as from waves) will further significantly reduce passable depths.

Figure 7-1: 2-year Recurrence Interval Flood Roadway Impacts; Chronic Flooding by 2040 to 2050

Pre-Storm Evacuation

Storm evacuation capability is a key consideration relative to roadway accessibility. A detailed analyses of New England hurricane evacuation needs and capabilities is presented in "New England Hurricane Evacuation Study, Technical Data Report", June 2016, prepared by the USACE and FEMA. Per this study, evacuation people statistics indicate that: during Category 1 and 2 hurricanes between about 8,200 and 10,750 people may require evacuation during severe flood events; during Category 3 and 4 hurricanes, an 90 and 260 people may require evacuation during severe flood events; and additional people evacuating from inland areas located outside of coastal flood inundation may be between 440 and 800 additional people. The vulnerability of the Town's roads to flooding effects evacuation capability.

Transportation Infrastructure Damage

Roadway damage associated with coastal flooding typically occurs due to: 1) scour, erosion and subsidence of the road bed; 2) debris impact damage; 3) sand overwash (roads adjacent to beaches and dunes); 4) damage to utilities located within roadways (above ground and below ground); 5) saturation and destabilization of road base course; and 6) corrosion and salt-related material damage. Bridge damage associated with coastal flooding typically occurs as a result of wave action due to: 1) scour at bridge piers; 2) hydrodynamic and impact loads to bridge piers; and 3) uplift loads on bridge decking.

A preliminary overview of the damage potential of Old Saybrook's roadways indicates the following:

- Old Saybrook's roads located within flood hazard zones will be subject to both flood inundation and waves. Wave heights range from minimal damage potential (wave heights less than 1.5 feet) to moderate damage potential (wave heights ranging from 1.5 feet to 3 feet) to severe damage potential (greater than 3 feet). **Figure 7-2** shows the wave heights predicted for the 2016 100-year return period flood. Most roads appear to be in relatively low wave energy environments.
- Several of the Beach Community roads are expected to be vulnerable to severe damage during the 100-year return period flood (and possibly more frequent floods), including Beach Road, portions of Red Bird Trail, Bayside Avenue, portions of Vincent Avenue, portions of Hartford Avenue, portions of Middletown Avenue, Barnes Road, Walker Avenue and Plum Bank Road. An additional road that is vulnerable to severe damage, at least during the 100-year return period flood, is Dock Road.
- Primary, key roads vulnerable to severe damage due to waves include Bridge Street (including the South Cove causeway bridges).
- A primary, key roadway with the potential for future damage due to wave exposure is an approximately 4,000-foot long section of Maple Avenue (Route 154). The road surface grades along this section range from about Elevation 21 feet NAVD88 (to the west) to Elevation 11 feet (to the east). The 100-year and 500-year stillwater elevations along this stretch of Route 154 are about 9.5 feet and 12.6 feet NAVD88, respectively. Currently, this road is not predicted to be inundated during the 100-year return period flood with some inundation predicted during the 500-year return period flood. Wave heights on the order of 4 to 6 feet are predicted along this section of road during the current 100-year return period flood and 500-year return period floods. Therefore, roadway flooding due to wave overtopping will occur, likely making this section of road unpassable during these probability flood events. During the 500-year return period flood, the eastern portion of the road will also be inundated, in addition to wave effects. Based on the existing roadway grades, marginal sea level rise will significantly increase the flood risk of this road. This section of Route 154 has direct frontage on Long Island Sound and is protected against erosion with a concrete and masonry revetment.
- Based on the flood elevations relative to bridge deck elevation, bridges with a moderate to high bridge damage potential during the 2016 100-year return period flood include:

  i. South Cove Causeway Bridges: High
  ii. Great Hammock Road Bridge over Back River: High
  iii. Nehantic Trail Bridge over Hager Creek: Moderate
  iv. Plum Bank Road Bridge over Plum Bank Creek: High
  v. Sequassen Avenue Bridge over tidal creek: High

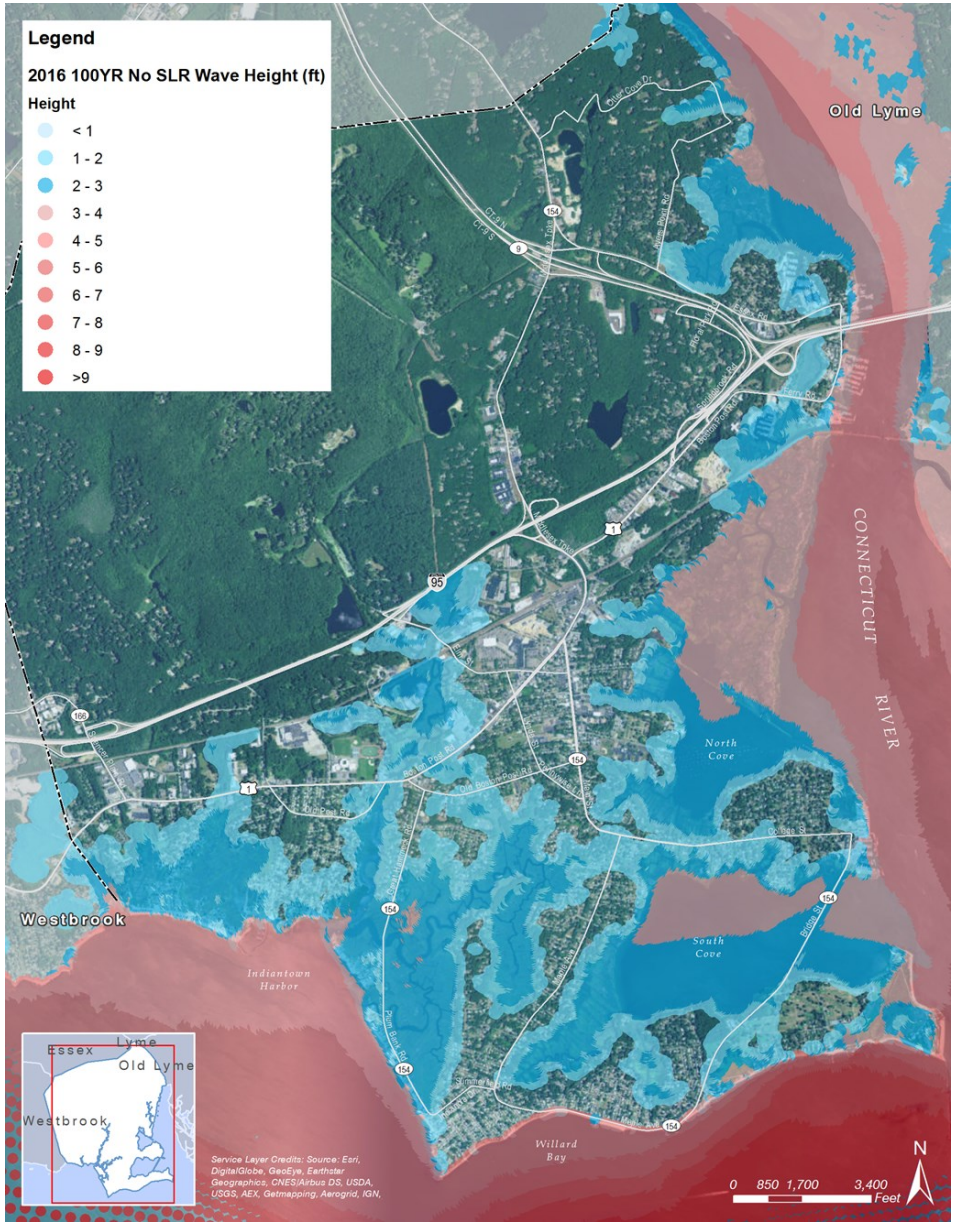


Figure 7-2: 100-year Recurrence Interval Flood Wave Heights

Technical Feasibility of Flood Mitigation Alternatives

Roadway flood mitigation alternatives typically include:

- Elevating the road, including bridges and replacement of roadway culverts
- Roadway perimeter flood protection including flood walls and berms
- Constructing a low bridge deck in lieu of a grade-supported road

Additional, passive, alternatives are: 1) to allow the road to temporarily flood (i.e., storm flood events) while minimizing flood-related damage; or 2) abandon the road.

There are several factors that limit the use of these alternatives. In particular, substantial roadway grade increases will need to accommodate existing intersections, driveways and abutting building first floor levels. Elevating roads more than about 3 feet (such as would be required over most of the inundated Old Saybrook roads to elevate them above the 100-year return period flood) will likely be technically challenging and cost prohibitive.

The other roadway flood mitigation alternatives requiring roadway modification will have similar issues. Perimeter berms and/or floodwalls will require openings at driveways that would need to be closed with deployable barriers during the flood event.

Installing bridge decks in lieu of elevating roads may be an effective alternative at specific roadways sections (such as along the section of College Street (Route 154) that is bounded by marsh on both sides.

Flood Mitigation Roadway Costs

A linear cost of roadway replacement for 2-lane undivided roads with elevation changes less than about 3 feet of $3 million per mile ($550 to $600 per linear foot) is appropriate for preliminary resilience planning (reference American Road & Transportation Builders Association). An additional linear cost to improve adjacent intersections, driveways and stormwater management of about $1 million per mile ($200 per linear foot) should also be assumed for preliminary resilience planning, for a total planning linear cost of $4 million per mile (+/- $750 per linear foot).

There is not, currently, much available, standardized data for roadway damage versus flood depth and waves. A preliminary, planning level, cost for roadway repair associated with flood damage is (ref. State of California, Department of Water Resources, Division of Flood Management, Flood Rapid Assessment Model (F-RAM, 2008):

- Cost per mile of highway inundated: $250,000
- Cost per mile of major road inundated: $100,000
- Cost per mile of minor road inundated: $30,000
- Cost per mile of gravel road inundated: $10,000

The unit costs presented above are not specific to Old Saybrook, are highly uncertain and should be used with caution by Old Saybrook. Although the repair and replacement unit costs presented above are highly approximate, they provide valuable insight for preliminary resilience planning and decision making:

- **Table 7-4** presents a (highly) approximate estimate of the cost to elevate all inundated roads assuming a unit cost of $4,000,000 per mile.
- **Table 7-4** does not include the potential cost of bridge replacement, including bridges that are components of key roadways. The (highly) approximate additional cost to include bridge replacement is shown below, based on Federal Highway Administration Bridges & Structures Bridge Replacement Unit Costs for 2017 (https://www.fhwa.dot.gov/bridge/nbi/sd2016.cfm).
    i) South Cove Causeway Bridges:
        - 250 lf by 40 ft. @ $440/sf = $4,400,000
        - 250 lf by 40 ft. @ $440/sf = $4,400,000
        - 250 lf by 40 ft. @ $440/sf = $4,400,000

    i) Great Hammock Road Bridge over Back River:
        - 35 lf by 30 ft @ $440 = $462,000

    i) Nehantic Trail Bridge over Hager Creek:
        - 65 lf by 35 ft @ $440 = $1,001,000

    i) Plum Bank Road Bridge over Plum Bank Creek:
        - 20 lf by 35 ft @ $440/sf = $308,000

    i) Sequassen Avenue Bridge over tidal creek:
        - 30 lf by 20 ft @ $440/sf = $264,000

- Highly approximate cost estimates to repair roads with severe damage potential due to waves, assuming unit costs of $250,000 per mile (State), $100,000 per mile (key municipal roads), and $30,000 per mile (community roads) are presented as shown below. These estimates are associated with predicted damage from waves associated with the 2016 100-year return period flood. This was the only return period flood analyzed; however, given the high vulnerability of these roads to coastal flooding, similar losses are also likely for higher probability coastal flood events.
    i) Beach Community Roads: 1.5 miles @ $30,000 per mile = +/- $50,000
    ii) State Roads (including Plum Bank Road): 1.5 miles @$250,000 per mile = +/- $400,000

	2-year	10-year	20-year	50-year	100-year	500-year
Municipal	$10,467,645	$29,619,188	$42,898,839	$56,106,946	$71,543,954	$111,953,050
State	$3,806,263	$9,787,332	$12,703,164	$14,874,116	$17,247,326	$22,231,640
Primary (Key Roads)						
Municipal	$298,642	$2,904,597	$4,853,878	$6,814,851	$9,226,714	$13,844,748
State	$3,420,336	$9,401,405	$12,317,237	$14,488,189	$16,861,398	$21,845,712

Table 7-4: Approximate Estimate of Roadway Replacement Assuming All Inundated Roads are Elevated

TRANSPORTATION INFRASTRUCTURE FLOOD RESILIENCE STRATEGY

Developing a transportation infrastructure resilience strategy for Old Saybrook requires consideration of several factors including:

- the frequency and effects (i.e., disrupted use) of nuisance flooding (i.e., Chronic Flood Inundation);
- the effects of lower probability extreme flood events, including infrastructure damage;
- the implications of roadway flooding for evacuation and emergency response capabilities; and

the technical feasibility and cost of flood mitigation alternatives.
The Amtrak rail line (as well as the Old Saybrook Rail Station are not located within flood hazard zones (up to the 2016 500-year return period flood). Access to and from the Old Saybrook Essential Facilities (necessary for emergency response and shelter) is limited and impacted by roadway flooding. The major routes providing ingress and egress to the Town, including I-95 and Route 9 and access ramps are not located within flood hazard zones (up to the 2016 500-year return period flood).

However, as documented in detail in **Attachment 4**, much of the Town's roadway system south of I-95 is very vulnerable to coastal flooding. Developed areas south of I-95 become isolated "islands" during major flood events. Primary, key roads (i.e. higher trafficked and main routes) become inaccessible and not passable. These roads are particularly important since they represent the Town's main arteries and are also essential for emergency evacuation and access for emergency response. A portion of the Town's roads also flood on a frequent basis (see 2 and 10-year return period flood inundation figures) and are predicted to flood "chronically" (on average about 26 times per year) by the year 2050. Overall future sea level rise will increase the Town's roadway flood issues.

Transportation infrastructure flood mitigation alternatives include:

- Elevating the road, including bridges and replacement of roadway culverts;
- Roadway perimeter flood protection including flood walls and berms;
- Constructing a low bridge deck in lieu of a grade-supported road;
- Allowing the road to temporarily flood (i.e., storm flood events) while minimizing flood-related damage;
- Employ "flood applicable" emergency response vehicles and equipment capable of passing flooded roads; and
- Abandon select roadways.

Since it is unlikely that elevating or providing flood protection to all impacted roads to above the 100-year (or 500-year) return period flood elevations will be feasible from either a cost or technical perspective, the optimal resilience strategy will be to find a balance between: 1) near-term roadway improvements; 2) preventing future roadway damage; 3) ability to provide emergency response; 4) evacuation requirements; and 5) the effect of future sea level rise on each of these. The optimal strategy would also prioritize future actions (including considering and planning for some roadway abandonment) as well as support adaptation in the future.

Additional analyses and future Town discussion/meetings will be required to develop the transportation infrastructure strategy and long term Town plans for roadway improvements. A preliminary strategy is proposed as follows:

Step 1: Meet with ConnDOT to discuss the findings of the Town's Coastal Resilience study as they relate to State roads and discuss flood mitigation alternatives, funding and responsibility for improvement of State roads. These meetings will provide the Town with a reasonable understanding of what the State is prepared to do relative to State-managed roads, so the Town can plan accordingly.

Step 2: Work with the Town's Natural Hazard Risk Management and Emergency Response professionals to create/revise the Town's evacuation route in light of the findings of this study. Also discuss the feasibility of purchasing and training on "flood applicable" emergency response vehicles and equipment, recognizing that providing flood mitigation to all vulnerable roads may not be feasible.

Step 3: Identify near-term roadway improvements, prioritizing: 1) high trafficked roadways vulnerable to high frequency (future chronic) flooding, as identified by the 2 and 10-year return flood inundation analysis; 2) primary, key roads required for evacuation.

Step 4: Perform preliminary engineering analyses of the roads identified in Step 3 to establish appropriate flood mitigation approach and elevation.

Step 5: Estimate flood damage liability and evaluate benefits of investing in roadway protection versus post-disaster relief funding. In particular, consider future flood vulnerability of Rt. 154/Walnut Avenue with direct exposure to Long Island Sound.

Step 6: Several roads (e.g., Plum Bank Road) are located in highly vulnerable areas. The benefits of on-going repair and maintenance of these roads should be evaluated relative to abandonment at some point in the future.

Step 7: Prepare a Long-Term Roadway Improvement and Maintenance Plan, including cost projections, schedule and financing options.

TRANSPORTATION RESILIENCE FUNDING SOURCES

Applicable programs that serve as potential sources of funding for transportation infrastructure design and construction include:

- Transportation Investment Generating Economic Recovery (TIGER) program (FHWA and State of Connecticut);
- Nature-Based Resilience for Coastal Highways (FHWA);
- Municipal and Resilience Bonds; and
- Town taxes.

State of Connecticut Transportation Capital Infrastructure Program

The U.S. Department of Transportation announced on September 7th, 2017 the opportunity for state and local stakeholders to apply for $500 million in discretionary grant funding through the Transportation Investment Generating Economic Recovery (TIGER) program. Connecticut transportation funding such as the TIGER Discretionary Grant program (which includes federal funds from U.S. DOT or Federal Highway Administration) are potential sources of funding for resiliency projects that have a transportation component. This includes typical State-owned transportation systems (roads, bridges, rail and bus) as well as pedestrian trail corridors. Certain maritime uses, including port infrastructure projects are also included. Connecticut DOT also has funding to conduct planning studies to address the impacts of climate change and extreme weather.

"The TIGER grant program is a highly competitive program whose winners will be awarded with the funding they need to rebuild the infrastructure of their communities," said Secretary Elaine L. Chao. "TIGER grants will continue to fund innovative projects that will improve the safety of America's passengers and goods."

The Consolidated Appropriations Act, 2017 appropriated $500 million, available through September 30, 2020, for National Infrastructure Investments otherwise known as TIGER grants. As with previous rounds of TIGER, funds for the fiscal year (FY) 2017 TIGER grants program are to be awarded on a competitive basis for projects that will have a significant impact on the Nation, a metropolitan area, or a region. The FY 2017 Appropriations Act specifies that TIGER Discretionary Grants may not be less than $5 million and not greater than $25 million, except that for projects located in rural areas the minimum TIGER Discretionary Grant size is $1 million. Additional information on the TIGER Program can be found at:

https://www.transportation.gov/tiger

Federal Highway Administration; Nature-Based Resilience for Coastal Highways

The Federal Highway Administration (FHWA) is producing research and technical assistance that will enable transportation agencies to use natural and nature-based features, also called natural infrastructure or green infrastructure, to improve the resilience of transportation systems. FHWA sponsored five pilot projects to assess the potential for nature-based techniques to protect specific locations along coastal roads and bridges. FHWA is also developing a white paper, regional peer exchanges, and an implementation guide.

During 2016, FHWA awarded five applied research projects (pilots) in the amounts ranging from $50,000 to $100,000 for each project. The funds did require a local match. The non-federal share must be at least 20 percent and 50 percent is preferred. In-kind contributions may count as match. Additional information on this program can be found at:

https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/green_infrastructure/

These five pilot projects were the result of a 2016 research funding opportunity to conduct assessments of green infrastructure solutions to improve the resilience of coastal highways and bridges to climate change impacts. Coastal green infrastructure includes dunes, wetlands, living shorelines, oyster reefs, beaches, and artificial reefs. These features may offer protection from waves, erosion, sea level rise, and storm surge.

This program may be a source of future funding for similar transportation projects that would require that the Town of Old Saybrook partner with the Connecticut Department of Transportation, RiverCOG, etc.

The funding recipient must be a state department of transportation, metropolitan planning organization, federally recognized tribal government, or Federal Lands Management Agency. However, partnerships with other organizations such as natural resource agencies, non-profit organizations, universities, etc. are encouraged. The scope includes US coastal areas (East Coast, West Coast, Gulf Coast, Great Lakes, Alaska, Hawaii, Puerto Rico, US Virgin Islands, and US territories in the Pacific Ocean). Eligible projects are those that analyze the feasibility of green infrastructure solutions to protect coastal roads. Eligible expenses include staff or contractor hours to conduct the analysis and document the results.

Municipal and Resilience Bonds

Standard Municipal Bonds can be utilized for resiliency projects. Catastrophe Bonds can also be obtained by the Town to insure against natural hazard loss. Resilience bonds modify the existing catastrophe bond insurance market to capture the savings from a lowered risk of insurance payouts and then use that value as rebates to invest in resilient infrastructure projects.

Taxes

Taxes are also a source for roadway improvements.

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Elm Street: This stretch of Elm Street is highly vulnerable to flooding due to: 1) low elevation roadway grades; 2) proximately to tidal water body; and 3) surcharging of stormwater outfalls, piping and catch basins. Flood inundations limits based on the effective FEMA FIRM are shown here. Flood protection is complicated by the presence of Research Parkway and roadway flood mitigation of the roadway will also require flood protection here to prevent parking lot flooding from entering onto the road.

View toward roadway underpass beneath Amtrack (above) and toward culvert over Oyster River (below)

FEMA Special Flood Hazard Areas around Elm Street

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Main Street/College Street (Route 154): This portion of Main Street and College Street flood during coastal storm events due: 1) to proximity of tidal waters to the north and south; and 2) low elevation street grades. Flood inundations limits based on the effective FEMA FIRM are shown here. Flood mitigation is complex due to number of cross streets and driveways.

An alternative may be to modify less extent of the roadway. The limits of the current 10-year recurrence interval flood is shown below.

FEMA Special Flood Hazard Areas around Main Street and College Street (above). The GZA-predicted food limits from the current 10-year recurrence interval flood are shown below.

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Sections of Route 1 Post Road: Route 1 Boston Post Road is a primary, key road as well as the access route to the Town's emergency shelter. Sections of this road will flood during coastal flood events with probabilities as frequent as 5 to 10-year return period. The limits of the FEMA special flood hazard areas and GZA's predicted 10-year recurrence interval flood are shown below.

FEMA Special Flood Hazard Areas around Main Street and College Street (above). The GZA-predicted food limits from the current 10-year recurrence interval flood are shown below.

CANDIDATES FOR NEAR-TERM ROADWAY IMPROVEMENT

Candidates for near-term roadway improvements:

Sections of Maple Avenue: The southern and northern portions of Maple Avenue flood during coastal flood events. Maple Avenue is a primary, key road as well as a likely evacuation route. Sections of this road will flood during coastal flood events with probabilities as frequent as the current 10-year return period flood. The limits of FEMA special flood hazard areas are shown below. Flood protection of the northern section of road could be integrated with flood protection of Main Street and College Street. Flood protection is complicated by the large number of cross roads and driveways.

FEMA Special Flood Hazard Areas around southern portion of Maple Avenue The GZA-predicted food limits from the current 10-year recurrence interval flood are also shown below.

FEMA Special Flood Hazard Areas around northern portion of Maple Avenue The GZA-predicted food limits from the current 10-year recurrence interval flood are also shown below.

Essential Facilities

Essential facilties are those facilities that are necessary for emergency response and recovery and pose a substantial, risk to the community at large in the event of failure, disruption of function, or damage by flooding. Essential facilities are classified as Flood Design Class 4 per ASCE/SEI 24-14. Flood Design Class 4 structures are evaluated for risk relative to the 100-year recurrence interval flood (plus a minimum freeboard) or the 500-year recurrence interval flood, whichever is higher. The Town's Essential Facilities include:

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

There are two police facilities including:

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

There are five fire and rescue facilities including:

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

The three healthcare facilities include:

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

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

Public Emergency Shelter:

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

Attachment 4 presented a detailed evaluation of the coastal flood risk of the Town's' Essential Facilities. **Table 7-5** presents the Essential Facilities risk profile.

	CURRENT	2041	2066	2116
LOCATION				
POLICE STATION AT 36 LYNDE STREET	Low	Moderate	Moderate	Moderate
FIRE DEPARTMENT AT 310 MAIN STREET	High	High	High	High
EMERGENCY MANAGEMENT AT 302 MAIN STREET (TOWN HALL)	High	High	High	High
AMBULANCE ASSOCIATION AT 316 MAIN STREET	High	High	High	High
EMERGENCY SHELTER AT 1111 BOSTON POST ROAD (OLD SAYBROOK SENIOR HIGH SCHOOL)	Low	Moderate	High	High

Table 7-5: Essential Facilities Risk Profile

ESSENTIAL FACILITIES FLOOD MITIGATION CONSIDERATIONS

A requirement of Essential Facilities is that, in addition to protecting their buildings and the operations within these buildings, they have to have ready access into and out of the facility. Fire stations and ambulance facilities also need to have large garage doors that can be opened without risk of floodwaters entering the building. Further, under low probability floods, the roadways in the vicinity of the Essential Facilities will also be flooded. To meet these needs, permanent or deployable measures that provide flood protection to both building and exterior vehicle areas appear to be a reasonable flood mitigation strategy.

ESSENTIAL FACILITIES RESILIENCE AND ADAPTATION STRATEGY

Resilience and adaptation strategies to achieve flood mitigation include:

- permanent flood mitigation measures such as perimeter flood walls and flood protection berms;
- modifications to the buildings such as dry floodproofing; and
- temporary, deployable measures

Perimeter flood walls and deployable measures do not meet Federal, State and local flood regulations and ordinances. These regulations apply to new construction, a condition of substantial damage and a condition of substantial improvement. Each of these conditions will require compliance with applicable flood regulations and ordinances. The Old Saybrook Ambulance Facility is located within the current FEMA AE zone, making it particularly vulnerable to flooding. Relocation of the Town's Ambulance services should be considered.

Commercial and Industrial Districts

Attachment 4 presented a detailed evaluation of the coastal flood risk of the Town's' Commercial and Industrial Districts. **Table 7-6** presents the districts risk profile. The most significant districts in terms of commercial and recreational use and flood vulnerability are Saybrook Point SP-1 through SP-3. **Figure 7-4** shows the districts relative to FEMA special flood hazard areas.

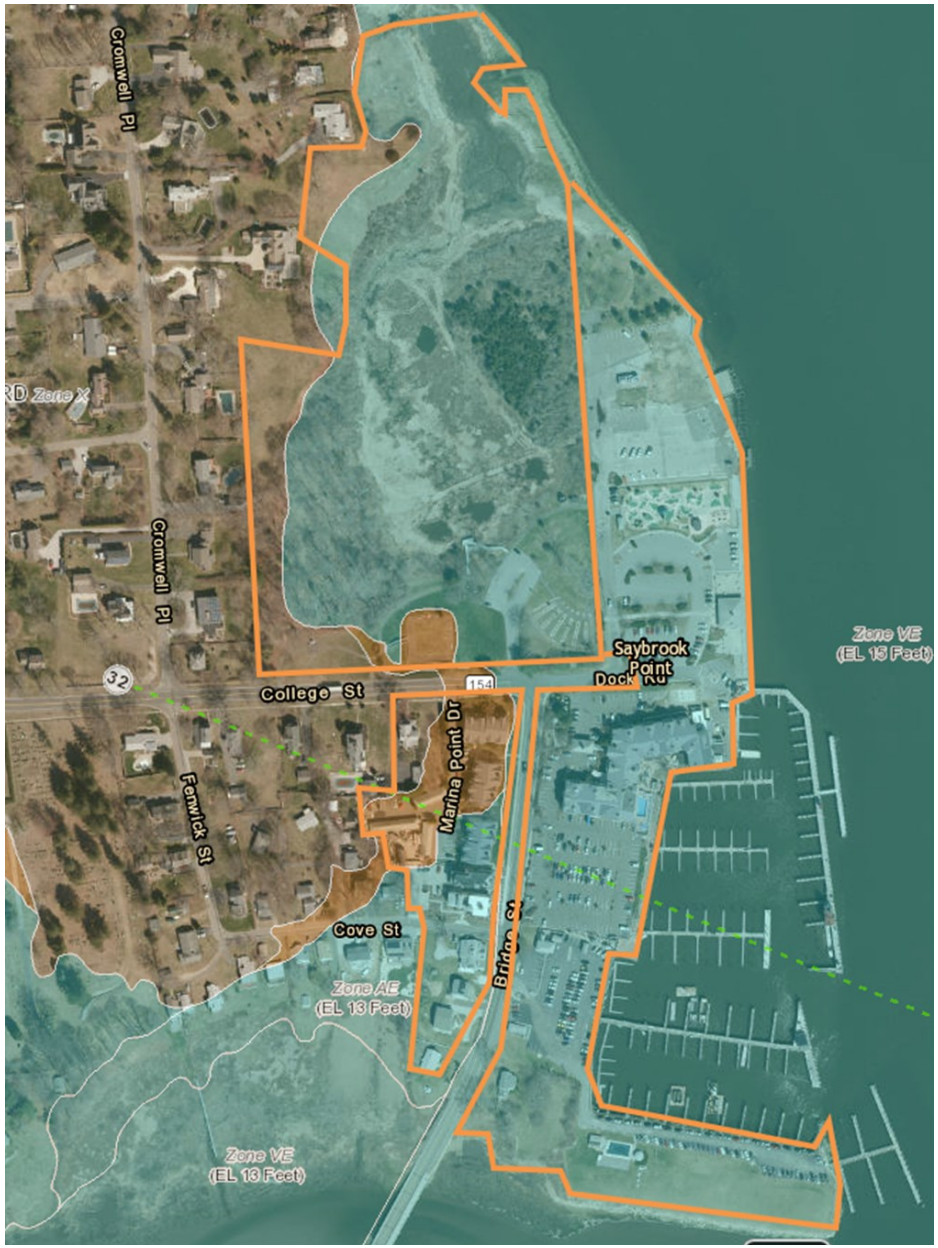


Figure 7-4: SP-1, SP-2 and SP-3 Commercial Districts at Saybrook Point

	Current	2041	2066	2116
LOCATION				
SAYBROOK POINT SP-1 THROUGH SP-3	High	High	High	High
CENTRAL BUSINESS B-1	Low	Moderate	Moderate	Moderate
SHOPPING CENTER B-2	High	High	High	High
RESTRICTED BUSINESS B-3	High	High	High	High
GATEWAY BUSINESS B-4	Low	Moderate	High	High
INDUSTRIAL I-1	Low	Moderate	High	High
MARINE COMMERCIAL DISTRICT	Low	Moderate	High	High

Table 7-6: Commercial and Industrial Districts Risk Profile

SAYBROOK POINT ADAPTATION STRATEGY

Saybrook Point floods from overtopping of the existing waterfront bulkeads. approximately 1,600 foot long section of stone bulkhead (north side) and sheetpile bulkhead (south side) fronting private and Town-owned property along the Connecticut River at Saybrook Point. Based on available Lidar, the top of the wall is about Elevation 5 feet NAVD88 and the toe of wall is about Elevation 0 feet NAVD88. The developed area inland of the bulkhead is low-lying, with ground surface elevations generally between 5 and 10 feet, which means that it floods frequently - it is vulnerable to flooding with a 2-year and greater recurrence interval. Based on the Town's assessors data, the waterfront parcels are privately-owned.

Given the high value of these waterfront parcels, and the likelihood that will be partially or completely re-developed, creation of an overlay zone for future commercial development within these districts (the Town currently zones for 6 overlay districts).

The overlay zone would achieve resilience and adaption during new development by:

- By specifying minimum grade and building levels based on a Design Flood Elevation that is compliant with flood regulations and ordinances but also considers sea level rise;
- Construction of a new combined bulkhead/seawall; and
- Perimeter flood protection around existing commercial structures to remain, noting that substantial improvement or new construction would require compliance with flood regulations and ordinances and the requirements of the overlay zone.

Historic Properties

There are three historic districts and 335 historic properties located within Old Saybrook. The Historic Districts include: 1) the North Cove Historic District; 2) the South Green Historic District; and 3) the Fenwick Historic District. The first two historic districts are included in this study. **Attachment 4** provides a detailed assessment of the flood vulnerability of these properties.

The NFP defines a "historic structure" as "any structure that is:

- Listed individually in the National Register of Historic Places (a listing maintained by the Department of Interior) or preliminarily determined by the Secretary of the Interior as meeting the requirements for individual listing on the National Register; (This includes structures that are determined to be eligible for listing by the Secretary of the Interior as a historic structure. A determination of "eligibility" is a decision by the Department of the Interior that a district, site, building, structure or object meets the National Register criteria for evaluation although the property is not formally listed in the National Register.).
- Certified or preliminarily determined by the Secretary of the Interior as contributing to the historical significance of a registered historic district or a district preliminarily determined by the Secretary to qualify as a registered historic district;
- Individually listed on a state inventory of historic places in states with historic preservation programs which have been approved by the Secretary of the Interior; or
- Individually listed on a local inventory of historic places in communities with historic preservation programs that have been certified either:
    i. By an approved state program as determined by the Secretary of the Interior or
    ii. Directly by the Secretary of the Interior in States without approved programs."

NFIP gives special consideration to the unique value of historic buildings, landmarks, and sites in two ways:

1. Historic structures do not have to meet the floodplain management requirements of the program as long as they maintain their historic structure designation. They do not have to meet the new construction, substantial improvement, or substantial damage requirements of the program. This exclusion from these requirements serves as an incentive for property owners to maintain the historic character of the designated structure (44 CFR §60.3). It may also serve as an incentive for an owner to obtain historic designation of a structure.
2. A designated historic structure can obtain the benefit of subsidized flood insurance through the NFIP even if it has been substantially improved or substantially damaged so long as the building maintains its historic designation. The amount of insurance premium charged the historic structure may be considerably less than what the NFIP would charge a new non-elevated structure built at the same level. Congress requires that the NFIP charge actuarial rates for all new construction and substantially improved structures (National Flood Insurance Act of 1968, 42U.S.C. 4015).

RESILIENCE AND ADAPTATION STRATEGY FOR HISTORIC PROPERTIES

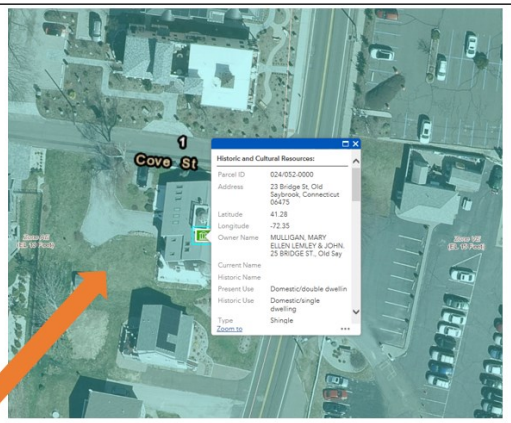
The challenges of providing flood mitigation for historic structures are that they ownership is a mix of public and private properties, they are located in low-lying areas that are highly vulnerable to flooding and most typical flood modifications would negatively affect the historical character of the structures and neighborhood aesthetics.

Given the exemption of these structures from State and federal flood regulations, there are more options available for flood mitigation of these structures than would normally be allowed under federal and State flood regulations. A reasonable strategy would be to provide flood protection at the property scale using:

- Perimeter landscaped flood walls; or
- Temporary, deployable flood protection measures.

For the former, the Town should establish standards and guidance for flood protection walls that are consistent with zoning and the aesthetic and historical character of the districts and modify the zoning regulations accordingly. The responsibility for the flood mitigation installation and cost would be the property owner.

Example



Risk Profile:

- Flood vulnerability: 20-year recurrence interval flood (10-yr between 2020 and 2040
- Coastal AE Zone Elevation 13 feet NAVD88
- Ground Surface: Elevation +/- 7 feet NAVD88
- 100 yr recurrence interval wave height: 1.5 feet

Natural Resources (Beaches)

Attachment 3 presents a detailed evaluation of shoreline change, including beach erosion. Old Saybrook beaches generally include: 1) barrier spits, separating the marsh from Long Island Sound, from Chalker Beach to just north of Cornfield Point; and 2) pocket beaches between shoreline structures and natural promontories, from Cornfield Point to Old Saybrook Point. Both types of shoreline identified general face south-southwest and are exposed to long fetches and Long Island Sound waves.

The morphology of the shoreline extending from Chalker Beach (including Chalker Beach) to just north of Cornfield Point consists predominantly of barrier spits (beaches) and marsh. The barrier spits are separated by river and creek inlet channels, creating large areas of shallow sediment and tidal flat in the vicinity of these features. Certain portions of this stretch of shoreline also include artificial fill placed within former marsh. Barrier spit and marsh morphologies are, by nature, very dynamic. Absent man-made structures, the natural morphological change consists of: 1) migration of the barriers spits inland over the marsh; 2) dynamic movement of the river and creek inlets; and 3) dynamic movement of shallow sediment areas/tidal flats.

This type of shoreline is generally characterized by erosion and dynamic movement of sediment. Sea level rise will accelerate the natural landward movement of the barrier spits. The shoreline, however, has been heavily modified by: 1) construction of hard shoreline structures, in particular groins designed to interrupt longshore transport; 2) development with roads and houses; and 3) placement of artificial fill. Although these structures affect the natural coastal processes, they do not, on net, prevent the natural tendency of the shoreline toward dynamic movement change and often increase erosion. The groins have been successful in trapping sand locally, but overall they drastically impact the natural longshore sediment transport. In addition, the overall availability of sediment is diminished within Long Island Sound.

The net, long term effect for the Old Saybrook shoreline including Chalker Beach to just north of Cornfield Point is long term, moderate (1 to 2 feet per year) erosion of the beaches with highly impactful, episodic erosion associated with coastal storm flooding and wave action. Sea level rise will amplify and accelerate shoreline change. Inadequate sediment supply to replace alongshore and offshore transport will require beach nourishment to mitigate erosion.

The morphology of the shoreline extending from Cornfield Point to Old Saybrook Point consists of glacial moraine and drift bluffs. Major sections of shoreline are fortified with revetments. The average shoreline change rates indicate minor to moderate erosion and accretion (less than 0.5 foot per year to 1.5 feet per year).

Under a natural setting, the glacial drift deposits provide a source of beach sediment. Under a developed setting, such as the Old Saybrook shoreline, revetments and seawalls: 1) eliminate this sediment source; and 2) create wave reflection and erosion, such that the shoreline erodes to the base of the revetment or sea wall.

The beaches of Old Saybrook provide recreational and ecological value, shoreline protection and (to a lesser extent) flood mitigation. However, the effect of sea level rise will be to accelerate shoreline erosion, in particular within areas characterized by barrier spit beach and marsh morphology. These areas are highly dynamic. They are also, typically low-lying and highly vulnerable to flood inundation and high velocity wave effects. The presence of groins and other shoreline structures have localized benefit but, negatively impact the overall shoreline system.

BEACH ADAPTATION STRATEGY

For shoreline areas experiencing moderate to severe erosion, there are limited options to mitigate long term erosion. These include:

- Do nothing, which will ultimately require retreat;
- Managed, voluntary retreat from the beaches;
- Periodic beach nourishment;
- Beach nourishment with vegetated dune construction; and
- Living Shorelines.

In general, Connecticut Statute promotes (and effectively now requires) non-structural, natural and nature-based projects except where structural alternatives are necessary to protect existing inhabited structures, infrastructure and water dependent uses.

Feasible, less environmentally damaging alternatives to structures are considered to include:

- Moving houses landward from floodwaters and wave action;
- Elevating houses vertically;
- Restoring or creating a dune or vegetated slope between the house and the water to absorb storm waves and protect against erosion; and
- Create a Living Shoreline.

Reasonable mitigation measures and techniques are considered to include: 1) beach nourishment to replace sand supply that may be adversely affected by a seawall or groin; and 2) compensation for hardening one part of a shoreline by removing the equivalent extent of flood and erosion control structures from another part of shoreline.

There are localized opportunities for development of Living Shorelines (including new fringe marsh, vegetated bluffs); however, these opportunities are limited. Due to the shoreline exposure to wind and long fetches, additional wave attenuation (robust rock sills, submerged breakwaters or offshore breakwaters) would be required along with mudline elevation enhancement. Living Shorelines will also modify the recreational use of the beach as well as result in habitat change

Beach Nourishment

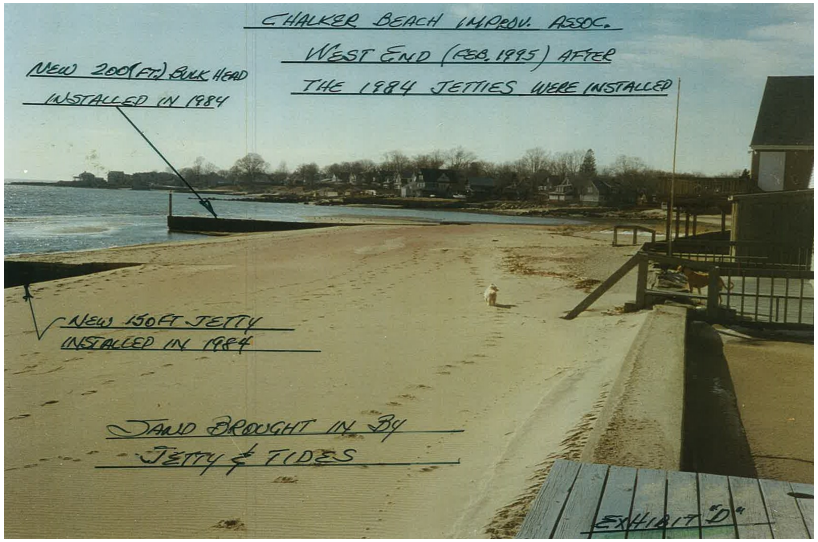
Connecticut does not have an established beach fill program. The U.S. Army Corps of Engineers (USACE) replenishes beaches on a case-by-case basis, mostly with trucked upland sources. Local maintenance dredging projects are also a potential source of sand. While beach nourishment is primarily an activity of the USACE, the State does provide some matching funds including the total cost of flood and erosion control projects benefiting state property, 66% of the cost of projects benefiting municipal property and 33% of the cost of projects benefitting private properties. The State funding for the Flood and Erosion Control program is limited (about $1.5M annually) and not much has gone to beach nourishment). State bonding may also be available for flood and erosion control projects (e.g., the State bonded a $2M beach erosion study and restoration project at Hammonasset Beach State Park using navigation dredge materials from the Housatonic River. The USACE Connecticut Report (current as of September 30, 2017) is attached. Beach nourishment can also be performed in conjunction with local maintenance dredging projects.

Beach Nourishment with Dune Construction

The shoreline extending from Chalker Beach (including Chalker Beach) to just north of Cornfield Point is little over 2 miles in length. Effectively, none of this shoreline has dunes and beach berms are limited. Beach nourishment and dune creation would typically cost on the order of $600 to $700 per linear foot. The cost to replenish the entire shoreline would be on the order of +/-$7.5M to $8.5M; however, beach nourishment projects would be localized and segmented to conform to existing shoreline structures (e.g., the Chalker Beach shoreline). Beach nourishment and dune restoration would be required periodically, since natural sources of sand (littoral drift) to support stable beaches are limited and interrupted by the numerous groins. Sea level rise will increase the rate of erosion and, therefore the demand for beach nourishment. Areas experiencing moderate to severe erosion (e.g., Plum Bank) will likely require periodic beach nourishment. A more detailed shoreline analysis would be required to further define beach nourishment requirements, but replenishment of the order of an average of every 10 years (along with groin maintenance) is not unreasonable for preliminary planning purposes.

Maintenance of Existing Groins, Jetties and Breakwaters

Maintenance of existing groins will help preserve existing beaches. Construction of new groins will not be allowed.



Chalker Beach 1980s Groin Maintenance Program

Example of engineered dune at Indiantown

Land Acquisition

Overview

Managed Retreat is a strategy outlined in the Town's 2015 SLRCAC Report as a potential solution that should be considered by the Town to develop both a near-term and long term climate adaptation strategies**. Attachment 4** identifies several areas with properties that are highly vulnerable to coastal flooding today and will become increasingly more vulnerable to coastal hazards in the future due to sea level rise.

This Study does not identify nor recommend specific areas within the Town for implementation of a Retreat strategy. Building upon the study findings, this section does identify four (4) categories for consideration as opportunities for managed retreat and future land acquisition by the Town. These include:

- Coastal properties located in the VE Zone
- Properties located in areas at risk to future marsh advancement
- Properties located in areas suitable for future levees as flood protection

Property located outside flood hazard zones to accommodate future development and relocation

Coastal Properties Located with the FEMA VE Zone

Based on the Resilience Study risk and vulnerability results, the properties at highest risk to future sea level rise are coastal properties located within the FEMA Coastal High Hazard Zone (Zone VE). The limits of the Coastal VE High Velocity Wave Zone are shown on **Figure 7-5**. The ground surface elevations in the study area ranges from 3 feet NAVD88 to 10 feet NAVD88. The base flood elevations for the VE Zone ranges from 15 feet NAVD88 to 18 feet NAVD88. These properties are exposed to significant flood and waves, resulting in a high probability for damage. They are also located in areas characterized as barrier spit beaches, which are naturally dynamic and subject to erosion. The flood risk of these areas will increase significantly in the future due to sea level rise and it will become increasingly difficult and expensive for property owners to adapt. Property values within these areas may also decrease due to the coastal erosion and flood risk.

The delineated are shown on **Figure 7-5** includes 176 parcels of land located within the VE Zone starting on Route 154 at the bend where Indianola Drive turns into Plum Bank Road, and extending north and west along the coast through Saybrook Manor, Indiantown, and to the Town line in Chalker Beach. Of the 176 parcels, 159 of the parcels include structures with an assessed tax value based on the Tax Assessor's data provided for this study. Single family residential properties make up most of building structures totaling 138 followed by 10 condominiums (all of which located on Shetucket Trail). The remaining 28 properties are a mix of open land without structures (e.g. salt meadow, rear land), two-family, land with outbuildings, land with multiple houses, and non-profit and municipal properties.

Table 7-7 provides a tax analysis of the 176 parcels included in the study area based on data provided by the Town of Old Saybrook. The total assessed tax valuation for the 176 properties is $115,460,200. Based on the Town of Old Saybrook's mill rate of 19.66 - which results in a payment of $19.66 for each $1,000 of taxable property's assessed value - the total estimated annual tax revenue for the Town is $2,269,967. The assessed land value for the 176 parcels - not including the assessed structures valuation - accounts for 67% of the overall assessed value at just over $1.5 million.

The beaches along the shoreline are vulnerable to coastal erosion in the near term that will become increasingly vulnerable to more intensive coastal erosion over the long term. These vulnerabilities will be further compounded by sea level rise that will result in the need for a continuous and ongoing beach nourishment program over the long term as an alternative to a managed retreat. Such a program will increase in cost and the frequency of need for beach nourishment over time that will not be sustainable or feasible over the long term. Below is a breakdown of the location and number of coastal properties by beach community based on the Water Pollution Control Authority (WPCA) district boundaries.

- Plum Bank – 56 properties
- Chalker Beach – 48 properties
- Great Hammock Beach – 26 properties
- Saybrook Manor – 17 properties
- Indiantown – 15 properties

Plum Bank, Chalker Beach and Great Hammock Beach have the highest three number of properties located in the Zone VE.

Figure 7-5: Limits of FEMA Coastal High Velocity (VE) Wave Hazard Zone

Table 7-7: Tax Assessment Properties located in VE Zones (Figure 7-5)

Estimated total assessed value	$115,461,200
Town Mill Rate	$19.66*
Estimated Tax Revenue from delineated area	$2,269,967
Town-wide Property Tax Revenue (2015)	$40,543,368
Percent of Tax Revenue for delineated area	5.6%

*The Town of Old Saybrook's current mill rate is 19.66 which results in the payment of $19.66 for each $1,000 of a taxable property's assessed value. For example, if a house is assessed at $300,000 to determine what the taxes would be take $300,000 and multiply the figure by .01966 and the taxes come out to be $5,898 for the year.

Properties Located in Areas at Risk to Future Marsh Advancement

Several properties in Old Saybrook are located along or near intertidal marshlands. Many of these properties are located within FEMA's Zone AE (i.e. areas with a 1% annual chance of flooding where base flood elevations are provided). While these properties are not as vulnerable as those located in the Zone VE, these properties still have a 26% chance of flooding during the life of 30-year mortgage making these properties the next most vulnerable areas to future coastal flooding. The Nature Conservancy's 2014 study entitled, "A Salt Marsh Advancement Zone Assessment of Old Saybrook, Connecticut" (2014 TNC Study) projects the full extent of marsh advancement by the 2080s to be 1,042 acres, of which 217 acres (21% of the total) are occupied by built structures and associated infrastructure. Based on an evaluation of the results from the Resilience Study's risk and vulnerability assessment results and the 2014 TNC Study, the built structures are expected to provide fewer opportunities for managed retreat than those properties located in the Zone VE outlined above. For additional details of the areas identified for marsh advancement refer to the 2014 TNC Study.

Properties Located in Areas Suitable for Future Levees as Flood Protection

In the future the Town may consider evaluating a levee system as a potential form of flood protection. To construct a FEMA certified levee would likely require the acquisition of some parcels of land in Town that have not been identified as a part of this study. However, for this analysis it is important to note that it is likely that some properties may need to be acquired or easements would need to be put in place to support the development of a levee. The number of properties is expected to be minimal. Identifying the locations and number of properties that may need to be acquired would require an additional feasibility study. The number and locations of properties would largely be dependent on the potential locations where a levee system could be feasibly built. It is recommended that such a study include a benefit-cost analysis for multiple alternative locations to determine whether the cost of the proposed system(s) would result in providing enough flood protection to justify the cost of construction and maintenance.

Land Outside of Flood Zones to Support Future Development

Areas north of I-95 provide land located at higher ground surface elevations that are typically over 20 feet NAVD88, and thus less vulnerable to future coastal flooding hazards. In the long-term, especially if the Town is successful in developing program that results in the acquisition and demolition of numerous properties, it is recommended that the Town identify areas north of I-95 for future development due to the potential decrease in tax revenues. This will assist the Town in maintaining the local tax base and making Old Saybrook a more resilient community.

Conclusions

One of the suitable adaption options supporting a voluntary Managed Retreat strategy for the Town outlined in the Resilience Study is voluntary acquisition and demolition of threatened properties. The voluntary acquisition and/or relocation of these structures will provide the opportunity for enhancement of these beach communities including shoreline habitat and greater public access. Voluntary relocation or voluntary acquisition/demolition of structures located within the Zone VE of the study area is appropriate along the currently-developed portions of the shoreline in the study area. Based on the analysis outlined in this section, it is recommended that the Town 1) continue to conduct resiliency outreach and education to homeowners living in the beach communities based on the neighborhood resiliency workshops conducted for the Resilience Corridor and Chalker, 2) identify specific properties for voluntary acquisition and demolition or relocation through the workshop process and begin to develop FEMA Hazard Mitigation Assistance (HMA) grant applications to assist in the acquisition of properties at greatest risk to the future impacts from coastal flood hazards. Both recommendations are outlined in greater detail below.

Recommendations

1. Resiliency Workshops in the Low Beach Communities

The three beach communities (Plum Bank, Chalker Beach and Great Hammock Beach) with the highest number of coastal properties located in the Zone VE are excellent candidates for conducting future resilience workshops focused on: 1) the current and future coastal flood risks with respect to specific neighborhoods; 2) the general resiliency measures that may be included as a part of a voluntary Managed Retreat strategy including voluntary acquisition and demolition of threatened coastal properties; and 3) the resiliency financial programs (e.g. FEMA HMA grant programs) available to residents and the Town to pursue for acquisition projects. The Town has already begun the process by conducting workshops and developing resiliency measures - as recommend above - for Chalker Beach and a portion of Route 154 that connects Town Center to Saybrook Point (Resilience Corridor). The workshop materials used during these workshops will serve as a template for additional workshops in other vulnerable areas of Town along the shoreline in the future.

2. Identify Specific Properties for Voluntary Acquisition and Demolition and FEMA HMA Grant Application Development

Properties located within the Zone VE will typically increase the competitiveness of such properties for one of FEMA's Hazard Mitigation Assistance (HMA) programs due to the increased risk of coastal flooding making such properties more likely to meet HMA program eligibility requirements. Therefore, properties located in the Zone V or VE should serve as the priority for the Town in the near-term to consider for voluntary acquisition and demolition and location. It will be critical for the Town to coordinate the development of FEMA HMA grant applications with the State Hazard Mitigation Officer (SHMO) at state of Connecticut's Department of Emergency Services and Public Protection. Additional details on FEMA's HMA Grant programs can be found at:

http://www.ct.gov/demhs/cwp/view.asp?a=4062&q=515030

Note that even though coastal properties located in the Zone VE serve as potential candidates for HMA grant funding, that does not guarantee that each of properties will meet FEMA's Hazard Mitigation Assistance (HMA) eligibility requirements independently. This is especially relevant with respect to FEMA's Benefit-Cost Analysis (BCA) requirement. It is recommended that if one (1) property does not meet FEMA's BCA requirement independently, that the Town consider including other properties (or just one more) that when combined as one project result in an overall BCA that is eligible.