City of West Haven
Coastal Resilience Plan

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Image: Kenneth Casper

Prepared for

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This plan was prepared within the scope of a West Haven Coastal Resiliency Plan and WPCP Outfall Line Study project, funded under a Community Development Block Grant Disaster Recovery (CDBG-DR) grant awarded to the City of West Haven, Connecticut, for coastal resilience planning.

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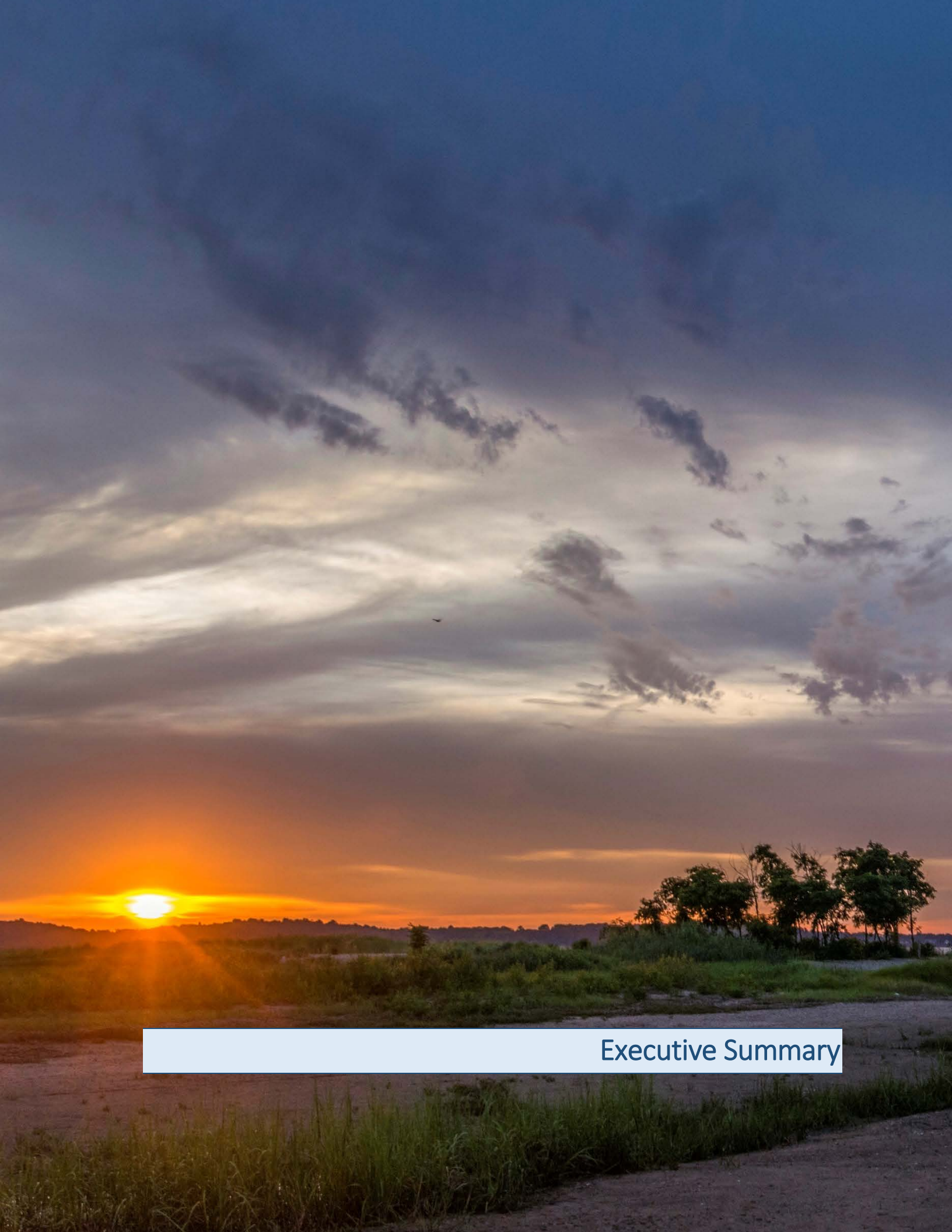
Acronyms

ADCIRC	-	Advanced Circulation Model
CDBG	-	Community Development Block Grant
CDBG-DR	-	Community Development Block Grant - Disaster Recovery
CHAMP	-	Coastal Hazard Analysis Modeling Program
CT DEEP	-	Connecticut Department of Energy and Environmental Protection
FEMA	-	Federal Emergency Management Agency
FIS	-	Flood Insurance Study
HUD	-	United States Department of Housing and Urban Development
IPCC	-	Intergovernmental Panel on Climate Change
LiMWA	-	Limit of Moderate Wave Action
LMI	-	Low-Moderate Income
MHHW	-	Mean Higher High Water
MSL	-	Mean Sea Level
NACCS	-	North Atlantic Coast Comprehensive Study
NAVD88	-	North American Vertical Datum of 1988
NFIP	-	National Flood Insurance Program
NOAA	-	National Oceanic and Atmospheric Administration
POCD	-	Plan of Conservation and Development
SCRCOG	-	South-Central Regional Council of Governments
SFHA	-	Special Flood Hazard Area
SWE	-	Stillwater Elevation
TNC	-	The Nature Conservancy
USACE	-	United States Army Corps of Engineers
WPCP	-	Water Pollution Control Plant



Executive Summary

Setting

West Haven had over 55,500 residents at the 2010 census, living within 10.8 square miles of land. The city has 3.5 miles of publicly accessible beaches.

Recent events such as Hurricane Sandy[1], increasingly frequent nuisance flooding, and changes to the National Flood Insurance Program (NFIP) have underscored the risks associated with occupying coastal areas and highlighted the fact that property owners and municipalities bear a heavy financial burden to recover from these types of events.

This Coastal Resilience Plan (CRP) has been developed as a toolbox to build resilience in the coming years. It presents a menu of citywide and location-specific options that are available to adapt to changing conditions and prepare for the future events.

Funding

Preparation of this CRP was funded through the United States Department of Housing and Urban Development's (HUD) Community Development Block Grant Disaster Recovery Program (CDBG-DR). The money was allocated to HUD through the 2013 Disaster Relief Appropriations Act, which designated aid for communities affected by Hurricane Sandy.

This program is intended to highlight underserved low-to-moderate income (LMI) populations and communities for additional consideration. LMI neighborhoods in West Haven that fall within coastal hazard areas include those bounded by:

- Forest Rd, Boston Post Rd, the northern West Haven border and the West River
- Boston Post Rd, Campbell Ave, Route 95 and West River
- Route 95, 1st Ave, Main St, and the mouth of the West River
- Blohm St, 2nd Ave, Beach St, Peck Ave
- Blohm St, Campbell Ave, Palace St, and Savin Ave

Additionally, much of downtown West Haven, including areas bounded by Blohm St, Campbell Ave, Peck Ave, and Brown St, as well as areas north of Brown St, are LMI. Portions of these areas fall within flood hazard areas surrounding both the Cove River and Old Field Creek.

Planning Process

The goal of this program is to address the current and future social, economic, and ecological resilience of the city's shoreline to the impacts of sea level rise, and anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion.

The planning process was based on the coastal resilience planning process established by The Nature Conservancy (TNC).

Many regulations, plans, projects, and programs are maintained by West Haven to advance coastal resilience. This plan acknowledges the contribution these resources make to the city's resilience capabilities, and is designed to work *with* these existing documents and actions. Examples include the SCRCOG Multi-Jurisdiction Hazard Mitigation Plan and The Harbor Management Plan.

[1] Often called "Superstorm Sandy," the official title of the event according to the U.S. Department of Housing and Urban Development is "Hurricane Sandy."

The four steps of the process are:

1. **Assess Risk and Vulnerability**
2. **Identify Solutions**
3. **Take Action**
4. **Measure Effectiveness**

The process included a vulnerability and risk assessment, review and selection of adaptation and resilience options, and public involvement in the form of three public meetings and an internet survey.

Risk and Resilience Concepts

In the context of hazards, **risk** is the product of **vulnerability** and **frequency**. This means that the frequency with which a particular event occurs, combined with the number of assets vulnerable to the effects of that event, determines the risk posed by that event.

In the context of **coastal** hazards, risk depends on:

- The **vulnerability** of coastal communities and infrastructure
- The **frequency** of flooding and storm events

Coastal storms are believed to be increasing in frequency[2], and flooding will increase in frequency as sea level continues to rise[3]. **Thus, even if coastal vulnerabilities remain static, risks will increase.** If vulnerabilities increase, due to development in hazard areas or failure to maintain protective structures, risks will increase more dramatically. Alternatively, if vulnerabilities are **reduced** through adaptation, risk can be held steady into the future. If vulnerabilities can be reduced even further, then risks can be lowered in the face of a changing climate, leading to **increased resilience**.

Resilience is the ability to resist, absorb, recover from, and adapt to disasters. **Coastal Resilience** refers specifically to coastal hazards such as sea level rise, erosion, and coastal storms.

Planning Neighborhoods

For the purposes of this plan, the coastal neighborhoods of West Haven are broken into the following:

- **Oyster River** – the western border of West Haven, on the eastern bank of the Oyster River
- **Oyster River Point** – extends eastward from the mouth of the Oyster River until Oyster River Point
- **Ocean Avenue South –** southern end of Ocean Avenue before, also known as Rocky Beach
- **Ocean Avenue Beaches –** the coastline from South Street to Cove River with wide sandy beaches
- **Cove River** – a tidal wetland that extends far inland.
- **Captain Thomas Boulevard –** from that road to the Sound, between Kelsey Ave and Washington St
- **Campbell Avenue** –north of Captain Thomas Boulevard, including three LMI neighborhoods
- **Sandy Point –** the sandy coastline from Washington Ave eastward, including Sandy Point

[2] According to the National Oceanic and Atmospheric Administration, NASA, The Intergovernmental Panel on Climate Change, and the Union for Concerned Scientists, climate change will likely lead to increased intensity of storms, including tropical cyclones (such as hurricanes). For example, see <http://www.gfdl.noaa.gov/global-warming-and-hurricanes>.

[3] A tide gauge is operated by the National Oceanic and Atmospheric Administration at the Port of New Haven. Examination of tidal data collected at this gauge from August 1999 through June 2016 show that mean sea level has been increasing at a rate of 0.24 inches (or 6.19 millimeters) per year.

- **Old Field Creek** – the area surrounding Old Field Creek
- **City Center** – east of Campbell Avenue, north of Brown Street and south of Interstate 95
- **Spring Street** – east of Campbell Avenue, between Interstate 95 and Route 1
- **Allingtown** – north of Boston Post Road, south of Saint Lawrence Cemetery, and east of Forest Road
- **Cemetery and Yale Bowl** – the Saint Lawrence Cemetery and Yale University sport fields

Vulnerability and Risk Assessment

Generally, coastal **hazards** can include:

- **Stillwater Inundation**
- **Wave Setup and Runup**
- **Wave Action**
- **Erosion**
- **Insufficient Drainage**
- **Wind**
- **Debris**

West Haven already has experience with coastal hazards. Beaches have had to be nourished to combat erosion, buildings have taken damage from storms, and low-lying roads experience nuisance flooding during rain events and very high tides. Rising waters and increasing storm severity and frequency will exacerbate existing problems and create new problems in other parts of the city.

Coastal **vulnerabilities** can fall under a variety of categories, as follows:

- **Social** – residents, business community, visitors
- **Economic** – property, businesses, municipal resources, tourism, future development
- **Infrastructure** – roads, railroads, drainage, seawalls, tide gates, marinas, municipal facilities
- **Utilities** – water supplies, septic systems, telecommunication, electricity
- **Emergency Services** – Fire, police, medical, sheltering, evacuation, egress
- **Natural Systems** – tidal wetlands, beaches and dunes, other coastal landforms

The following table lists types of assets that exist on the West Haven shoreline, and the hazards that threaten them:

Vulnerable Assets and Hazards that Threaten Them

	Asset	Hazards
Economic	Residential Property	Flood Damage to Structure & Contents Wave Action Damage to Structure Erosion of Foundations Wind Damage Debris
	Businesses	Flood Damage to Structure & Contents Wave Action Damage to Structure Erosion of Foundations Wind & Debris Damage
	Tourism	Damage to Restaurants and Stores Damage to Natural Resources Erosion of Beaches
Infrastructure	Roads & Bridges	Inundation of Low Roads Clogging of Bridge Underpasses Undermining by Coastal Erosion
	Railroads	Inundation of Low Sections
	Drainage	Insufficient Capacity Outfalls Below High Sea Levels Surcharging during Surge Events
	Tide Gates	Overtopping Failure (Clogging)
	Shore Protection	Overtopping Undercutting
Utilities	Water Supply	Pipe Corrosion from Saltwater Wave Damage to Water Mains
	Wastewater	Flood or Wave Damage to WPCP Flood Damage to Pumping Stations Wave Damage to Outfall Pipe Wave Damage to Sewer Pipes
	Gas, Electric, Communication	Wind Damage to Grid Flood Impacts on Response Flood Damage to Buried Infrastructure
Emergency	Emergency Facilities	Flood & Wind Damage to Facilities Flood& Wind Damage to Equipment
	Access & Evacuation	Isolation by Flooding of Road Isolation by Wave Damage to Roads
Cultural	Natural Resources	Damage from Waves and Wind Drowning by Rising Seas Secondary Impacts of Protective Measures
	Historic Resources	Direct Impacts, as Listed for other Properties Secondary Impacts during Response & Recovery

Risks and vulnerabilities in the city of West Haven were determined through review of city planning documents, discussion with city representatives, collection of public input at meetings and through an online survey, and utilization of current and future hazard zone mapping tools.

The table below lists vulnerable neighborhoods and the level of risk facing different assets within them:

Summary of Vulnerabilities and Risks by Neighborhood

Neighborhood	Structures	Roads	Other Assets
Oyster River	**Low Risk**	**Moderate Risk**	**Low Risk** Senior Living Center, Habitat
Oyster River Point	**Low Risk**	**Low Risk**	**Moderate Risk** Floodway, Pump Station
Ocean Ave South	**Minimal Risk**	**Minimal Risk**	**Moderate Risk** Erosion, Sewer Line
Ocean Ave Beaches	**Low Risk**	**Low Risk**	**Moderate Risk** Fire Station, Pump Station, Erosion
Cove River	**Low Risk**	**Moderate Risk**	**Moderate Risk** Habitat, Pump Station, School
Captain Thomas Blvd	**High Risk**	**High Risk**	**Low Risk** Drainage, Isolation
Campbell Avenue	**High Risk**	**High Risk**	**Moderate Risk** Drainage, Critical Facilities
Sandy Point	**Minimal Risk**	**High Risk**	**High Risk** WPCP, Erosion, Habitat
Old Field Creek	**High Risk**	**High Risk**	**High Risk** Habitat, Pump Station
City Center	**Low Risk**	**Moderate Risk**	**Low Risk** Erosion, Marina
Spring Street	**Moderate Risk**	**High Risk**	**High Risk** Industrial Sites, Radio Tower
Allingtown	**Minimal Risk**	**Low Risk**	**Moderate Risk** Drainage, Tide Gate
Cemetery & Yale Bowl	**Minimal Risk**	**Minimal Risk**	**Low Risk** Cemetery

Among the greatest threats to West Haven's shoreline are:

- Inundation and erosion of beaches
- Erosion of properties at the eastern and western ends of the City
- Inundation of roads connecting West Haven to Milford and New Haven
- Flooding of tidal wetlands and surrounding properties

Adaptation

The Intergovernmental Panel on Climate Change (IPCC) published the landmark paper "Strategies for Adaptation to Sea Level Rise" in 1990. Three basic types of adaptation were presented in the report:

- *Retreat*: abandonment of the coastal zone
- *Accommodation*: use of at-risk land continues, but prevention of flooding is not pursued
- *Protection*: at-risk land is protected from coastal hazards

In 2010, the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean and Coastal Resource Management published *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. The manual lists seven categories of adaptation:

- Impact Identification and Assessment
- Awareness and Assistance
- Growth and Development Management
- Loss Reduction
- Shoreline Management
- Coastal Ecosystem Management
- Water Resource Management and Protection

Elements of *protection, retreat*, and *accommodation* are found in several of these categories and subcategories of adaptation.

Planning measures include emergency preparation and response, redirection of development, and procedural and financial modifications. **Structural** measures include construction of permanent or temporary flood barriers, floodproofing, and elevation of buildings. Any measures taken should be robust enough to provide adequate protection, and flexible enough to allow for adjustment under changing conditions. This typically requires a combinations of methods rather than a single solution.

Site-specific measures pertain to floodproofing specific structures on a case-by-case basis. Neighborhood-scale measures apply to a specific group of buildings that are adjacent to each other. Large-scale structures might include large dike and levee systems or tide gates that can prevent tidal surge from moving upstream.

To develop a suite of viable options for the city's consideration, coastal resilience projects undertaken by other communities were reviewed, local physical and political factors were considered, and options were discussed with West Haven municipal officials and residents.

The suite of options most applicable to the City of West Haven is summarized in the following table:

Categories of Options	Specific Options
Shoreline Protection	Seawalls & Bulkheads, Groins, Floodwalls & Levees
	Beach & Dune Management
	Bioengineered Banks & Artificial Reefs
	Tide Gate Improvement & Tidal Wetland Management
Infrastructure Improvements, Retrofits, and Hardening	Inland Runoff Management & Surcharge Prevention
	Road Elevation & Alternate Route Construction
	Sewer Pumping Station Retrofit & Water Pollution Control Facility Upgrades
Structure Protection	Elevation, Floodproofing, Floodwalls or Barriers
	Adaptive Re-use (Floodable Lower Floors)
	Property Acquisitions
Regulatory Tools	Flood Damage Prevention Ordinance Modifications
	Zoning Regulations Modifications:
	Rolling Easements
	Road Retirement
	Improve Departmental Collaboration & Flood Plain Coordinator Role
	Improve Ordinance Enforcement & Inspection
	Join FEMA Community Rating System Program

The following table summarizes where different adaptation options are most applicable:

Neighborhoods	Shore Protection						Infrastructure					Structures				Regulatory			
	Hard Protection	Beach & Dune Management	Tide Gate Improvement	Tidal Wetland Creation	Artificial Reefs	Bioengineered Banks	Inland Runoff Management	Surcharge Prevention	Road Elevation	Alternate Route Development	Pumping Station Retrofit	Structure Elevation	Structure Floodproofing	Floodwalls or Barriers	Adaptive Re-use	Zoning Changes	Rolling Easements	Road Retirement	Property Acquisition
Oyster River	X		X				X		X	X	X	X				X	X		X
Oyster River Point	X					X			X		X					X	X		
Ocean Avenue South	X					X													
Ocean Avenue Beaches		X					X	X	X		X	X	X						
Cove River			X				X		X		X	X	X	X		X	X		X
Captain Thomas Blvd		X						X	X			X	X	X	X	X			
Campbell Avenue							X	X	X	X		X	X	X	X	X			
Sandy Point		X						X	X			X	X		X		X	X	
Old Field Creek				X			X		X		X	X		X		X	X	X	X
City Center	X				X	X											X		
Spring Street	X			X			X		X	X	X	X	X				X		X
Allingtown							X		X									X	
Cemetery & Yale Bowl									X										

Key aspects of West Haven's resilience efforts moving forward will include:

- Beach and dune replenishment and nourishment through sediment placement and control efforts
- Tidal marsh protection through tide gate upgrades, zoning regulations, and ordinance enforcement
- Hybrid shoreline protection, including bioengineered banks
- Facilitation of retrofits to individual structures
- Large-scale resilience projects designed to protect entire neighborhoods
- Flood protection measures for larger residential and commercial structures and complexes

West Haven is also encouraged to enact regulatory and procedural changes, including:

- Broaden the definition of "Substantial Improvement" in City floodplain regulations
- Altering zoning regulations to encourage resilient construction methods
- Development of evacuation and access plans in areas where flooding cannot be entirely prevented

Concept Designs

This plan presents three conceptual plans for infrastructure improvement projects designed to build resilience. These are:

1. Beach and dune nourishment from Altschuler Beach to Morse Park
2. Tide gate upgrade on the Cove River
3. Seawall repair at Oyster River Point

Details of these concept designs are included in the appendices of the Plan.

Implementation

The Planning Department is the appropriate entity for prioritizing and tracking the actions presented in this plan. This department's involvement will ensure that objectives from the Coastal Resilience Plan are addressed in a coordinated manner with other planning documents such as the Plan of Conservation and Development, the Harbor Management Plan, and the Hazard Mitigation Plan.

Specific actions in this coastal resilience plan will be implemented by specific departments such as the Building Department, the Community Development Administration, Planning and Development, Parks and Recreation, and Public Works.

A matrix summarizing coastal resilience actions and implementation strategies is provided on the next page. A legend defining abbreviations used in that matrix is provided below:

Implementation Matrix Legend:

Department

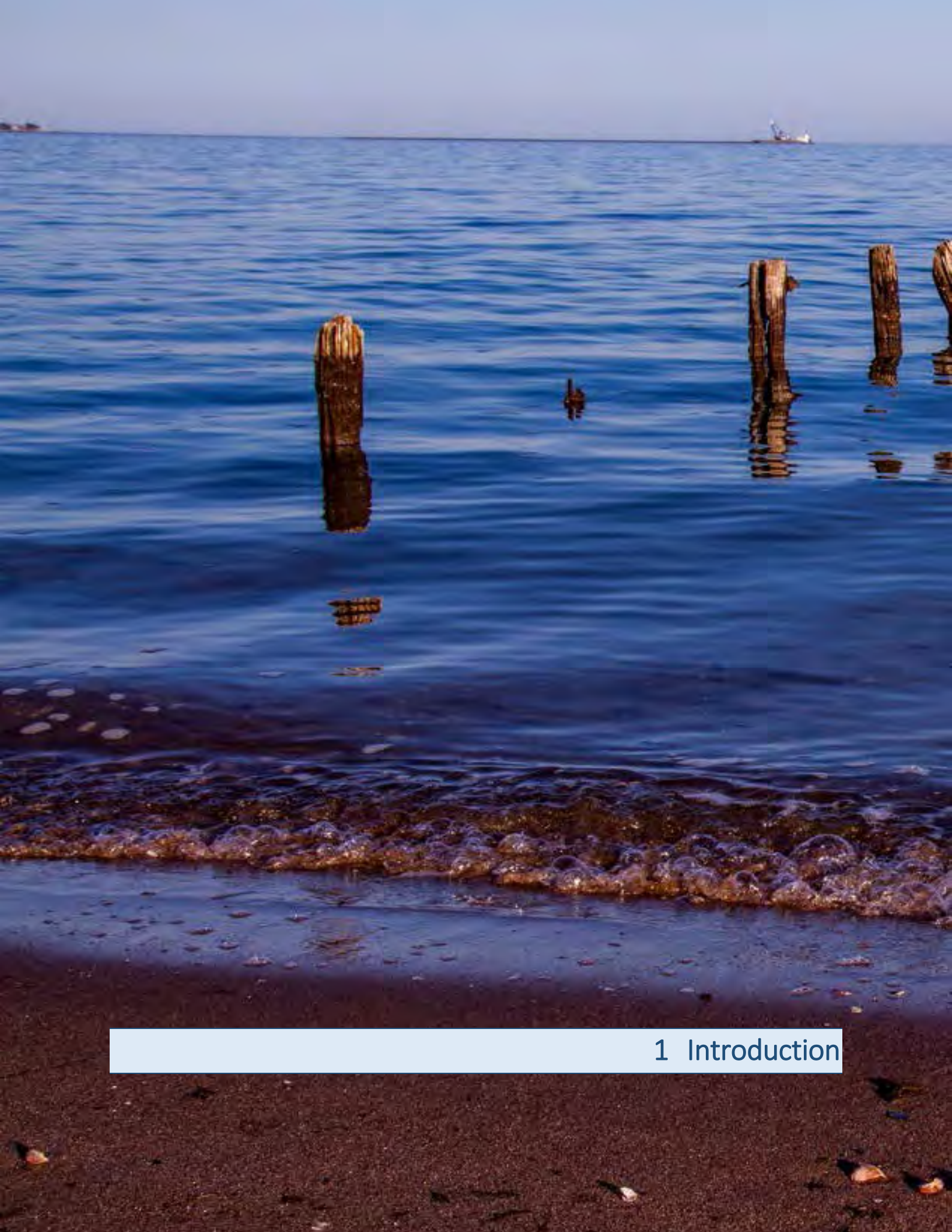
- Building – Building Department
- CDA – Community Development Administration
- EM – Emergency Management Director
- Engineer – City Engineer
- Mayor – Mayor's Office
- P&D – Planning and Development Department
- Parks & Rec – Parks and Recreation Department
- PW – Public Works Department

Funding Source

- CT-CIRCA – CT Institute of Resilience & Climate Adaptation
- CT-SHPO – CT State Historic Preservation Office
- EPA-CWA – EPA Clean Water Act Grant
- FEMA-HMA – FEMA Hazard Mitigation Assistance
- HUD-CDBG – HUD Community Development Block Grant
- NOAA-RCR – NOAA Regional Coastal Resilience Grant
- NRCS – NRCS Watershed Funds
- NROC – Northeast Regional Ocean Council
- OB – City / Department Operating Budget
- USACE-205 – US Army Corps of Engineers Section 205 Funds

	Action	Responsible Department	Timeframe	Funding Sources
			2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080	
	Citywide Regulatory Changes			
R1	Relax height restrictions, expand "special uses" definition, simplify special permit application to facilitate elevation projects	P&D		OB
R2	Increase "lookback period" in Substantial Improvement definition to 5-10 years.	P&D		N/A
R3	Adopt freeboard that exceeds the state-recommended 1 ft, as follows: • X: 0.2% Annual Chance Zone - at 2% Annual Chance Flood Elevation • A and AE Zones - 24 inches • Coastal AE & VE Zones (waterward of LiMWA) - 36 inches	P&D		N/A
R4	Enforce V zone standards in coastal A zones (to LiMWA)	P&D		N/A
	Citywide Procedural Changes			
Pr1	Conclusively establish the role of Flood Plain Manager or Administrator for the City and foster cooperation among departments	Mayor		N/A
Pr2	Improve collaboration of city departments with the Emergency Manager	EM		N/A
Pr3	Collaborate between the Building Department and Community Emergency Response Teams to assist with post-disaster evaluation and building triage.	EM		N/A
Pr4	Enforce Floodplain Regulations on Public Utility Companies	Engineer		N/A
Pr5	Implement Floodplain Development Fee	P&D		N/A
Pr6	Join the FEMA Community Rating System Program	P&D		OB
Pr7	Develop a Formalized Beach and Dune Management Plan	Park&Rec		CT-CIRCA USACE-205
Pr8	Develop and adopt Beach and Dune Protection Ordinances	P&D		CT-CIRCA
Pr9	Improve emergency sheltering capabilities.	EM		FEMA-HMA
Pr 10	Implement POCD objectives relevant to coastal resilience, including: • Waterfront development should be dominated by water-dependent uses • Other water-related uses should be separated by road, other land, or beach • Develop open space links between neighborhoods, parks, boardwalk, etc.	P&D		OB
Pr 11	Implement relevant Harbor Management Plan actions including: • Preservation and enhancement of tidal wetland resources • Application of urban runoff reduction measures on a watershed basis	HMC		EPA-CWA NRCS
Pr 12	Implement Water Pollution Control Facility adaptation measures, including outfall pipe replacement as described in Black & Veatch report.	PW		EPA-CWA
	Citywide Promotion of Property Protection			
PP1	Perform a cultural resources survey to identify those located in coastal risk zones.	Building		CT-SHPO
PP2	Promote floodproofing of non-residential buildings	CDA		OB
PP3	Partner with property owners to apply for FEMA grants to elevate homes	CDA		FEMA-HMA HUD-CDBG
PP4	Promote home-elevation loan programs such as the defunct Shore Up program	CDA		OB
PP5	Implement recommendations of the "CT Historic & Cultural Resources Coastal Resiliency Planning Report on Municipal Capabilities and Risk" West Haven report	P&D		CT-SHPO
	Educational Projects			
Ed1	Perform education and training programs for municipal personnel and staff to identify nexuses between their areas of responsibility and coastal resilience	Mayor		OB NROC
Ed2	Install signage along West Haven boardwalk and at public beaches to educate the public about coastal hazards and the city's resilience projects	Park&Rec		OB
Ed3	Educate property buyers about likely future risks faced by properties, even if they are outside current hazard zones.	Building		OB
	Oyster River Projects			
OR1	Prevent new development on open spaces adjacent to Oyster River to allow for future marsh migration.	P&D		N/A
OR2	Implement Rolling Easements to encourage the gradual inland migration of development and tidal marsh.	P&D		N/A
OR3	Elevate Woodmont Road to 13 or 14 ft NAVD88 to maintain passage during future storms (increase culvert size & number of openings to improve flow regime.	PW		FEMA-HMA
	Oyster River Point Projects			
OP1	Adopt and enforce more stringent floodway regulations.	Building		N/A
OP2	Gradually re-route utility infrastructure away from shoreline where possible.	PW		OB
	Ocean Avenue South Projects			
OS1	Implement Woodruff Street seawall repair as per the Woodruff Street concept design memo (extend as needed to protect entire sanitary sewer line)	PW		FEMA-HMA
OS2	Gradually re-route utility infrastructure away from shoreline where possible.	PW		OB

	Action	Responsible Department	Timeframe	Funding Sources
			2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080	
	Ocean Avenue Beaches Projects			
OB1	Implement floodproofing, grading, and other flood mitigation measures to protect West Shore Fire Dept. while maintaining its historicity and ability to operate during emergencies.	EM		FEMA-HMA CT-SHPO
OB2	Nourish beach from South Street to Ivy Street. Construct Dune on backside of beach. Install fencing and dune crossovers to prevent degradation by pedestrians.	PW		USACE-205 FEMA-HMA NOAA-RCR
	Cove River Projects			
CR1	Upgrade Cove River Tide Gates as per the Cove River Tide Gate concept design memo	PW		USACE-205 CIRCA
CR2	Improve bridge & channel on Cove River at Painter Drive & West Main Street	PW		FEMA-HMA OB
CR3	Study, design, construct Cove River Channel & retention basins to reduce flooding at Greta St. & West Spring St.	PW		NROC CIRCA NRCS
	Downtown South Projects (includes projects applicable to Captain Thomas Boulevard, Campbell Avenue, and Sandy Point Planning Neighborhoods)			
DS1	Nourish beach from Savin Rock Conference Center to Morse Avenue. Construct continuous dune to elevations described in concept design memo. Install fencing and dune crossovers to prevent degradation by pedestrians.	PW		USACE-205 FEMA-HMA NOAA-RCR
DS2	Explore short-term mitigation options at West Walk Condominiums, including construction of floodwalls with deployable floodgates around complex.	Building		HUD Grants (CDBG)
DS5	Implement a zoning overlay to promote flood-smart development in areas that will be vulnerable to flooding in the future but are outside existing hazard zones.	P&D		OB
DS4	Pursue other property-specific adaptation measures based on type of property and type of risk	CDA		HUD-CDBG
DS6	Implement Downtown South conceptual plan.	CDA		Multiple
DS3	Explore long-term mitigation options at West Walk Condominiums, including addition of a third floor and elevation of internal living spaces. Apply to other condominiums if successful.	CDA		HUD-CDBG
	Old Field Creek Projects			
OF1	Continue to partner with property owners to buy out repeatedly damaged homes, and convert to open space.	CDA		FEMA-HMA NOAA-RCR
OF2	Complete elevation of 1st Avenue and Beach Street.	PW		FEMA-HMA
OF3	Construct plunge pool at Peck Avenue to lower sediment input to system.	PW		NRCS EPA-CWA
OF4	Elevate Blohm Street and upgrade crossing at Old Field Creek to Bridge	PW		FEMA-HMA
	New Haven Harbor Projects			
NH1	Construct bioengineered bank at Bayview Place condominiums to mitigate erosion and prevent collapse	PW		CIRCA NOAA-RCR
NH2	Construct green infrastructure shoreline projects, including bioengineered banks east of 1st Avenue.	PW		CIRCA NOAA-RCR
	Spring Street Projects			
SS1	Prevent new development on open spaces adjacent to West River to allow for future marsh migration.	P&D		N/A
SS2	Acquire and demolish unused industrial sites and convert to open space.	CDA		FEMA-HMA NOAA-RCR
SS3	Implement Rolling Easements to encourage the gradual inland migration of development and tidal marsh.	P&D		N/A
SS4	Partner with property owners to buyout repeatedly damaged homes, and convert to open space.	CDA		FEMA-HMA NOAA-RCR
SS5	Elevate Spring Street to 10 ft NAVD88 to maintain access during future storm events.	PW		FEMA-HMA
SS6	Pursue acquisition of industrial uses within 1% annual-chance flood zones	CDA		FEMA-HMA NOAA-RCR
	Allingtown, Cemetery and Yale Bowl Projects			
AI1	Extend pedestrian walkway from Marginal Drive to Derby Avenue providing safe and enjoyable public access to the river for walking, nature study, and fishing	Park&Rec		OB
AI2	Implement green infrastructure for storm runoff reduction	PW		EPA-CWA



1 Introduction

Recent events such as Tropical Storm Irene and Hurricane Sandy, increasingly frequent nuisance flooding during astronomical higher tides, and changes to the National Flood Insurance Program (NFIP) have underscored the risks associated with occupying coastal areas and highlighted the fact that property owners and municipalities bear a heavy financial burden to recover from these types of events.

The City of West Haven ("West Haven" or "The City") is utilizing funding from the United States Department of Housing and Urban Development (HUD) Community Development Block Grant (CDBG) to build up its physical, economic, and social resilience to coastal hazards. This particular grant falls under the category of "Recovery Eligible Activities" and aims to address vulnerabilities observed after Superstorm Sandy by developing coastal resiliency planning at the municipality level.

Resilience is the ability to resist, absorb, recover from, and adapt to disasters. **Coastal Resilience**, referring specifically to coastal hazards such as sea level rise, increased flooding, and more frequent and intense storm surges, can be achieved by decreasing coastal vulnerabilities (and likewise, decreasing risks) through increased adaptation and planning.

This Coastal Resilience Plan ("The Plan") has been developed as a toolbox to build coastal resilience in the coming years. As time passes and our collective understanding of sea level rise is refined, West Haven will have the option to update this plan to reflect the city's evolving approaches to building resilience.

1.1 Project Goal

The overall goal of the "coastal resilience program" undertaken by the City of West Haven is to address the current and future social, economic, and ecological resilience of the city's shoreline to the impacts of sea level rise and anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion. Emphasis is placed on benefiting underserved, low-to-moderate income populations and their communities.

The planning process was loosely based on the coastal resilience planning process established by The Nature Conservancy (TNC) (http://coastalresilience.org/approach/, see Figure 1). The four steps of the process are:

5. **Assess Risk and Vulnerability**, including alternative current and future storm and sea level rise scenarios with community input
6. **Identify Solutions**, focusing on joint solutions across social, economic and ecological systems
7. **Take Action** at key sites to help communities identify and implement solutions
8. **Measure Effectiveness** to ensure efforts are successful

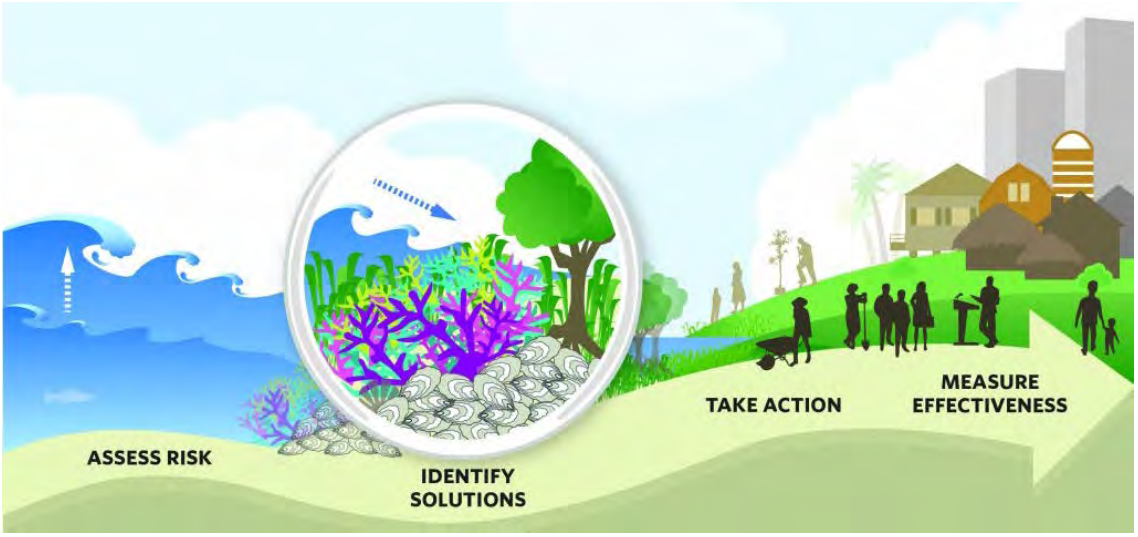


Figure 1: Steps to Coastal Resilience.
Image from www.reefresilience.org

In reality, this four-step process commenced years ago when other planning efforts involved the public, such as the City's participation in the South Central Region Multi-Jurisdiction Hazard Mitigation Plan. The specific planning process for this coastal resilience plan included a vulnerability and risk assessment, review and selection of adaptation and resilience options, and public involvement in the form of three public meetings and an internet-based survey.

1.2 Project Funding

Preparation of this Community Coastal Resilience Plan was funded through the HUD CDBG Disaster Recovery Program (CDBG-DR). The money was allocated to HUD through the 2013 Disaster Relief Appropriations Act, which designated aid assistance for communities affected by Hurricane Sandy.

This program is intended to highlight underserved low-to-moderate income (LMI) populations and communities for additional consideration. Figure 2 shows LMI neighborhoods in West Haven. Those that fall within coastal hazard areas include those bounded by:

- Forest Road, Boston Post Road, the northern West Haven border and the West River (The Allingtown Neighborhood)
- Boston Post Road, Campbell Avenue, Route 95 and West River (Front Avenue and Spring Street Neighborhood)
- Route 95, 1st Avenue, Main Street, and the mouth of the West River
- Blohm Street, 2nd Avenue, Beach Street, Peck Avenue (around Old Field Creek)
- Blohm Street, Campbell Avenue, Captain Thomas Boulevard, The West Haven Housing Authority Surfside Apartments, and Savin Avenue (Surfside Apartments are within this area)

Additionally, much of downtown West Haven, including areas bounded by Blohm Street, Campbell Avenue, Peck Avenue, and Brown Street, as well as areas north of Brown Street, are LMI tracts. Portions of these areas fall within flood hazard areas surrounding both the Cove River and Old Field Creek.

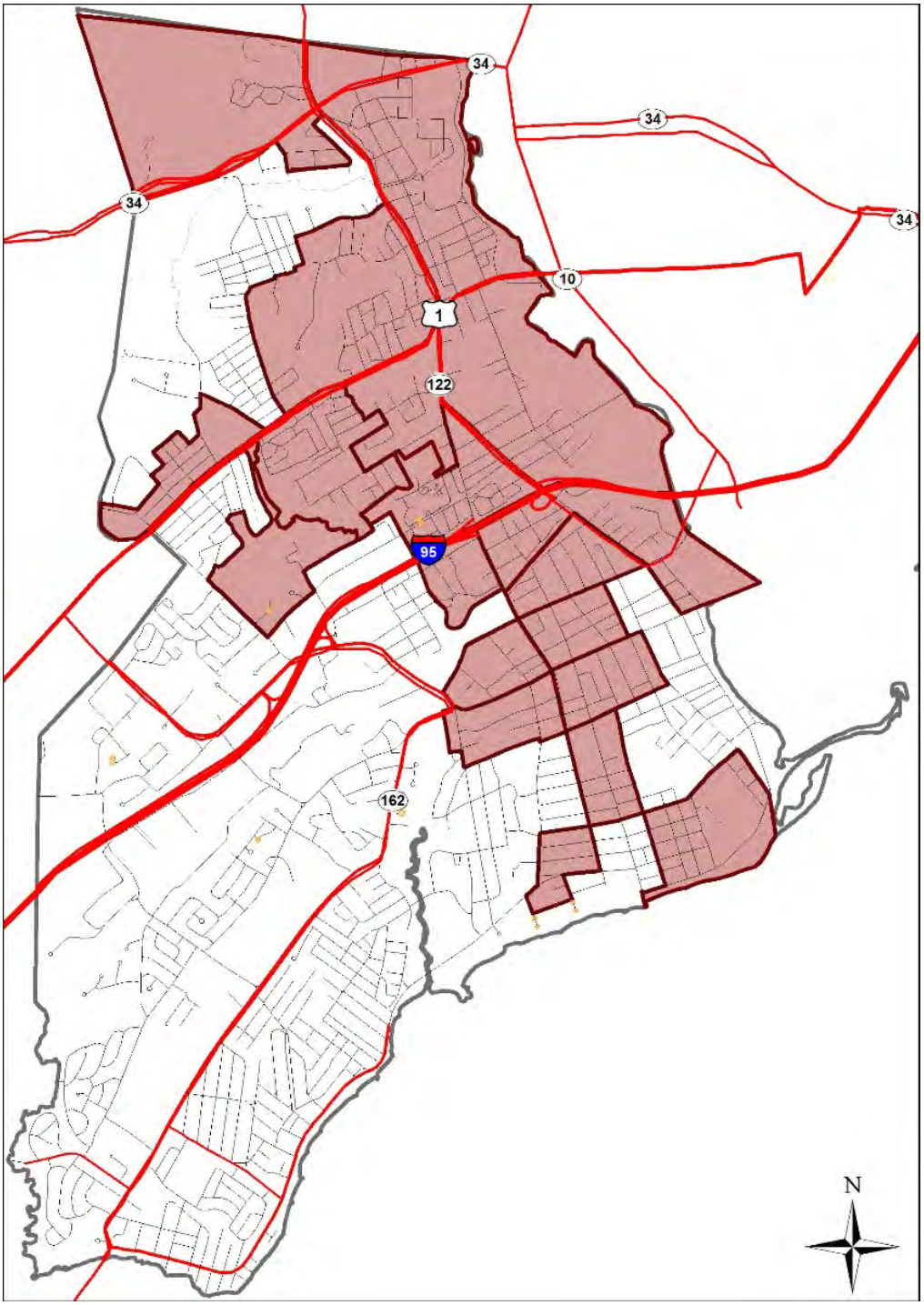


Figure 2: LMI neighborhoods of West Haven.

2 Vulnerability and Risk

2.1 Risk and Resilience Concepts

In the context of hazards, **risk** is the product of **vulnerability** and **frequency**. Here, vulnerability refers to the number of people, structures, and infrastructure vulnerable to a hazard event, as well as the degree to which those assets are incapable of withstanding the effects of that event.

The frequency with which a particular event occurs, combined with level of vulnerability to that event, determines the risk posed by that event.

Risk = Vulnerability X Frequency

This combination can be simplified into the following possibilities:

- **Low** Vulnerability and **Low** Frequency = **Low** Risk
- **Low** Vulnerability and **High** Frequency = **Moderate** Risk
- **High** Vulnerability and **Low** Frequency = **Moderate** Risk
- **High** Vulnerability and **High** Frequency = **High** Risk

		Vulnerability		
		Low	Med	High
Frequency	Low	Minimal Risk	Low Risk	Moderate Risk
	Med	Low Risk	Moderate Risk	High Risk
	High	Moderate Risk	High Risk	Extreme Risk

Figure 3: Risk Matrix Depicting Combination of Levels of Vulnerability & Frequency

In the context of coastal hazards, risk depends on:

- The **vulnerability** of coastal communities and infrastructure
- The **frequency** of flooding and storm events

Coastal storms are believed to be increasing in frequency, and flooding will increase in frequency as sea level continues to rise. **Thus, even if coastal vulnerabilities remain static, risks will increase.**

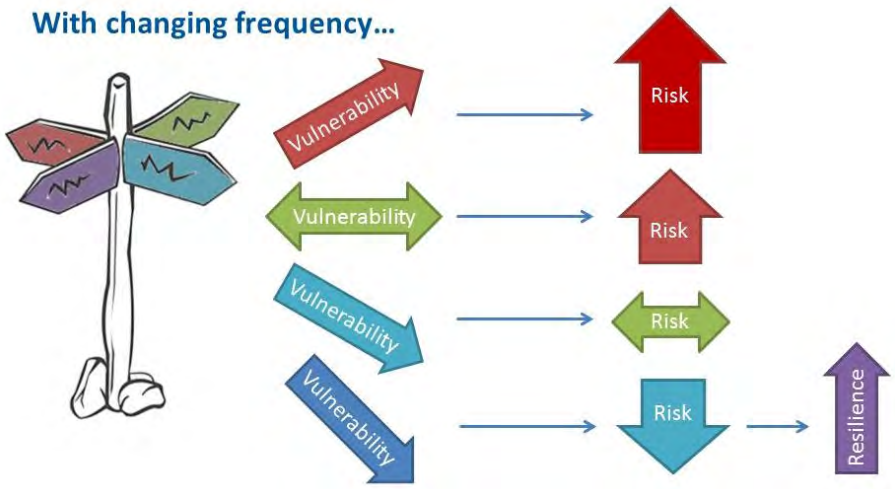


Figure 4: Conceptual model depicting how changing hazard frequency will affect future risk.

If vulnerabilities increase as well, due to new development in hazard areas (increasing the number of vulnerable assets) or failure to maintain existing protective structures (increasing the level of vulnerability of assets), risks will increase more dramatically. Alternatively, if vulnerabilities are **reduced** through adaptation, risk levels can be held steady into the future. If vulnerabilities can be reduced even further, then risks can be lowered in the face of rising sea level and increased coastal storms, leading to **increased resilience**.

2.2 Existing Conditions

2.2.1 Setting

West Haven had over 55,500 residents at the 2010 census, living within 10.8 square miles of land. The city has 3.5 miles of publicly accessible beaches, which is one-quarter of the publicly accessible beaches in Connecticut.

The West Haven Plan of Conservation and Development (POCD, adopted July 13, 2004, undergoing an update to be adopted in 2017) includes the statement, "protection of West Haven's natural resources… helps to preserve the city's community character and essential natural systems, while improving the quality of life for all of West Haven's residents."

Specific coastal resources of interest listed in the plan were:

- **Coastal Water:** threatened by pollution
- **Tidal Wetland:** Oyster River, Cove River, West River, Old Field Creek
- **Rocky Shorefront:** Bradley Point, Savin Rock, Oyster River Beach; feeding and refuge areas
- **Intertidal Flat:** transition between estuarine embayment & tidal wetland; productive habitat
- **Beach and Dune:** including 1.5-mile multi-use boardwalk that links several public beaches
- **Shellfish Concentration Areas:** eastern oysters or hard-shell clams; closed to harvest
- **Modified Bluffs and Escarpments:** erodible, significant sediment sources, often with seawalls
- **Riparian Corridors:** West River, Old Field Creek Tidal Estuary, Cover River, Oyster River

The Coastal Resources chapter of the POCD describes some of the different planning areas along the West Haven shoreline, and potential development opportunities at each:

West Haven's Annual "Icy Plunge for the Cure"
Image: Viktoria Sundqvist - New Haven Register

- **Long Island Sound Shorefront**: This area is noted for its sandy beaches, public access areas to the waterfront, and a multi-use walk/bike path. Guidelines for a new development strategy set forth by the plan include soliciting public input, balancing development with preservation of this coastal resource, ensuring pedestrian safety, and maintaining public and visual access to beach.
- **Oyster River, Cove River, and Old Field Creek Tidal Estuaries/Corridors:** The POCD noted that the City had no specific stormwater regulations, making protection of these tidal wetlands difficult. Roadside dumping was specifically cited as a problem. The plan suggested improving public access to these areas.
- **West River Corridor:** The banks of the West River were historically used for heavy industrial and manufacturing operations. Monitoring and remediation of ongoing pollution was a high priority here. The POCD pointed to the West River Crossing project (redeveloping acres of old industrial properties into a shopping and tourism center) as a good model for redevelopment in this area. Guidelines for new development include allowing only water-dependent activities or public access along the waterfront, and reserving land for open space and recreation, including the former landfill.

Much of the West Haven's development moving into the future is expected to consist of infill and redevelopment, and specifically will focus on being "transit oriented development." Thus, development will be directed away from currently undeveloped areas, and may be centered on the train station.

"Planning Neighborhoods"

For the purposes of this report, the coastal neighborhoods of West Haven are broken into the following:

- **Oyster River** – the western border of West Haven, on the eastern bank of the Oyster River. Single Family homes, with relatively high-income, characterize this area. Includes a Senior Living Center, a condominium complex, and a number of commercial properties. Oyster River does not have tide gates.
- **Oyster River Point** – extends eastward from the mouth of the Oyster River until Oyster River Point. Waterfront homes sit behind a boulder revetment structure and seawalls, overlying a rocky shoreline. The area is mostly single-family homes and is relatively high-income.
- **Ocean Avenue South –** southern end of Ocean Avenue before it hooks west at Oyster River Point, also known as Rocky Beach, is demographically and physically similar to Oyster River Point, with single-family waterfront homes, a protective revetment, bulkhead, and seawall system, and an underlying rocky coastline.
- **Ocean Avenue Beaches –** the coastline from South Street to Cove River has wide sandy beaches between stone groins (beach names include South Street Beach, Prospect Beach, and Seabluff Beach). Set back from the beaches are single-family homes, some multi-family homes, and at least one condominium complex. Other features of note include a Mosque, a retirement center, an inland pond, a pumping station, the West Shore Fire Department headquarters, and a number of retail stores. Development is somewhat more dense in this area than in the previously described neighborhoods.
- **Cove River** – a tidal wetland that extends far inland. The area includes relatively dense neighborhoods of single-family homes and small retail stores, as well as the commercial nodes at the intersection of Jones Hill Road and Platt Avenue, and Main Street and Wagner Place/Kelsey Avenue. Also in this neighborhood is the West Haven High School, the industrial area along Hood Terrace, and the Central Fire Department. The areas to the east of Painter Drive and North of Chestnut Street are categorized as LMI neighborhoods. The Cove River tidal flows are moderated by tide gates.
- **Captain Thomas Boulevard –** from the first row of structures on the north side of Captain Thomas Boulevard south to Long Island Sound, extending from Kelsey Avenue to Washington Street. This area consists mainly of multi-family homes, condominiums, and apartment buildings, along with a number of non-residential properties and parks. Includes a West Haven Housing Authority apartment complex and a church that fall within an LMI census block. Sandy beaches are between both stone and cement groins, in some sections with a dune. The Savin Rock trail runs east-west behind the beach.
- **Campbell Avenue** – extends north of the Captain Thomas Boulevard neighborhood, and includes three separate LMI neighborhoods as well as major roads running in both the north-south and east-west directions. Features of note include the Oceanside Condominiums building, the Savin Rock Community School building, The West Haven Child Development Center and West Haven Adult Day Care, The Savin Park Condominium complex, and Apple Rehab West Haven. This neighborhood overall is relatively low income, consisting of condominium and apartment complexes, and multi-family houses. The waterfront is not included in this neighborhood's extent.

- **Sandy Point –** here includes the sandy coastline, heavily influenced by currents from Long Island Sound, that runs from Washington Avenue eastward, wraps north to include the West Haven Water Pollution Control Plant (WPCP), and stretches east into New Haven Harbor to include Sandy Point. Much of this shoreline includes a dune, which stretches continuously from Washington Avenue to Morse Avenue. This area contains unique ecological resources and vulnerabilities, unique sediment transport dynamics, and the WPCP.
- **Old Field Creek** – includes most of the area surrounding Old Field Creek, as well as a section of the New Haven Harbor coastline north of the Water Pollution Control Facility. It does not include areas north of Brown Street, which is being analyzed as part of the "City Center" neighborhood. The Old Field Creek tidal wetland is controlled by self-moderating tide gates beneath Beach Avenue, which allow some tidal exchange between the wetland and Long Island Sound, while preventing high water from flooding inland areas.
- **City Center** – east of Campbell Avenue, north of Brown Street and south of Interstate 95. The southern section along Martin Street consists mainly of single- and multi-family homes. The northeastern section around Water Street and Elm Street consists of a variety of waterside industrial and commercial buildings.
- **Spring Street** – east of Campbell Avenue, between Interstate 95 and Route 1. The area is mixed residential, commercial, and industrial, with multi-family homes and apartments, a cemetery, retail centers, auto-repair centers, active and abandoned factories, and at least one landfill. It is an LMI neighborhood. The eastern side of the neighborhood borders the tidal wetland of the West River, downstream of a set of tide gates. The eastern side of the West River is also a commercial/industrial area in New Haven.
- **Allingtown** – sits north of Boston Post Road, south of the Saint Lawrence Cemetery, and east of Forest Road. It is an LMI neighborhood. The West River to its east is upstream of a tide gate operated by the City of New Haven, and designed to allow for tidal exchange while preventing high water from flooding upstream communities. The neighborhood is mostly multi-family residential, with a cluster of commercial and industrial buildings along Route 1.
- **Cemetery and Yale Bowl** – consists of the Saint Lawrence Cemetery and Yale University sport fields.

As this project progresses, and additional planning area was delineated. This "Downtown South" area includes all of the "Captain Thomas Boulevard" planning neighborhood, the southeastern section of the "Campbell Avenue" planning neighborhood, and the westernmost spit of the "Sandy Point" planning neighborhood. A separate report titled "Downtown South Neighborhood Resilience Concepts" was prepared for that planning area as a part of this project, but is not included in this Coastal Resilience Plan document.

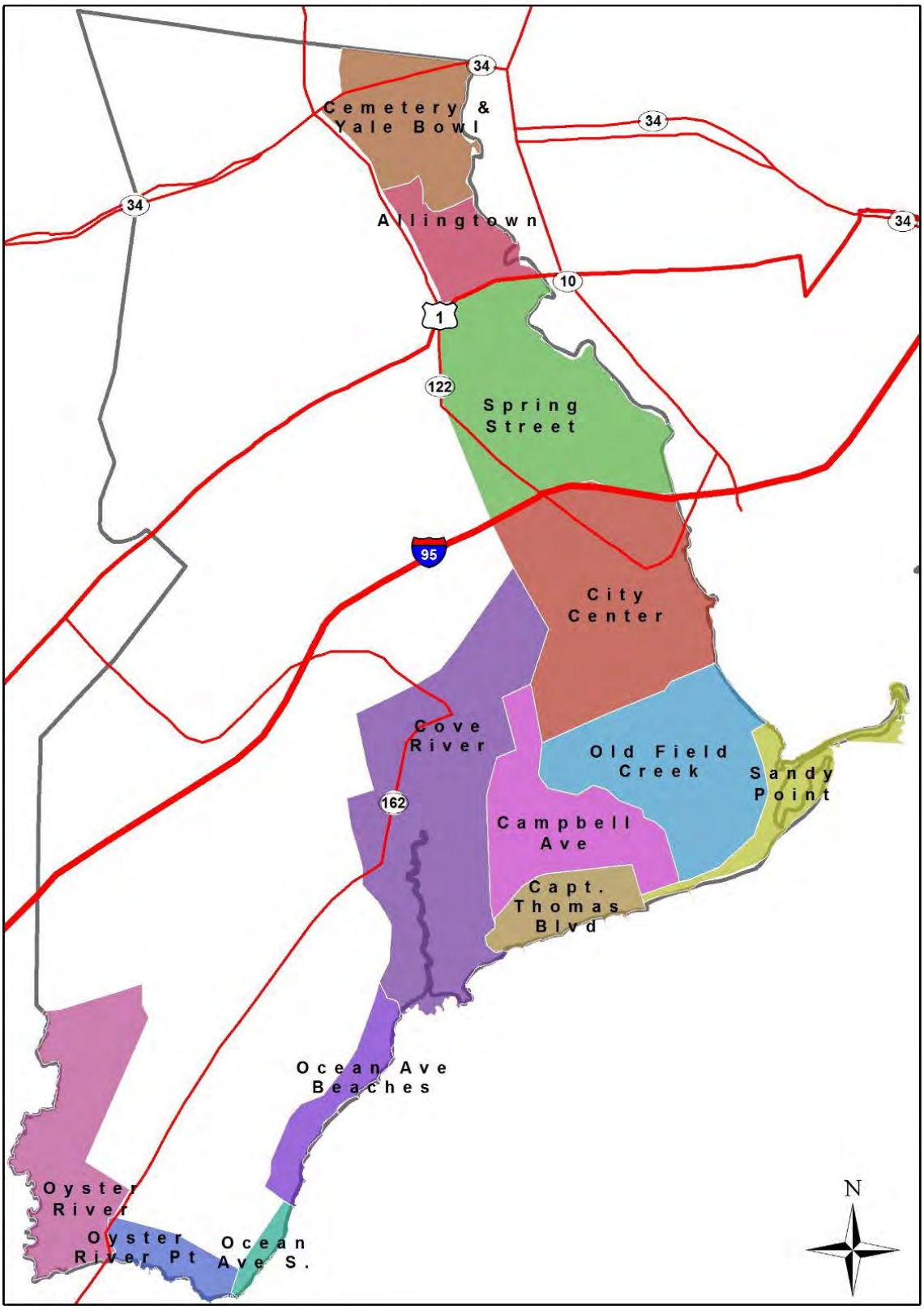


Figure 5: Coastal "Neighborhoods" of West Haven, Defined for the Purposes of this Document.

2.2.2 Existing Capabilities

There are a suite of existing regulations, plans, projects, and programs within the city of West Haven that relate to, address, or are otherwise pertinent to the city's pursuit of becoming a more resilient coastal community. This plan acknowledges the contribution that these resources make to West Haven's resilience capabilities, and was designed to work *with* these existing documents and actions. These resources (described in Appendix A) include the following:

- South Central Regional Council of Governments (SCRCOG) Multi-Jurisdiction Hazard Mitigation Plan (2013)
- Connecticut Natural Hazards Mitigation Plan Update (2014)
- West Haven POCD, 2004 (update adoption anticipated in 2017)
- West Haven Zoning Regulations
- West Haven City Ordinances
- West Haven Harbor Management Plan (adoption anticipated in 2017)
- Southern Connecticut "Regional Framework for Coastal Resilience" (2015-2017)
- Connecticut Shoreline Change Analysis (2014)
- Conceptual Regional Sediment Budget for the United States Army Corps of Engineers (USACE) North Atlantic Division (March 2015)
- North Atlantic Coast Comprehensive Study (NACCS; 2015)
- Connecticut Coastal Design Project (2013)
- Long Island Sound Comprehensive Conservation and Management Plan
- Long Island Sound Resource and Use Inventory and Blue Plan
- Connecticut Climate Change Preparedness Plan (2011)
- An Honors Thesis by Ryan Orlowski from Southern Connecticut State University

Figure 6 depicts the sections of the West Haven Coastline addressed by various planning documents, including the SCRCOG Multi-Jurisdiction Hazard Mitigation Plan, The West Haven POCD, The West Haven Harbor Management Plan, The Regional Framework for Coastal Resilience, and this Coastal Resilience Plan.

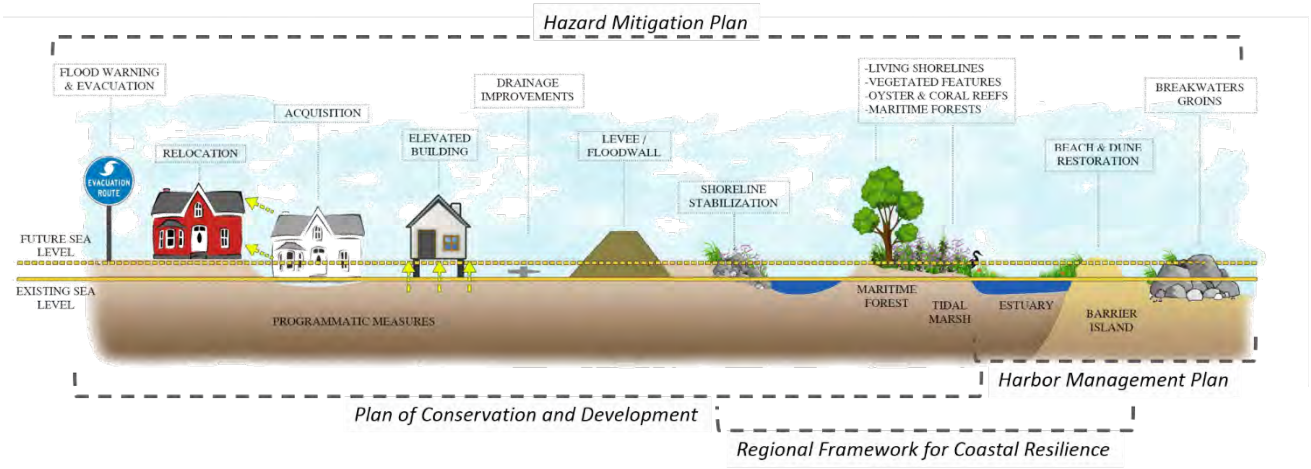


Figure 6: Sections of the West Haven Coastal Area Addressed in Various Planning Documents

Most of the relevent municipal planning documents recognize sea level rise and coastal storms as a key issue in need of consideration. The SCRCOG Multi-Jurisdiction Hazard Mitigation Plan identifies locations at risk of future sea level conditions, tracks mitigation projects, and suggests additional strategies. The POCD names sea level rise as an important factor in future development, and considers the effect it will have on emergency services. West Haven's Municipal Ordinanaces and Zoning Regulations include many requirements to protect property from flooding, but sea level rise and climate change are not explicitly included.

The studies being performed by the City, the State, and other parties add to the base of knowledge in West Haven with regard to future conditions, vulnerabilities, and adaptation options. The Connecticut Department of Energy & Environmental Protection (CT DEEP) Shoreline Change study points to specific erosion risk zones and can inform development of sediment management projects. The NACCS results provide suggestions with regards to prioritizing areas for protection and choosing applicable adaptation projects. Other studies, many still ongoing, cover a wide range of topics such as shoreline change and sediment dynamics, the future evolution of coastal hazards and socio-economic vulnerabilities, aquatic and shoreline habitats, and multi-hazard effects on coastal resilience.

WHAT DO OTHER STUDIES SAY ABOUT WEST HAVEN?

Conceptual Regional Sediment Budget for USACE North Atlantic Division (March 2015)

A conceptual regional sediment budget (CRSB) was developed for the USACE North Atlantic Division as a component of the Comprehensive Hurricane Sandy study.

Net sediment transport in Long Island Sound was found to be toward the west with local reversals. The CRSB along the West Haven shoreline was found to be "stable," although it is noted as having high exposure. The CRSB for Long Island Sound was found to be accreting.

The report recommends "better characterization of regional sediment transport patterns for beaches along Long Island Sound. Although this area is less vulnerable to direct impact from hurricanes and northeasters, there are navigation channels and sediment management activities that could reduce future erosion of this area."

Monitoring the state of these projects and plans, ensuring collaboration and communication between the responsible entities, and building on this baseline to fill knowledge and implementation gaps, will be essential in creating a resilient City.

2.2.3 Existing Challenges

West Haven already has experience with coastal hazards:

- The City's beaches have had to be nourished many times to combat ongoing erosion.
- Businesses and homes along Beach Street have suffered damage from recent large storms.
- Low-lying roads around Cove River and Old Field Creek (including Painter Drive and Morse Avenue) experience nuisance flooding during rain events and particularly high tides.

Rising waters and increasing storm severity and frequency will exacerbate existing problems and give rise to as yet nonexistent problems in other parts of the city.

2.3 Sea Level Rise

Sea Levels on the Connecticut shoreline have been rising between 10.2 and 24 inches per 100 years

2.3.1 Existing Conditions and Historic Trends

A tide gauge is operated by the National Oceanic and Atmospheric Administration (NOAA) at the Port of New Haven, across New Haven Harbor from West Haven. This gauge has been operating since August 11, 1999.

According to data collected by this gauge (available online at tidesandcurrents.noaa.gov), the mean sea level (MSL) in New Haven Harbor is negative (-) 0.24 feet, or 0.24 feet below the North American Vertical Datum of 1988 (NAVD88). The average maximum elevation of high tide ("mean higher-high water, or MHHW") is 3.39 feet above the MSL, or 3.15 feet elevation, NAVD88. These figures will vary along West Haven's coastline, as well as over time. In fact, tidal data for the year 2016 shows a MHHW of 3.8 feet NAVD88 and a MSL of -0.57 feet NAVD88.

WHAT DO OTHER STUDIES SAY ABOUT WEST HAVEN?

Analysis of Shoreline Change in Connecticut: 100 Years of Erosion and Accretion (July 2014)

CT DEEP, UConn CLEAR, and CT Sea Grant

The analysis shows the following trends along the West Haven shoreline:

Accretion
Across from Abbot Park, At Cove River, Peck Avenue Beach, Eastern End of Sandy Point

Erosion
At Oyster River, Along Beach Street, Captain Thomas Boulevard, Ocean Avenue, and New Haven Harbor

Examination of seventeen years of tidal data collected at this gauge (from August 1999 through June 2016) show that **MSL has been increasing at a rate of 0.24 inches (or 6.19 millimeters) per year**, while MHHW has been rising at a rate of 0.34 inches (8.74 millimeters) per year. It is important to note that this 17-year time period is relatively limited in the context of sea level rise.

The nearest long-term gauge to West Haven is the tide gauge in Bridgeport, CT. Based on tide gauge data collected at that station between 1964 and 2016 (50 years), MSL has been increasing at a rate of **2.87 millimeters (0.11 inches) per year**, equivalent to a rise of 0.94 feet over 100 years. Another station in New London, CT, has measured an increase of **2.58 millimeters per year**, or 0.85 feet-per-100-years, based on measurements since 1938. These observations and trends are summarized in Figure 7.

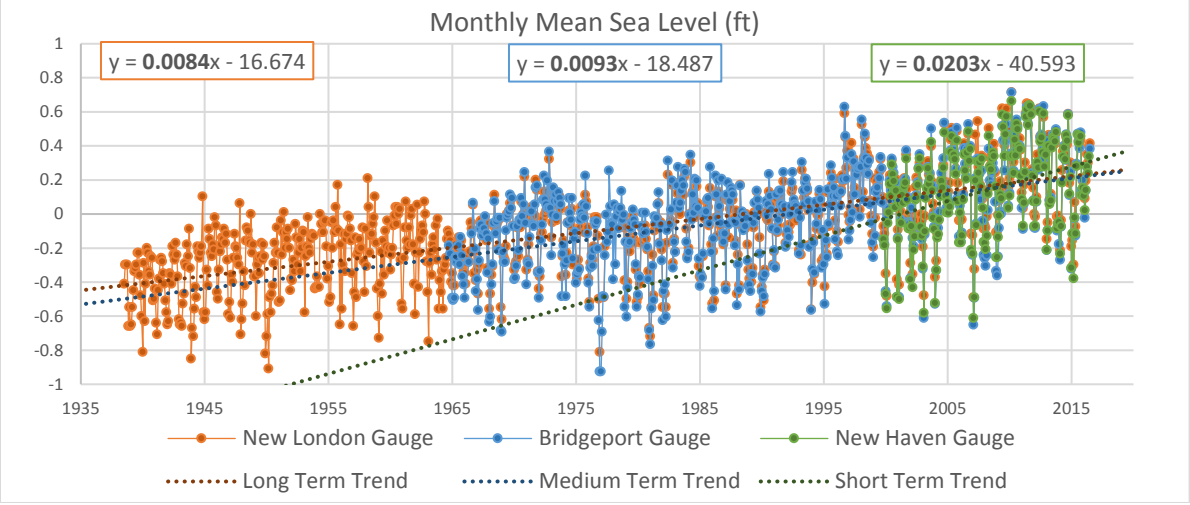
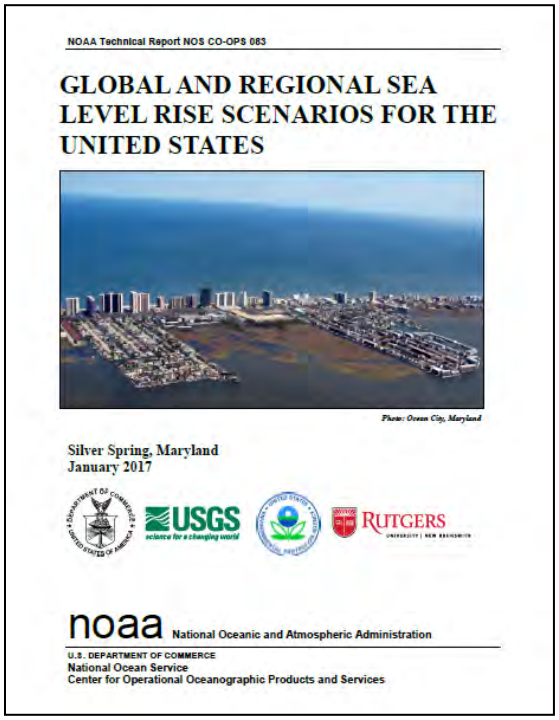


Figure 7: Observed Sea Level Data from 3 Tide Gauges in Connecticut

2.3.2 Sea Level Projections

In its landmark 2001 report, the Intergovernmental Panel on Climate Change (IPCC) projected that global sea level may rise nine to 88 centimeters (0.30 - 2.89 feet) during the 21st century. According to the most recent update, *Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 2013*, these predictions have been revised to a rise of **28 to 98 centimeters (0.9 to 3.2 feet)** by 2100 relative to 1986-2005 levels.


NOAA Technical Report NOS CO-OPS 083

GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES

Photo: Ocean City, Maryland

Silver Spring, Maryland
January 2017

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

The January 2017 NOAA Technical Report titled *Global and Regional Sea Level Rise Scenarios for the United States* builds on and updates their December 2012 Report, and is the current reference for sea level rise planning in the United States. The report's updated global mean sea level range for the year 2100 is between **0.3 and 2.5 meters (1.0 to 8.2 feet)** above current levels.

Sea level rise is not consistent around the world, and is affected by local variations in currents, temperature, and changes in land surface elevation. It has long been expected that the rate of sea level rise in Connecticut will be slightly higher than the global projections due to the effects of regional subsidence. However, more recent studies have asserted that changes in ocean circulation will increase the relative sea level rise along the Atlantic coast even more.

The NOAA report finds that sea level along the Northeast Atlantic Coast is projected to be greater than the global average for almost all future scenarios. In Connecticut specifically, sea level rise is projected to be 0 to greater than 1 meter (3.3 feet) higher than the rise in global mean sea level.

Relative Sea Level on the Connecticut Coast is Projected to Rise 1-8 feet Above 2000 Levels by 2100.

Projections of the rate and extent of sea level rise in the future were used to determine West Haven's vulnerabilities to future coastal conditions. Uncertainties exist with regard to multiple factors that contribute to sea level change, including the rate of change in the land surface elevation, the extent and rate of glacial melting, and changes in human development and greenhouse-gas emission patterns. For this reason, multiple projections are available.

The USACE hosts a sea level rise web tool ("Sea-Level Change Curve Calculator") that provides sea level projections using both USACE and NOAA projections at existing tidal gauges. The most recent version (2015.46) was used for this assessment; note that projections developed for the 2017 NOAA technical report have not yet been incorporated into this tool, and the curves presented here reflect the projections of the previous report (2012).

Rates are as follows:

- **NOAA Low and USACE Low:** historic rate of sea level change is the rate of change moving forward.
- **NOAA Intermediate Low and USACE Intermediate:** ocean warming and the local rate of vertical land movement determine sea level change rate.
- **NOAA Intermediate High:** the projected rate assuming both ocean warming and a moderate rate of melting of the arctic ice sheets.
- **USACE High:** considers both the most recent (IPCC) projections and modified National Research Council projections with the local rate of vertical land movement added.
- **NOAA High:** rate based on heating of the oceans and a maximum loss of the ice caps.

Calculated sea level rise using this tool is depicted in the following table and graph. In each case, the base year is 1992.

Table 1: Sea Level Rise in Bridgeport

Gauge 8467150, Bridgeport, CT NOAA's Regional Rate: 0.00807 feet per year Values expressed in feet relative to the 1992 Local Mean Sea Level (LMSL)					
Year	USACE Low NOAA Low	USACE Int NOAA Int-Low	NOAA Int-High	USACE High	NOAA High
2010	0.14	0.17	0.24	0.27	0.31
2020	0.23	0.30	0.45	0.52	0.63
2030	0.31	0.44	0.72	0.84	1.04
2040	0.39	0.59	1.05	1.24	1.56
2050	0.47	0.77	1.43	1.72	2.19
2060	0.55	0.96	1.87	2.26	2.91
2070	0.63	1.17	2.37	2.89	3.74
2080	0.71	1.40	2.92	3.58	4.67
2090	0.79	1.65	3.54	4.35	5.70
2100	0.87	1.91	4.21	5.20	6.83

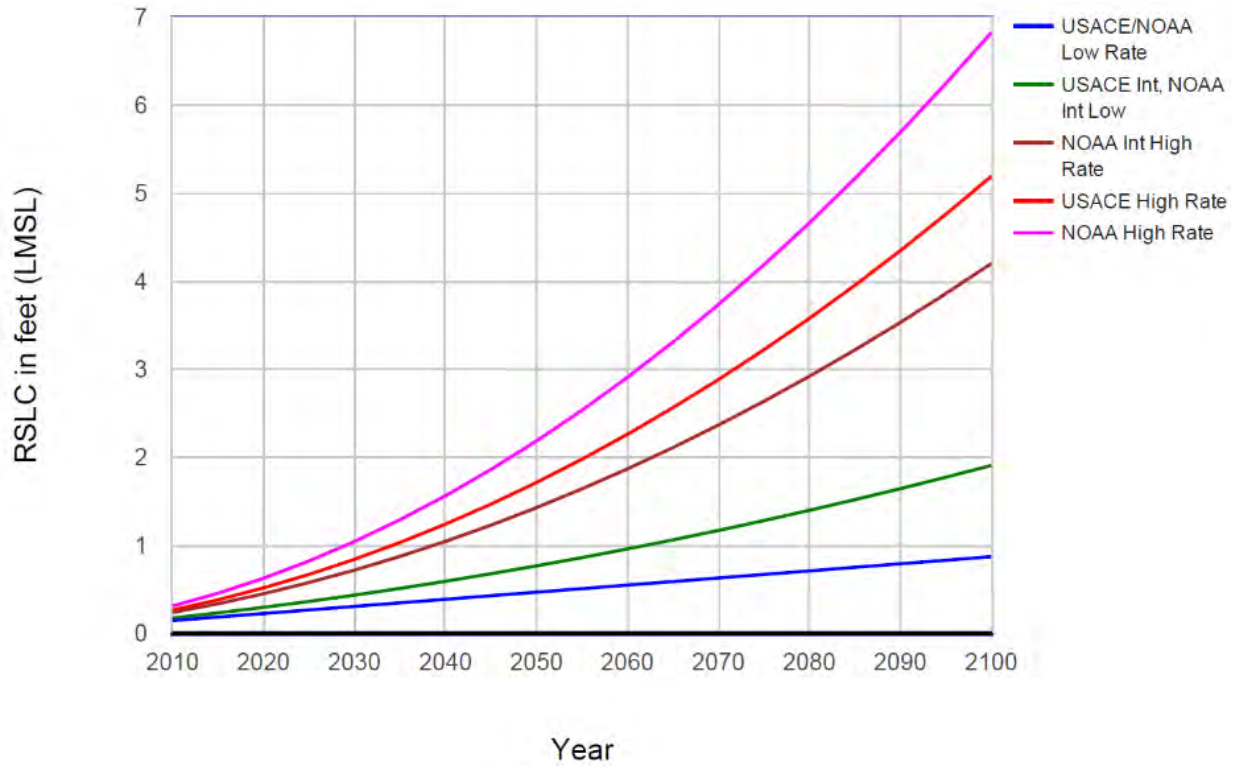


Figure 8: Relative Sea Level Change Projections; Gauge 8467150, Bridgeport, CT

The ranges calculated in Figure 8 and Table 1 are quite wide, but even the low projections show that sea level rise will continue throughout the current century. For planning purposes, it is advisable to use medium or high sea level rise projections such that a community will be better protected against worst-case scenarios.

More information on sea level rise projections is presented in Appendix B.

2.4 Specific Vulnerabilities and Risks

2.4.1 Summary

West Haven's coastal neighborhoods are diverse, and each will be faced with a combination of vulnerabilities with sea level rise and the increased incidence and severity of coastal storms. Generally, coastal **hazards** can include:

- **Stillwater Inundation** – flooding from high water without the effects of waves
- **Wave Setup and Runup** – wave action allows water to reach otherwise protected areas
- **Wave Action** – can cause damage to buildings directly
- **Erosion** – removal of material can degrade beaches and undermine buildings and infrastructure
- **Insufficient Drainage** – submerged outlets or insufficient capacity can create flooding
- **Wind** – can cause direct damage by blowing debris into structures

Risks and vulnerabilities in the city of West Haven were determined through review of city planning documents (such as the Multi-Jurisdiction Hazard Mitigation Plan and the POCD), discussion with city representatives, collection of public input at meetings and through an online survey, and utilization of the TNC Coastal Resilience Mapping Portal (See Appendix B for more details).

Among the greatest threats to West Haven's shoreline are:

- Inundation and erosion of beaches
- Erosion of properties at the eastern and western ends of the City
- Inundation of roads connecting West Haven to Milford and New Haven
- Flooding of tidal wetlands and surrounding properties

Risks are anticipated to increase over time due to sea level rise and climate change, and may be compounded by continuing trends of increased development and population growth. High winds during storm events, which are also predicted to increase with climate change, may put further pressure on vulnerable areas.

Coastal **vulnerabilities** can fall under a variety of categories, as follows:

- **Social** – residents, business community, cultural and historic resources
- **Economic** – property, businesses, municipal resources, tourism, future development
- **Infrastructure** – roads, railroads, drainage, seawalls, tide gates, marinas, municipal facilities
- **Utilities** – water supplies, septic systems, telecommunication, electricity
- **Emergency Services** – Fire, police, medical, sheltering, evacuation, egress
- **Natural Systems** – tidal wetlands, beaches and dunes, other coastal landforms

Vulnerabilities can also be viewed in the context of primary and secondary impacts. **Primary impacts** describe direct damages to building and infrastructure, while **secondary impacts** include disruptions to commerce, isolation of areas from emergency services, and the like.

The most vulnerable aspects of West Haven's coastal area are:

- Residential structures
- Transportation infrastructure
- Wastewater utilities
- Natural systems
- Economic stability and tourist draw

Vulnerable assets in West Haven, and the risks they face, are summarized as follows:

- **Homes & Businesses** – damage to structures and contents from inundation, erosion, wind, and debris.
- **Tourism** – damage to restaurants, retail stores, natural and aesthetic resources, and beaches
- **Roads, Railroads & Bridges** – submersion by high water or eroded by waves
- **Stormwater Drainage** – more intense rainfall overwhelming capacity, high sea levels preventing drainage and causing surcharging (water flowing backward through drain pipes)
- **Tide Gates** – overtopping by higher sea levels, clogging from sediment and debris
- **Shore Protection Infrastructure** – overtopping by high water, failure during intense storms
- **Utility Infrastructure** – corrosion by saltwater, damage from wave action, inundation of pumping stations, damage from wind, difficulty addressing damages due to flooded roads
- **Emergency Services** – direct damage from inundation, waves, and wind; loss of emergency access due to flooded or eroded roads
- **Natural Resources** – wetlands, beaches, and dunes vulnerable to rising waters and more intense storms
- **Historic Resources** – Integrating historic preservation into coastal resilience presents a unique challenge, since adaptation and mitigation must be balanced with the preservation of the character of historic resources

WHAT DO OTHER STUDIES SAY ABOUT WEST HAVEN?

Connecticut Historic & Cultural Resources Coastal Resilience Planning (2017)

A series of historic preservation initiatives administered by the State Historic Preservation Office, Department of Economic and Community Development, and the National Park Service.

This project provides direct outreach to regional councils of government and municipalities in the state's coastal counties to assist with resiliency planning and bolster consideration of historic resources in community planning processes.

This project has not yet been completed.

The report finds that West Haven has hundreds of locally significant historic resources that have not been nominated to the state or federal registers of historic places. Historic resources are somewhat addressed in municipal planning documents, ordinances, and regulations.

The report recommends performing a survey of sites with potential historic value, and nominating them for listing on the State or National Register of Historic Places.

Table 2 summarizes vulnerable assets, the hazards they face, and areas at risk. Vulnerabilities and risks within West Haven are described in significant detail in Appendix B.

Table 2: Vulnerable Assets, Hazards that Threaten Them, and Areas at Risk to Those Hazards:

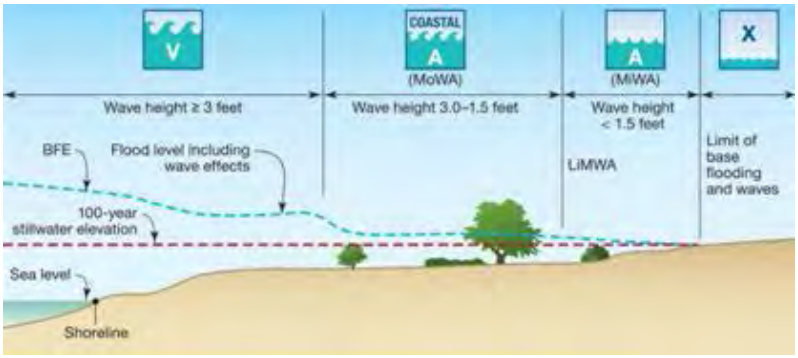
	Asset	Hazards	At Risk Areas	
Economic	Residential Property	Flood Damage to Structure & Contents Wave Action Damage to Structure Erosion of Foundations Wind & Debris Damage	Oyster River Point & Ocean Ave South 1st Avenue Cove River Old Field Creek Front Avenue	
	Businesses	Flood Damage to Structure & Contents Wave Action Damage to Structure Erosion of Foundations Wind & Debris Damage	Beach Street City Center Front Avenue	
	Tourism	Damage to Restaurants and Stores Damage to Natural Resources Erosion of Beaches	Beach Street Downtown South Area Ocean Avenue Beaches	
Infrastructure	Roads & Bridges	Inundation of Low Roads Clogging of Bridge Underpasses Undermining by Coastal Erosion	3rd Avenue Beach Street Blohm Street Brown Street Captain Thomas Blvd Educational Way Front Avenue Morse Avenue Ocean Avenue	Park Street Peck Avenue Platt Avenue Routes 1, 122, 162 Spring Street Washington Ave West Walk Woodmont Road
	Railroads	Inundation of Low Sections	West River	
	Drainage	Insufficient Capacity Outfalls Below High Sea Levels Surcharging during Surge Events	Allingtown Painter Drive 3rd Ave Extension	
	Tide Gates	Overtopping Failure (Clogging)	Old Field Creek Cove River West River	
	Shore Protection	Overtopping Undercutting	Oyster River Point Ocean Avenue South	
Utilities	Water Supply	Pipe Corrosion from Saltwater Wave Damage to Water Mains	Low-Lying Coastal Areas	
	Wastewater	Flood or Wave Damage to WPCP Flood Damage to Pumping Stations Wave Damage to Outfall Pipe Wave Damage to Sewer Pipes	Oyster River Point & Ocean Ave South Cove River Captain Thomas Blvd Old Field Creek & Sandy Point	
	Gas, Electric, Communication	Wind Damage to Grid Flood Impacts on Response Flood Damage to Buried Infrastructure	Citywide Low-Lying Coastal Areas	
Emergency	Emergency Facilities	Flood & Wind Damage to Facilities Flood& Wind Damage to Equipment	Ocean Avenue Beaches	
	Access & Evacuation	Isolation by Flooding of Road Isolation by Wave Damage to Roads	Old Field Creek & Sandy Point Captain Thomas Boulevard Campbell Avenue City Center Savin Rock Community School Area	
Cultural	Natural Resources	Damage from Waves and Wind Drowning by Rising Seas Secondary Impacts of Protective Measures	Tidal Wetlands Beaches and Dunes Natural Coastlines	
	Historic Resources	Direct Impacts, as Listed for other Properties Secondary Impacts during Response & Recovery	Locally Significant Sites throughout City	

2.4.2 Vulnerable Neighborhoods

Different neighborhoods and areas of West Haven face different hazards presented by current and future daily high tide and storm conditions. In order to assess vulnerabilities across the City, the following spatial hazard data were analyzed:

FEMA Special Flood Hazard Areas

The 1% annual chance (100-year) flood has been adopted by the Federal Emergency Management Agency (FEMA) as the "base flood." Special Flood Hazard Areas (SFHAs) are the areas at risk of inundation during the base flood, as delineated as part of the NFIP. FEMA uses a variety of flood zones to delineate areas of annual chance flood hazard, summarized in the figure below:



Wave Set-Up and Run-Up

Average sea level, without accounting for wave effects, is called **stillwater elevation (SWE)**. Wave effects create an effective water surface higher than SWE, and can overtop barriers significantly higher than SWE. Wave effects include:

- **Waves:** water surface fluctuates above and below SWE, increasing the height of the hazard zone.
- **Wave Setup:** as waves move into shallow water, they slow, and increase in height.
- **Wave Runup:** after a wave breaks on the shore, the momentum of the water pushes it farther up the shoreline, such that when it finally stops and begins to recede it is at a higher elevation than wave set-up.

Conceptual representation of stillwater elevation (SWEL), wave setup, and wave runup.

The magnitude of wave effects is related to the topography of the coastline. Two products that analyze this were reviewed for this study:

- **Coastal Hazard Analysis Modeling Program version 2.0 (CHAMP 2.0):** developed by FEMA. Used for the 2013 New Haven County Flood Insurance Study (FIS), with results available in database form. Data include: 1%-annual-chance SWE, wave setup, wave heights, coastal structure failure analyses, runup analysis. CHAMP data were extracted from the New Haven County FIS at 7 transects along the West Haven area coastline.
- **Advanced Circulation Model (ADCIRC):** utilized by the USACE for the NACCS following Hurricane Sandy. Total water level data for storms of different magnitudes were extracted from the USACE Coastal Hazards System, a data storage system. NACCS data were extracted at 11 points along the West Haven area coastline.

It is important to note that the conditions at a given transect or point may not reflect those at adjacent properties. Further analysis would be required to verify or correct the results for areas currently without transects. See Figure 9, below, for locations of wave data collection.

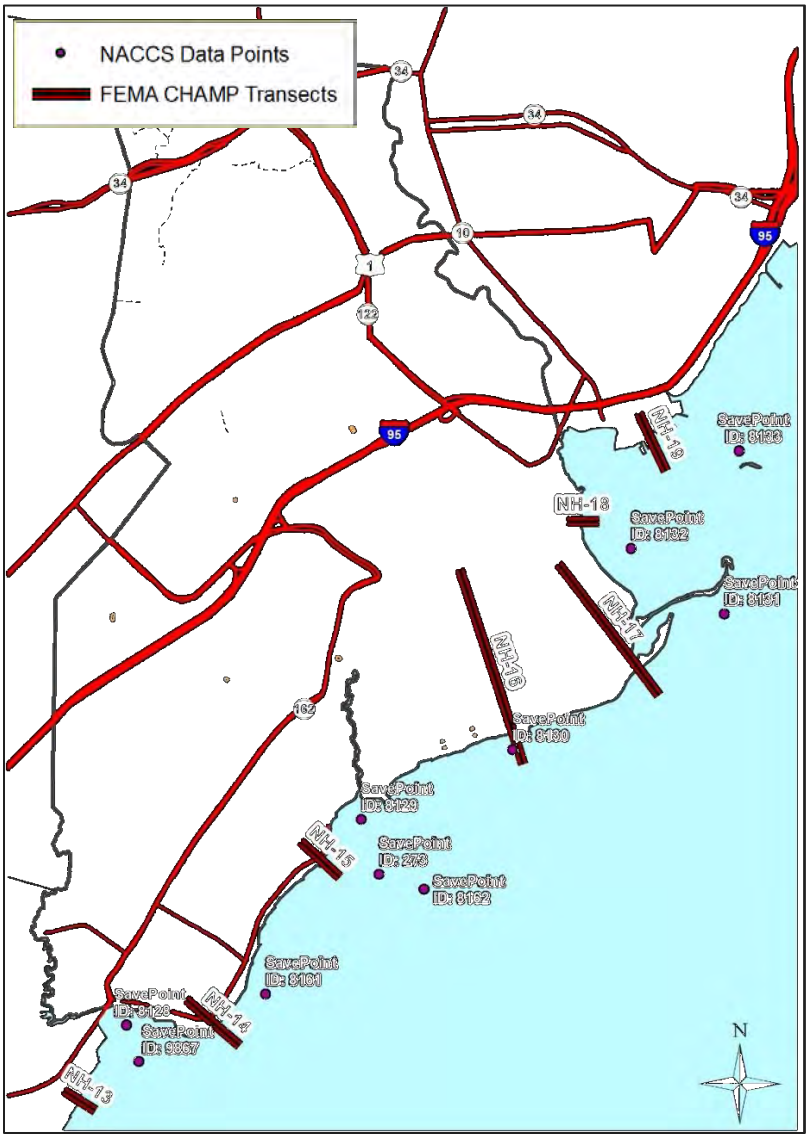


Figure 9: Locations where Wave Effect Data were Generated

Sea Level Rise Projections

The expected extent of flooding from sea level rise and storm surge effects was determined using the TNC Coastal Resilience Mapping Portal, as described in Appendix B section 3.2.3. It is important to note that this tool predicts future conditions based on data available during the model development in 2011-2012. The most immediate projections (those of conditions in the 2020s) have the highest level of confidence, with uncertainty increasing further into the future.

Vulnerabilities by Neighborhood

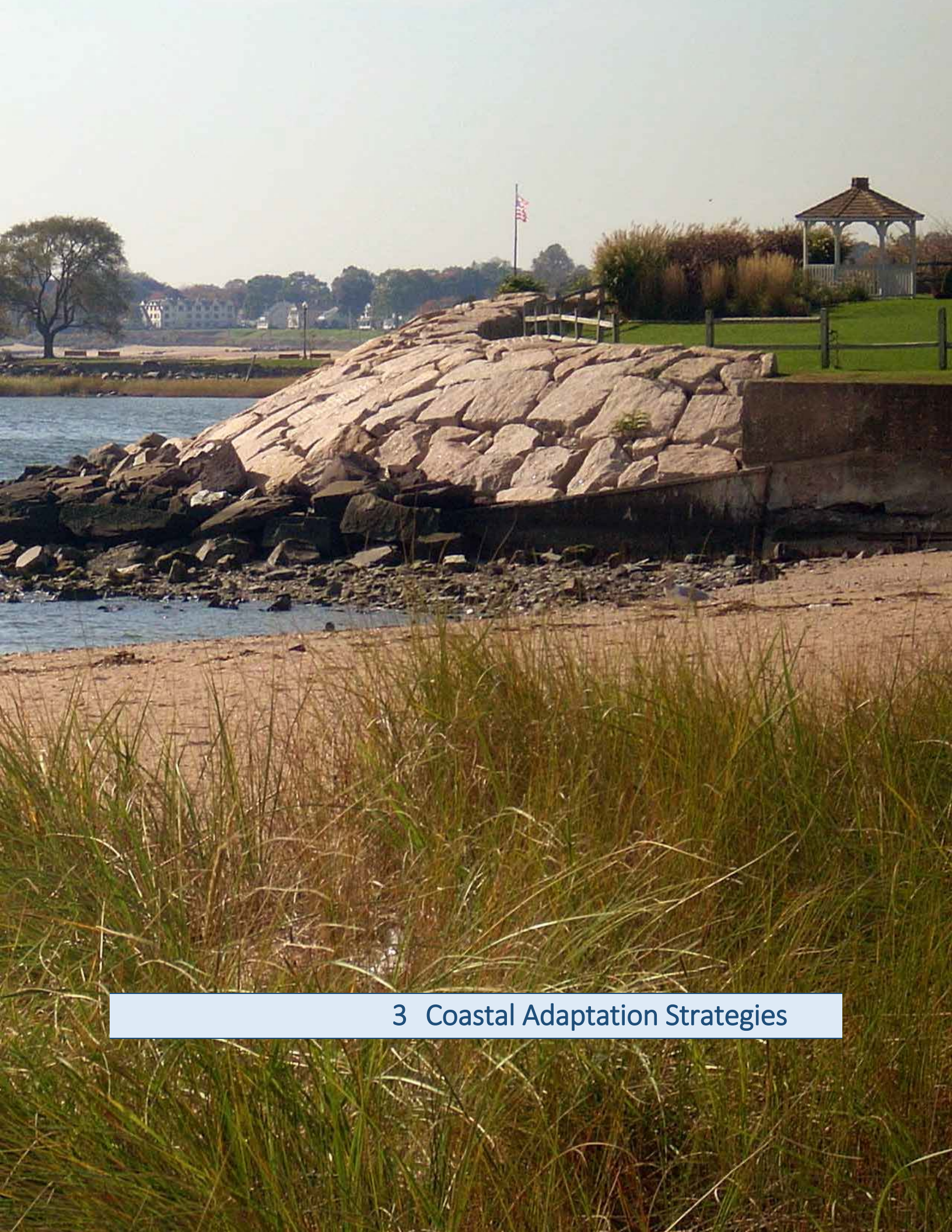
FEMA SFHA maps, CHAMP and ADCIRC results, and the TNC sea level rise and storm surge mapping tool were used to assess risk and vulnerability at different neighborhoods along the West Haven coast. This analysis is presented in detail in Appendix B sections 4.2 and 4.3 and is summarized below.

Table 3: Summary of Vulnerabilities and Risks by Neighborhood

Neighborhood	Structures	Roads	Other
Oyster River	**Low Risk** · Homes, retail on Rt. 162, vulnerable to surge	**Moderate Risk** · Woodmont Rd & Rt. 162 vulnerable to 2080s high tide	**Low Risk** · Isolation of Senior Living Center with surge · Habitat vulnerable to sea rise
Oyster River Point	**Low Risk** · Low inundation risk · Wave & runup risk	**Low Risk** · Templeton St vulnerable to 2080s high tide · Ocean Ave @ unnamed brook, Rt. 162	**Moderate Risk** · Hazards in floodway of unnamed brook · Trumbull St. pumping station vulnerable to 2050s surge
Ocean Avenue South	**Minimal Risk** · Minimal inundation risk · Wave & runup risk	**Minimal Risk** · No roads in hazard zones	**Moderate Risk** · Erosion risk. · Sewer line damage
Ocean Avenue Beaches	**Low Risk** · Minor inundation risk during surge	**Low Risk** · Ocean Ave vulnerable to very high tides	**Moderate Risk** · Abbot park vulnerable to drainage issues · Fire station: direct risk & risk of lost egress with surge · Dawson Ave. pumping station vulnerable to surge · Beach erosion risk
Cove River	**Low Risk** · Minor but widespread surge risk on wetland periphery, northern edge	**Moderate Risk** · Captain Thomas Blvd, Painter Ave, vulnerable to 2080s high tide · Educational Way, Platt Ave, Painter Dr. area vulnerable to surge	**Moderate Risk** · Habitat loss with rising seas · Savin Ave pumping station vulnerable to surge · High School vulnerable to surge
Captain Thomas Boulevard	**High Risk** · Low high-tide risk · West Walk, mall, church, other residential & retail, vulnerable to surge · Surfside vulnerable to 2080s hurricane surge	**High Risk** · Captain Thomas Blvd, other roads, vulnerable to surge	**Low Risk** · Areas vulnerable to drainage issues · Possible isolation of Surfside under surge conditions

Neighborhood	Structures	Roads	Other
Campbell Avenue	**High Risk** · Minimal high-tide risk · Widespread surge inundation risk to homes, retail, restaurant	**High Risk** · Minimal high-tide risk · Widespread inundation risk to roads with surge; isolation risk	**Moderate Risk** · Vulnerable to drainage issues · Child Development Center & Adult Daycare Center vulnerable to surge
Sandy Point	**Minimal Risk** · Few structures included in "neighborhood"	**High Risk** · High tide inundation risk for Beach St & 1st Ave	**High Risk** · Isolation, direct damage risk to WPCP at 2080s high tide · Beach erosion risk · Habitat vulnerable to sea rise
Old Field Creek	**High Risk** · Areas on creek edge are vulnerable to 2080s high tide (but should be protected by tide gate) · Widespread surge risk on wetland periphery	**High Risk** · Beach Ave, Washington Ave, Blohm St, Peck Ave, 3rd Ave, vulnerable to high tide · Widespread road inundation risk with surge; isolation risk	**High Risk** · Habitat vulnerable to sea rise · Jones St pumping station vulnerable to high tide
City Center	**Low Risk** · Commercial/industrial 2080 high tide, surge, vulnerability	**Moderate Risk** · Brown St, Water St, 2080s high tide vulnerability · Elm St, others, vulnerable to surge; isolation risk	**Low Risk** · Runup, erosion risk · Water dependent business (West Cove Co-op Marina) vulnerable
Spring Street	**Moderate Risk** · Mostly commercial/ industrial 2080s high tide vulnerability · Homes vulnerable to surge	**High Risk** · Spring St, Front St, Rt 1 vulnerable to 2080s high tide; isolation risk · Railroad vulnerable to surge	**High Risk** · Contamination of floodwater from active & abandoned industrial sites · WAVZ-AM tower vulnerable
Allingtown	**Minimal Risk** · Low risk to structures	**Low Risk** · Rt 1 vulnerable to high tide	**Moderate Risk** · Inadequate drainage system · Tide gate vulnerable to surge
Cemetery & Yale Bowl	**Minimal Risk** · Low risk to structures	**Minimal Risk** · Marginal Dr. (access road) vulnerable to high tide	**Low Risk** · Inundation of cemetery

More information about neighborhood vulnerabilities, including wave runup modeling results, is discussed in Appendix B.

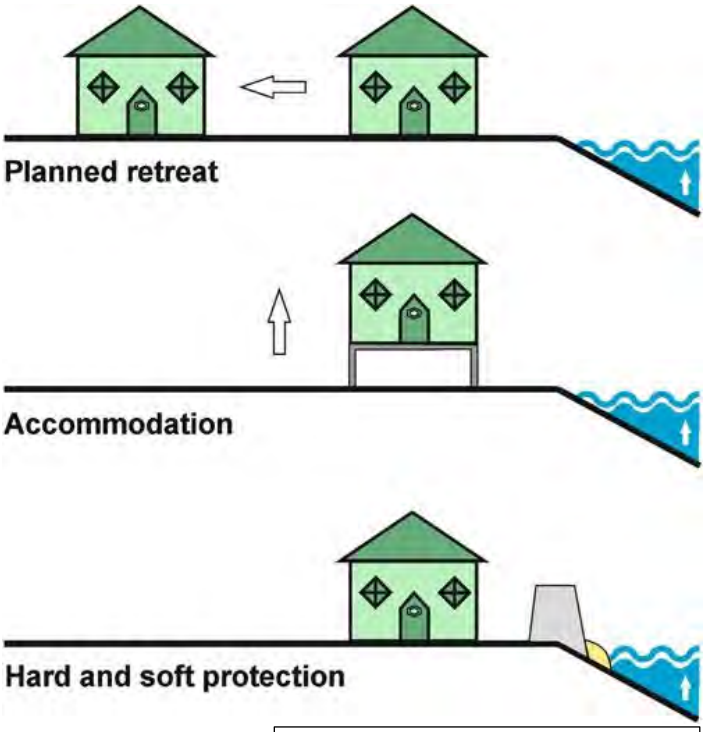


3 Coastal Adaptation Strategies

3.1 Approaches to Adaptation

The IPCC published the landmark paper "Strategies for Adaptation to Sea Level Rise" in 1990. Three basic types of adaptation were presented in the report:

- *Retreat*: abandonment of the coastal zone with no effort to protect the land from the sea.
- *Accommodation*: use of at-risk land continues, but prevention of flooding is not pursued.
- *Protection*: at-risk land is protected from coastal hazards so existing uses can continue.



https://sites.google.com/site/ccbangladesh/

In 2010, the NOAA Office of Ocean and Coastal Resource Management published the manual *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. According to the manual, NOAA's seven categories of "Climate Change Adaptation Measures" are:

- Impact Identification and Assessment
- Awareness and Assistance
- Growth and Development Management
- Loss Reduction
- Shoreline Management
- Coastal Ecosystem Management
- Water Resource Management and Protection

Elements of *protection, retreat*, and *accommodation* are found in several of these categories and subcategories of adaptation. NOAA notes that these adaptation measures are organized into categories that describe their primary purpose but, in many cases, they serve multiple purposes and could fit into multiple categories.

A thorough evaluation of adaptation approaches and options is described in Appendix C. This chapter provides an overview.

3.2 Adaptation Options

Coastal adaptation strategies include both planning (nonstructural) and structural modifications.

Planning measures include:

- Emergency preparation and response
- Redirection or retreat of development
- Procedural, regulatory, and financial modifications

Structural measures include:

- Construction of dikes, seawalls, groins, and jetties
- Installation of temporary flood barriers
- Floodproofing of buildings
- Elevation of buildings

Ideally, any measures taken should be sufficiently robust to provide adequate protection, and flexible enough to allow for adjustment under changing conditions. Such robustness and flexibility typically require a combinations of methods rather than a single solution.

Structural measures can be site-specific, "neighborhood-scale," or large-scale structures that protect many miles of infrastructure.

- Site-specific measures pertain to floodproofing specific structures on a case-by-case basis.
- Neighborhood-scale measures apply to a specific group of buildings that are adjacent to each other.
- Large-scale measures might include large dike and levee systems or tide gates that can prevent tidal surge from moving upstream.

Table 4 provides a summary of adaptation and resilience methods considered for West Haven.

Table 4: Summary of Adaptation Options

Measure	Summary	Benefits	Barriers to Implementation
Protective Infrastructure			
Hard Bank Protection	Structure parallel to shore (seawall, levee, bulkhead, revetment)	Long-lasting Effective	False sense of security Expensive maintenance Ecosystem damage
Sediment Management Structures	Hard structures reduce wave energy, manage sediment	Long Lasting May support natural processes	Permitting Down-drift sand deprivation Does not mitigate surge
Beach & Dune Management	Replenish sediment & dunes	Natural processes & habitat Aesthetic & Recreation Value	Regular maintenance Short lifespan if not maintained
Hybrid Techniques	Natural features reduce wave energy, trap sediment	Natural processes & habitat Aesthetic Value	Somewhat limited areas of applicability
Tidal Wetland Management	Creation/restoration of tidal marsh	Support Critical Habitat Reduce wave energy	Limited areas of applicability Must be very extensive to mitigate surge

Measure	Summary	Benefits	Barriers to Implementation
Community Infrastructure			
Inland Runoff Management	Slow & store water upstream, lower stress in low coastal areas	Prevent exacerbation of coastal issues Support other measures	Cost Maintenance
Surcharge Prevention	Drain low areas while preventing backflow	Support other protection methods	May be expensive Requires maintenance Doesn't address direct hazards
Transportation Infrastructure	Elevate roads or create alternative egresses	Protect emergency access and evacuation	Impact on adjacent properties
Water Distribution	Protect public water system sources & distribution	Maintain critical infrastructure, quality of life, property values	Cost
Wastewater Treatment	Protect sewer lines, pumping stations, & treatment facilities	Maintain critical infrastructure Avoid compounding hazards	Cost
Property Protection			
Elevation	Raise structure above flood level	Reduce insurance premium Open to residences Permitted in V zones	Harder to access "Dead space" under structure Difficult for some buildings
Wet Floodproofing	Retrofit lowest floor to allow flooding	Relatively inexpensive	Extensive post-flood cleanup Inappropriate for most residential
Dry Floodproofing	Waterproof structure Barriers at openings	Relatively inexpensive Doesn't require extra space	Manual barrier installation Subject to storm predictions Vulnerable to flow & waves Inappropriate for most residential
Floodwalls & Levees	Install concrete or earthen barriers	Prevent water contact with structure & need for retrofits	May require large area Obstructs views
Temporary Flood Barriers	Deployable & removable barriers	Prevent water contact with structure & need for retrofits Relatively inexpensive	Manual installation Subject to storm predictions Short-term only
Relocation	Move structure to safer location	All vulnerability removed Open to residences	Cost, decreased value of new site Loss of Neighborhood Cohesion
Adaptive Re-use	Maintain structure, change to floodable use	Low disruption, low cost	Limited applicable uses Risk persists
Acquisition & Demolition	Sell property & convert to public open space	Landowner compensated All vulnerability removed Public & habitat benefit	Municipal Cost Loss of Neighborhood Cohesion Requires landowner interest
Regulatory Tools			
Floodplain Management	Increase standards for structures in risk zones	Protect new & improved construction	Older structures often exempt Doesn't address climate change
Zoning Regulations	Prevent hazardous development patterns, allow inland migration	Control level of risk in hazard areas, plan for future changes, integrate multiple priorities	Balance with economic pressures Public pushback possible
Rolling Easements	Legal & property-right measures encourage gradual inland migration	Work with landowners for mutual benefit	Private landowner may not be willing partners
Public and Institutional Education			
Education and Outreach	Keep municipal staff and the public informed	Public & institutional support for other policies & programs	None

3.3 Options Relevant to West Haven

The comprehensive list of options presented above and evaluated in Appendix C includes adaptation measures that may be technically, financially, or otherwise not feasible for West Haven to implement; not relevant to West Haven's particular geography, geology, and hazard profile; socially or politically unacceptable to West Haven's citizens

To develop a suite of viable options for the city's consideration, coastal resilience projects undertaken by other communities were reviewed, local physical and political factors were considered, and options were discussed with West Haven's municipal officials and residents. Details of this process are discussed in Appendices C and G.

The suite of options most applicable to the City of West Haven is summarized in Table 5:

Table 5: Adaptation Options for West Haven

Categories of Options	Specific Options
Shoreline Protection	Seawalls & Bulkheads
	Groins
	Floodwalls & Levees
	Beach & Dune Management
	Bioengineered Banks
	Artificial Reefs
	Tide Gate Improvement
	Tidal Wetland Management
Infrastructure Improvements, Retrofits, and Hardening	Inland Runoff Management
	Surcharge Prevention
	Road Elevation
	Alternate Route Development
	Sewer Pumping Station Retrofit
	Water Pollution Control Facility Upgrades
Structure Protection	Elevation
	Floodproofing
	Floodwalls or Barriers
	Adaptive Re-use (Floodable Lower Floors)
	Property Acquisitions
Regulatory Tools	Flood Damage Prevention Modifications: • Freeboard • V zone standards in Coastal A zones • Increased Substantial Improvement Lookback Period
	Zoning Regulations Modifications: • Height Limit Flexibility • Tidal Marsh Protection and Advancement • Zoning Overlays
	Rolling Easements
	Road Retirement
Procedural Tools	Strengthen and Consolidate Flood Plain Coordinator Role
	Improve Departmental Collaboration
	Improve Ordinance Enforcement & Inspection
	Join FEMA Community Rating System Program
	Evacuation and Alternate Route Planning

3.3.1 Application of Adaptation Options in West Haven

The following section summarizes some of the specific adaptation options that may be relevant to different problem sites around West Haven. Many of the sites are listed under multiple options, indicating that there are multiple approaches to resiliency at that location, or that the best option would be to implement multiple adaptation measures in unison.

Hard Shoreline Protection

Options in many densely developed West Haven neighborhoods will be limited in order to ensure basic protection of important assets. Some of this protection may be accomplished through shoreline management and protective structures.

Sections of the City with assets such as structures, roads, and other infrastructure located very close to the water may require hard shoreline protection. Such areas may include those that are not geographically conducive to softer shoreline protection, those without the space to implement other protection methods, those with high banks susceptible to erosion, or those with naturally hard or rocky shorelines where structures may be vulnerable to wave action.

Areas include:

- Oyster River
- Oyster River Point
- Ocean Avenue South
- 1st Ave along New Haven Harbor
- Parts of Spring Street/Front Ave

Options include:

- Seawalls
- Bulkheads
- Revetments
- Dikes

Additional hard protections not necessarily parallel to the shoreline, or parallel but offshore, include jetties, breakwaters, and groins. Groins already exist all along the West Haven shoreline from South Street

WHAT DO OTHER STUDIES SAY ABOUT WEST HAVEN?

North Atlantic Coast Comprehensive Study (January 2015)

The NACCS was authorized by the Disaster Relief Act of 2013 on January 29, 2013. The study area included the Atlantic Ocean coastline, back-bay shorelines, and estuaries within portions of the USACE North Atlantic Division.

Analysis of risk areas and the comparison of management measures are part of the NACCS Tier 1 Analysis. The area defined as "Area_CT1_K" includes the shoreline encompassing New Haven harbor, including New Haven and a significant portion of the West Haven shoreline.

In this area, manmade structural risk reduction options such as **deployable floodwalls**, **floodwalls**, and **levees** are suggested. Non-structural risk reduction strategies such as "**Beach Restoration with Dunes**" and "**Beach Restoration with Breakwaters**" are suggested for the Sandy Point, Captain Thomas Boulevard, Cove River, and Ocean Avenue Beaches neighborhoods. **Wetland restoration** is also suggested for the Sandy Point, Spring Street, City Center, and Oyster River neighborhood.

West Haven Seawall. Image: David Murphy

Beach to Old Field Creek. The **only site** where installation of a new groin is recommended is at the mouth of the Cove Rive in order to prevent sediment from clogging the tide gate outlet.

Offshore breakwaters already protect West Haven; three large structures are located about two miles south and southeast of the city, and an "L"-shaped structure intersects the Sandy Point sand bar to the east. These structures were constructed to maintain the New Haven Harbor shipping channel. The current permitting framework in Connecticut and Long Island Sound are such that **installation of new breakwaters is unlikely to be successfully pursued, especially since breakwaters are already present offshore**.

Soft Shoreline Protection

Some sections of West Haven can be made more resilient using soft shoreline protection, which is often more aesthetically acceptable and more supportive of natural systems and processes.

Areas where soft protection measures can be implemented include:

- Ocean Avenue Beaches
- South of Captain Thomas Blvd and Campbell Ave
- Sandy Point
- Beach Street

Options for soft shoreline protection include:

- Dune Restoration
- Sediment Management
- Beach Nourishment

The beach across from Morse Park underwent a significant nourishment project in 2016.

Dune restoration or construction is a great fit for much of West Haven; dunes already exist along Beach Street and in front of the West Walk condominiums. Dunes must be located a significant distance from the water line (50 to 100 feet), and must be wide (greater than 20 feet), to be able to maintain their forms. Beaches south of Captain Thomas Boulevard, Campbell Avenue, and Beach Street may be good candidates for this work.

It may also be possible to construct a dune on a beach that is currently unsuitable if other beach building and nourishment projects are undertaken first. The Ocean Avenue Beaches area may be a candidate for this kind of project, especially at Abbot Park.

West Haven Dune
Image: David Murphy

WHAT DO OTHER STUDIES SAY ABOUT WEST HAVEN?

Connecticut Coastal Design Project (2014-2015)

The Coastal Design Project was coordinated by the TNC Coastal Resilience Program to create a dialogue between engineers, regulatory agents, geomorphologists, landscape design professionals, and natural resource managers around implementation of ecosystem-supportive shoreline protection projects.

West Haven falls within the "District C" Shoreline District, comprised of glacial drift and rock. District C is a less ideal location for natural infrastructure like living shorelines. This conclusion is not based on site-specific studies or detailed analysis of West Haven's coastal resources.

Created and Restored Tidal Wetlands and Reefs

Due to intentional maintenance of such ecosystems, most areas of West Haven that can support tidal wetlands already do.

West Haven's significant tidal wetlands include:

- Oyster River
- Cove River
- Old Field Creek
- Sandy Point Estuary
- West River

Most of these are protected from wave energy and include tide gates that control flooding. Sandy Point is vulnerable to wave action, but has been accreting and increasing in size, and so has low erosion risk.

Tidal wetland restoration or creation may be successful at the following sites:

- The southern portion of the eastern shore of West Haven adjacent to New Haven Harbor
- Near Spring Street on the bank of the West River

There are already small pockets of tidal wetland along New Haven Harbor, and more significant areas of tidal wetland along the West River. Wetlands can be expanded through changes in land use along the West River, and through created tidal-wetland technologies along New Haven Harbor.

Artificial reefs, like the Stratford reef ball project may have a parallel feasible setting in West Haven within **New Haven Harbor**. The harbor is protected from the highest wind and wave hazards due to both the natural geography and constructed breakwaters, and sediment for wetland growth is input to the system from the Mill, Quinnipiac, and West Rivers. Any reefs constructed within the harbor would have to avoid interfering with navigation.

The West Haven shore between Oyster River and Sandy Point is unlikely to contain any sites suitable to such a project where the reef balls would survive a powerful coastal storm.

West Haven Tidal Wetland
Arnold Gold-New Haven Register

WHAT IS A LIVING SHORELINE?

Many definitions of "living shoreline" are available in the literature. Restore America's Estuaries (2015) defines them as "any shoreline management systems that is designed to protect or restore natural shoreline ecosystems through the use of natural elements and, if appropriate, man-made elements. Any elements used must not interrupt the natural water/land continuum to the detriment of natural shoreline ecosystems."

SAGE (2015) notes that living shorelines achieve multiple goals such as:

- Stabilizing the shoreline and reducing current rates of erosion and storm damage
- Providing ecosystem services and increasing flood storage capacity
- Maintaining connections between land and water ecosystems to enhance resilience.

In general, the living shorelines of interest to communities in Connecticut include tidal marsh restoration or protection projects, bioengineered bank protection, beach nourishment, and vegetated dune restoration or creation.

Bioengineered Banks

Hard structures protecting the coast deflect wave energy down- and up-shore to adjacent areas, increasing risk at those sites. Additionally, when a structure does fail, it leaves a gaping hole that can open the previously protected area to rapid erosion.

Incorporation of **bioengineered banks** into shoreline protection methods could reduce, rather than deflect, wave energy in some areas, thereby reducing deterioration of adjacent structures. Additionally, CT DEEP is more likely to authorize hybrid or bioengineered methods than new hard structures. Finally, implementing this type of green infrastructure supports local ecosystems and improves the aesthetic and recreational value of a site.


Bioengineered Bank
MA Office of Coastal Zone Management

Appropriate areas for bioengineered banks include:

- Parts of the shoreline abutting New Haven Harbor
- The WPCP
- The industrial complex on Water Street
- Condominium on Bayview Place
- Ocean Avenue South (possibly)
- Oyster River Point (possibly)


Green Runoff Management
greencitiesbluewaters.wordpress.com

Given the presence of a "hard" seawall paired with a granite block revetment along the shoreline at Ocean Avenue South and Oyster River Point, it not suggested that the City pursue that option at those locations at this point.

Infrastructure Retrofits and Upgrades

Drainage

Some areas of West Haven have adequate protection from inundation and wave action, but still experience damage due to failing, inadequate, or malfunctioning drainage infrastructure.

Some of these areas would benefit from improved control of inland stormwater runoff, which has nowhere to go during high sea-level events.

Duck Bill Flap Gate
Surcharge Prevention

These areas include:

- Oyster River
- Upstream Cove River (Main Street & Painter Drive to Savin Avenue & Elm Street)
- Allingtown
- Front Avenue
- 3rd Avenue Extension
- Abbott Park

Other areas of West Haven may be vulnerable to storm-drain "surcharging." These include low-lying areas along the shoreline, such as:

- Ocean Avenue Beaches
- Captain Thomas Boulevard
- Beach Street

Roadways and Transportation

The layout of West Haven is such that even if some major roads are impassable, other routes should remain open for most residents. Nevertheless, there are some neighborhoods that might be isolated under high sea level conditions. Alternate routes would need to be determined for those that areas that would continue to be accessible but would have major throughways cut off. Under current conditions there are already roads that experience chronic flooding.

Some of the most significant roads at risk in West Haven are listed in section 2.4.1.

Areas of the City vulnerable to isolation include:

- East of Old Field Creek
- Beach Street
- Captain Thomas Boulevard

Many other areas risk being cut-off from the *most direct* routes to and from emergency service facilities during flooding or future high tide events. The southwestern part of the City, near Oyster River, could face difficulties evacuating if Woodmont Road and Route 163 are flooded.

Transportation adaptation options for these neighborhoods may include:

- Roadway elevation
- Roadway strengthening and reinforcement
- Roadway abandonment
- Mapping of alternative routes
- Construction of alternative routes

Elevation of Beach Street and First Avenue between Monahan Place and Morse Avenue is currently being pursued. This is an important adaptation measure that will improve emergency travel across Old Field Creek and to and from the WPCP.

Wastewater

The City of West Haven is served by a single WPCP, so vulnerabilities inherent to private septic systems are not a significant concern. Sections of the WPCP are within a mapped floodplain and will be affected by sea level rise and coastal storms. The plant is already protected through measures such as floodwalls, but continued maintenance and improvement of its flood mitigation methods will be necessary moving into the future.

Importantly, Beach Street, which leads to the WPCP, has already experienced flooding during surge events. Projections show that the road (at its current elevation) will experience regular nuisance flooding during non-storm conditions by the 2020s, limiting access to and from the plant. Elevation of Beach Avenue to maintain access to this critical facility during flood events is recommended.

Other approaches that can complement or replace road elevation are those that would allow personnel to maintain facility operation throughout a storm. These include:

- Floodproofing structures and components
- Protecting electric supply
- Elevating electrical systems, utilities, and offices
- Upgrading emergency power generators and installing backup fuel supplies
- Designating flood-safe spaces
- Implementing remote-access and operation programs
- Constructing floodwalls around the facility
- Constructing a flood control dike around the facility

A specific vulnerability being addressed in this Coastal Resilience Plan lies in the WPCP outfall pipe, which carries treated wastewater southeast away from the City, and discharges it deep underwater into Long Island Sound. The current pipe was installed in 1968, and has subsequently undergone a variety of repairs and maintenance projects. The pipe interacts with local currents and sediment dynamics, and is vulnerable to erosion and impacts from debris. The outfall's vulnerabilities, and a plan for installing an upgraded outfall, are detailed in a separate study funded by the same grant that funded this plan.

Many of West Haven's sewer pumping stations lie within hazard zones and may be vulnerable to sea level rise. Examples include:

- The "Main" pumping station (P.S.)
- Jones Street P.S.
- Savin Avenue P.S.
- Dawson Avenue P.S.
- East Avenue P.S.
- Cove River P.S.

A pumping station can be made resilient through:

- Elevation of station or components
- Flood-proofing of station or components
- Securing station components against the effects of waves
- Installation of floodwalls or flood control dikes surrounding station
- Acquisition of deployable floodwalls or inflatable dikes for use at stations

- Installation of flood alarms to warn of the failure of floodproofing mechanisms
- Use of submersible pumps
- Installation of standby power and backup fuel supplies
- Designing station for rapid repair (focus on return of capability rather than prevention of damage)
- Conversion from a gravity to a pressure system, and subsequent retirement of pumping stations

Pumping station components that may need to be elevated, made water-tight, or made water-proof, include:

- Manhole structures
- Electrical equipment
- Electrical transformers and generators
- Vents, vent pipes, and doors
- Fuel tanks and chemical storage tanks

The pumping stations with the highest priority for protection are the Jones Street P.S. and the Main P.S.

The revetment and seawall pair at Oyster River Point and Ocean Avenue South protects an important wastewater pipe; failure of the seawall on the landward side of the revetment and subsequent failure of the wastewater pipe could shut down sewer services for a large area of the City. Maintenance of this hard shoreline protection structure is suggested above.

Private Property Protection

All properties within flood zones are required to have flood protection measures implemented when substantial improvement or substantial damage thresholds are triggered, but additional actions should be taken to prepare for rising seas. Furthermore, there are some areas of West Haven where neighborhood-scale protective measures, such as construction of seawalls or nourishment of beaches, are not feasible or would not provide complete reduction of risk to individual structures. In such areas, individual property owners should implement additional flood protection measures.

These areas include the neighborhoods of:

- Oyster River
- Ocean Avenue Beaches
- Cove River
- Captain Thomas Boulevard
- Campbell Avenue
- Old Field Creek
- Spring Street.

Where nonresidential properties exist in these neighborhoods, floodproofing may be implemented instead of elevation.

Some neighborhoods include larger buildings and complexes that may be suitable for relatively large-scale flood barrier projects. Adaptation options for those sites can include:

- Construction of permanent floodwalls
- Installation of deployable floodwalls
- Utilization of temporary flood barriers during flood events

Neighborhoods with such sites include:

- Captain Thomas Boulevard
- Campbell Avenue
- Old Field Creek
- The upstream end of Cove River

Specific sites include:

- West Haven Housing Authority Surfside Building
- West Walk Condominium Complex
- The Soundview at Savin Rock
- Oceanside Condominiums
- One Peck Avenue
- Savin Beach Condominium Complex
- Super 8 West Haven
- West Street Industrial Area

Some of these sites already have measures implemented that reduce risk of flood damage (for example, the first floor of the Oceanside Condominiums building has no residential units and is mostly a reception area and parking garage).

Elevation of detached single or two-family residential properties should be pursued in all neighborhoods with flood risk.

Regulatory Tools

Regulatory tools apply throughout West Haven, and will vary based on the needs of specific locations. Some specific suggestions are as follows:

- *Freeboard* – West Haven does not enforce any freeboard standard in its municipal code, although the State Building Code does. The city may consider implementing a requirement of one or more feet of freeboard to provide additional protection, and to accommodate future increases in flood elevation. Possible freeboard standards that exceed the State Building Code may be as follows:
  - *X: 0.2% Annual Chance Zone - at 0.2% Annual Chance Flood Elevation*
  - *A and AE Zones - 24 inches*
  - *Coastal AE Zone (waterward of the Limit of Moderate Wave Action) - 36 inches*
  - *VE Zone - 36 inches*
- *Building Height Standards* – West Haven's building height standards vary between zones and building type, and sometimes allow for exceptions on a case-by-case basis. Most zones along the shoreline have "as-of-right" height limits of 35 feet, with allowances for special permits and uses (based on issuance of a special permit by the zoning commission). Relaxing height limits in some zones, expanding definitions of special use, and simplifying the special permit application process, may help developers or owners comply with both height standards and floodplain elevation requirements.

- *Applying VE Zone Standards in AE zones* – A "Coastal A Zone" is a SFHA AE-zone located waterward of the "Limit of Moderate Wave Action" (LiMWA) as delineated by FEMA (see section 2.4.2). Wave heights during a 1% annual-chance storm are between 1.5 and 3.0 feet in these zones (contrasted with greater than 3.0 feet in VE zones and less than 1.5 feet in AE zones). These zones are regulated as AE zones, but enforcing stricter VE zone standards can increase resilience.
    - West Haven has Coastal A zones located around Sandy Point and Old Field Creek, Cove River, and Oyster River. Areas that currently fall within Coastal A zones include:
        - Baybrook Plaza near Oyster River
        - Bradley Point and Seabluff Beach
        - the closed restaurant at 3rd Avenue Extension and Beach Street
        - Structures at the eastern end of Monahan Place
    - Old Saybrook is an example of a municipality where VE zone standards are applied in the Coastal A Zone.
- *Substantial Damage and Substantial Improvement* – Currently, the definition of Substantial Damage within West Haven's floodplain management regulations refers to damage incurred over the course of ten years, while the Substantial Improvement lookback period is only one year. If the definition of Substantial Improvement were changed to apply to alterations or repairs made over a multiple years, a greater number of properties that are not compliant with the NFIP would be brought into code more often.
    - *Here it is recommended that the substantial improvement lookback period be increased to the 5 to 10 year range.*
- *Tidal Marsh Protection and Advancement* – Of the four significant tidal marshes in West Haven, two are almost entirely regulated by tide-gates; appropriate operation of these gates will diminish the need or opportunity for inland marsh advancement. Oyster River and the West River downstream of Route 1 are unregulated, and present positive opportunities for regulations supporting tidal marsh advancement. There is limited existing green space near Beatrice Drive along the Oyster River that could be regulated. On the other hand, there is significant open space east of Front Avenue along the West River that may potentially support tidal marsh advancement.
- *Zoning Map Overlays* – Significant areas not currently included in flood zones, especially around Campbell Avenue, Old Field Creek and along the West River, are projected to be affected by future storms. Development of Zoning Overlay districts may be advisable in these areas.
- *Rolling Easements and Other Regulatory Tools* - Encouraging the gradual inland migration of development, and consequently the allowance for inland migration of coastal landforms and ecosystems, may be applicable in West Haven. Areas that may benefit in particular from such regulatory changes include those along the Oyster River, inland of the Ocean Avenue beaches, seaward of Captain Thomas Boulevard, around Old Field Creek, and along the West River.

3.3.2 Procedural Tools

- Conclusively establish the role of Flood Plain Manager or Administrator for the City and foster cooperation among departments
    - Work with the State NFIP Coordinator to ensure that the appropriate individual is identified by the State as the local Floodplain Manager or Administrator. Ensure that the Building Department, Planning and Development Office, and City Engineer work together to manage flood-related projects.
- Improve collaboration with the Emergency Manager
    - The Emergency Manager, Floodplain Manager or Administrator, and other relevant personnel and departments, must communicate about emergency flood planning, loss of utilities (including the WPCP), and other coastal emergencies.
    - Emergency Manager should outline flood response roles and responsibilities for all City agencies, and incorporate into Emergency Operations Plan
- Expand Emergency Shelter Capacity
    - New public buildings should be considered for future shelter designation, and built according to FEMA/National Disaster Preparedness Training Center Hurricane Resilient Building Design Standards.
    - Develop strategically placed backup shelters in case areas are cutoff due to flooding or other road blockages.
- Collaborate between the Building Department and Community Emergency Response Teams (CERT)
    - The Building Department should work with CERT teams to assist with post-disaster evaluation and building triage.
    - CERT teams should be trained to conduct storm damage surveys.
- Enforce Flood Plain Regulations on Public Utility Companies
    - Activities of utility companies within floodplains are commonly overlooked, but can have significant repercussions. Damage to utilities due to failure to comply with floodplain regulations can negatively impact an entire community's attempt to recover from a storm event.
- Routinely Inspect Floodway Encroachments
- Implement Floodplain Development Fee
    - City should collect fees on floodplain development permits for a separate fund to help with consumer outreach and information for residents in flood zones.
- Join the FEMA Community Rating System program
    - By going above and beyond the minimum floodplain management requirements, West Haven can reduce insurance premiums for all City property owners.
- Coastal Management Plans
    - Develop a Formalized Beach and Dune Management Plan
    - Adopt Beach and Dune Protection Ordinances
- Historic Resource Preservation
    - West Haven's POCD lists 860 locally-significant historic sites, but they are not listed on a historic register, and there is no mechanism in place to ensure their preservation.
    - The City should implement the recommendations of the "Report of Municipal Capabilities and Risks: West Haven" produced by the Connecticut Historic & Cultural Resources Coastal Resiliency Planning project (under the State Historic Preservation Office).
    - West Haven should take the first step of performing a historic resource survey of the City to identify those resources at risk.

3.3.3 Property Acquisition and Conversion to Open Space

Property owners in the Old Field Creek area have already opted for the city to purchase their properties, and further acquisitions are underway in that neighborhood. Property acquisition may be useful in many other parts of the city, although this plan recognizes that the magnitude of retreat in the Old Field Creek neighborhood will not be appropriate in other areas.

Based on the locations of hazards and the layout of different neighborhoods, the areas where such actions are most likely to be pursued successfully include:

- Oyster River
- Cove River
- Old Field Creek (properties on creek margins that have not yet been acquired)
- West River in the Spring Street/Front Ave neighborhood

3.4 West Haven Options Summary

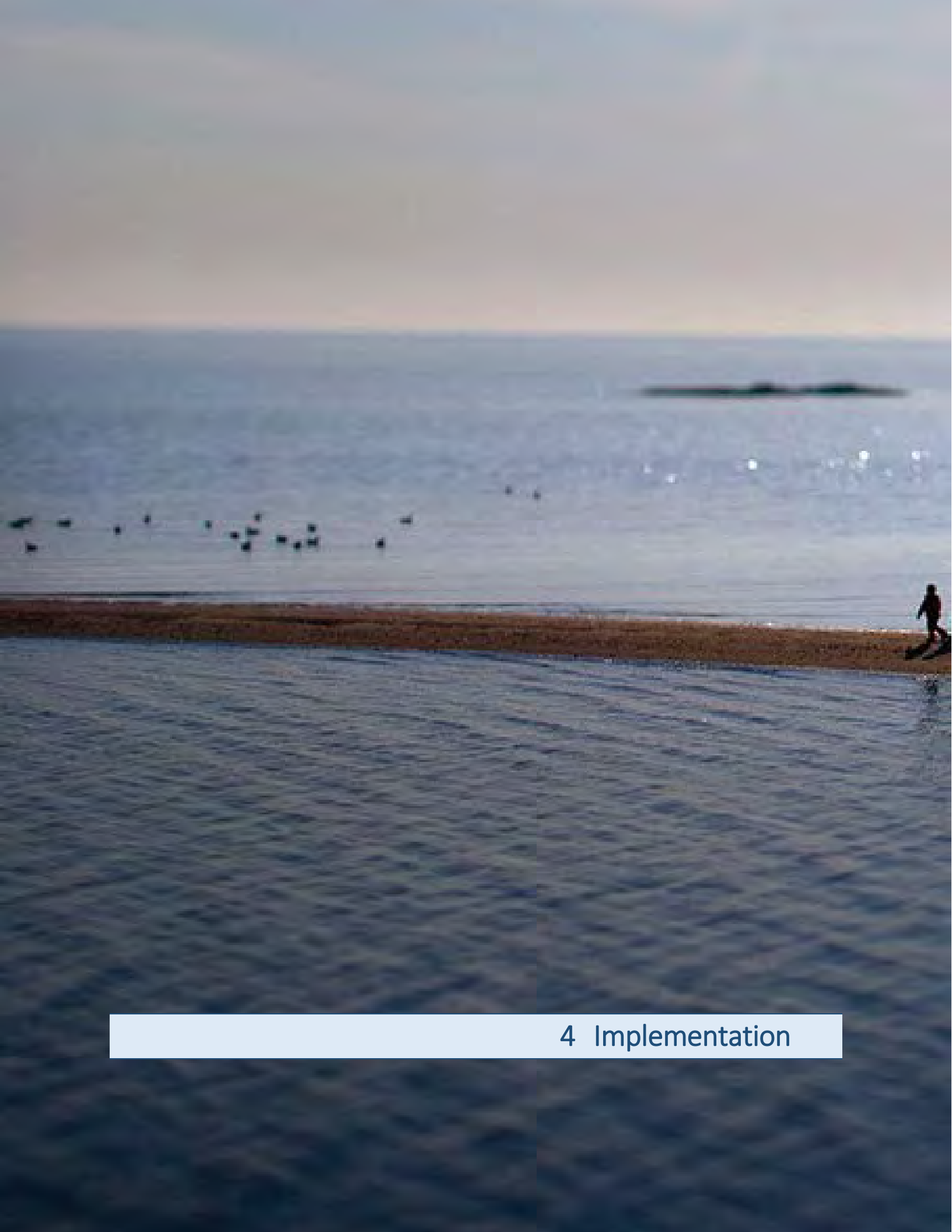
The following table summarizes where different adaptation options are most applicable throughout the West Haven shoreline.

	Shore Protection						Infrastructure					Structures				Regulatory			
Neighborhoods	Hard Protection	Beach & Dune Management	Tide Gate Improvement	Tidal Wetland Creation	Artificial Reefs	Bioengineered Banks	Inland Runoff Management	Surcharge Prevention	Road Elevation	Alternate Route Development	Pumping Station Retrofit	Structure Elevation	Structure Floodproofing	Floodwalls or Barriers	Adaptive Re-use	Zoning Changes	Rolling Easements	Road Retirement	Property Acquisition
Oyster River	X		X				X		X	X	X	X				X	X		X
Oyster River Point	X					X			X		X					X	X		
Ocean Avenue South	X					X													
Ocean Avenue Beaches		X					X	X	X		X	X	X						
Cove River			X				X		X		X	X	X	X		X	X		X
Captain Thomas Blvd		X						X	X			X	X	X	X	X			
Campbell Avenue							X	X	X	X		X	X	X	X	X			
Sandy Point		X						X	X			X	X		X		X	X	
Old Field Creek				X			X		X		X	X		X		X	X	X	X
City Center	X				X	X											X		
Spring Street/Front Ave	X			X			X		X	X	X	X	X				X		X
Allingtown							X		X									X	
Cemetery & Yale Bowl									X										

Beach and dune replenishment and nourishment through sediment placement and control efforts will be a large part of West Haven's resilience efforts. Tidal marsh protection and enhancement through tide gate improvement, zoning regulations, and ordinance enforcement, will continue to support this important ecological and social resource while preventing development in hazardous areas. The city is encouraged to explore the use of hybrid alternatives to hard shoreline protection, including bioengineered banks, in appropriate areas such as along New Haven Harbor.

Facilitating structural retrofits will also be a central aspect of West Haven's coastal resilience efforts moving forward. Large-scale resilience projects designed to protect entire neighborhoods should be pursued, but it will not be possible to guarantee protection from all future coastal hazards. There are a number of larger residential and commercial structures and complexes located within coastal risk areas for which a variety of flood protection measures can be implemented, including permanent or temporary floodwalls and dry and wet floodproofing.

West Haven should enact regulatory and procedural changes to support resiliency efforts, including making the definition of "Substantial Improvement" apply more broadly (thus requiring more structures to be brought into compliance with flood zone regulations) and altering zoning regulations to encourage resilient construction methods. For areas such as the Old Field Creek neighborhood, robust evacuation route and emergency access planning and communication will be essential for ensuring the safety of residents where floods cannot be entirely prevented.



4 Implementation

The Planning and Development Department is the appropriate entity for prioritizing and tracking the actions presented in this plan. This department's involvement will ensure that objectives from the Coastal Resilience Plan are addressed in a coordinated manner with other planning documents such as the POCD, the Harbor Management Plan, and the West Haven section of the SCRCOG Multi-Jurisdiction Hazard Mitigation Plan.

Specific actions in this coastal resilience plan will be implemented by specific departments such as the Building Department, the Community Development Administration, Planning and Development, Parks and Recreation, and Public Works.

4.1 Implementation Matrix

A matrix of coastal resilience actions and implementation strategies is provided below.

Table 6: West Haven Coastal Resilience Plan Implementation Strategy

	Action	Responsible Department	Timeframe														Funding Sources
			2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080		
Citywide Regulatory Changes																	
R1	Relax height restrictions, expand "special uses" definition, simplify special permit application to facilitate elevation projects	P&D	■														OB
R2	Increase "lookback period" in Substantial Improvement definition to 5-10 years.	P&D	■														N/A
R3	Adopt freeboard that exceeds the state-recommended 1 ft, as follows: • X: 0.2% Annual Chance Zone - at 2% Annual Chance Flood Elevation • A and AE Zones - 24 inches • Coastal AE & VE Zones (waterward of LiMWA) - 36 inches	P&D		■													N/A
R4	Enforce V zone standards in coastal A zones (to LiMWA)	P&D		■													N/A
Citywide Procedural Changes																	
Pr1	Conclusively establish the role of Flood Plain Manager or Administrator for the City and foster cooperation among departments	Mayor	■														N/A
Pr2	Improve collaboration of city departments with the Emergency Manager	EM	■														N/A
Pr3	Collaborate between the Building Department and Community Emergency Response Teams to assist with post-disaster evaluation and building triage.	EM	■														N/A
Pr4	Enforce Floodplain Regulations on Public Utility Companies	Engineer	■														N/A
Pr5	Implement Floodplain Development Fee	P&D	■														N/A
Pr6	Join the FEMA Community Rating System Program	P&D	■														OB
Pr7	Develop a Formalized Beach and Dune Management Plan	Park&Rec		■													CT-CIRCA USACE-205
Pr8	Develop and adopt Beach and Dune Protection Ordinances	P&D		■													CT-CIRCA
Pr9	Improve emergency sheltering capabilities.	EM		■													FEMA-HMA
Pr 10	Implement POCD objectives relevant to coastal resilience, including: • Waterfront development should be dominated by water-dependent uses • Other water-related uses should be separated by road, other land, or beach • Develop open space links between neighborhoods, parks, boardwalk, etc.	P&D		■	■												OB
Pr 11	Implement relevant Harbor Management Plan actions including: • Preservation and enhancement of tidal wetland resources • Application of urban runoff reduction measures on a watershed basis	HMC		■	■												EPA-CWA NRCS
Pr 12	Implement Water Pollution Control Facility adaptation measures, including outfall pipe replacement as described in Black & Veatch report.	PW	■														EPA-CWA
Citywide Promotion of Property Protection																	
PP1	Perform a cultural resources survey to identify those located in coastal risk zones.	Building	■	■													CT-SHPO
PP2	Promote floodproofing of non-residential buildings	CDA	■	■	■	■	■	■	■	■	■	■	■	■	■		OB
PP3	Partner with property owners to apply for FEMA grants to elevate homes	CDA	■	■	■	■	■	■	■	■	■	■	■	■	■		FEMA-HMA HUD-CDBG
PP4	Promote home-elevation loan programs such as the defunct Shore Up program	CDA	■	■	■	■	■	■	■	■	■	■	■	■	■		OB
PP5	Implement recommendations of the "CT Historic & Cultural Resources Coastal Resiliency Planning Report on Municipal Capabilities and Risk" West Haven report	P&D	■	■	■	■	■	■	■	■	■						CT-SHPO

	Action	Responsible Department	Timeframe	Funding Sources
	Educational Projects			
Ed1	Perform education and training programs for municipal personnel and staff to identify nexuses between their areas of responsibility and coastal resilience	Mayor		OB NROC
Ed2	Install signage along West Haven boardwalk and at public beaches to educate the public about coastal hazards and the city's resilience projects	Park&Rec		OB
Ed3	Educate property buyers about likely future risks faced by properties, even if they are outside current hazard zones.	Building		OB
	Oyster River Projects			
OR1	Prevent new development on open spaces adjacent to Oyster River to allow for future marsh migration.	P&D		N/A
OR2	Implement Rolling Easements to encourage the gradual inland migration of development and tidal marsh.	P&D		N/A
OR3	Elevate Woodmont Road to 13 or 14 ft NAVD88 to maintain passage during future storms (increase culvert size & number of openings to improve flow regime.	PW		FEMA-HMA
	Oyster River Point Projects			
OP1	Adopt and enforce more stringent floodway regulations.	Building		N/A
OP2	Gradually re-route utility infrastructure away from shoreline where possible.	PW		OB
	Ocean Avenue South Projects			
OS1	Implement Woodruff Street seawall repair as per the Woodruff Street concept design memo (extend as needed to protect entire sanitary sewer line)	PW		FEMA-HMA
OS2	Gradually re-route utility infrastructure away from shoreline where possible.	PW		OB
	Ocean Avenue Beaches Projects			
OB1	Implement floodproofing, grading, and other flood mitigation measures to protect West Shore Fire Dept. while maintaining its historicity and ability to operate during emergencies.	EM		FEMA-HMA CT-SHPO
OB2	Nourish beach from South Street to Ivy Street. Construct Dune on backside of beach. Install fencing and dune crossovers to prevent degradation by pedestrians.	PW		USACE-205 FEMA-HMA NOAA-RCR
	Cove River Projects			
CR1	Upgrade Cove River Tide Gates as per the Cove River Tide Gate concept design memo	PW		USACE-205 CIRCA
CR2	Improve bridge & channel on Cove River at Painter Drive & West Main Street	PW		FEMA-HMA OB
CR3	Study, design, construct Cove River Channel & retention basins to reduce flooding at Greta St. & West Spring St.	PW		NROC CIRCA NRCS
	Downtown South Projects (includes projects applicable to Captain Thomas Boulevard, Campbell Avenue, and Sandy Point Planning Neighborhoods)			
DS1	Nourish beach from Savin Rock Conference Center to Morse Avenue. Construct continuous dune to elevations described in concept design memo. Install fencing and dune crossovers to prevent degradation by pedestrians.	PW		USACE-205 FEMA-HMA NOAA-RCR
DS2	Explore short-term mitigation options at West Walk Condominiums, including construction of floodwalls with deployable floodgates around complex.	Building		HUD Grants (CDBG)
DS5	Implement a zoning overlay to promote flood-smart development in areas that will be vulnerable to flooding in the future but are outside existing hazard zones.	P&D		OB
DS4	Pursue other property-specific adaptation measures based on type of property and type of risk	CDA		HUD-CDBG
DS6	Implement Downtown South conceptual plan.	CDA		Multiple
DS3	Explore long-term mitigation options at West Walk Condominiums, including addition of a third floor and elevation of internal living spaces. Apply to other condominiums if successful.	CDA		HUD-CDBG
	Old Field Creek Projects			
OF1	Continue to partner with property owners to buy out repeatedly damaged homes, and convert to open space.	CDA		FEMA-HMA NOAA-RCR
OF2	Complete elevation of 1st Avenue and Beach Street.	PW		FEMA-HMA
OF3	Construct plunge pool at Peck Avenue to lower sediment input to system.	PW		NRCS EPA-CWA
OF4	Elevate Blohm Street and upgrade crossing at Old Field Creek to Bridge	PW		FEMA-HMA

	Action	Responsible Department	Timeframe													Funding Sources
			2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	
New Haven Harbor Projects																
NH1	Construct bioengineered bank at Bayview Place condominiums to mitigate erosion and prevent collapse	PW														CIRCA NOAA-RCR
NH2	Construct green infrastructure shoreline projects, including bioengineered banks east of 1st Avenue.	PW														CIRCA NOAA-RCR
Spring Street Projects																
SS1	Prevent new development on open spaces adjacent to West River to allow for future marsh migration.	P&D														N/A
SS2	Acquire and demolish unused industrial sites and convert to open space.	CDA														FEMA-HMA NOAA-RCR
SS3	Implement Rolling Easements to encourage the gradual inland migration of development and tidal marsh.	P&D														N/A
SS4	Partner with property owners to buyout repeatedly damaged homes, and convert to open space.	CDA														FEMA-HMA NOAA-RCR
SS5	Elevate Spring Street to 10 ft NAVD88 to maintain access during future storm events.	PW														FEMA-HMA
SS6	Pursue acquisition of industrial uses within 1% annual-chance flood zones	CDA														FEMA-HMA NOAA-RCR
Allingtown, Cemetery and Yale Bowl Projects																
AI1	Extend pedestrian walkway from Marginal Drive to Derby Avenue providing safe and enjoyable public access to the river for walking, nature study, and fishing	Park&Rec														OB
AI2	Implement green infrastructure for storm runoff reduction	PW														EPA-CWA

Implementation Matrix Legend:

Department

- Building – Building Department
- CDA – Community Development Administration
- EM – Emergency Management Director
- Engineer – City Engineer
- Mayor – Mayor's Office
- P&D – Planning and Development Department
- Parks & Rec – Parks and Recreation Department
- PW – Public Works Department

Funding Source:

- CT-CIRCA – CT Institute of Resilience & Climate Adaptation
- CT-SHPO – CT State Historic Preservation Office
- EPA-CWA – EPA Clean Water Act Grant
- FEMA-HMA – FEMA Hazard Mitigation Assistance
- HUD-CDBG – HUD Community Development Block Grant
- NOAA-RCR – NOAA Regional Coastal Resilience Grant
- NRCS – NRCS Emergency Watershed Protection AND Watershed and Flood Prevention Operations
- NROC – Northeast Regional Ocean Council
- OB – City / Department Operating Budget
- USACE-205 – US Army Corps of Engineers Section 205 Funding

4.2 Funding Sources

As the appropriations related to Hurricane Sandy are exhausted in 2016 and 2017, the city will need to look toward the existing traditional state and federal funding sources as well as new and emerging funding sources to adapt to coastal hazards and become more resilient. Examples are described below.

New and Emerging Sources of Funding

Connecticut Institute of Resilience and Climate Adaptation (CIRCA) Municipal Resilience Grant Program

During each application cycle, up to $100,000 is available from CIRCA. Project proposals should develop knowledge or experience that is transferable to multiple locations in Connecticut and have well-defined and measurable goals. Additionally, preference is 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:

- Develop and deploy natural science, engineering, legal, financial, and policy best practices for climate resilience;
- Undertake or oversee pilot projects designed to improve resilience and sustainability of the natural and built environment along Connecticut's coast and inland waterways;
- 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
- Reduce the loss of life and property, natural system and ecological damage, and social disruption from high-impact events.

The city should access CIRCA grants as applicable projects are advanced from this plan.

Northeast Regional Ocean Council (NROC)

NROC is a state/federal partnership that facilitates the New England states, federal agencies, regional organizations, and other interested regional groups in their efforts to address ocean and coastal issues from a regional perspective. NROC builds capacity of New England communities through training and a small grants program to improve the region's resilience and response to impacts of coastal hazards and climate change. The city should access NROC grants as applicable projects are advanced from this plan.

National Oceanic and Atmospheric Administration (NOAA) Regional Coastal Resilience Grants

NOAA is committed to helping coastal communities address increasing risks from extreme weather events, climate hazards, and changing ocean conditions. To that end, NOAA's National Ocean Service is providing funding through competitive grant awards through the Regional Coastal Resilience Grants program. Awards are made for project proposals that advance resilience strategies, often through land and ocean use planning; disaster preparedness projects; environmental restoration; hazard mitigation planning; or other regional, state, or community planning efforts. Successful proposals demonstrate regional coordination among project stakeholders, leverage resources (such as funds, programs, partnerships, and others), and create economic and environmental benefits for coastal communities. Project results are evaluated using clear measures of success, with the end goal being improved preparation, response, and recovery.

Eligible applicants include nonprofit organizations; institutions of higher education; regional organizations; private (for profit) entities; and local, state, and tribal governments. Award amounts

typically range from $500,000 to $1 million for projects lasting up to 36 months. Cost sharing through cash or in-kind matches is expected. Applicants must conduct projects benefiting coastal communities in one or more of the 35 U.S. coastal states or territories.

Because the Regional Coastal Resilience Grants program favors regional approaches to resilience problems, the city should pursue future funds with a group of municipalities (such as the Council of Governments) or with the State of Connecticut.

Regional and National Design Competitions

Although the Rebuild By Design (RBD) competition and National Disaster Resilience Competition (NDRC) awards were announced in the last 3 years and the competitions are complete, they have provided a new model for screening and selecting resilience grant awardees in the United States. The city should keep abreast on future design competitions and consider pursuing these competitions as an individual applicant (if eligible), with a group of municipalities, or directly as an active participant with the State of Connecticut.

Traditional Sources of Funding

U.S. Department of Housing and Urban Development (HUD)

Community Development Block Grant (CDBG)

The Connecticut Department of Housing administers the CDBG program in Connecticut. The CDBG program provides financial assistance to eligible municipalities in order to develop viable communities by providing affordable housing and suitable living environments, as well as expanding economic opportunities, principally for persons of low and moderate income. It is possible that the CDBG funding program could be applicable for floodproofing and elevating residential and nonresidential buildings, depending on eligibility of those buildings relative to the program requirements.

CDBG Disaster Recovery (CDBG-DR)

After disaster declarations, and when funds are appropriated to HUD and the Connecticut Department of Housing, the City of West Haven should apply for CDBG-DR grants. The city has clearly been capable of securing CDBG-DR grants; several ongoing and upcoming resilience projects are funded by this program.

Natural Resources Conservation Service (NRCS)

The NRCS provides technical assistance to individual landowners, groups of landowners, communities, and soil and water conservation districts on land use and conservation planning, resource development, stormwater management, flood prevention, erosion control and sediment reduction, detailed soil surveys, watershed/river basin planning and recreation, and fish and wildlife management. Financial assistance is available to reduce flood damage in small watersheds and to improve water quality. Two major programs are described below.

Emergency Watershed Protection Program (EWP)

Through the EWP program, the U.S. Department of Agriculture's NRCS can help communities address watershed impairments that pose imminent threats to lives and property. Most EWP work is for the protection of threatened infrastructure from continued stream erosion. NRCS may pay up to 75% of the construction costs of emergency measures. The remaining costs must come from local sources and can

be made in cash or in-kind services. No work done prior to a project agreement can be included as in-kind services or part of the cost share. EWP projects must reduce threats to lives and property; be economically, environmentally, and socially defensible; be designed and implemented according to sound technical standards; and conserve natural resources.

Watersheds and Flood Prevention Operations

This program element contains two separate and distinct programs, "Watershed Operations" and "Small Watersheds." The purpose of these programs is to cooperate with state and local agencies, tribal governments, and other federal agencies to prevent damages caused by erosion, floodwater, and sediment and to further the conservation, development, utilization, and disposal of water and the conservation and utilization of the land. The objectives of these programs are to assist local sponsors in assessing conditions in their watershed, developing solutions to their problems, and installing necessary measures to alleviate the problems. Measures may include land treatment and structural and nonstructural measures. Federal cost sharing for installation of the measures is available. The amount depends upon the purposes of the project.

Federal Emergency Management Agency (FEMA)

Pre-Disaster Mitigation (PDM) Program

The Pre-Disaster Mitigation Program was authorized by Part 203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. The PDM program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of mitigation projects prior to disasters, providing an opportunity to reduce the nation's disaster losses through predisaster mitigation planning and the implementation of feasible, effective, and cost-efficient mitigation measures. Funding of predisaster plans and projects is meant to reduce overall risks to populations and facilities.

Hazard Mitigation Grant Program (HMGP)

The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not "lost" during the recovery and reconstruction process following a disaster.

HMGP is available only in the months subsequent to a federal disaster declaration. Because the state administers HMGP directly, application cycles will need to be closely monitored after disasters are declared.

Flood Mitigation Assistance (FMA) Program

The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP). FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities.

One limitation of the FMA program is that it is generally used to provide mitigation for structures that are insured or located in Special Flood Hazard Areas (SFHAs).

U.S. Army Corps of Engineers (USACE)

The U.S. Army Corps of Engineers provides 100% funding for floodplain management planning and technical assistance to states and local governments under several flood control acts and the Floodplain Management Services (FPMS) Program. Specific programs used by USACE for mitigation are listed below.

Section 205 – Small Flood Damage Reduction Projects

This section of the 1948 Flood Control Act authorizes USACE to study, design, and construct small flood control projects in partnership with nonfederal government agencies. Feasibility studies are 100% federally funded up to $100,000 with additional costs shared equally. Costs for preparation of plans and construction are funded 55% with a 35% nonfederal match. In certain cases, the nonfederal share for construction could be as high as 50%. The maximum federal expenditure for any project is $7 million.

Section 14 – Emergency Streambank and Shoreline Protection

This section of the 1945 Flood Control Act authorizes USACE to construct emergency shoreline and stream bank protection works to protect public facilities such as bridges, roads, public buildings, sewage treatment plants, water wells, and nonprofit public facilities such as churches, hospitals, and schools. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $1.5 million.

Section 208 – Clearing and Snagging Projects

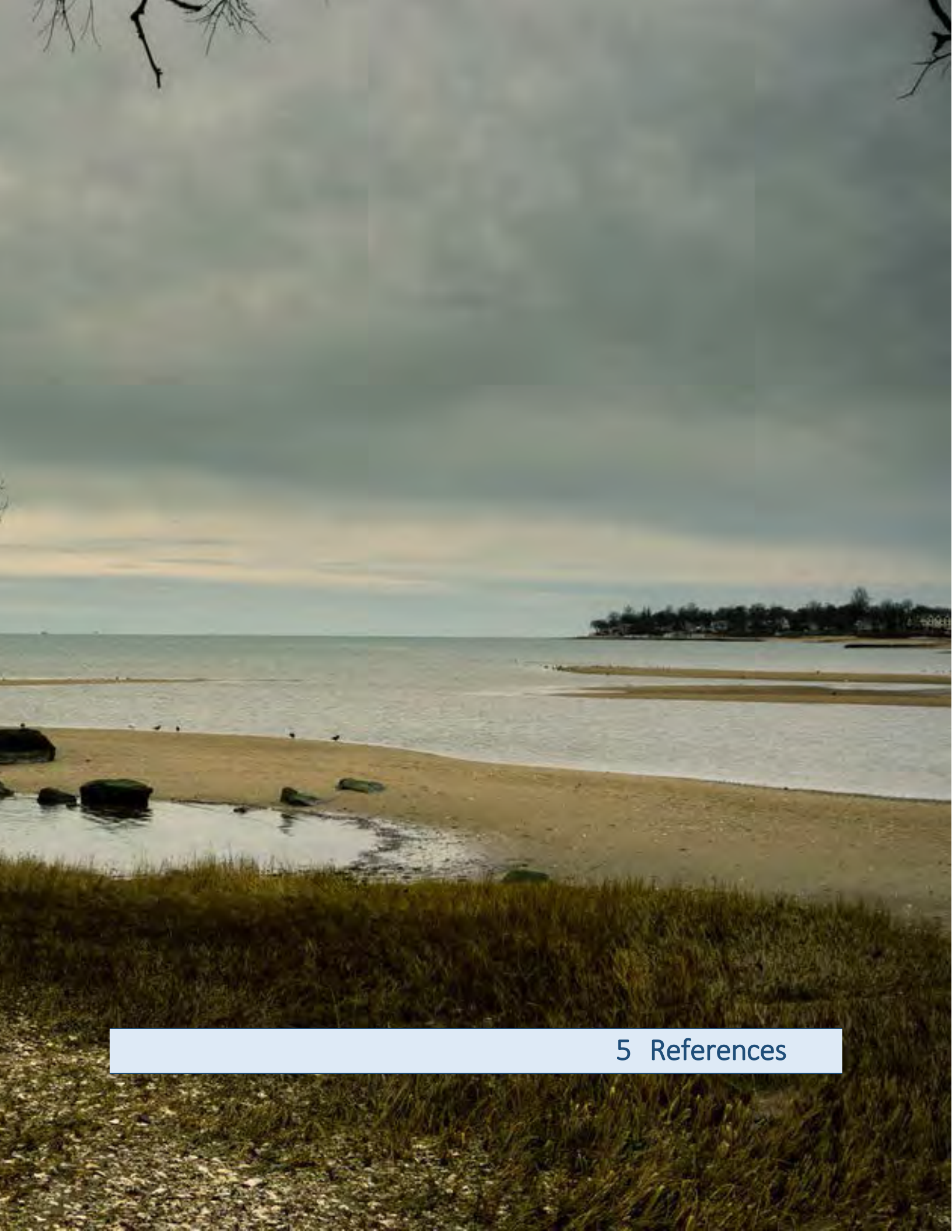
This section of the 1954 Flood Control Act authorizes USACE to perform channel clearing and excavation with limited embankment construction to reduce nuisance flood damages caused by debris and minor shoaling of rivers. Cost sharing is similar to Section 205 projects above. The maximum federal expenditure for any project is $500,000.

Section 205 – Floodplain Management Services

This section of the 1950 Flood Control Act, as amended, authorizes USACE to provide a full range of technical services and planning guidance necessary to support effective floodplain management. General technical assistance efforts include determining the following: site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages, or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural floodplain resources; and flood loss potentials before and after the use of floodplain management measures. Types of studies conducted under FPMS include floodplain delineation, dam failure, hurricane evacuation, flood warning,

floodway, flood damage reduction, stormwater management, floodproofing, and inventories of floodprone structures. When funding is available, this work is 100% federally funded.

In addition, USACE also provides emergency flood assistance (under Public Law 84-99) after local and state funding has been used. This assistance can be used for both flood response and postflood response. Corps assistance is limited to the preservation of life and improved property; direct assistance to individual homeowners or businesses is not permitted. In addition, USACE can loan or issue supplies and equipment once local sources are exhausted during emergencies.



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[4] Acquired by Milone & MacBroom, Inc. in 2005

APPENDIX A
Existing Resources and Capabilities

APPENDIX B
Risk and Vulnerabilities

APPENDIX C
Review of Options for Coastal Resilience

APPENDIX D
Cove River Tide Gate Coastal Resilience Concept

APPENDIX E
Beach and Dune Nourishment Coastal Resilience Concept

APPENDIX F
Woodruff Street Infrastructure Design Concept

APPENDIX G
Notes from Public Meetings

APPENDIX H
Results from Online Survey