REGIONAL FRAMEWORK for COASTAL RESILIENCE

NAHE STINAL REPORT
JUNE 2017







Acknowledgements:

The Core Team responsible for delivering this document - South Central Regional Council of Governments, The Nature Conservancy, and the Connecticut Metropolitan Council of Governments - sincerely thanks those individuals and organizations that contributed to the success of this Southern Connecticut Regional Framework for Coastal Resilience. Central to this endeavor was the commitment provided by the leadership and staff of the ten municipalities (Fairfield, Bridgeport, Stratford, Milford, West Haven, New Haven, East Haven, Branford, Guilford, and Madison). The core team greatly appreciated the time and energy provided by the project's advisory team including Yale University, Connecticut Department of Energy and Environmental Protection, Connecticut Department of Housing, and Connecticut Institute for Resilience and Climate Adaptation. In addition, we would like to recognize the contributions of Milone and MacBroom and GEI Consultants. Special thanks to the City of Milford for providing an exemplary workshop space on several occasions. Finally, we extend a special thanks to the National Fish and Wildlife Foundation staff and those at the United States Department of Interior that helped ensure all the necessary programmatic requirements were satisfied.

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The Southern Connecticut Regional Framework for Coastal Resilience is a joint project managed collaboratively by the South Central Regional Council of Governments, The Nature Conservancy, and the Connecticut Metropolitan Council of Governments.

Executive Statement:

The Southern Connecticut Regional Framework for Coastal Resilience, encompassing ten municipalities, was conceived and launched to provide proactive risk assessment, community engagement, conceptual design of on-theground projects, and a Final Report in hopes of minimizing the consequences of extreme weather and climate change while strengthening existing and future ecosystems. The principal guiding question used to foster this Regional Resilience Framework for Fairfield, Bridgeport, Stratford, Milford, West Haven, New Haven, East Haven, Branford, Guilford, and Madison was - "how do we create collaborative actions across and between municipalities to ensure a regional integration of resilience via strong and growing partnerships". This guiding question was advanced through a carefully devised fluid, yet functional, project team structure that integrated representation from all ten municipalities, regional organizations, non-profit entities, youth organizations, businesses, civic groups, state/ federal agencies, and a diverse array of community and regional-based stakeholders. The core and extended team structure accelerated collaboration on the principal project tasks: comprehensively cataloguing all potential resilience projects, community engagement and community resilience building via workshops and site visits, development of geospatial databases and online decision-support applications, and finally, the creation of conceptual designs for high priority projects. This collective endeavor represents the first time a Regional Resilience Framework process and approach has been conceived and advanced in the state of Connecticut. With this Regional Resilience Framework for Southern Connecticut in place, the projects and partnerships needed to comprehensively advance risk reduction and resilience for over 591,000 residents in ten municipalities across Fairfield and New Haven County representing 30% of Connecticut's coast has been given every opportunity to thrive.

Citation:

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Additional resources about this project can be found at:

- http://www.ctmetro.org/coastal-resilience
- http://scrcog.org/regional-planning/coastal-resilience



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EXECUTIVE SUMMARY

In the aftermath of Tropical Storms Irene and Sandy, the population centers of Greater New Haven and Bridgeport (Fairfield east to Madison – Fairfield and New Haven County) collectively recognized a significant level of exposure and vulnerability to the infrastructure, environment, and socio-economic assets from extreme weather events and a changing climate. To counteract immediate and longer-term risks and broaden dialogue on community resilience building, the Southern Connecticut Regional Framework for Coastal Resilience project was launched. The overarching goal of this project was prioritizing actions and strengthening partnerships by providing proactive risk assessment, community engagement, conceptual design of on-the-ground projects, and the following Final Report. The principal purpose being to advance a Regional Resilience Framework, built on projects and partnerships, needed to help comprehensively improve resilience for over 591,000 residents from ten municipalities within Fairfield and New Haven County that represent over 30% of Connecticut's coast. A core goal of this project was to strengthen the resilience of existing and future ecosystems including a diverse suite of services and co-benefits along-side existing and future development activities within a population center critical to the state of Connecticut's future.

The main objective of the project was to comprehensively prioritize resilience opportunities for residents across ten municipalities in Fairfield and New Haven County using where appropriate and feasible green and natural infrastructure to help enhance existing natural resources, improve public amenities, and reduce risk from hazards over immediate and longer term planning horizons. This "triple-bottom line approach to resilience" using natural infrastructure is this Regional Resilience Framework's hallmark and a critical consideration for other regions across the USA and globally. This collective endeavor represents the first time a Regional Resilience Framework process and approach has been conceived and advanced in the state of Connecticut. The Regional Resilience Framework provided a flexibly organizing structure and process that accelerated resilience across the urban and rural coastlines and watersheds with the project footprint. The conceptual designs developed as part of this project provide a wide range of common situations and hybrid solutions applicable well beyond the project area. This unique and critical Regional Resilience Framework has been achieved through a collaborative partnership between South Central Regional Council of Governments, the Nature Conservancy, and Connecticut Metropolitan Council of Governments alongside the ten municipalities, non-profit entities, state/federal agencies, academic institutions, youth organizations, businesses, and civic groups. It is the sincere hope of the project team, that the process and reports generated will help these communities and many others secure greater clarity on the common challenges they face while providing a positive vision for continued dialogue, resource sharing, and collaborative leadership needed to create a truly resilience region.

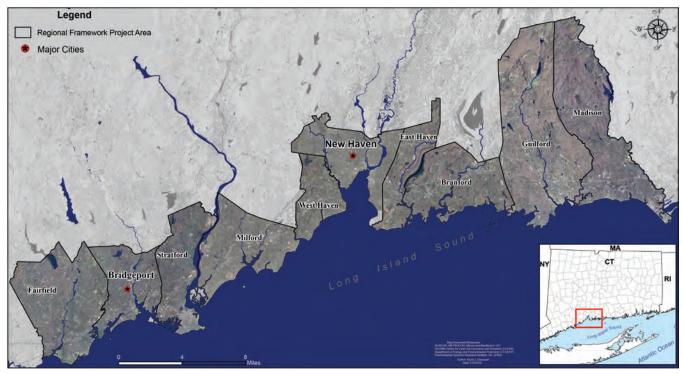
EXECUTIVE SUMMARY



SECTION 1: Introduction

Regional Resilience Framework Project Context

Geographically, the Southern Connecticut Regional Framework for Coastal Resilience encompasses the state of Connecticut's south central coast including the municipalities, from west to east, of Fairfield, Bridgeport, Stratford, Milford, West Haven, New Haven, East Haven, Branford, Guilford, and Madison (coastal Fairfield and New Haven County). The ten municipalities are represented by all three coastal U.S. Congressional Districts (Fourth, Third, Second) in Connecticut. This collection of municipalities encompasses much of the greater Bridgeport and New Haven region. This project area is serviced by two regional planning organizations (known as Council of Governments (COG) in Connecticut) with a combined population of 591,000 people (16% of state of Connecticut's population). The principal purpose of this project is to help improve the resilience for the region's half-million residents, community organizations, businesses and other stakeholders that represent municipalities, non-profit entities, COGs, and state and federal agencies among others. A core goal of the projects was to strengthen the resilience of existing and future ecosystems including a diverse suite of services and co-benefits along-side existing and future development activities.



Map 1: Southern Connecticut Regional Framework for Coastal Resilience Project Area

This project represents the first time that a Regional Resilience Framework has ever been advanced in the state of Connecticut. This unique and critically needed process and approach was accelerated by collaborative leadership and commitment of multiple organizations and the ten municipalities focused on mitigating the impacts of extreme weather events and hazards – in this case Tropical Storm Sandy – and a changing climate through a creative community resilience building process reinforced by the design of ten high-priority resiliency projects. Overall, this project will help to foster locally significant and regionally important community resilience building actions that address urgent needs across these municipalities that are currently unmet. The Southern Connecticut Regional Framework for Coastal Resilience is a joint project managed collaboratively by the South Central Regional Council of Governments, The Nature Conservancy, and the Connecticut Metropolitan Council of Governments (referred to herein as the Core Team).

Given the absence of a county governance structure in the state of Connecticut, the COGs coordinate and guide municipalities on local and regional issues of importance such as natural hazard mitigation planning, economic growth and redevelopment, conservation and transportation. The area serviced by this Final Report is covered by two COGs.

South Central Regional Council of Governments (SCRCOG) Service Area: The South Central Region of Connecticut is located within New Haven County and bordered

by Long Island Sound. The region is 369 square miles in size with 570,001 residents across fifteen municipalities and has an average population density of 1,544 people per square mile (U.S. Census Bureau 2010). The coastal municipalities in the project area serviced by SCRCOG include from west to east –Milford, West Haven, New Haven, East Haven, Branford, Guilford and Madison. These municipalities are situated among the geologic area referred to as the Coastal Lowlands, which is a narrow strip of level shore that runs along Long Island Sound with elevation at or near sea level. The remaining inland towns of Bethany, Hamden, Meriden, North Branford, North Haven, Wallingford and Woodbridge are in the Central Lowlands, which is characterized by a slightly to moderately sloping landscape of nutrient-rich farming soil.

Connecticut Metropolitan Council of Governments (MetroCOG) Service Area: The Connecticut Metropolitan Council of Governments service area is in Fairfield County about fifty miles east of New York City. Six jurisdictions make up the region: the three coastal communities of Fairfield, Bridgeport, and Stratford (within the project area) and the three inland communities of Easton, Monroe and Trumbull. The coastal communities are more developed and urban in character. The inland communities exhibit more suburban and rural characteristics. Together these communities encompass about 145 square miles with a combined population of over 318,000 people. The population density of this area, 2,193 people per square mile, is the highest of any region in Connecticut (US Census Bureau 2010).

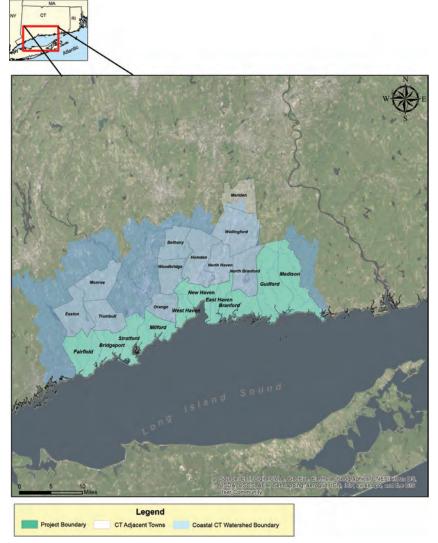
The Southern Connecticut Regional Framework for Coastal Resilience project matches the previous, current and future strategic direction for both SCRCOG and MetroCOG and helps facilitate their fulfillment of municipal and regional requirements as mandated by the state's Conservation and Development Policies Plan. These COGs provide a natural conduit for and means to synchronize efforts across the ten municipalities under their collective purview. Most importantly for this Regional Resilience Framework is that the project area spatially integrates two COGs, which has broadened the leveragability and reach of the project and better aligns with the indiscriminate geopolitical nature of natural hazards such as Tropical Storm Sandy. The collaboration between the COGs on an environmental, economic and social issue of such magnitude is currently unprecedented and unique within the state of Connecticut. This collaboration is even more important given the size and economic significance of Greater New Haven and Greater Bridgeport to the state of Connecticut. Largely because the project area has the highest density and most populated coastline on the Eastern Seaboard between New York City and Boston (US Census Bureau 2010).

Overview: It has long been recognized and recently driven home by events such as Tropical Storm Irene (August 2011) and Tropical Storm Sandy (October 2012) that the state of Connecticut's largest population centers (Greater New Haven and Greater Bridgeport) are significantly vulnerable to extreme weather events, sea level rise, flooding, erosion and coastal change among other hazards. All ten of the municipalities in the project area suffered from flooding of roadways, isolation of neighborhoods from critical community facilities, damage to houses and other structures, and impacts to coastal natural resources and infrastructure.

In response to previous and potential future scenarios, these ten municipalities through this Regional Resilience Framework endeavor identified high-priority projects

across the project area that if implemented would improve resilience to hazards such as sea level rise, coastal storms and inland flooding. The municipal leaders and staff utilized the project's process to work towards building capacity to respond to future coastal events and build community resilience. It was universally recognized across the municipalities that their coastal areas are a key asset and that immediate and full retreat from the shoreline by residents would be economically and socially damaging. From project onset, it was clear that creative project design ideas for adaptation with resiliency features were urgently needed in these communities to preserve coastal natural resources, shoreline access and recreation, and protection of vulnerable neighborhoods while building community resilience capacities for and among residents and businesses.

This Regional Resilience Framework therefore focused on collaboratively cataloguing all potential resilience projects and designing high-priority projects as identified by each of the ten municipalities. Advancing the designs for priority projects to implementation within each municipality will ultimately help to minimize the consequences of large-scale storms in Connecticut's and the Eastern Seaboard's most significant population centers and at the same time strengthen the resilience of existing and future natural ecosystems.



Map 2: Southern Connecticut Regional Framework for Coastal Resilience Project Boundary, Adjacent Towns, and Coastal Watersheds

INTRODUCTION 3

REGIONAL RESILIENCE FRAMEWORK: Objectives, Project Components, Outputs

OBJECTIVES: The main objective of this project was to comprehensively catalogue, assess, prioritize, and design resilience opportunities to help reduce risk to the 591,000 residents across ten municipalities and increase the viability of natural resources along a significant portion (approximately 30%) of Connecticut's coastline. This unique and critically needed initiative in Connecticut was achieved through the establishment and growth of the Regional Resilience Framework which was driven by the Core Team (SCRCOG, TNC, MetroCOG) and the ten municipalities alongside supporting non-profit entities, academic institutions, state and federal agencies, businesses and civic groups.

To achieve the objective, the Core Team executed four phased and reinforcing project components:

Project Component #1: Conduct a comprehensive natural/ green infrastructure assessment for the entire coastline and adjoining watershed for greater Bridgeport and New Haven (Fairfield east to Madison – Fairfield and New Haven County). This assessment identified and determined the type and feasibility of resiliency project opportunities that use natural/green infrastructure to protect adjoining communities and sustain natural resources over the long term. This opportunity assessment has and will continue to help inform future management, policies and practices within and across the ten municipalities and the region as part of this Regional Resilience Framework. This assessment also incorporated a survey of river infrastructure (i.e., dams, culverts) in adjoining, priority coastal watersheds that pose potential risk due to catastrophic failure or impaired conveyance as well as opportunities to improve connectivity, floodplain habitat condition and lessen runoff contribution from surrounding land uses.

Outputs and Outcomes: Detailed geospatial data sets and an assessment-characterization of the coastline and priority coastal watersheds for ten municipalities within the project area. This also included an initial prioritization of resiliency opportunities and reporting results on public-facing websites and reports distributed to all municipalities and other advisory organizations engaged with the project. The outputs from Component #1 provided the central core of the second phase of project – Component #2.

Project Component #2: Conduct community resilience building planning meetings and workshops to further prioritize and eventually integrate the coastal and watershed

assessment and other feasible environmental solutions into regional and municipal hazard mitigation, comprehensive planning and capital expenditure discussions. This community engagement effort included a legal, policy and regulatory audit of potential options to enable natural/green infrastructure applications going forward across the municipalities (i.e., setbacks, overlay zoning, etc.).

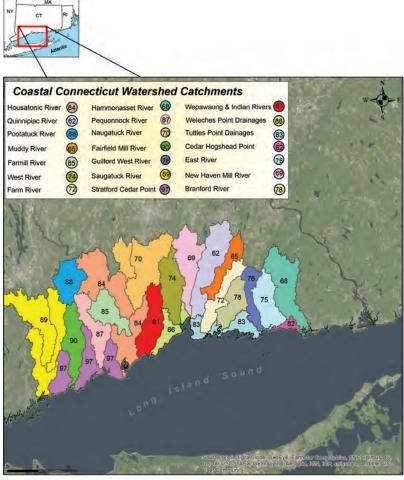
Outputs and Outcomes: Municipal and regional planning meetings, workshops, and field trips were conducted to increase awareness, recognition and integration of environmental solutions and policies into municipal and regional plans and consensus-based project lists to reduce risk to people and nature. The outputs from Component #1 and #2 provided the central core of the third phase of the project – Component #3.

Project Component #3: Scope and design of highest priority natural/green infrastructure projects to help reduce risk and improve resilience in ten municipalities across the project area. This involved contracting with an ecological engineering firm and academic institution to develop conceptual design plans for instructive and catalytic local projects with regional resilience impact ("triple bottom line of resilience"). The specific "designed" projects were selected through the community resilience building engagement process during Component #2.

Outputs and Outcomes: Final conceptual design plans for signature-catalytic resilience projects that were collaboratively developed to generate momentum to further advance environmental solutions to reduce risk for communities and strengthen natural resources.

Project Component #4: The final project component (herein) integrates Project Components #1, #2, and #3 as core elements of the Final Report. This Final Report serves as an immediate and long-term guide for future natural hazard mitigation, comprehensive plans and capital expenditures within and across the ten municipalities to advance this Regional Resilience Frameworks as well as similar endeavors elsewhere in the state of Connecticut and beyond. This is the first time a detailed, comprehensive risk management and community resilience building engagement effort anchored on prioritized resilience projects has ever been conducted at this scale in the state of Connecticut.

The ultimate outcomes of this project as reported herein include: 1) Component #1 - completed assessment of natural/green infrastructure opportunities; 2) Component #2 - comprehensive awareness resilience opportunities ready for integration into community mitigation approach, plans and actions; 3) Component #3 - design of highest priority resilience opportunities across the project area; 4) Component #4 - integration of three project components into



Map 3: Coastal Watersheds intersected by the Southern Connecticut Regional Framework for Coastal Resilience Project Area

the Southern Connecticut Regional Framework for Coastal Resilience Final Report.

Additional Project Context:

The funding for this project came through the Hurricane Sandy Coastal Resiliency Competitive Grant Program which was funded by the Hurricane Sandy disaster relief appropriation through the U.S. Department of the Interior (DOI) and administered by the National Fish and Wildfire Foundation (NFWF). The program supported projects that "reduce communities' vulnerability to the growing risks from coastal storms, sea level rise, flooding, erosion and associated threats through strengthening natural ecosystems that also benefit fish and wildlife." As such, grants were awarded to projects that "assess, restore, enhance or create wetlands, beaches and other natural systems to help better protect communities and to mitigate the impacts of future storms and naturally occurring events on fish and wildlife species and habitats."

Although numerous Community Development Block Grant Disaster Recovery (CDBG-DR) grants were awarded to

Connecticut communities in 2014-2016, these CDBG-DR grants were mainly geared toward hard infrastructure projects such as roadway elevation, utility hardening and protection, seawall and revetment repairs, and drainage projects. Few of the CDBG-DR awards were geared toward natural, green infrastructure and/or soft solutions (collectively, nature-based solutions) to reduce risks. Likewise, Federal Emergency Management Agency (FEMA) mitigation grants were awarded to Connecticut communities in 2014-2016, but these were mainly allocated to infrastructure projects, home elevations, and property acquisitions. Finally, the Rebuild by Design (RBD) and Natural Disaster Resilience Competition (NDRC) awards earmarked for Bridgeport are not necessarily obligated for significant natural/green infrastructure projects, although a handful of natural/green infrastructure projects may be designed from these awards.

Thus, the DOI/NFWF Hurricane Sandy Coastal Resiliency Competitive Grant awarded to the Core Team for this project is one of the few opportunities in Connecticut and elsewhere in the "Sandy-impacted area" to solicit, screen, and advance natural/green infrastructure projects and incorporate them into a Final Report.

The underlying design of this project has been informed by sound science derived through studies of storm surge and sea level rise implications in Connecticut and New York by

TNC's Coastal Resilience Program. The Coastal Resilience Program has worked directly with the NOAA Coastal Service Center (storm surge analysis – SLOSH), Association of State Floodplain Managers (FEMA-HAZUS replacement cost assessment) and NASA Goddard Institute for Space Studies/Columbia University (Connecticut-specific downscaled sea level rise projections) to inform the Coastal Resilience decision-support tool (www.coastalresilience. org) with highly-reliable risk visualization information for infrastructure, property, people and natural resources. Other key science resources that informed this project included reports, analysis and data provided through DOI's Northeast Climate Science Center (http://www.doi.gov/csc/northeast/index.cfm), NOAA's Digital Coast (http://www.csc.noaa. gov/digitalcoast/dataregistry/#/) and the USFWS's North Atlantic LCC (http://www.northatlanticlcc.org/projects). The internal forty-five DOI Sandy projects also presented opportunity to further inform the outcome and objective of this project. These applications of science also helped to amplify the urgent need to integrate municipal-based work within a regional context and scale.

INTRODUCTION 5





Population Growth & Housing Density since 1940 The state of Connecticut's two most populated cities are located in the project area, Bridgeport and New Haven. As the most populated city in the state, Bridgeport, with over 144,000 people and less than 16 square miles of land area, also has the highest density of housing — 3,570 units per square mile. New Haven is the second most populated city with approximately 130,000 people. At close to 19 square miles, New Haven has 2,940 units of housing per square mile (US Census 2010).

Although both cities are densely populated and developed, fewer people live in these cities today than in 1940. In the 2010 Census, New Haven's 1940 population of 160,605 had declined by 19% to 129,779. In Bridgeport, population loss was less dramatic during this time period, a 2% reduction from 147,121 to 144,229 (US Census 1940 & 2010).

In contrast to New Haven and Bridgeport, the suburban communities of the Connecticut coastline have seen significant population growth since 1940. From Madison to Fairfield (even including the negative growth in Bridgeport and New Haven), population has increased by 40% from 420,000 to 591,000 people. Most of these towns have experienced triple digit population growth during this time period. In Madison, fewer than 2,500 people lived in the Town in 1940. The 2010 population for Madison is now 18,269 – a 714% increase.

Housing

All municipalities have experienced an increase in housing since 1940. In the study area, the number of housing units has doubled from 122,000 to 244,000. In Guilford, less than 2,000 units of housing were reported in 1940, a housing density of 40 units per square mile. In 2010, housing increased by 405% to over 9,500 units, a density of 204 units per square mile. While Bridgeport and New Haven lost population between 1940 and 2010, the housing stock continued to increase. Almost 17,000 housing units were built in Bridgeport between 1940 and 2010 – a 42% increase from 40,000 to 57,000. There are now an additional 1,000 units of housing per square mile in Bridgeport than in 1940. New Haven's number of housing units increased by 25%, or by about 14,000 units during the same time period (US Census 1940 & 2010).

Waterfront Development

Waterfront development in the study area between 1940 and 2010 was likely similar to overall municipal growth. Census tract data prior to 1970 was unavailable, so it is difficult to determine what percentage of growth between 1940 and 1970 occurred in census tracts bordering the coastline. Comparison of census tract data between 1970 through 2010 found that housing increased by 25% in coastal tracts, from just under a total of 66,000 in the 1970 census to over 83,000 in 2010. Branford, Guilford and Madison experienced the most dramatic growth. In 1970, 6,600 housing units were in Branford's coastal census tracts. By 2010, the number of housing units increased by 72% to over 11,300. Madison and Guilford both added well over 1,000 new housing units in their coastal census tracts between 1970 and 2010, a 70+% increase period (US Census 1970 & 2010).

Only Bridgeport saw a decrease, as housing units located in the City's coastal census tracts decreased by 17% from 13,423 to 11,097 (US Census 1970 & 2010). This decrease was partly due to the buyout of 200+ homes in the 1990s for the Steel Pointe development.

Chart 1: Population Change, 1940-2010 (Source: US Census)

	Population, 1940	Population, 2010	Population % Change
Fairfield	21,135	59,404	181%
Bridgeport	147,121	144,229	-2%
Stratford	22,580	51,384	128%
Milford	16,439	52,759	221%
West Haven	30,021	55,564	85%
New Haven	160,605	129,779	-19%
East Haven	9,094	29,257	222%
Branford	8,060	28,026	248%
Guilford	3,544	22,375	531%
Madison	2,245	18,269	714%

Chart 2: Housing Change, 1940-2010 (Source: US Census)

	Houses, 1940	Housing Density, 1940 (sq. miles)	Houses, 2010	Housing Density, 2010 (sq. miles)	Housing % Change
Fairfield	6,177	207	21,648	724	250%
Bridgeport	40,233	2,519	57,012	3,570	42%
Stratford	6359	364	21091	1207	232%
Milford	6,899	311	23,074	1,040	234%
West Haven	8536	794	22446	2088	163%
New Haven	44,130	2,362	54,967	2,943	25%
East Haven	2,969	241	12,533	1,019	322%
Branford	3,330	153	13,972	640	320%
Guilford	1,900	40	9,596	204	405%
Madison	1,729	48	8,049	223	366%

Chart 3: Coastal/Tidal Estuary Census Tract Population & Housing Change, 1970-2010 (Source: US Census)

	Pop. 1970	Pop. 2010	% Change	Housing Density, 1970	Housing Density, 2010	% Change
Fairfield	12,832	11,992	-7 %	4,413	5,262	19%
Bridgeport	40,480	24,862	-39%	13,423	11,097	-17%
Stratford	13,285	12,524	-6%	4,445	5,495	24%
Milford	40,442	38,041	-6%	12,882	17,244	34%
West Haven	30,337	28,682	-5%	10,215	12,583	23%
New Haven	20,331	21,790	7 %	7,069	8,997	27 %
East Haven	85,26	9,357	10%	2,848	4,418	55%
Branford	17,736	22,118	25%	6,619	11,368	72 %
Guilford	5,562	6,702	20%	2,059	3,558	73 %
Madison	3,982	5,154	29%	1,897	3,228	70%

Social Vulnerability

In addition to having the highest population densities and most housing, Bridgeport and New Haven have significant numbers of socially vulnerable¹ residents. Socially vulnerable populations may have more difficulty in preparing for, responding to, and recovering from natural disasters, especially flooding. Indicators of social vulnerability include the percentage of people under five years of age, the percentage of people over 65 years of age, people whose income is below the poverty threshold and those with limited English proficiency.

In Bridgeport and New Haven, and to a lesser extent West Haven and East Haven, socially vulnerable populations have a larger presence. Twenty-seven percent of New Haven's population and 23% of Bridgeport's population are estimated to live in poverty. In both cities, 15% of persons 65 years or older are estimated to live in poverty. Almost a quarter of Bridgeport residents (or 32,000 people) are

estimated to speak English "less than very well". In New Haven and West Haven, about 12% of residents (14,000 and 6,000 respectively) are estimated to be less than proficient in English. Poverty is estimated to impact 14% of West Haven residents and 10% of East Haven residents (US ACOE 2015).

Most of the suburban municipalities that have seen significant population increases since 1940 do not have large numbers of socially vulnerable residents. The percentage of people in suburban municipalities who live in poverty is estimated between 4% and 8%. While between 15% and 21% of these communities' populations are estimated to be made up of people 65 or older, poverty is experienced by a smaller percentage of the senior population than the overall population. Most suburban towns have very few residents with limited English proficiency, only between 2% and 8% of residents are estimated to speak English less than very well (US ACS 2015).

Chart 4: Socially Vulnerable Population (Source: US ACOE)

	Pop. Estimate > 5 yrs.	% > 5 yrs.	Pop. Estimate 65+	% 65 yrs or over	% People in Poverty	% 65+ in Poverty	LEP Estimate	% LEP
Fairfield	3,539	6%	9,091	15%	4%	4%	2,941	5%
Bridgeport	10,608	7 %	14,439	10%	23%	15%	32,423	24%
Stratford	1,151	4%	5,390	19%	8%	6%	3,567	7 %
Milford	2,341	4%	8,992	17 %	7 %	7 %	1,911	4%
West Haven	3,146	6%	7,230	13%	14%	9%	6,315	12%
New Haven	7,967	6%	13,453	10%	27%	15%	14,109	12%
East Haven	1,397	5 %	5,035	17 %	10%	7 %	1,689	6%
Branford	955	3%	5,980	21%	7 %	5%	807	3%
Guilford	829	4%	4,568	20%	5%	4%	550	3%
Madison	657	4%	3,816	21%	4 %	4%	311	2%

Transportation

Southern Connecticut's multi-modal transportation infrastructure facilitates local and regional mobility, with vital links to New York City, Boston and Hartford. The proximity of the most heavily utilized transportation networks (such as Metro North's New Haven Line and Interstate 95) to the shoreline demonstrate the historic importance of Long Island Sound and water access to the state's economy. However, this proximity also increases the vulnerability of the transportation network (and the population it serves) to sea level rise and coastal storms.

Vehicular travel is the predominant mode of travel throughout Connecticut. In Southern Connecticut, Interstate 95 and US Route 1 run east-west through all municipalities in the project area. The Merritt Parkway (State Route 15) also provides an east-west connection through inland portions of some project area towns, such as Fairfield and Stratford. In Stratford, State Route 15 crosses the Housatonic River into Milford and becomes the Wilbur Cross Parkway, which runs in a more northeasterly direction toward Hartford. Route 8/25 begins in Bridgeport and runs northwesterly as Route 25 (toward Trumbull, Monroe and Newtown) and northeasterly as Route 8 (toward the Naugatuck Valley and Waterbury). In New Haven, Interstate 91 begins at the intersection with I-95 and runs north toward Hartford. Except for Route 15 (due to height and weight restrictions), these roads facilitate much of the freight movement through Southern Connecticut.

One of the busiest commuter railroads in the nation, the New Haven Main Line links the Connecticut coastline to New York City's Grand Central Terminal. Running in a similar east-west direction as I-95, almost all project area municipalities have at least one commuter rail station. Metro North provides commuter service between New Haven and New York. Commuter service eastbound from New Haven (Branford, Guilford and Madison) and ultimately to New London is provided by Shoreline East. Medium distance and long distance passenger service is provided by Amtrak in New Haven and Bridgeport. North-south connections are provided by MNR's Waterbury branch line in Bridgeport and Amtrak's New Haven-Hartford-Springfield line in New Haven.

Greater Bridgeport Transit, Milford Transit and CT Transit provide fixed route bus service in the more populated municipalities of the project area. Service is most concentrated in Bridgeport and New Haven, with some routes in East Haven, Fairfield, Milford, Stratford and West Haven. The three easternmost municipalities of Branford, Guilford and Madison are less densely populated and do not have regular bus transit service.

While the vehicular, bus and rail modes of transportation facilitate travel in much of the project area, air and waterborne modes also support passenger travel and freight movement. Both Bridgeport and New Haven have deep water ports. The Port of New

Chart 5: Rail Operators, Stations & Connections (Source: MetroCOG)

Municipality	Operator(s)	Number of Stations	Other rail connections		
Fairfield	Metro North	3	none		
Bridgeport	Metro North, Amtrak	1; a 2nd station in design	Yes – to MNR's Waterbury branch		
Stratford	Metro North	1	none		
Milford	Metro North	1	none		
West Haven	Metro North	1	none		
New Haven	Metro North, Shore Line East, Amtrak	2	Yes – to Amtrak's New Haven- Hartford-Springfield line		
East Haven	None	0	none		
Branford	Shore Line East	1	none		
Guilford	Shore Line East	1	none		
Madison	Shore Line East	1	none		

Haven is the busiest port between New York and Boston. The Bridgeport and Port Jefferson Steamboat Company provides regular passenger and vehicular ferry service between Bridgeport Harbor and Port Jefferson, Long Island; a cross-sound trip typically takes an hour and 15 minutes. The City of Bridgeport owns Sikorsky Memorial Airport (located in Stratford). Sikorsky is a general aviation airport; regularly scheduled commercial service is not available. Tweed New Haven Airport (located in East Haven) provides commercial and general aviation services.

Connecticut Coast Then and Now

The Connecticut coast borders Long Island Sound, a low energy tidal estuary that is buffered from the open ocean by Long Island, New York.² There are 1,065 miles of salt-water influenced coastline in Connecticut.³

Geologic History

Glaciation and changes in sea level have sculpted the Connecticut coastline over the last 100,000 years. Around 20,000 years ago the glaciers began to retreat from Connecticut. Various types of sediment and rock that define the current surficial geology of the state were deposited. Fine sediments, created from sedimentary and igneous bedrock, were deposited in the central portion of the state while the eastern and western portions received consolidated and hard sediments from metamorphic bedrock.⁴

In some areas, the retreating glaciers created high, inverted, spoon-shaped formations. These formations, or drumlins, are higher than the surrounding topography, making these areas less susceptible to damage from storms and sea level rise. Sasco Hill in Fairfield and Grover Hill area in Bridgeport are some examples of drumlins in the study site.⁵

As the glaciers melted, sea level began to rise. The retreating glaciers created Lake Connecticut in what is currently Long Island Sound. The terminal moraine (an accumulation of glacial debris at the point of furthest glacial advancement) separated Lake Connecticut from the open ocean. As sea level continued to rise, it eventually surpassed the moraine and tidal currents entered Lake Connecticut and created the tidal estuary known as Long Island Sound.⁶

In Long Island Sound, tidal forces and rising seas reshaped Connecticut's shoreline. Tidal action eroded sections of the shore, moving the sediment to other regions on the Connecticut coast that developed into beaches. Between 1,500 and 2,000 years ago, slow rising seas gave rise to inter-tidal salt marshes.⁷ Salt marshes are established when rates of accretion, deposits of inorganic material and build

up from decaying marsh vegetation, outpace sea level rise. These unique ecosystems offer numerous environmental and hazard mitigating benefits. Fish use them as nurseries, salt marsh plants clean water entering the Sound, and marshes themselves dampen waves during storms. When outpaced by sea level rise, marshes become submerged and/or eroded. Currently, as sea level rise continues to accelerate, marshes are beginning to be outpaced and may soon suffer substantial losses along the Connecticut coast unless afforded opportunities for advancement into upland areas.

Colonial History

When European settlers began inhabiting the region in the 17th century, they began to modify the environment and terrain. Dams were constructed on rivers for mill operations which impeded the flow of freshwater to the Sound and the migration of many fish species.⁸ Salt marshes were initially hayed and later ditched to drain water and increase marsh hay yields. By 1900, 50% of marshes between Southport and the Connecticut River (slightly larger than the study site) were ditched, drastically impacting the marsh ecosystem.⁹

Salt marshes were also filled to increase the amount of developable land on the coast. Much of this filling took place during the development of the railway in the 1800s, and the interstate system in the mid-1900s. These areas were often filled with polluted material and are now susceptible to inundation from storms and sea level rise. Sikorsky airport, owned by the City of Bridgeport and located in Stratford, was built entirely on filled salt marsh.¹⁰ (Figure 1)

In the study region, Fairfield south of Interstate 95, as well as Long Wharf in New Haven, are prime examples of coastal areas filled for development. In Fairfield, the coastal area was initially used for farming and later became residential. In contrast, the filled in area in New Haven became home to Union Train Station and numerous commercial properties. These areas are flat, close to sea level, and naturally should be hydrologically connected, leaving them very susceptible to inundation.

Tide gates were installed throughout the coast to drain marshes and power coastal mills. These tide gates allow water to flow in and restrict flow at high tide. The water is returned to the Sound through a narrow channel or mill waterwheel. This slow return of water often caused prolonged inundation of salt marshes and resulted in extensive vegetation change. While the tidal mills have been removed, the tidal gates are still present in many communities, impacting the tidal flow.¹¹

Salt marshes were frequently used as landfills since they were deemed undesirable and could be purchased

cheaply. Fletchers Creek, in Milford, Pink Creek, in Fairfield, Seaside Park in Bridgeport, Short Beach in Stratford and Sybil Creek in Branford are just some of the coastal landfills designated in the study region.¹²

The shoreline was heavily developed during the last century. Not only did the construction of transportation facilities fill in marshes, but it also created a barrier between the Sound and many coastal communities. Coastal properties were prime development areas for real-estate and most of the Connecticut coastline is lined with houses.¹³ This shoreline development not only creates hazards for the individuals living there, but also prohibits natural advancement of coastal features inland.

Coastal protection became a priority during the environmental movement of the 1960's and 1970's. The Tidal Wetlands Act of 1979 prevented the further destruction of Connecticut's remaining marshes. ¹⁴ Other conservation movements and changes in local zoning and building requirements have deterred further construction on the shoreline.

Shoreline Change

The Connecticut coastline is a dynamic system, constantly changing from a variety of cyclic and non-cyclic factors. Long-term shoreline trends are often inconsistent, as areas frequently change from periods of erosion to periods of accretion. Short-term shoreline change is often defined by a large storm event. Coastal erosion caused by large storm events can dramatically alter a shoreline after years of accretion. Therefore, it is important to look at shoreline trends over several time scales.¹⁵

In 2014, the Connecticut Department of Environmental Protection, Connecticut Sea Grant and the University of Connecticut Center for Land Use Education and Research

(CLEAR) conducted an Analysis of Shoreline Change in Connecticut. The team used GIS analysis to compare shorelines from 1880 to 2006. They used transect lines to quantify the short-term and long-term change and summarized the results by town. See Chart 6 (next page) for the summary of shoreline change for the ten towns in the study region. ¹⁶

The short-term change was calculated between 1983 and 2006 while the long-term change was measured over the entire 126 years (1880 to 2006). It is important to note that the net shoreline movement (NSM) minimum and maximum indicate areas of expansion and erosion within each town and represent the dynamic nature of the Connecticut coast. Only Stratford, Madison and Guilford averaged net loss over the entire period, while the remaining seven towns all experienced expansion.¹⁷

Geomorphology of Connecticut's Coast

Driving Factors

Connecticut s coast borders Long Island Sound, a tidal estuary buffered from the open ocean by Long Island, New York. Due to the reduced fetch (distance traveled by wind or waves over open water), waves in Long Island Sound are characteristically short and steep and are derived from local winds.¹⁸

Long Island Sound has a semi-diurnal tide cycle, in which there are two high tides and two low tides every 24 hours and 50 minutes. The geomorphology of Long Island Sound creates a funneling effect that produces higher tides on the western shore. The mean high tide varies from 2.6 feet in the east to 7.2 feet in the west. The mean spring tide has an even higher variance, from 3.1 feet in the east to 8.3 feet



Figure 1. Aerial imagery of Bridgeport (Sikorsky) Airport in 1934 and 2013 (SOURCE: State of Connecticut 1934; GBRC 2013).

in the west. This funneling effect also amplifies surges from tropical events, making the western coast more susceptible to damage. ²⁰

Sediment transport along the Connecticut coast is variable and localized. Beaches separated by a headland experience different impacts of longshore transport. Sediments deposit on the eastern side while the western side is sediment starved and erodes. Although sediment transport is localized, it is often consistent through time. From a hazard management perspective, proper management and functioning of erosion control structures are dependent on the ability to accurately predict sediment transport. For example, existing jetties and groins were designed to trap sediment with the direction and amplitude of the littoral drift in mind.²¹

Risk Factors

Coastal flooding is an increasing risk for coastal populations and infrastructure in Connecticut.²² As sea level continues to rise, and storm frequency and intensity increase, hazard mitigation steps need to be in place now. Most vulnerable to inundation are coastal areas that have been altered, either through fill or channel alteration. These

areas were naturally flooded and thus are often the first areas inundated during storm events.

Development along the coast prevents the natural movement of the coast, creating conflict between storms and infrastructure. Salt marshes, which act as natural buffers to dampen storm surge, need low-lying undeveloped land to advance when sea level rises. The lack of viable land for marshes to advance onto puts the coast at greater risk in the future.

Due to high cost, and environmental impact, structural flood mitigation should be the last resort in hazard mitigation. Other less impactful and cost-effective actions include improved land use, strategic retreat, better use of floodplains, and robust evacuation planning. To achieve these actions, a collaboration among all invested parties including local, regional, Tribal, State, Federal, NGOS. Academia, business and industry is required. While structural flood mitigation, or hardened shorelines are not ideal, they are inevitable in some situations. Municipalities must adopt a combination of structural, nonstructural, and natural methods to reduce risk. Most important, pre-disaster planning can save communities approximately 75% of post-event costs.²³

Chart 6: Analysis of Shoreline Change in Connecticut (Source: DEEP, UCONN, CLEAR)

	Short Term Change				Long Term Change				
Town	NSM Min	NSM Max	NSM Ave	EPR Ave	NSM Min	NSM Max	NSM Ave	EPR Ave	LRR Ave
Fairfield	-31.37	20.28	-5.12	-0.24	-30.69	104.86	8.87	0.07	0.12
Bridgeport	-30.51	92.65	-3.33	-0.23	-51.62	343.97	42.82	0.22	0.28
Stratford	-47.43	50.05	-5.56	-0.26	-102.56	162.42	-12.52	-0.1	-0.06454
Milford	-82.67	289.45	8.09	0.38	-117.6	369.83	16.63	0.06	0.06
West Haven	-73.53	140.46	-6.21	-0.24	-72.09	110.77	7.49	0.03	0.16
New Haven	-18.05	28.76	0.03	0.02	-36.75	791.13	166.23	0.1	0.16
East Haven	-7.78	32.33	1.15	0.05	-82.21	84.58	5.06	0.05	0.08
Branford	-26.52	21.45	0.82	0.04	-80.29	78.48	1.08	0.01	0.018
Guilford	-21.21	55.29	5.05	0.24	-203.67	111.53	-8.02	-0.07	-0.08
Madison	-40.11	11.88	-3.64	-0.17	-204.63	63.34	-8.78	-0.07	-0.05

NSM Newt Shoreline Movement

EPR End Point Rate (How fast Shoreline Moved)

LRR Linear Regression Rate

Policy Framework

In Connecticut, state agencies and municipalities have varying levels and types of authority over coastal infrastructure and land uses. The Connecticut Department of Energy and Environmental Protection (DEEP) has much of the responsibility for regulating activities in tidal wetlands and coastal waters seaward of the Coastal Jurisdiction Line (CJL). Since Connecticut is a home rule state, municipalities have control over a broad range of activities – including inland wetlands and watercourses, planning, zoning, buildings, open space, erosion and sediment control, town property, public works and the establishment of boards and commissions. State legislation provides much of the policy framework for the implementation of this authority, as local ordinances may not conflict with state law.

State agency actions that could impact the environment are regulated through the Connecticut Environmental Policy Act (CEPA, akin to the National Environmental Policy Act). CEPA requires that before taking an action which would have a major impact on natural resources, the agency must undergo a review process which generates an Environmental Impact Evaluation (like the federal environmental impact statement). Multiple state agencies and the potentially impacted municipalities are involved in the review.

At the regional level, COGs provide municipalities with a forum for regional planning and coordination. The COGs are not regulatory entities and do not have authority over coastal development or land use. Rather, COGs may assist and advise municipalities with decisions that could impact coastal resources. In addition to COGs, Soil and Water Conservation Districts are authorized to develop soil and water conservation, erosion, and sediment control programs. These districts may hold real property, assist with DEEP programs and provide comments on local and regional projects.

The State of Connecticut has entered partnerships with other states to protect shared natural resources. The New England Water Pollution Control Commission approves the water quality classification standards for interstate water bodies, waterways and tidal waters. The Interstate Environmental Commission is a partnership between Connecticut, New York and New Jersey to address water quality in the western portion of Long Island Sound and portions of adjacent rivers and estuaries. The Commission has the authority to restrict sewage discharge in the area and may develop and enforce regulations regarding pollution.

The restoration and protection of Long Island Sound is a state requirement for municipal and regional plans of conservation and development (having a coastal border). These plans must be "made with reasonable consideration for restoration and protection of the ecosystem and habitat of Long Island Sound" and "designed to reduce hypoxia, pathogens, toxic contaminants and floatable debris in the

sound." While legislation for the Connecticut Conservation and Development Policies Plan does not specify Long Island Sound, the impacts of natural hazards on infrastructure and natural resources, and strategies to mitigate these hazards must be included in the state plan.

Using the local Plans of Conservation and Development (POCD) as a framework, municipal zoning commissions are empowered to make regulations for buildings, structures, land uses, and other aspects of zoning. Soil erosion and sediment control and the environment of Long Island Sound (in coastal communities) are state mandated requirements for local zoning regulations. While buildings and structures are regulated at the local level, all municipalities are required to adopt and enforce Connecticut's State Building Code, which covers structural, materials, electrical, plumbing, and fire control requirements.

Connecticut's water pollution legislation is more restrictive than the federal Clean Water Act. DEEP is responsible for administering the legislation and ensuring compliance with the federal CWA, as well as setting water quality standards and developing a comprehensive plan for the prevention, control and abatement of water pollution. In addition to managing surface and ground water quality, DEEP uses these standards to inform the issuance of discharge permits and orders to abate pollution. If a municipality is ordered to abate pollution, it must establish a water pollution control authority (WPCA). WPCAs may also be established regionally. Stormwater is also regulated by DEEP, but there has been past interest in the creation of municipal stormwater authorities. Coastal water quality is further regulated through the state's Coastal Management Act.

Connecticut's Coastal Management Act is the primary legislation that guides policies to minimize or eliminate "adverse impacts on coastal resources" caused by coastal development, facilities, and uses. State actions, DEEP regulations and all major state plans must be consistent with the CMA, and the determination based on CMA considerations supersedes other reviews. Following a model program and regulations developed by DEEP, municipalities are required to review coastal site plans for buildings, uses, flood control structures and other activities so as to determine the potential adverse impact on coastal resources. The Zoning Commission (or another commission designated for coastal planning purposes) incorporate both coastal management and zoning considerations in the coastal site plan review, with an emphasis on non-structural mitigation measures that are less damaging to the environment. Municipalities must also consider water quality degradation as part of the review, since the CMA considers coastal water quality degradation as an adverse impact.

Through the CMA, DEEP may also provide comments on any revisions to local POCDs, other community plans, zoning regulations and related ordinances which could impact coastal resources. In addition to DEEP, these revisions must also be submitted to the COG for comment prior to adoption.

DEEP is responsible for coordinating, monitoring and analyzing state and local floodplain management activities, and for assisting municipalities with the development of non-tidal floodplain regulations. Complementing DEEP's floodplain management authority, the agency also has the power to establish encroachment lines along waterways and floodprone areas. Any obstruction, encroachment or hindrance beyond these lines requires a DEEP permit. While municipalities are also authorized to establish encroachment lines independent of DEEP's lines, DEEP may alter the municipal lines and regulate any encroachments over the DEEP lines. Independent of DEEP, municipalities have the authority to require the removal of material from a waterway if it could prevent the free discharge of flood waters (with the exception of some transportation projects).

Under the CMA, flood and erosion control structures/ systems (hard stabilization) must be referred to DEEP for comment. These structures and systems may only be approved after finding that there is no feasible, less damaging alternative and that all reasonable mitigation measures and techniques have been implemented. In addition to hard stabilization activities, dredging, excavation, dumping, placement of fill and similar activities require a DEEP permit (through legislation independent of the CMA). DEEP has the discretion to require that the sand, gravel or other material is made available at cost to a coastal municipality for use in a flood or erosion control system, beach nourishment or habitat restoration project.

Municipalities may establish a Flood and Erosion Control Board (FECB), which is empowered to plan, lay out, acquire, construct, reconstruct, repair, maintain, supervise and manage a flood or erosion control system. If the system is approved by DEEP, a municipality may enter an agreement with the federal and/or state government. All dams, dikes, and similar structures which might pose a public danger by failure are subject to DEEP jurisdiction and require a permit for any activities related to the structure.

While DEEP has most of the authority over tidal wetlands, inland wetlands and watercourses are regulated at the municipal level. The state's inland wetlands and watercourses act authorizes the municipality to implement the act through an inland wetlands agency (or an existing board or commission). The designated agency is responsible for evaluating permits for regulated activities.

Connecticut's Shoreline Assessments

Two key sets of resources for understanding the State's shoreline have been published in the last few years, reflecting a growing interest in making shoreline communities more resilient coupled with increased funding for research and additional funding available after disasters such as Hurricane Sandy. These are the Analysis of Shoreline Change in Connecticut as mentioned earlier and the North Atlantic Coast Comprehensive Study (NACCS) documentation. Both are described below.

Analysis of Shoreline Change in Connecticut

The Analysis of Shoreline Change in Connecticut [DEEP, CT Sea Grant, and University of Connecticut Center for Land Use Education and Research (UCONN-CLEAR), 2014] conducted a GIS analysis using maps of the Connecticut shoreline from several different time periods between 1880 and 2006 (100+ years). The goal of the project was to "provide a high-level, quantifiable data set describing CT shoreline trends from both a statewide, regional, and a localized perspective." The report notes that results from the analysis represent shoreline movement under past conditions and are not intended for use in predicting future shoreline positions or future rates of shoreline change. The authors additionally note that the materials presented can be "reasonably used to:

- identify areas that have historically exhibited erosion or accretion trends;
- identify areas that have shown a "trend reversal" from the long term to the short term (either
- changing from erosion to accretion or vice-versa);
- generally assess the speed or magnitude of change; or
- support or direct research investigations or planning purposes."

Additionally, the authors note that the materials presented "should not be used to:

- differentiate/explain the cause of change;
- state with certainty the magnitude or speed of change at a given location;
- · predict future rates and/or amount of change; or
- develop engineering or design plans without a review of underlying data."

The GIS data developed during the study and provided by CT Sea Grant were instructive for understanding the historical changes that have occurred in the ten municipalities of the project. Furthermore, the data were useful for backing up anecdotal information and statements made by municipal participants during this Regional Resilience

Framework project; particularly during the scoping of the conceptual designs. For example, the GIS data documented the severe erosion that has occurred at Chittenden Beach in Guilford, which helped justify design elements for the living shoreline conceptual design at this location. The study also documented the lack of shoreline change that has occurred at Madison Surf Club in Madison allowing for attention to be focused on designing a restored dune without needing to incorporate design elements to retard dune structure movement.

North Atlantic Coast Comprehensive Study (NACCS)

The NACCS report ("North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk") [U.S. Army Corps of Engineers, 2015] was published in January 2015. The NACCS addresses the coastal areas defined by the extent of Sandy's storm surge in the District of Columbia and the States of New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, and Virginia. The two goals of the study were:

- Provide a risk management framework consistent with the NOAA/USACE Infrastructure Systems Rebuilding Principles
- Support resilient coastal communities and robust, sustainable coastal landscape systems, considering future sea level and climate change scenarios, to manage risk to vulnerable populations, property, ecosystems, and infrastructure

Key findings, outcomes, and opportunities of the NACCS include the following:

- Flood risk is increasing for coastal populations and supporting infrastructure.
- Improved land use, wise use of floodplains, responsible evacuation planning, and strategic retreat are important and cost-effective actions.
- Communities should adopt combinations of solutions, including nonstructural, structural, natural and nature-based, and programmatic measures to manage risk, where avoidance is not possible.
- Communities must identify their acceptable level of residual risk to plan for long-term, comprehensive, and resilient risk management.
- Many opportunities exist to improve risk management, including enhancing collaboration, building new partnerships, and strengthening pre-storm planning.
- Addressing coastal risk requires collaboration among local, regional, Tribal, State and Federal entities, NGOs, academia, business, and industry.
- Resilience can be encouraged through the use of a coastal storm risk management framework and contin-

- ued commitments to advance the state of the science with respect to sea level and climate change, storm surge modeling, ecosystem goods and services, and related themes.
- Strategic and comprehensive monitoring is required to fully assess and adapt the coastal system to avoid future damages. Monitoring information must be made available to the public in a timely manner that allows rapid decision-making by public and private partners.
- Pre-disaster planning and mitigation can save communities approximately 75 percent of post-storm costs.

The above findings are consistent with many other studies and sets of conclusions that have been circulated in the last few years. The statement that "Communities should adopt combinations of solutions, including nonstructural, structural, natural and nature-based, and programmatic measures to manage risk, where avoidance is not possible" is consistent with the goals of the Regional Resilience Framework project.

One of the most potentially useful components of the NACCS was the development of updated modeling that is somewhat like the traditional modeling developed for the Flood Insurance Studies. Specifically, storm surge modeling was conducted for the NACCS using the ADvanced CIRCulation (ADCIRC) long-wave hydrodynamic model. Results include water surface elevations for different storms of varying recurrence intervals, similar to the FEMA modeling found in the FIS. These results can be used to help establish design parameters for conceptual designs, as was done for the conceptual designs in this Regional Resilience Framework project.

Unfortunately, the state-by-state planning assessments contained in the NACCS were not as detailed for Connecticut as they were for other states. The Connecticut shoreline was analyzed as one segment instead of being divided into numerous segments ("There is one planning reach in Connecticut, designated as CT1. CT1 is the entire coast of the state. This reach includes all of the state's more densely populated coastal municipalities including: New Haven, Milford, Stratford, Bridgeport, Norwalk, and Stamford"); and the narratives provided for individual municipalities or groups of municipalities were somewhat generalized. The following narratives are taken from the NACCS Report:

- CT1_G: Madison: This area of high exposure runs from the Hammonasset area of Madison to the East River.
 It includes significant pockets of residential development and its supporting infrastructure (local roads and utilities).
- CT1_H: Guilford: Between downtown Guilford and the coast there are pockets of residential and commercial development, including their supporting municipal

infrastructure, that were determined to be significant enough to be listed as an area of high exposure. The area includes Guilford Harbor and state roads Route 146 and 1.

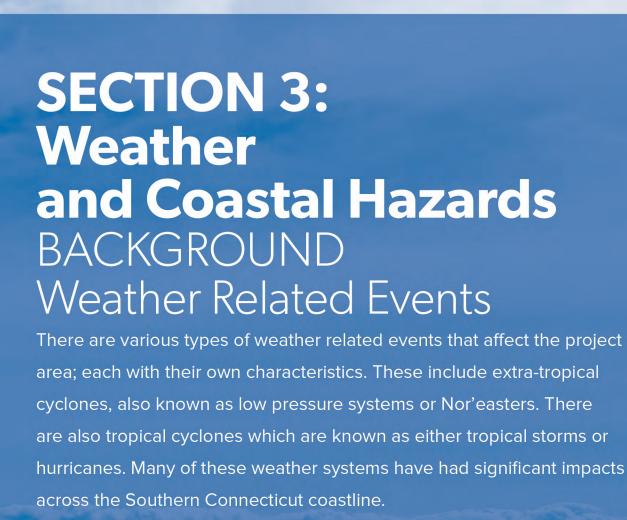
- CT1_I: Branford: This area of high exposure extends from the Seaview Avenue area of Branford to Lindsey Cove. It includes several densely populated areas as far inland as Route 1 as well as Branford Harbor and the downtown area. Many commercial facilities fall within this area including several recreational boating marinas. The town's wastewater treatment facilities are in the area of high exposure as well. Several important local and state roads (e.g. Route 146 and 1) are included in the area of high exposure.
- CT1_J: East Haven: This area of high exposure encompasses most of the coastal zone of East Haven from the Farm River on the east side to Morris Cove in New Haven Harbor. The area reaches inland as far as Route 1 and includes possibly thousands of residential properties, some fairly significant commercial properties (Proto Drive and Commerce Street), the New Haven Airport, and much municipal property and infrastructure.
- · CT1_K: New Haven: The area of high exposure identified for this stretch of coastline includes the cities of New Haven and West Haven. This area of high exposure is the first of several densely populated and developed portions of the coastline in Connecticut that would be subject to very significant damage if a Sandy-like event were to hit. This area begins at the Morris Cove on the east side of New Haven Harbor and terminates at the Prospect Beach area in West Haven. The area extends as far inland as Sackett Point Road along the Quinnipiac River. There are several thousand residential, commercial, industrial, and municipal structures located in this area of high exposure. New Haven Harbor is surrounded with many petroleum and bulk cargo based industries that rely heavily on the port for moving those products. The area includes two major interstate highways, Routes 95 and 91, that are critical to the region for moving traffic. There are many important rail lines that run through this area as well. There are several wastewater treatment facilities located here that are subject to inundation.
- CT1_L: Milford through Fairfield: This area of high exposure is the largest stretch of contiguous impacted coastline in the Connecticut reach. It begins at the Point Beach area of Milford and ends at Southport village in Fairfield. It includes the cities of Milford, Stratford, Bridgeport, and Fairfield. All of these communities were hard hit during Hurricane Sandy. The area of high exposure extends inland beyond the Route 95 corridor and includes many state and local roadways. Major ports in the area include Milford Harbor, Stratford Harbor, and Bridgeport Harbor. There

are thousands of residential, commercial, industrial, and municipal structures located in this area of high exposure. Bridgeport Harbor is surrounded with many petroleum and bulk cargo based industries that rely heavily on the port for moving those products. There are several wastewater treatment facilities located here that are subject to inundation as well as state and local parks, Sikorsky Airport in Stratford, and a major rail line that connects the New York City area to the northeast region.

The level of detail provided in the NACCS narratives for Madison, Guilford, Branford, East Haven, New Haven, and Milford-Fairfield was less than the detail provided by reviewing the individual plans and studies associated with each municipality. Nevertheless, they demonstrate the vulnerabilities and risks present in these communities.

A final piece of potential utility from the NACCS is the Conceptual Regional Sediment Budget for USACE North Atlantic Division [U.S. Army Corps of Engineers 2015]. The report notes that "development of a detailed working sediment budget is fundamental to better sediment management. A conceptual sediment budget is the first phase in development of the working budget and is intended to provide a general framework based on existing transport information from which a more detailed sediment budget can be later prepared based on rigorous data analysis and numerical modeling." This portion of the NACCS found that Long Island Sound was generally a location of accretion, and that various parts of the Connecticut shoreline were balanced between erosion and accretion.





Nor'easters are relatively common in this region and can occur during all months of the year except in the summer. Some are large and have been known to last upwards of several days resulting in significant impact along the coast, as well as inland areas. The most critical aspects of these events are wind, rain and or snow. During Nor'easters, the wind comes out of the northeast. This is true within Long Island Sound where the current geographical position flows from northeast to southwest which orients perfectly with northeasterly winds. Most of the time these storm systems often occur in conjunction with large snowfalls, which has made emergency response and recovery much more challenging. This is especially true within the project area which has the highest coastal population between New York and Boston.

Hurricanes and Tropical Storms have resulted in significant impacts. Hurricanes of high intensity (Category 3 or greater) are not as common as a Category 1 or 2. However, these systems have resulted in tremendous amount of damage along the Connecticut shoreline. Tropical Cyclones feed off energy from extremely warm waters and therefore contain an inner warm core (the eye); an extra-tropical cyclone usually contains an inner cool core. Winds from a hurricane circulate counter-clockwise with the strongest winds associated along the right-front quadrant (right side) of the system. The most amount of rainfall usually occurs along the left quadrant or the left side of the storm system. The right quadrant also forces the highest storm surge due to the highest winds, fetch, and onshore flow. Therefore, determining the track and the intensity of these systems is critical for emergency purposes.

Hurricane 1938 (Great New England Hurricane/Long Island Express): On September 21, 1938, one of the most destructive hurricane hit the Southern Connecticut coastline as a Category-3 hurricane. Winds reached approximately 121 mph with gusts exceeding 183 mph. Roads, homes, buildings and other structures were completely flooding or underwater along the Southern Connecticut coast. This large system generated copious amounts of rainfall prior to the hurricane making landfall between the cities of Bridgeport and New Haven. Many places along the Connecticut river valley experienced significant riverine flooding with rainfall rates exceeding 2 inches per hour with many areas measuring over 17 inches of total rainfall. The storm surge along the coast was extremely destructive and costly with many structures along the coast swept right off their foundations. The surge along the coast reached astounding levels from 10 to 12 feet and above. The mean low-water storm tide was measured at 14.1 feet in Stamford, 12.8 feet in Bridgeport, and 10.58 feet in New London which still remains as record high water level today. The hurricane struck with little warning and was responsible for 600 hundred deaths and over 308 million dollars in damage

across the northeast region. The 1938 hurricane still holds the record as the worst natural disaster in Connecticut's history.

Tropical Storm Sandy: On October 29, 2012, Sandy made landfall along the New Jersey coastline. A Connecticut tide gauge measured a storm surge of 9.83 feet above normal tide levels in Bridgeport and New Haven measured a surge of at around 9.14 feet, which resulted in record water levels occurring at many stations during the height of the storm. The following inundation data is expressed above ground level: Fairfield and New Haven Counties averaged between 4 to 6 feet, while both Middlesex and New London Counties averaged anywhere between 3 to 5 feet. The highest storm tide and greatest inundation occurred along central portions of the Connecticut coast with the highest-water mark recorded at 5.5 feet above ground level in Milford. Connecticut. Other inundation measurements of at least 5 feet were recorded for areas near the City of New Haven. Fairfield County had the highest max measurements ranging from at 4.5 to 5.8 feet. Per the National Ocean Service tide gauges, Bridgeport and New Haven both reported water levels around 5.82 feet and 5.54 feet above mean high high water (MHHW). This indicates that the inundation may have exceeded 6 feet above the ground level in parts of Fairfield and New Haven Counties. Farther to the east, the highest marks measured by the United States Geological Survey in Middlesex and New London 3.8 feet and 3.2 feet above ground level which were recorded in Clinton and Old Lyme, respectively. In addition, New London reported a water level of 4.95 feet above MHHW. The maximum inundation along the eastern parts of the Connecticut coast were estimated to be between 3 to 5 feet above the ground level. As Sandy slammed into the Jersey coastline, she never lost her large wind field and large radius of maximum winds, as it transitioned from a hurricane into a "hybrid system" containing both tropical and extratropical characteristics. However, the storm retained its hybrid status throughout landfall. The wind field from Sandy was record setting - stretching over 1,000 miles in diameter. The overall minimum central pressure of Sandy was estimated to be around 940 mb, which occurred on the 29th of October, just a few hours before landfall. This currently is the lowest barometric pressure ever recorded to make landfall along the US coast above Cape Hatteras; even surpassing the Hurricane of 1938. Sandy's death toll rose to 147 deaths (5 located in Connecticut). Sandy's damage was calculated at 65 billion dollars in damage, making it the second costliest weather disaster in United States history.

Sea Level Rise Projections

Beginning in 2008 through 2010, the Nature Conservancy contracted with NASA Goddard Institute of Space Studies and Center for Climate Systems Research at Columbia University to generate down-scaled sea level rise projection for coastline of Connecticut, New York City region, and Long Island New York. These sea level rise projections were incorporated directly into the Nature Conservancy's Coastal Resilience tool (www.coastalresilience.org).

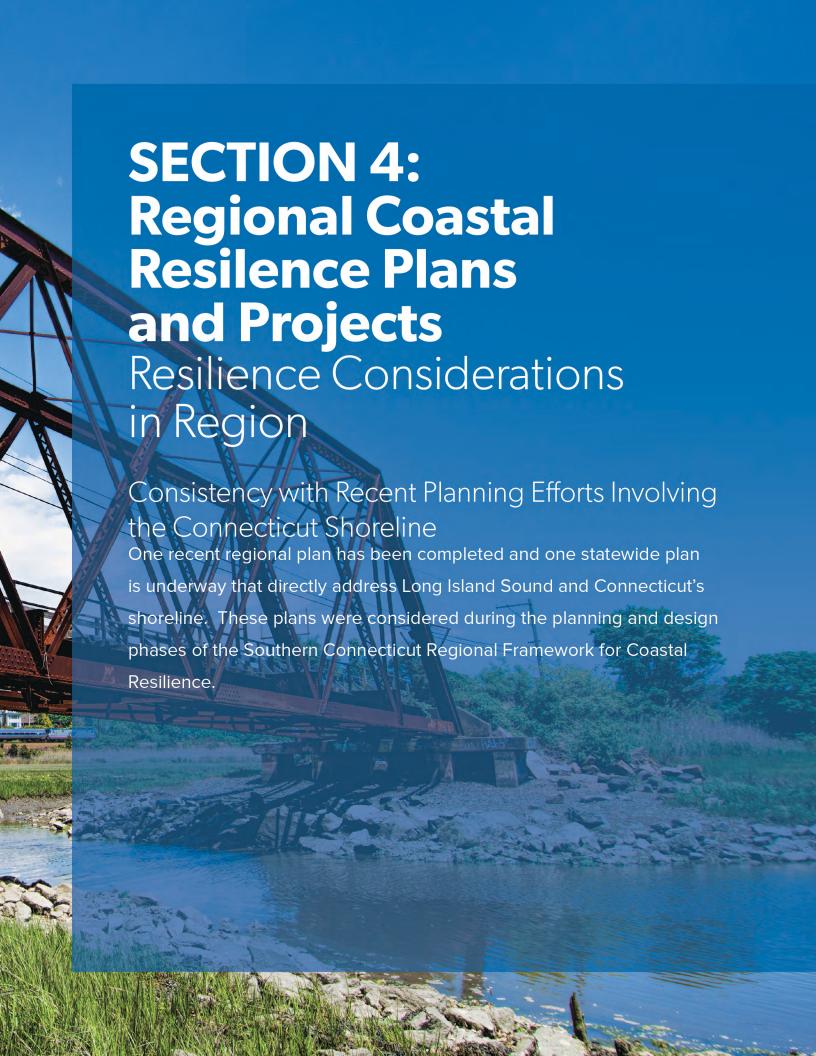
The sea level rise projections from NASA/Columbia were modeled using 7 Global Circulation Models across 3 IPCC emissions scenarios (B1, Ab1, A2). In addition, historic tide gauge date, observed land subsidence, local differences in mean ocean density, circulation changes, thermal expansion of sea water, and changes in ice mass due to temperature increases were incorporated into these down-scaled projections. The modeling methodology was originally developed for the New York City region as part of the New York City Panel on Climate Change per a study funded by the New York State Energy Research and Development Authority (NYSERDA). An updated description of the methodology and the resulting sea level rise projections are provided in the New York City Panel on Climate Change's report entitled Climate Risk Information 2013 (http://www. nyc.gov/html/planyc2030/downloads/pdf/npcc_climate_ <u>risk_information_2013_report.pdf</u>). Since the original sea level rise projections were run by NASA/Columbia a supplemental analysis per New York States ClimAID Program in 2014 has resulted in an increase in projections up to 58 inches in the 2080s for New York City (http://www.dec. ny.gov/energy/45202.html#projections).

Starting in 2008, the State of Connecticut initiated a climate change study in accordance with Section 7 of Public Act No. 08-98, An Act Concerning Connecticut Global Warming Solutions, the Governor's Steering Committee (GSC) on Climate Change that established an Adaptation Subcommittee. The GSC charged the Adaptation Subcommittee

with evaluating, the projected impact of climate change in the state on: (1) Infrastructure, including, but not limited to, buildings, roads, railroads, airports, dams, reservoirs, and sewage treatment and water filtration facilities; (2) natural resources and ecological habitats, including, but not limited to, coastal and inland wetlands, forests and rivers; (3) public health; and (4) agriculture. This assessment effort is to be followed by a report due in mid-2010 that also contains the results of the above impacts assessment and recommendations for changes to existing state and municipal programs, laws or regulations to enable municipalities and natural habitats to adapt to harmful climate change impacts and to mitigate such impacts. The sea level rise projections incorporated and adopted by the State of Connecticut in the final report entitled "The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health" where adopted directly from the New York Panel on Climate Change (NPCC - PlaNYC) as detailed in the document Climate Risk Information (2009 – Section 3: Future Projections Page 13)(http://pubs.giss.nasa.gov/ docs/2009/2009_Horton_etal_1.pdf) as well as the update in 2013 (referenced above).

In summary, the sea level rise projections presented in the Nature Conservancy's Coastal Resilience Tool were developed under contract by NASA Goddard Institute of Space Studies and the Center for Climate Systems Research at Columbia University. These very same projections were incorporated into the New York Panel of Climate Change (NPCC – PlaNYC) in 2009 and subsequently revised upwards in 2013. The 2009 sea level rise projections from NASA/Columbia were not only incorporated into the NPCC-PlaNYC actions plans but were also incorporated into the State of Connecticut's legislatively mandated, Governor's Adaptation Subcommittee's report on climate change impacts in Connecticut (Section II: Climate Change Projections and Risk Assessment – Page 8).





Long Island Sound Comprehensive Conservation and Management Plan

The Long Island Sound Comprehensive Conservation and Management Plan 2015 – Returning the Urban Sea to Abundance [Long Island Sound Study, 2015] was a collaborative effort prepared by the Long Island Sound Study. The Long Island Sound Study (LISS) was authorized by Congress in 1985 and involves federal, state, interstate, and local government agencies, non-government organizations, industries, universities, and community groups to restore and protect the Sound. At least three objectives from the management plan are directly aligned with the *Regional Framework for Coastal Resilience*:

- Objective 2-1c: To increase or maintain resiliency of coastal habitats and the services they provide.
 - Strategy 2-1c1: Identify and prioritize upland, wetland, and aquatic habitats that are vulnerable to climate change impacts and take action to mitigate or adapt to these impacts.
 - HW-11: Develop and promote the use of living shoreline habitat protection methods (dunes, shorelines, coastal marshes) and living shoreline monitoring protocols.
 - HW-12: Promote the conversion of existing armored shorelines (seawalls, riprap, bulkheads, etc.) to softer living shorelines to mitigate the impacts of new (and authorized) armored shorelines.
- Objective 3-4a: To encourage and facilitate the development of regional, state, and local sustainability, mitigation, and resiliency plans and integrate them into community comprehensive plans.
 - Strategy 3-4a1: Provide support to municipalities to facilitate the development and updating of sustainability and resiliency plans that incorporate current concepts on these topics.
 - SC-23: Develop a handbook, website, and, or, other materials (e.g., regulations, funding sources, and best practices) to be used by municipal officials to aid in the development of sustainability and resiliency plans and their integration into comprehensive plans.
 - SC-24: Conduct region-wide and town-specific workshops to assist municipalities in developing sustainability and resiliency plans and integration into their comprehensive plans.
 - SC-25: Support communities as they develop and adopt new or updated stand-alone Municipal Sustainability Plans.
 - SC-26: Support communities as they develop and adopt new or updated Coastal Resiliency Plans.

- Objective 4-3a: To frame sustainability, adaptation, and resilience in relation to the drivers of ecosystem change:
 - Strategy 4-3a2: Consider the spectrum of desired ecosystem outcomes when planning and implementing resiliency of both built and natural systems.
 - SM-33: Incorporate desired ecosystem outcomes for planning and implementation of Hurricane Sandy Relief funds and ongoing coastal resiliency programs.

The planning and design phases of the Regional Framework for Coastal Resilience have helped advance progress toward these objectives and strategies.

Connecticut Blue Plan

Public Act 15-66, An Act Concerning a Long Island Sound Blue Plan and Resource and Use Inventory, was signed on June 19, 2015 and went into effect on July 1, 2015. This "Blue Plan" legislation establishes a process by which Connecticut will develop an inventory of Long Island Sound's natural resources and uses and, ultimately, a spatial plan to guide future use of the Sound's waters and submerged lands. Currently, Connecticut's Coastal Area Management Program protects coastal resources and guides development along the State's shoreline. The development of a Blue Plan for Long Island Sound will supplement the Coastal Area Management Program's existing authority in the deeper offshore reaches of the Sound.

At the present time, draft goals for the Blue Plan have been published for comment. At least three objectives are directly aligned with this Regional Resilience Framework including:

Goal 1: Healthy Long Island Sound Ecosystem

- 1. Reflect the value of biodiversity and ecosystem health in regard to the interdependence of ecosystems
- Identify and protect special, sensitive or unique estuarine and marine life and habitats, including, but not limited to, scenic and visual resources
- Adapt to evolving knowledge and understanding of the marine environment, including adaptation to climate change and rise in sea level

The planning and design phases of the Regional Resilience Framework helped to advance progress toward these objectives.

Coastal Resilience Planning in Region and Municipalities

scroog: The South Central Regional Council of Government's Multi-Jurisdiction Hazard Mitigation Plan (HMP) for Bethany, Branford, Hamden, Madison, North Branford, North Haven, Orange, Wallingford, West Haven and Woodbridge received FEMA Approval on June 24, 2014. The HMP planning process adhered to Federal Emergency Management Agency (FEMA) standards and requirements for local hazard mitigation plans. The purpose of the HMP is to help reduce the South Central Region's vulnerability to natural hazards and ease the burden of keeping communities safe and resilient. The HMP identifies hazard risks and mitigation actions to reduce or eliminate those risks. Through the Plan, the participating municipalities are eligible for FEMA mitigation program funding before and after potential natural disasters.

The participating municipalities have been diligently working to advance or further evaluate their respective mitigations actions. The SCRCOG has been advancing the regional mitigation actions by obtaining grant funding to advance to resiliency efforts. The SCRCOG has received a FEMA Pre-Disaster Mitigation Grant Award to update the HMP, which will include the following additional communities in the region: East Haven, Guilford, Milford and New Haven.

MetroCOG: The multi-jurisdictional Natural Hazard Mitigation Plan update for the Greater Bridgeport Region was formally approved by FEMA on July 22, 2014. Since approval of the Plan, some recommendations have been implemented. Bridgeport's efforts have been described in the National Disaster Resilience Competition and Rebuild by Design sections. The Town of Fairfield is in the process of flood proofing the wastewater treatment plant and improving drainage in the downtown area. The Town also applied for entry into the Community Rating System program, a FEMA program that provides homeowners with a discount between 5% and 40% on flood insurance premiums. The Town's Class 8 rating will reduce premiums by 10%, a total savings of over \$400,000. Stratford's low-lying Lordship Boulevard/State Route 113, the only access road to a coastal neighborhood, was elevated from 5 ½ feet to seven feet.

TNC: The Nature Conservancy's Coastal Resilience Program has been providing services for all the ten municipalities in the project area since inception in 2007. The services provided have included the development of the Coastal Resilience Tool (www.coastalresilience.org) to help municipal-based leadership and staff by geospatially projecting with the most relevant data on hazards and risk along the coast of Connecticut. In addition, TNC has championed state-level policy modifications and educated

communities on alternative ways to reduce risk and improve resilience from the neighborhood to regional scale. TNC also generated a parcel-scale Salt Marsh Advancement Zone Assessment for all 24 coastal municipalities to define implications for both the existing built environment from downscaled sea level rise projections and for existing salt marsh looking to advance upslope. Finally, TNC has created the Community Resilience Building process that has helped over forty-five municipalities identify strengths and weakness and collaboratively develop comprehensive and prioritized resilience action plans. The original applications of the Community Resilience Building process have helped municipalities such as Bridgeport, Fairfield, Stratford, Madison, and Guilford move into a leadership role on resilience in the state of Connecticut.

Select Municipalities: The municipalities of Madison, Branford, Milford, and Stratford were each able to secure a CDBG-DR grants to generate individual community-based resilience plans. The grant money was allocated from the 2013 Disaster Relief Appropriations Act, which aided communities that were impacted by Tropical Storm Sandy and Irene. The planning documents for the municipalities of Madison, Branford, and Milford were completed by consultants and their respective municipality. In addition, the City of Stratford hired a consulting firm using CDBG-DR funds to complete the municipal resilience plan in 2016.

The municipality of Guilford also develop a coastal resilience plan funded in part by the Small Town Economic Assistance Program (STEAP) and by NOAA through the Gulf of Maine Council on the Marine Environment and The Northeast Regional Ocean Council; part of the New England Municipal Resilience Initiative. The coastal resilience plan for Guilford was initiated in 2008 by TNC who brought Yale University (in 2012) to the partnership with the municipality eventually resulting the generation of their resilience plan.

The respective coastal resilience planning documents provide an opportunity for each municipality to become more resilient; economically, socially, and environmentally, towards coastal hazards and the effects of climate change. The plans all went through a multi-step, community resilience building process, from generating awareness of coastal hazards and risks, assessing coastal risks, and prioritizing opportunities. Additional steps included identifying strategies, actions, and measures that can be employed to minimize consequences and create more resilient communities. Lastly, these resources provide plans to pursue opportunities and available measures to help improve coastal resilience along the Southern Connecticut coastline.

The coastal hazards for each municipality are thoroughly identified and explained in all the plans in terms of their vulnerability and risk. These hazards included but are not limited to 1) flooding from high water without the effects of waves, 2) wave setup and wave run-up, focused more towards wave action, 3) erosion and scour along coastal banks and at beaches along the immediate shoreline where roads and other forms of infrastructure are prone to collapse, 4) stormwater and drainage-related flooding due to submerged outlets/discharge points or overflows of sewer and drainage systems, and 5) wind (fetch) causing damage with blowing debris into structures or allowing waters to surge further inland and flood out critical infrastructure. The coastal plans then go on to identify and discuss concepts of resilience, risk, vulnerability, frequency, and hazard probability. The plans for Madison, Guilford, Branford, and Milford use a formula within "the context of hazards," which is defined as Risk = Vulnerability * Frequency or Risk = Vulnerability + Frequency. Each of the four plans closely assess the formula and how it provides a foundation for resilience, ultimately leading to the assumption that risk depends on the vulnerability of coastal communities and infrastructure, and the frequency of flooding and storm events. Summarizing that all coastal hazards, weather related or not, will continue in "Frequency" and "Intensity," making communities more susceptible to risks. However, the Town of Stratford uses a somewhat different "risk-based approach" defining that Risk = Hazard Probability * Vulnerability. This approach defines that all hazards that have a "chance" of occurring no matter what the circumstances are and that vulnerable to those risks is universal. The Stratford plan then clarifies the "probability or occurrence" and the "uncertainty" of all coastal hazards and how communities must recover and adapt to become more resilient

All coastal risks were assessed and broken down for each priority project based at either neighborhood or district scales in the plans. For the municipalities of Madison, Guilford, Branford, and Milford the focus was at the neighborhood scale by identifying each priority site with its geographic location, physical features, vulnerabilities, and risks. The hazards have been described based on their risk and vulnerability criteria for each neighborhood site. In addition, the four coastal resilience plans utilized TNC's Coastal Resilience mapping portal to project downscaled sea level rise and/or hurricane inundation scenarios, and salt marsh advancement zones for the 2020s, 2050s, and 2080s. A total of five categories were used to represent potential flood risk: none, low, medium, high, and critical for each priority site that was selected. The Stratford plan categorized the project sites using the Town's Plan of Conservation and Development (POCD) to represent each priority area by district, this includes the Town Center (TC), Employment Growth District (EGD), Housatonic Riverfront

(HR), Stratford Greenway Network (SGN), and the Environmental and Coastal Preservation (E&CP). Each area was described based on its geographic location, physical features, flood risks, and vulnerabilities. All coastal flood data used was modeled by the consultant which included the tides, waves, storm surge, and sea level rise. The flood scenarios represented from the modeling were based on the years 2015, 2040, 2065, and 2115. Flood risks for each site were then broken down and categorized as either low, moderate or high. All FEMA flood data standards were used for these plans as well as other outside resources and previous studies. Many vulnerabilities were also explained based on the sites overall risk, this included, but were not limited to select categories: social, economic, infrastructure, utilities, emergency services, and natural systems. The categories were then further reviewed and examined based on the sites key assets and services. All vulnerabilities, risks, and available opportunities were gathered and determined from open meetings, workshops, surveys, site assessments, previous plans, reports, and studies.

The plans for the municipalities of Madison, Guilford, Branford, Milford, and Stratford provide a clear catalogue of their strategies, actions and measures for the high priority areas selected. Two plans of greatest importance for all of these four plans were the SCRCOG Multi- Jurisdiction Hazard Mitigation Plan (Madison, Branford, Milford) as well as the MetroCOG Multi- Jurisdiction Hazard Mitigation Plan (Stratford). Reports, studies, and other outside resources supported the development of these strategies and actions particularly with IPCC's "Strategies for Adaptation to Sea Level Rise", developed in 1990. This plan focused around three critical terms; Retreat, Accommodation, and Protection, each helped define and categorize many of the available opportunities and actions discussed in the planning documents. Another resourceful document that was used was NOAA's manual "Adapting to Climate Change: A planning guide for State Managers" and TNC's "Adapting to the Rise: A Guide for Connecticut's Coastal Communities" which helped define and explain the municipalities strategy, action, approaches, and available options for each high priority project by categorizing them as nonstructural, structural, nature-based features or green and natural infrastructure in an effort to provide protection and reduce risk. Other outside reports and studies that assisted in development of actions and measures were the, "Connecticut Recovery Resource Guide" and the EPA, "Rolling Easements" (Titus 2011). Nonstructural category consisted of more traditional strategies concentrated on adopting or changing guidelines for preparedness, emergency response, and available financial options. On the more structural side of the matrix, some methods included hard protection like dikes, sea walls, or temporary flood barriers. For methods of soft protection, the focus was more towards beach restoration, dune nourishment and restoration of tidal wetlands.

Hybrid approaches or a combination of both hard and soft solutions, focused more on beach stabilization and bioengineered banks. Other opportunities and actions were directed towards infrastructure and complying with local, state, and federal codes and regulations. Opportunities included, flood proofing or elevating a building, relocating or moving a structure, retrofitting or improving stormwater drainage and sewer systems, and other flood protection measures. Many of these strategies, actions, costs, benefits, and tradeoffs were reviewed with project teams and local town officials to identify the most comprehensible solutions to community resilience building and mitigate the impacts from coastal hazards.

The Guilford plan was the first coastal resilience plan that was adopted by a municipality in Connecticut. This planning document served as the groundwork and foundation for the other municipalities to adopt coastal resilience plans into their planning procedures - most directly Branford, Milford, and Madison. Essentially, all coastal resilience plans provided actions and scopes for implementation, as well as broader recommendations. For the municipalities of Madison, Guilford, Milford, and Stratford several strategic steps were identified and discussed regarding what procedures should be taken and who is responsible for that particular process. The first step of implementation, focused more on identifying or creating a suitable municipal agency or coastal resilience team to lead the plan of action. Second, a municipality would then utilize or form a hazard mitigation committee to identify and prioritize actions that have been strategically identified in the planning document. Third, the hazard mitigation committee or another municipal agency/ department would coordinate and carefully review objectives in an orderly and manageable fashion to ensure that all objectives are met in the plan. Fourth, actions would then be thoroughly reviewed and discussed within this coastal resilience plan by other municipal agencies and departments, like the planning and zoning, a flood and erosion control board, public works, land use, or emergency management. Once the coastal resilience plan has been implemented, future changes can be made or adopted to support and enhance future hazard mitigation plans and development of conservation plans, with a central focus on reducing risk from coastal hazards and building community resilience along the Southern Connecticut coastline.

Significant Regional Resilience Projects: The National Disaster Resilience Competition (NDRC) provides support for community recovery from past disasters and builds local capacity to withstand and quickly recover from future disasters and disruptions. Through the NDRC, nearly \$1 billion in U.S. HUD Disaster Recovery funds were awarded to communities recently impacted by natural hazards. These funds will help communities to better understand their risks

and develop resilience strategies to protect the well-being and safety of residents.

The core concept of NDRC award to the state of Connecticut is organized around Metro North's New Haven line and transit-oriented development (TOD) nodes. Resilient corridors will link these nodes to coastal communities and critical infrastructure. Recently, Connecticut has made a commitment to heavily invest in the state's transit system by building new stations and increasing service. Low carbon and sustainable development around this system will form the physical foundation for a resilient future. Taking advantage of the unique geological ridgelines running perpendicular to the coast, these corridors will provide safe access to high ground and an organizational structure for new infrastructure and development.

Projects that will strengthen resiliency in coastal communities throughout Connecticut include:

State Agencies Fostering Resilience (SAFR) \$3.5M:

A regional vulnerability assessment and conceptual framing of coastal resilience.

Connecticut Connections Coastal Resilience Plan - \$8.3M: A resiliency plan for coastal, Sandy impacted municipalities in Fairfield and New Haven Counties with the goal of providing accessible inland and coastal flooding information at the watershed scale.

Bridgeport's South End neighborhood is a low-lying peninsula bounded by Cedar Creek, Black Rock Harbor, Long Island Sound and Bridgeport Harbor. A vibrant and diverse community, the South End is made up of residential areas, historic districts and landmarks, industrial facilities, educational institutions, regional transportation systems, and critical energy and wastewater infrastructure. The neighborhood's geography and elevation has made it vulnerable to storm surge and sea level rise. Projects that are being supported through NDRC funds include:

\$5.2 million: Elevated street with integral multi-functional wall to protect against flooding from tidal water and storm surge, and to ensure an evacuation route during major storm events.

Bridgeport Eastern South End Storm Surge Protection - \$35.6 million: Earthen berm and greenway extending to the Bridgeport/Port Jefferson Ferry Landing from onshore combined sewer overflow treatment park at the southern terminus to the reinforced railroad viaduct wall at the northern end.

Study - \$300,000: Analysis of how new and existing energy infrastructure can be housed within the newly constructed berm and raised streets and investigate opportunities for replication.

Bridgeport South End Floodplain Stormwater Design - \$300,000: Guidelines and recommendations using Main Street development at the eastern terminus of University Avenue as a precedent.

Bridgeport South End Resilience Center - \$1 million: a community center that also serves as a satellite Rebuild by Design Center.

Many of the projects in Bridgeport selected for NDRC funding were identified through a previous initiative, Rebuild by Design (RBD). Launched by HUD in 2013, RBD was a multistage design competition to promote resilience in communities affected by Tropical Storm Sandy. Winning projects and proposals were awarded HUD CDBG-DR funds. The goal of the competition was two-fold: to promote innovation by developing regionally-scalable but locally-contextual solutions that would strengthen resilience, and to fund implementation strategies through the public and private sectors. The competition process improved regional coordination and resilience both at the local level and across the United States. Objectives of the competition included:

- Better understand vulnerabilities, strengths, and interdependencies;
- Generate regionally applicable solutions that increase resilience, promote innovation, and integrate local efforts:
- Build capacity of local communities and federal agencies while promoting an integrated regional approach;
- Connect to local efforts and strengthen the collaboration within governments and between government, business, academic, non-profit, and other organizations;
- Ignite innovation, outside-the-box perspectives, and address new trends; and
- Execute world-class projects with regional impact (either large scale or replicable across the region).

In Bridgeport, a multidisciplinary design team prepared an integrated resilience framework, Resilient Bridgeport: Claim the Edge, Connect the Center. By utilizing a watershed planning approach, a framework was developed around the way water flows through and around a community, and the effect on safety and flood risk during both regular rainfall events and exceptional storms. Through an intense public participation process that engaged a wide range of stakeholders, environmental restoration, economic development, and neighborhood revitalization were also incorporated into the framework. The place-specific design solutions identified through this process range from green streets in upland areas to wetland park buffers along the coastline. However, all share the following objectives:

- Integrate multiple lines of defense and resilience to provide redundancy and higher levels of safety;
- Facilitate the flow of materials and people along waterways and waterfronts in order to strengthen the regional economy and ecology; and
- Connect residents to water resources and restore the centrality of water to Bridgeport's identity.

A \$10 million award through HUD CDBG-DR will fund a project to reduce the risk of chronic storm water flooding in some of the City's most vulnerable public housing, located in the South End/Black Rock Harbor area. While the combined NDRC and RBD funds will significantly improve resilience in the South End, there are opportunities to strengthen citywide resiliency. The South End improvements will catalyze support for, funding of and the ultimate implementation of design solutions throughout the City, with the potential for replication in other vulnerable areas of the Northeast coastline. The Resilient Bridgeport framework also identified place-based design solutions that have not secured implementation funding. Future opportunities include a bridge that also serves as a surge barrier at the mouth of Black Rock Harbor, a floodwall from the rail station to Congress Street, a network of green streets in the East Side neighborhood and a new Congress Street bridge to reconnect the East Side with Downtown.

REGIONAL RESILIENCE FRAMEWORK PROJECT: Context, Selection, Types and Strategies

Regional Resilience Framework Project Context

The DOI/NFWF Hurricane Sandy Coastal Resiliency Competitive Grant awarded to SCRCOG in collaboration with TNC and MetroCOG is one of the few opportunities to solicit, screen, and advance natural/green infrastructure projects and incorporate them into the Southern Connecticut Regional Framework for Coastal Resiliency. To successfully execute on all aspects of this project's four components the following steps were taken by the core team and partners.

PROJECT COMPONENT #1: Project Field Reconnaissance, Catalogue, Geospatial Database

Initial Meetings

Potential resilience projects and coastal vulnerabilities were discussed at the individual project coordination meetings in each of the ten municipalities. Municipal staff engaged included the following departments: planning, public works, engineering, and emergency management. Land use and conservation commission members were invited to participate in appropriate meetings. The consulting team in partnership with TNC explained to the municipal teams assembled the goals of Project Component #1 to (1) develop a list of all coastal resilience projects including green, gray, and hybrid projects; and (2) through adaptive meeting facilitation, help brainstorm projects that were or could be "recast" as green or hybrid. The facilitators provided necessary backgrounds in geology, hydrology, engineering, flood management, and ecology to effectively facilitate the meetings. Base mapping specific to each municipality were used for discussion purposes. Visual aids were used to identify new potential locations. Detailed meeting notes were prepared to document the discussion at each meeting (Appendix A).

Field Reconnaissance

Field reconnaissance of potential resilience projects were scheduled for June and July 2015. The goal of each field reconnaissance day was to visit as many of the sites as possible that could potentially be addressed with green or hybrid approaches. As such, the potential for designing a green or hybrid solution was the criteria for deciding whether a specific site should be visited. If a coastal project could only be implemented with gray or traditional methods such as seawalls, bulkheads, road elevation, and/or building elevation, then it was not to be explicitly included in the field reconnaissance. However, if a gray or traditional project site was passed or traversed during field reconnaissance, it was noted or briefly discussed by participants.

Field notes were recorded on paper maps. These maps were prepared beforehand using ESRI ArcGIS products to enable rapid identification of FEMA flood zone boundaries and LiDAR topography in the field. Aerial photography was used as the base layer for the field maps. Field notes included observations that would affect further evaluation of each site such as signs or flooding, erosion, or risks that were not otherwise evident on the maps or described in the resources listed above. Photo documentation of potential resilience projects was conducted. Photographs were taken with the following perspectives, at a minimum, if conditions were safe and appropriate: facing offshore, facing onshore from the edge of water, and lateral views from east and west or north and south (depending on the orientation of the coastline). Additional photographs were taken to document specific vegetation, coastal structures that were present, evidence of damage from prior storms, etc. In some instances, multiple photographs were taken with the goal of later assembling a panorama view. Detailed field reconnaissance "meeting notes" were prepared to document the discussion at each day of field reconnaissance (Appendix A).

Project Selection Criteria

Some resilience projects had merit but did not appropriately reduce risks in a manner consistent with the goals of the Hurricane Sandy Coastal Resiliency Competitive Grant Program. During the execution of the Regional Resilience Framework, key factors were used during Project Component #1 when screening potential natural/green infrastructure projects in the ten municipalities including:

- · Is the project feasible?
- · Can the project be permitted?
- Will the project be effective at improving resilience?
- Will risks to ecosystems be reduced?
- Will risks to people and the built environmental also be reduced?
- Can the project be funded?
- Is the project consistent with the community's Plan of Conservation and Development, Municipal Coastal Program, Harbor Management Plan, Natural Hazard Mitigation Plan, Coastal Resilience Plan, etc.?
- Will the project create conflicts with federal and state coastal zone management policies by impairing public access or discouraging nearby water-dependent uses?
- How does the project related to future conditions as viewed using TNC's Coastal Resilience tool and web-based decision support system depicting future combinations of sea level rise projections and storm surge in the 2020s, 2050s, and 2080s?

Not all of these questions are easily answered. For example, the regulatory climate is changing rapidly, and something that cannot be permitted today may be permitted in several years. Likewise, funding sources are changing rapidly as disaster-related funds are exhausted (FEMAs HMGP, HUDs CDBG-DR, Rebuild by Design, NDRC, etc.) and other sources are being initiated (state funds, green banks, etc.). During this project, as many of the above questions were answered as possible during the solicitation and screening of resilience projects.

Geospatial Database Development

The risk reduction and resilience projects (a) gathered from reports, studies, plans, and grant applications, (b) discussed at the municipal meetings, and (c) reviewed during the field reconnaissance were individually entered into an Excel spreadsheet and converted to an Access database for use with ArcGIS. The geospatial database was also used to create a freely accessible application (Regional Resilience Project Application – Appendix I).

PROJECT COMPONENT #2: Community Engagement

Stakeholder Engagement Activities

The principal objective of Project Component #2 was to create an opportunity to explore and define risk and resilience opportunities at a municipal and an interconnected regional scale and strengthen support for the Regional Resilience Framework. In addition, Project Component #2 was designed to enable the ten municipalities to reach consensus on projects to advance in Project Component #3 as part of the larger Regional Resilience Framework. To realize these objectives a series of sequential engagement steps were employed. The first step was a stakeholder engagement workshop to ensure a collaborative process that increased awareness of risk and resilience opportunities at the municipal and regional scale and to surface top tier projects to be carried forward in subsequent steps of Project Component #2.

SeaSketch Workshop

To facilitate a group-based qualitative process, the project team utilized a web-based planning application known as SeaSketch. SeaSketch is a marine spatial planning tool developed at the University of California, Santa Barbara's Marine Science Institute. Spatial data including project locations and storm surge inundation extents were loaded into the SeaSketch software and presented via the program's interface. Individual teams from each of the ten municipalities were then engaged in a project prioritization process. To execute on this exercise, the project team used a built in survey function to create two surveys which helped guide users to identify high risk areas and then high risk projects. The first survey allowed users to create polygons for high risk areas and then assign points, totaling 100, to the each of three categories based on potential impact (infrastructure, ecologic and economic). The projects identified during Project Component #1 were added to the application and users were be asked to complete the second survey which identifies specific projects within the previously identified high risk areas. Each project was allocated a combined total of 100 points between infrastructure, ecologic and economic to determine the sector at greatest risk. The information was compiled and analyzed by the project team to assist in identifying the coastal resiliency projects throughout the project area.

Site Visits (Highest Priority Project Sites)

The second step of Project Component #2 was to conduct project site visits for each of the ten municipalities to strengthen cross-municipal relationships and share specifics on individual, high priority projects via robust exchange on opportunities and/or concerns amongst municipal-based practitioners. The third step of Project Component #2 was to conduct a workshop focused on preliminary conceptual designs for the agreed upon high priority projects across

the municipalities. The municipal and core team used a qualitative method to reach consensus on high priority projects based on local and regional knowledge of observed risk to ecosystems, property, and/or communities during recent extreme weather events (i.e., Irene and Sandy).

Box 1: Definitions of Green Infrastructure (GI)

EPA: Gl uses **vegetation**, **soils**, **and natural processes to manage water** and create healthier urban environments.

American Rivers: Gl is an approach to water management that protects, restores, or mimics the natural water cycle. GI is effective, economical, and enhances community safety and quality of life. Gl incorporates both the natural environment and engineered systems to provide clean water, conserve ecosystem values and functions, and provide a wide array of benefits to people and wildlife. GI solutions can be applied on different scales, from the house or building level, to the broader landscape level. On the local level, GI practices include rain gardens, permeable pavements, green roofs, infiltration planters, trees and tree boxes, and rainwater harvesting systems. At the largest scale, the preservation and restoration of natural landscapes (such as forests, floodplains and wetlands) are critical components of green infrastructure.

The Nature Conservancy: Gl solutions are planned and managed natural and semi-nat**ural systems** which can provide more categories of benefits, when compared to traditional gray infrastructure. Gl solutions can enhance or even replace a functionality that is traditionally provided by man-made structures. GI solutions aim to build upon the success that nature has had in evolving systems that are inherently sustainable and resilient. GI solutions employ ecosystem services to create more resource efficient systems involving water, air and land use. Gl solutions are designed to fulfill a specific need, such as water purification or carbon sequestration, while often offering location-specific and valuable co-benefits, such as enhanced habitat for wildlife.

PROJECT COMPONENT #3:

Conceptual Design

Project Component #3 consisted of a series of iterative engagements with individual, municipal-based teams and the contractor to generate conceptual designs for high priority projects (see Section 5 and Appendix E). The high priority project selection and design benefited from agreed upon definitions and the current policy context on natural and green infrastructure identified early in the Regional Resilience Framework project process.

Natural and Green Infrastructure Defined:

In the context of natural and green infrastructure, opportunities to reduce risks may include environmentally-friendly beach stabilization, restoring dunes, restoring tidal wetlands, oyster reef creation/enhancement, improving the hydrology of coastal areas, improving/removing infrastructure, living shoreline techniques, and assisting local planning for major storms under current and future conditions. In some cases, a combination of green and hardened infrastructure ("hybrid approaches") may be appropriate (Box 1).

Policy Context for Natural and Green Infrastructure:

There have been numerous developments in the state of Connecticut over the past three years to address concerns of shoreline stabilization in a changing environment and climate. Public Act 12-101 set forth many initiatives to address sea level rise, revise the regulatory procedures applicable to shoreline protection, and promote living shorelines. As a component of the Act, two terms which have been integral to the interpretation of Coastal Management Act (CMA) flood and erosion control structure policies were defined and expanded for the first time:

"For the purposes of this section, "feasible, less environmentally damaging alternative" includes, but is not limited to, relocation of an inhabited structure to a landward location, elevation of an inhabited structure, restoration or creation of a dune or vegetated slope, or living shorelines techniques utilizing a variety of structural and organic materials, such as tidal wetland plants, submerged aquatic vegetation, coir fiber logs, sand fill and stone to provide shoreline protection and maintain or restore costal resources and habitat;" and

"Reasonable mitigation measures and techniques" includes, but is not limited to, provisions for upland migration of on-site tidal wetlands, replenishment of the littoral system and the public beach with suitable sediment at a frequency and rate equivalent to the sediment removed from the site as a result of the proposed structural solution, or on-site or off-site removal of existing shoreline flood and erosion control structures from public or private shoreline property to the same or greater extent as the area of shoreline impacted by the proposed structural solution." [CGS section 22a-92, as amended].

These changes have introduced the application of living shoreline approaches. Due to potential regulatory implications of what the definition of a living shoreline might entail, the Connecticut Department of Energy and Environmental Protection (DEEP) has developed a working definition of "living shoreline" through research of other coastal states, NOAA, and UConn. The current working definition of living shorelines according to CTDEEP is:

"Living shorelines: A shoreline erosion control management practice which also restores, enhances, maintains or creates natural coastal or riparian habitat, functions and processes. Coastal and riparian habitats include but are not limited to intertidal flats, tidal marsh, beach/dune systems, and bluffs. Living shorelines may include structural features that are combined with natural components to attenuate wave energy and currents." [other definitions will appear later in this report]

With the legislative and anticipated regulatory changes coupled with the influx of funding after Hurricane Sandy, the time is ideal for selecting and designing natural and green infrastructure (in other words, nature-based) risk reduction methods along the Connecticut shoreline as provided by this Regional Framework for Coastal Resilience project.

Review of Available Resources About the Connecticut Shoreline and Natural/Green Infrastructure

Connecticut Coastal Design Project: Current Opportunities and Constraints for Connecticut's Coast — Non-Structural/Natural Infrastructure

At least one published resource bridges the gap between the many publications that promote green infrastructure and nature-based risk reduction solutions throughout the United States; this is the report Connecticut Coastal Design Project: Current Opportunities and Constraints for Connecticut's Coast — Non-Structural/Natural Infrastructure (Whelchel et al. 2015). The design project was a key outcome of work conducted under The Nature Conservancy's Coastal Resilience Program in 2014-2015. The documentation lists many important outcomes and findings of the workshops and interviews conducted for the project. The key characteristics of a successful natural infrastructure

project in Connecticut were identified:

- Appropriate location
- Sustainable design
- · Multiple beneficiaries
- · Cost effectiveness
- · Stakeholder understanding

Furthermore, the characteristics of ideal locations for successful natural infrastructure projects in Connecticut were identified:

- · Appropriate physical and environmental conditions
- · Surrounding land use
- · Adequate frontage and scale
- · Strategic opportunities for initial projects

The project identified 11 obstacles to advancing natural infrastructure approaches and projects along the Connecticut coast. In 2015 and 2016, several entities (Restore America's Estuaries) have made progress addressing these obstacles through conferences (Living Shoreline conference in December 2015) and design workshops. One of the obstacles, as stated in the TNC report, was ideal for addressing in the context of this Regional Resilience Framework project:

"Currently, there is no natural infrastructure project design guidance developed specifically for Connecticut's coastal environment (generally: rocky shoreline, low energy, sediment starved). When official design guidance is made available, Connecticut's coastal engineer professionals and natural resource managers can develop a greater understanding of nonstructural options and installation strategies. The design guidance should include specific criteria (e.g. 1.5' wave, slope, fetch, etc.) for siting natural infrastructure projects. The guidance should also include a regulatory mechanism to increase the incorporation of natural infrastructure features in standard hard infrastructure projects (e.g., New Haven harbor). The guidance document(s) need to come from CT DEEP which will require education, training, and workshops for CT DEEP staff. The coastal engineering community is well suited, if willing, to support this type of collaborative education effort."

This Regional Resilience Framework project has not directly produced design guidance, but the ten conceptual designs demonstrate the use of design criteria in the characteristics of designs. This information can be used in the coming years to help develop guidance, along with the outcomes of the ongoing efforts.

CT Sea Grant Climate Adaptation Academy

CT Sea Grant's Climate Adaptation Academy developed and held three separate sessions about the use of living shorelines in Connecticut. The first two sessions were held in 2015 and presented basic concepts to attendees as well as examples of recent and nearby living shoreline projects.

Shortly after the end of the design phase for this Regional Resilience Framework project, CT Sea Grant convened the third living shorelines session. The session was convened as a design charrette, and held at Harkness State Park on September 15, 2016. The various types of living shorelines discussed during the design charrette included beach/ dune nourishment, marsh edge erosion control, living reefs, wave attenuation devices such as reef balls, marsh sills, slope regrading/ planting, and toe of slope fiber log approaches. One important point of contention during the design charrette was whether certain fortified coastal banks could be considered living shorelines, even if designed using combinations of gray and green techniques. This Regional Resilience Framework project is somewhat unencumbered by the definition of living shoreline, since all nature-based risk reduction methods are considered.

The ten conceptual designs for this Regional Resilience Framework projects (Section 5) considered some of the techniques discussed during the CT Sea Grant Climate Adaptation Academy design charrette: beach/dune nourishment, marsh edge erosion control, living reefs, wave attenuation devices such as reef balls, marsh sills, slope regrading/planting, and toe of slope fiber log approaches.

SUMMARY OF REGIONAL FRAMEWORK PROJECT SELECTION: Screening and Development

Beginning in the spring of 2015, available resource documents and direct solicitation of knowledgeable staff and practitioners in each of the ten municipalities was conducted in order to identify and generate a robust and comprehensive list of resilience-related projects across the study area (Project Component #1). The project list was then screened for potential re-casting as nature-based, green, or hybrid projects as needed and then advanced for inclusion in the ArcGIS database of all resilience projects across the ten municipalities (coastal and inland). For completeness, all coastal resilience projects that represented a constructible project on the ground were reviewed and input to the GIS database. The graphic (Figure 2) illustrates the range of projects in a typical coastal context that were reviewed. Community resilience projects like generators and evacuation signs were not included, nor were resilience planning efforts. However, hard infrastructure projects like road elevations were included, along with groups of home elevations or acquisitions, even though these types of projects had little ability to incorporate nature-based, green, or hybrid project elements.

Only nature-based, green, or hybrid projects were considered for design (Section 5). These projects tended to fit within the smaller box on the graphic (Figure 2), bracketed by hard infrastructure and inland projects on the left and the traditional breakwater and groin projects that are located within water on the right. The projects were then sorted based project Type (Box 2) and Strategy (Box 3).

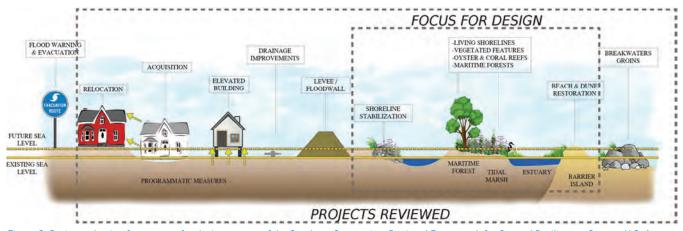


Figure 2: Project selection focus areas for design as part of the Southern Connecticut Regional Framework for Coastal Resilience. Source: U.S. Army Corps of Engineers

Box 2: Regional Framework Project Type Terminology

Coast Natural Infrastructure

Mostly made up of coastal systems such as beaches, dunes, Marshes, and Estuaries. These types of natural infrastructures are critical along the coast because they reduce wave attenuation, provide protection from storm surges and flooding, and act as natural barriers to protect the vulnerable coastline and its many ecosystems from rising sea levels and future coastal storms. Ideally, implementing and constructing these green or hybrid solutions would provide the essential protective measures that are needed to restore these natural coastal systems in an effort to become resilient against a changing climate.

Hard Infrastructure

Is comprised of buildings, critical facilities, roads, bridges, and dams that provide us with an overall network of systems that allow our economy to function properly using transportation systems and emergency services. Improving and updating these assets is essential to prevent future destruction from all natural hazards. Ideally, upgrading, flood proofing, and retrofitting many of these structures with green solutions or other environmentally safe and stable materials will eventually strengthen our overall system and provide an effort to protect all critical infrastructures from climate change.

Inland Natural Infrastructure

As you step away from the coastline, there are many other networks and ecosystems that lie within in both urban and rural settings. Floodplains, floodplain benches, riparian buffers, wet meadows, depressions, riverine corridors, flood protection systems, and bioengineered banks are all inland structures that provide our ecosystems with protection from both urban and rural flooding, whether it's from impervious runoff or high-end rainfall events. Many of these structures could be retrofitted with green or hybrid solutions in order to restore many of the inland natural habitats and essentially protect lives, properties, homes, and roads from future erosion and flooding.

Shoreline Infrastructure

The shoreline consists of revetments, bulkheads, groins, breakwaters, jetties, riprap, and tide gates, which are all forms of hard structures. Hardening many of these exposed coastlines has provided crucial protection in absorbing wave energy, reducing coastal inundation and erosion along the immediate coast. Some have provided near-shore habitat for marine life such as vegetation and living organisms. Many of these structures have held our shoreline intact, especially providing protection from rising sea levels. However, hardening the coastline is not always the answer; we must look beyond and examine all other available options, whether it's retrofitting these structures with green solutions or using other reliable resources and materials to bulk-up our shorelines. Each of these structures has their advantages and disadvantages and we must take that into accountability when hardening our changing coastline.

Stormwater Management

Many projects focus on stormwater infrastructure and network systems located within both an urban and rural landscape. These structures include culverts, outfalls, pipes, channels, permeable pavement, green roofs, street planters, rain gardens/bioswales, infiltration galleries, green street concepts, and other drainage systems. All of which can help develop and improve LID strategies and BMP's within a city and suburban landscape. Implementing, upgrading, and monitoring stormwater infrastructure and drainage systems are vital for reducing all types of runoff, whether it's from imperious surfaces or from high-end storm events. Improving the overall network of drainage systems would essentially accommodate more flow and provide further flood protection at critical gaps. Retrofitting and installing green and natural infrastructure techniques would enhance and modify these stormwater management systems by increasing waterways, storage, and infiltration of runoff, while mitigating future flooding and erosion within cities and towns.

Other

A variety of projects that are currently situated at the coast or near inland areas that have been identified as either current projects or are a placeholder for future resilience opportunities and solutions along the coast. These selected project sites could be further reviewed along the immediate shoreline in an effort to become more resilient against the frequency and intensity of future storms.

Box 3: Regional Framework Project Strategy Terminology

Abandon

To remove or discard something previously built; left alone.

Acquire/Demolish

To obtain or take over with approval; removed or replaced with something else (open space).

Create

Implement, develop, or construct something new.

Create Floodplain

Design, develop, and construct a new or existing landscape into a wetland or depression utilized for periodic flooding or overflow.

Create Floodplain Bench

Develop and construct a relatively narrow inclined landscape (stair –like) or similar as a fluvial terrace.

Elevate

To increase in height or to raise up

Enhance

To build up or to strengthen; improve the quality, value or extent.

Enhance/Modify

A combined effort in strengthening, improving, or by adding to the quality, value, and extent.

Flood Proof

To develop, redevelop or construct a system/ structure that would control or prevent flooding.

Increase Capacity

Increase the amount of space or storage; exceed limit

Modify

To adopt and improve; add existing to or change.

New Area

To remove and improve; to tidy up

Nourish (Managed)

Nourishment is occurring periodically for previously identified landscapes (beaches or dunes)

Nourish (New)

Nourishment could be applied to new landscapes (beaches or dunes) that have never been nourished before

Re-align

Reshape or to change direction; move differently than its original position.

Relocate

To move from one place to the next.

Remove Obstruction

To remove or discard an object in the way.

Replace in Kind

To put something back that is similar, a replacement designed for that specific site.

Replace with other

To put something back that is different, a replacement designed differently with modifications for that site.

Restore

To reinstall, renew, and redevelop back to its original state

Restore (Direct Repair)

To fix, repair, renovate, revamp to its former condition

Restore (Tidal Flow)

Improve the flow of water through channelized areas back to its original state.

Scour Mitigation

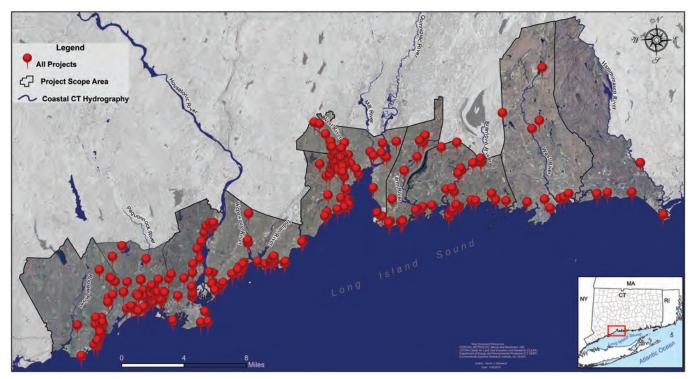
To stop, prevent, or control the wearing of materials from wind, water, and ice.

Undetermined

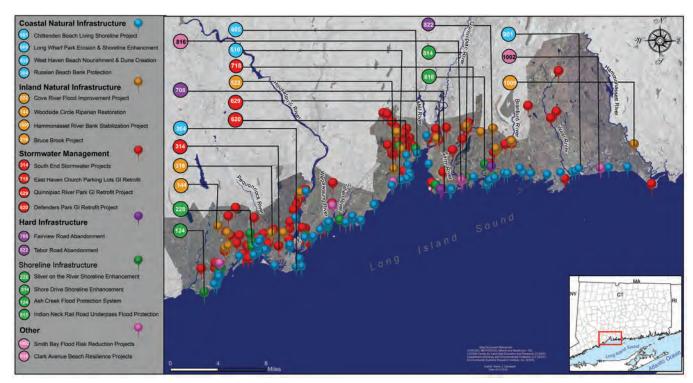
Not known just yet; future planning and strategies are in place.

Regional Resilient Projects:

Over 322 projects were identified and catalogued across the ten municipalities during Project Component #1 (Map #4). Each of the projects represents an initiative that if implemented would help to reduce risk and improve resilience at a local and ultimately, a regional scale. The projects have been categorized by type (see Box 2) (Map #5, #6, #7) (Coastal Natural Infrastructure (Map #9), Hard Infrastructure (Map #13), Inland Natural Infrastructure (Map #14), Shoreline Infrastructure (Map #16), Stormwater Management (Map #17), Other (Map #5) and by intended strategy



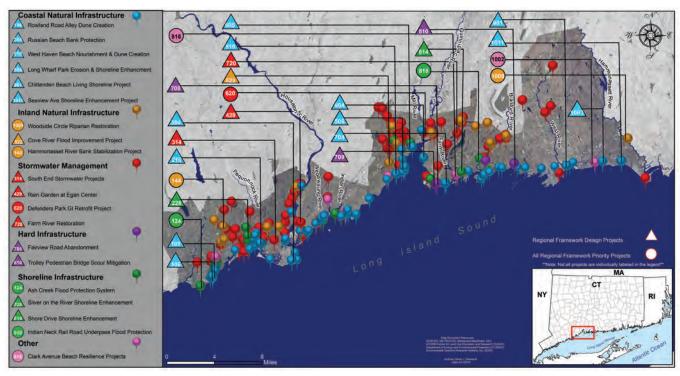
Map 4: All Projects



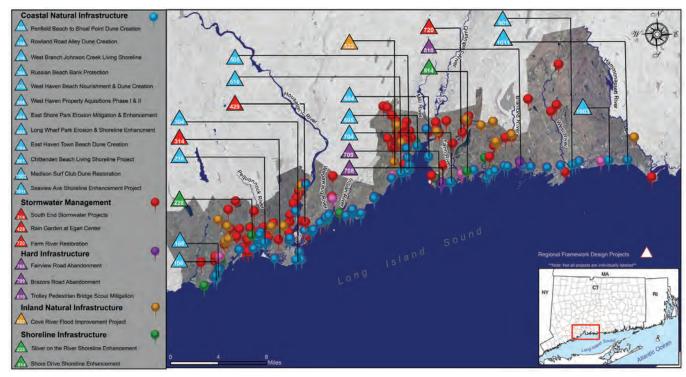
Map 5: All Projects by Type

(see Box 3) (Map #10, #15, #11, #12). Descriptions of priority projects as determined by representatives from the participating municipalities that reflect the various combinations of "type" and "strategy" are provided below. A full list of the projects is provided in Appendix C (Regional Resilience Framework Projects) as well as online via the Regional Re-

silience Framework Project Application (see Appendix I for directions on use) on the Coastal Resilience-Connecticut decision support tool (www.coastalresilience.org or www.maps.coastalresilience.org/Connecticut/).



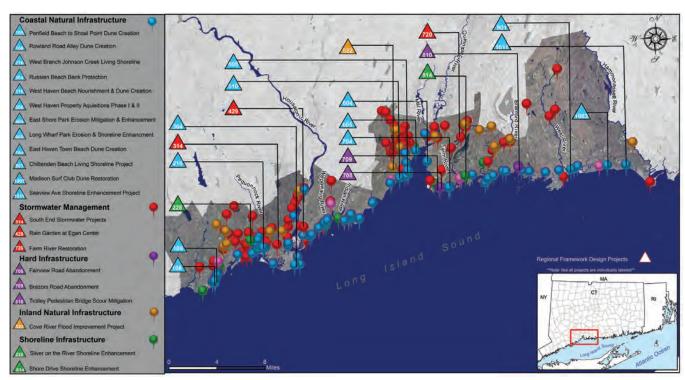
Map 6: All Projects by Type plus Conceptual Design Projects



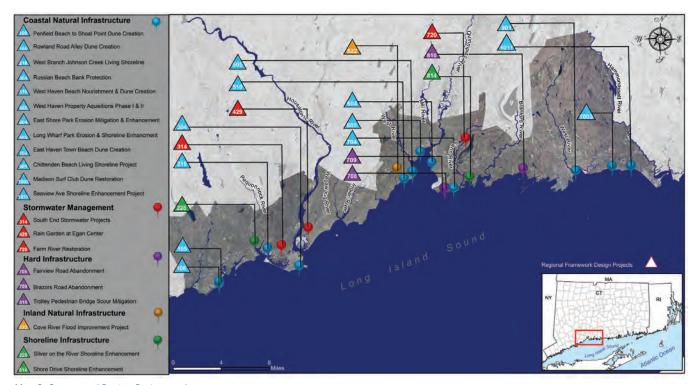
Map 7: All Projects by Type plus Conceptual Design Projects only

As part of Project Component #3 a suite of high priority projects as determined and defined by the core team and municipalities were advanced through a conceptual design process. Those projects have been integrated and

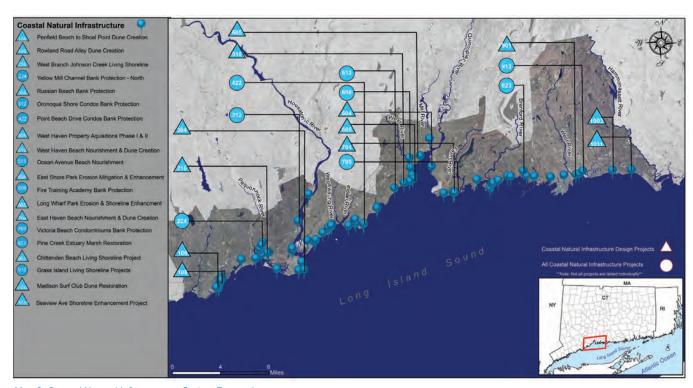
described below and in Section 5; these projects are also visually presented for reference on Map #7 and Map #8 and Appendix E.



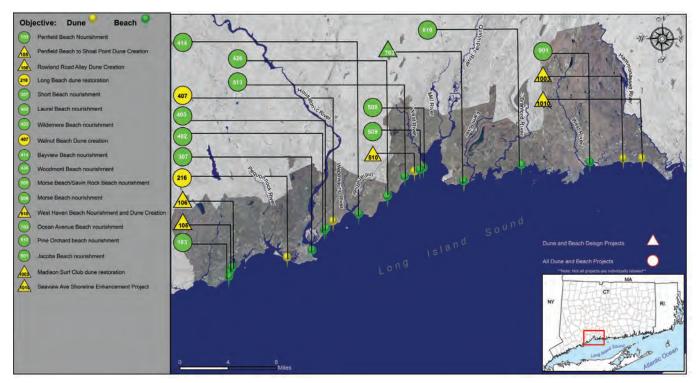
Map 7: All Projects by Type plus Conceptual Design Projects only



Map 8: Conceptual Design Projects only



Map 9: Coastal Natural Infrastructure Project Type only



Map 10: Dune/Beach Project Strategy Projects only

REGIONAL RESILIENCE PROJECT DESCRIPTIONS: Type and Strategy:

TYPE: Coastal Natural Infrastructure: (Map #9)

STRATEGY: Dune Creation and/or Enhancement

FAIRFIELD: Penfield Beach to Shoal Point Dune Creation (Map #9; Section 5; Appendix E)



Credit: Milone and MacBroom

DESCRIPTION: The project site is located toward the end of Penfield Beach nearest to Shoal Point. The intersection of Penfield Beach Road and Reef Road lie immediately to the north. Most of beach is extremely low-lying with little to no ground surfaces rising above 10 feet. This relatively low elevation poses a real flood threat for the adjoining densely populated residential neighborhoods and major west to northwest access routes. This section of beach contains approximately 11 to 12 private properties and homes. The lots closest to the ocean in this area have about a 3 to 4 ft. private conduit along the front of their properties. Immediately south, there are two groins that run perpendicular to this section of beach. In-between the two groins the beach is much wider and there is more build-up of sand. Overall. the beach is narrow with a limited to non-existent dune structure especially between the flood wall and the foreshore. Due to the proximity of beachfront properties and major access routes and the need to protect against flooding the project would create dunes on the existing beach. The dune ridgeline would be constructed to sufficient elevation to reduce storm surge along the entire length of the project area. Invariably the created dune structure would

need to be rebuilt over time, as needed, due to storm impacts. The project would also ensure ongoing recreational use of the beach was maintained.

FAIRFIELD: Rowland Road Alley Dune Creation (Map #9)



Credit: TNC

DESCRIPTION: The project site is at the intersection of Fairfield Beach Road and Rowland Road. The site contains a narrow alley that runs in-between four homes perpendicular to the beach. The alley contains a very low-lying conduit that enables storm surge to pass directly between the homes and onto Fairfield Beach Road, Rowland Road, and into the Pine Creek estuary. This high-density area contains homes and businesses that experienced severe flooding impacts from both Irene and Sandy. This entire area is vulnerable to future flood events unless measures are implemented. The project will consist of creating and designing a dune protection system that will reduce this conduit and provide flood protection from future storm events for many residential neighborhoods and businesses within this area of Fairfield. A high dune system along the alley would eliminate this storm surge conduit as well as maintaining access for residents to the beach.

FAIRFIELD: Fairfield Beach Club Dune Creation (Map #9; #10)



Credit: Milone and MacBroom

DESCRIPTION: This project site is located at the Fairfield Beach Club, which is positioned along Penfield Beach Road between Jennings Beach and Rickards Beach. The entire area was heavily impacted by Sandy. One area that continues to be a growing concern is the low-lying tennis courts located immediately along the back edge of the property. The courts acted as a primary pathway for storm surges that flooded this area of Fairfield. This project represents an alternative and/or future complement to the flood protection system proposed to run along Fairfield Beach Road. This project would create a dune ridge system that could be designed and implemented along the back portion of the beach to reduce coastal flooding and storm surges through the club's property into the adjoining neighborhood.

FAIRFIELD: Jennings Beach Existing Dune Enhancement (Map #9; #10)



Credit: Milone and MacBroom

DESCRIPTION: Jennings Beach lies east of Fairfield's Beach Club and is perpendicular to South Benson Road, which is the only available access in and out of Jennings Beach. Immediately east is Fairfield's Marina and U.S. Coast Guard station, which are situated alongside the mouth of Ash Creek and the Jennings Beach Jetty. There is a considerable amount of beach and dune like systems with dense vegetation located along the back edge of beach. The width is approximately 230 ft. from the toe of the dune to the foreshore. The Town of Fairfield recently (2016) dredged sand out of Ash Creek to nourish this section of beach. This beach and dune ridge (not a true dune) provided flood protection to homes directly behind the ridge during Irene and Sandy. Although the dune ridge was not overtopped, the neighborhoods adjacent to the dune system were flooded from storm surge on Ash Creek. This project represents an opportunity for future nourishment, dune enhancement or creation of additional dunes in front of the existing dune ridge at Jennings Beach. Ideally, this project is considered in the context of a more comprehensive flood protection program in this area.

STRATFORD: Long Beach Dune Restoration (Map #9; #10)



Credit: Milone and MacBroom

DESCRIPTION: Long Beach is located along Long Beach Avenue. The landscape along this section of Stratford's coastline forms a barrier beach with dune structures facing the Long Island Sound with a channel and tidal marshes located on opposite side of the barrier. Long Beach Avenue access road runs in-between with Stratford Airport just to the north where it abuts the extensive tidal marsh system. Over the years, the dune system has been consistently nourished by the municipality. Several groins that were installed along the beach during 1960's have likely affected this section of Stratford's shoreline. The storm surge during Sandy completely overtopped this entire area and washed out a good portion of the beach and barrier. A low profile dune system remains that could be restored or enhanced to pre-existing heights which would be beneficial for the onsite habitat and species as well as critical infrastructure to the north. A beach nourishment and dune restoration/ enhancement project could serve as part of a more comprehensive flood protection system which does not alter the characteristic of the existing habitat and could enhance recreational opportunities.

MILFORD: Walnut Beach Dune Creation (Map #9; #10)



Credit: Milone and MacBroom

DESCRIPTION: This multiple phase project for Walnut Beach focuses on an area along the beach facing the side of the boardwalk running parallel to Walnut Beach. The project would involve the creation and enhancement of a dune like system that would serve as a natural barrier/berm to provide further localized flood protection for the adjacent roadway and condominiums to the west. Dunes created could serve as part of a localized flood protection system for the residential neighborhood between Viscount Drive and Nettleton Avenue.

WEST HAVEN: West Haven Beach Nourishment and Dune Creation (Map #9; Section 5; Appendix E)



Credit: Milone and MacBroom

DESCRIPTION: The project site is located at the West Haven Beach. Currently, the city of West Haven has the most amount of public beach in the state of Connecticut stretching over three miles. The area contains many public amenities including a walkway extending the length of the beach with open views of Long Island Sound. Immediately

adjacent to the walkway is Altschuler Place, a residential area with a large number of condos and single family homes. Currently, the condominium association has a pedestrian easement with the city of West Haven. As a result, it is the municipality's responsibility to repair and maintain this public amenity. During the 1970s the beach was constantly nourished to a width of approximately 300 feet, but since then it has retreated to about 150 feet in width. The beach itself contains 2 or 3 groins that extend outward into the Sound that do hold some sand in place. The dune system is somewhat limited in this section with vegetation scattered throughout the site. Turf grass and other types of vegetation can be found along the back edge of the beach and the walkway. Just to the west of the immediate project area, the dune structure is much wider and higher. The project would consist of restoring and building up the original dune structure, while nourishing the existing beach. The outcome of this project will be a continuous high dune ridge and lower dune structures that will reduce storm surge and inundation to adjacent housing while increasing recreational and ecological benefits.

EAST HAVEN: Town Beach Dune Creation (Map #9)



Credit: TNC

DESCRIPTION: The project site is currently located at the East Haven Town Beach. Immediately to the north is Cosey Beach Road. This road runs parallel with the beach as does a 4 ft. concrete wall situated between the beach and road extending the entire length of the beach (approximately 835 ft.). To the north and east of Cosey Road there are many residential neighborhoods, businesses, and critical facilities. The entire area is low-lying; consequently, this area experienced significant flooding and damage during both Irene and Sandy. There is no dune protection system currently, but there is a considerable amount of beach between the water's edges and the concrete wall. This site is a candidate for the creation and design of a low dune protection system to help reduce the risk of storm surge

directly impacting the new wall and critical infrastructure that lies along and to the north of Cosey Beach Road. This project will improve the beach and dune system and help maintain a recreational option for all citizens of East Haven.

MADISON: Madison Surf Club Dune Restoration (Map #9; Section 5; Appendix E)



Credit: Milone and MacBroom

DESCRIPTION: This project site is located at the Surf Club Town Beach. There is roughly 1,050 linear feet of beach along this section of shoreline. Roads, residential homes, businesses, a golf course, and athletic fields are in proximity to the north and east of the site. This low-lying area was critically impacted by storm surge and flooding from both Irene and Sandy. The two weather systems breached a portion of the dune and deposited sand into the tidal wetland to the rear of the site. Many nearby homes, businesses and roads, especially Parker Avenue to the east, were flooded. The town took immediate action by adding additional sand to repair the 300-foot breach to reduce frequent tidal flooding that constantly exacerbated the issue well after the storms. This 300-foot gap is still vulnerable to future weather events and state officials have denied the towns request to remove sand from the tidal wetlands. Ultimately, this project consists of restoring the dune system and providing flood protection at a critical gap. Without a dune structure, future storm surges will continue to erode the breach and flood out nearby residential areas, facilities, roads, and businesses.

MADISON: Seaview Avenue Shoreline Enhancement (Map #9)



Credit: TNC

DESCRIPTION: This project site is located along the eastern portion of Madison's shoreline. The project adjoins Seaview Ave which intersects Middle Beach Road from the west. A bridge separates the two road connections over a small tidal channel that flushes an extensive salt marsh located northwest of the site. A steep embankment is also located along the ocean side of the road with many private stairs cases and wooden walkways leading over the marsh and dunes down towards the private beaches. This project would improve public access and reduce the amount of foot traffic heading towards the beach by conjoining and raising walkways over existing marsh and dune structures to allow for marsh advancement and natural habitat growth. In addition, the project would enhance the dunes along this section of beach to reduce future coastal flooding along Seaview Avenue.

STRATEGY: Beach Nourishment

As indicated on Map #10 and in Appendix C there were a multitude of projects identified that were intended to provide sand to existing beaches from across the region in addition to the dune-related projects listed above. Ongoing, routine, and recent beach nourishment occurs at Penfield Beach (Fairfield), Jennings Beach (Fairfield), Laurel Beach (Milford), Woodmont Beach (Milford), Ocean Avenue Beach (West Haven), and Jacobs Beach (Guilford). Additional beach nourishment projects identified by the municipalities include:

STRATFORD: Short Beach Nourishment

Short Beach has been nourished routinely over the last decade. This project represents future and ongoing nourishment effort to maintain a high priority public amenities for the municipality and surrounding areas.

MILFORD: Wildemere Beach Nourishment

Wildemere Beach is not nourished and is narrow or nonexistent at high tide. A wide beach like Laurel Beach is desired by residents and the City; this project may reduce risk of damage during storm events, and it could provide a platform for creation of a dune ridge.

MILFORD: Crescent Beach Nourishment

Crescent Beach has not been nourished with sand in decades. This project would focus on future and ongoing beach nourishment that could help reduce wave energy at the adjacent road.

MILFORD: Bayview Beach Nourishment

Bayview Beach is an area that has been identified as potentially benefitting from beach nourishment to reduce risk of damage from coastal storms. This could serve as one component of resilience projects for the Bayview neighborhood. Nourishing the beach at this location could possibly lower the wave heights and reduce the risk of the privately-owned seawalls from being undermined by erosion and scour.

WEST HAVEN: Morse Beach Nourishment

Morse Beach had 20,000 cubic yards of sand placed in early 2016 to restore the beach width post Sandy. This effort will reduce wave energy during future coastal storms and will help satisfy the recreational needs of the City.

WEST HAVEN: Morse Beach-Savin Rock Beach Nourishment

This section of West Haven Beach is periodically nourished with sand. The last nourishment was completed in 1994. This project represents future and ongoing beach nourishment events to augment the recreational needs of the City. There is a solid opportunity to create a dune ridge on the existing beach platform.

BRANFORD: Pine Orchard Beach Nourishment

The Pine Orchard Beach in front of the seawalls is limited in width and submerged during high tides. Nourishment may help reduce wave energy at the seawalls for this site. However, it is important to note that nourishment may be needed periodically as sediment get washed out over time.

STRATEGY: Living Shoreline Establishment

GUILFORD: Chittenden Beach Living Shoreline (Map #9, #11; Section 5; Appendix E)



Credit: Milone and MacBroom

DESCRIPTION: The Chittenden Beach Project is located toward the southern end of the newly renovated park and athletic fields. There is a walkway that extends over the marsh and down towards the small semi-circle beach. The project area is just south of the Guilford Yacht Club and immediately next to the mouth of the West River. The surrounding area is extremely low-lying with most of the area contained in FEMA's flood hazard zones. The entire area suffered a significant amount of damage from Sandy. This multi-component project has been described as a living shoreline. "A Living Shoreline is a shoreline with management approaches that use natural elements, such as vegetation, to protect shorelines from erosion, provide or enhance habitat and water quality and preserve the natural processes and connections between riparian, intertidal and subaqueous areas" (Guilford CCR Plan). Ideally, this project would focus on a few components including the installation of an offshore breakwater or some type of hybrid structure for wave attenuation at this high-energy site. The second component would focus on reconstructing a new groin at the mouth of the West River towards Chaffinch Island Point. Another would be to add sediment behind a rocky sill with marsh grass planting along this half-moon shaped section of beach to nourish, restore, and stabilize the tidal marsh. The outcome of the project will help mitigate future erosion and provide further flood protection of nearby infrastructure and amenities.

BRIDGEPORT: West Branch Johnson Creek Living Shoreline (Map #9, #11; Section 5; Appendix E)



Credit: Milone and MacBroom

DESCRIPTION: This project site is on the east facing part of Johnson Creek inlet at the intersection of Central Avenue and Trowel Street. The area is extremely low-lying and within the FEMA flood zones. This area was severely inundated by Sandy. Most, if not all, runoff flows into two catch basins located at the intersection of Central and Trowel, then discharge from at 36" RCP culvert into the tidal wetland. Scour and erosion has occurred along this section of roadway and barricades have been placed at the edge of the road to prevent further loss of the soil and asphalt. Ideally, this project along Johnson Creek would consist of shoreline stabilization with the opportunity for public access. The primary focus would be to develop a greenway or living shoreline that would extend from PC Metals, and wrap itself around both the east and west sides of the inlet, eventually connecting to the East End Yacht Club. A living shoreline was evaluated in 2013 to provide shoreline stabilization and enhance public access. The City has acquired parcels on the west side of the inlet and is focused on obtaining easements for the rest of the parcels located along Webster Avenue.

GUILFORD: Grass Island Living Shoreline (Map #9, #11)



Credit: Milone and MacBroom

DESCRIPTION: This project is located directly across from Jacobs's beach in the Guilford Harbor. The project area is situated towards the end of a small peninsula off Circle Beach Road. Immediately to the east lies the mouth of the East River as it empties into Guilford Harbor. The East River State Boat Launch is also located on the eastern side of the peninsula directly across from the East River Marsh Wildlife Area. The site contains a small, narrow beach that wraps around the tip of the peninsula facing the marina. There are some dunes with dense vegetation located towards the center of Grass Island with beachfront homes and properties located at the far southern side facing Long Island Sound. The area is extremely low-lying and vulnerable to future coastal storms and sea level rises. Ideally, an integrated groins, beach enhancement, and marsh restoration effort east and west of the harbor would help reduce long term and immediate risks to this area. This living shoreline project would use green infrastructure or hybrid solutions to protect this vital section of coastline.

BRANFORD: Stony Creek Beach Living Shoreline (Map #11)



Credit: Milone and MacBroom

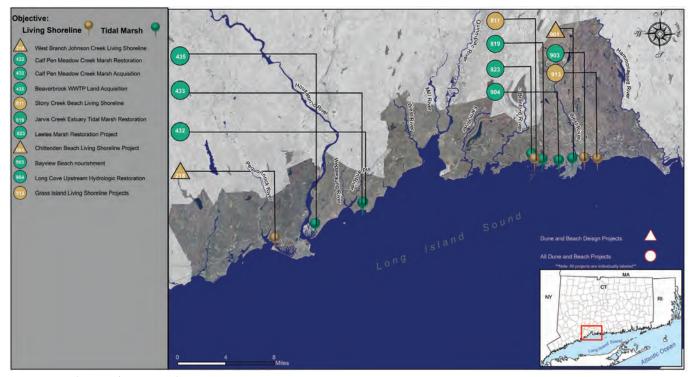
DESCRIPTION: Stony Creek Beach is located along Thimble Island Road and directly east of Pleasant Point. This area was certainly impacted by storm surges and inundation from Sandy. This area of Branford's coastline provides a vital public amenity to town residents for accessing Stony Creek Beach. The site consists of a stone cement pile wall located on either side of the beach with a patch of tidal vegetation located immediately north on the opposite side of the gazebo. On the southern side of the beach there is small grassy park containing a walkway and benches. The stone pile wall extends along the park with 36" RCP discharging into the Sound. At low tide, most of the area is composed of mud flats while at high tide the water level reaches the bottom portion of the pipe. Ideally, this project would incorporate intertidal vegetation along portions of the north and south walls of the beach with the possibility of using the northern vegetation site as a reference site. The result would mitigate the erosion occurring along the walls and enhance the overall ecological value for this area.

NEW HAVEN: Long Wharf Park Erosion Mitigation and Shoreline Enhancement (Map #9; Section 5; Appendix E)



Credit: TNC

DESCRIPTION: Long Wharf Park is located along Long Wharf Drive immediately parallel to Interstate I-95. Sargent Drive runs on the opposite side of I-95 but intersects Long Wharf Drive at two critical sections. The site is immediately north of the Long Wharf Nature Preserve and south of downtown New Haven and Union Station. The project area is approximately six to seven acres with all of it lying in FEMA's flood hazard zones. The area did experience a significant amount of flooding, erosion, and damage along the shoreline from both Irene and Sandy. Adjacent to the culverts is the nature preserve which serves as a reference site for future resilience projects in this area. The most severe erosion onsite begins just north of the veteran memorial and extends to the southern end of the riprap section near the food vendors and visitors center. An asphalt walkway is located just above the shoreline, which has collapsed in many sections along the top portion of the eroded bank. The slope of the bank is somewhat gentle with a one to three-foot vertical drop. The distance between the edge of the Long Wharf Drive and the eroded bank along I-95 is approximately 22 feet. This is a critical low-line area because of the proximity to a sewer main with any sustained damage having devastating impacts to the City and surrounding infrastructure. The city of New Haven would like to revitalize this entire landscape with either green or hybrid solutions. A living shoreline approach in the intertidal zone may be possible. The results of this project would not only improve the overall aesthetics of this vital shoreline amenity, but also provide protection at a critical gap from future erosion and coastal flooding.



Map 11: Living Shoreline/Tidal Marsh Strategy Projects only

Other Projects with Living Shoreline Elements: (see Appendix C)

Stratford: Reef Ball Project - Concrete reef balls were installed at Stratford Point in 2014 as an experimental erosion mitigation and sediment accretion project. The balls were installed in two rows, covering about 3.5 acres of intertidal zone. The concrete reef balls are one of the first examples of hybrid living shoreline designs in the state of Connecticut. This pilot project demonstrates the usefulness of incorporating living shorelines into Connecticut's shoreline management strategy.

BRIDGEPORT: RBD #S.2 Breakwater Creation

This Rebuild by Design project is one component of the #S.2 living shoreline. The breakwater would be constructed offshore to help facilitate survival of the living shoreline. Despite the technical feasibility of this project, it is important to note that implementing a new breakwater may be difficult and alternative living shoreline designs should be pursued.

Bridgeport: RBD #S.2 Living Shoreline Creation

This Rebuild by Design project is one component of the #S.2 living shoreline. The living shoreline would be constructed near the shoreline at the northeast end of Seaside Park.

STRATEGY: Tidal Marsh Restoration and Enhancement

MILFORD: Calf Pen Meadow Creek Marsh Restoration (Map #11)



Credit: TNC

DESCRIPTION: Calf Pen Meadow Creek is located along Melba Street as the bridge as if flows from Summer Place and all the way towards Buckingham Ave to the north. Many backyard properties along the left side of Melba Street and right side of Summer Place extend into the marsh. Over many years the sediment and other debris have built up due to past weather events, spring tides, and other natural processes. This project would focus on removing that sediment located along the center line of the channel and marsh (approximately 40 acres) to help restore the tidal conveyance in the creek and therefore the longterm viability of this ecosystem. This project was originally funded by NRCS but the focus was on a much smaller sediment removal project further upstream. The entire project would provide further protection of nearby private properties and ultimately restore the channel and marsh back to its original state. The NRCS will acquire seven privately-owned parcels of tidal marsh associated with Calf Pen Meadows Creek. This will ensure that additional risk to surrounding homes will be minimized.

WEST HAVEN: West Haven Property Acquisition and Restoration (Map #9)

DESCRIPTION: The project is a multiphase project located in West Haven. Phase I of the project is being enabled by NRCS who have obligated funding for the acquisition of 13 properties along the southern portion of 3rd Avenue. The project site is located north of Morse Park and along lower portion of the 3rd Avenue Extension and Blohm Street. This area is extremely low-lying and has experienced significant flooding during previous storm events. The topography of

the area is somewhat bowl-shaped towards the tidal marsh with much of the area contained within FEMA's flood Hazard Zones. These homes are to be removed with the area converted into open space to help with the advancement of salt marsh and natural habitat. Other green or natural infrastructure techniques such as vegetated swales, berms, or floodplain benches could be installed here. This will alleviate the further loss of homes and provide protection of roads and other critical infrastructure surrounding the Old Field Creek tidal marsh.

BRANFORD: Jarvis Creek Estuary Tidal Marsh Restoration (Map #11)



Credit: Milone and MacBroom

DESCRIPTION: The Jarvis Creek Estuary is situated along Route 146; otherwise known as Leetes Island Road. This entire are is extremely low-lying and was significantly impacted by Sandy's storm surge as well as routine storm events. Due this flooding, Leetes Road may need to be raised in the future. Ideally, this would reduce the frequency of flooding along this section of Route 146; a major road in and out of the town of Branford. Further studies and assessments maybe warranted for this area of Jarvis Creek. Other potential flood protection systems, either green or hybrid solutions, should be further reviewed. This potential project could eventually provide future resilience opportunities for the Jarvis Creek Estuary. Ongoing studies of this the Jarvis Creek tidal marshes may reveal problems to address with resilience projects such as potentially reconstructing the tide gates.

BRANFORD: Pine Creek Marsh Restoration (Map #9)

DESCRIPTION: The Pine Creek project site lies just to north of the Branford Trolley Bridge, Pleasant Point, and the Amtrak rail line. There continues to be ongoing studies of the Pine Creek tidal marshes which may provide additional concerns. This project would focus on restoring the tidal flow and enhancing the estuary at Pine Creek.

GUILFORD: Long Cove Upstream Hydrologic Restoration (Map #11)



Credit: Milone and MacBroom

DESCRIPTION: This project is focused on the upper portion of Long Cove. Sachem Head Road intersects with Route 146 and Water Street immediately next to the Long Cove Marsh. Mulberry Point Road then intersects Route 146 on the eastern side of the tidal marsh. The surrounding area contains many residential homes and neighborhoods along Route 146, as well as Sam Hill Road to the north. Water Street (Route 146) runs underneath the rail line and along the backside of tracks and the marsh. The entire area is extremely low-lying and has experienced a tremendous amount of flooding from both rainfall and coastal storms. Most of the topography in the area is sloped away from the marsh allowing Water Street to act like a bowl; constantly flooding from runoff and storm surge during high impact events. The final component of the Long Cove project would consist of removing or breaching an obstruction immediately next to the tidal marsh to allow for proper drainage of precipitation to the estuary. The outcome would alleviate the constant flooding of Water Street and provide flood protection for Route 146; a major access road in and out of the town of Guilford. The Long Cove at Daniel Avenue Stream Channel Modification project compliments this hydrological restoration project. The other component would enhance the tidal creek channel at Daniel Avenue to reduce ongoing nuisance flooding.

STRATEGY: Coastal Bank Protection

BRIDGEPORT: Yellow Mill Channel Bank Protection – South and North (Map #9, #12)



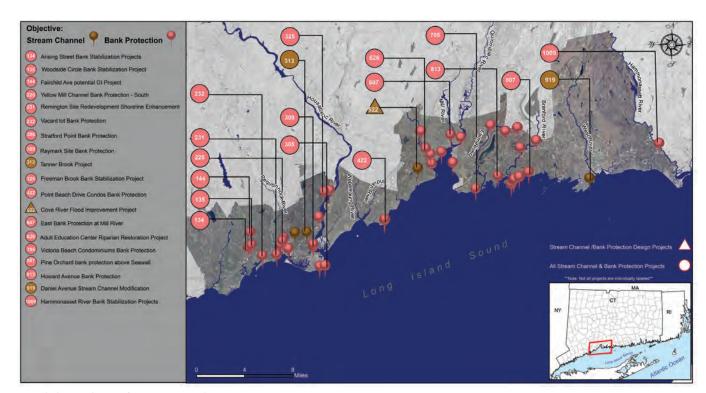
Credit: Milone and MacBroom

DESCRIPTION: A southern and northern section of the west bank of Yellow Mill Channel have experienced erosion that threatens Waterview Avenue. Two schools, Waltersville and Barnum, are adjacent to this property. The Waltersville School is most proximate to Waterview Ave and has had drainage issues in the past with most of the runoff flowing from northwest to southeast on the property and then draining into three catch basins located in the southeast

corner of the parking lot. Most of the runoff then discharges into the Yellow Mill Channel through a culvert along the embankment. Thus, this area has witnessed a considerable amount of erosion and scour along the bank. Waterview Avenue is vulnerable at this section due to its proximity to the river. Green infrastructure and hybrid shoreline-protection measures will be considered here to enhance the bank protection along this section of the Yellow Mill Channel.

BRIDGEPORT: Remington Shaver Site Redevelopment Shoreline Enhancement (Map #12)

DESCRIPTION: The Remington Shaver site is currently located along the southern section of Main Street and towards the northeast section of Seaside Park. This entire area consists of industrial properties and empty parking lots. The area will soon be remediated and redeveloped into a mixed use. East of the site is protected by bulkheads and riprap. Green or hybrid shoreline-protection measures will be employed when the site is redeveloped. A crescent shaped beach is also located along the front right quadrant of the Remington Shaver site, extending to Seaside Park. This area contains some beach with limited low dune vegetation and beach grass. The lower section of Remington will tie into a living shoreline/greenway as part of a Rebuild By Design project for the city of Bridgeport.



Map 12: Stream Channel/Bank Protection Strategy Projects only

BRIDGEPORT: Vacant Lot Bank Protection (Map #12)



Credit: Milone and MacBroom

DESCRIPTION: This project site is located along Wordin Ave, just south of Pine Street and Interstate I 95. This section of Bridgeport has limited public access to the banks of Cedar Creek. One entry point is located off Wordin Avenue along the channel's western bank. An empty lot exists on site and is adjacent to an old dilapidated building that was completely built out over the water. There is another building and parking lot that is immediately next to the site that looks to be occupied. The eastern banks of Cedar Creek are predominantly made up of steel sheet pile bulkheads. This empty parcel along the bank has been experiencing some erosion. Installing natural infrastructure to stabilize the bank or other hybrid approaches along this shoreline would be beneficial for future flood protection of adjacent properties in and around Cedar Creek.

STRATFORD: Russian Beach Bank Protection (Map #9, Section 5; Appendix E)



Credit: Milone and MacBroom

DESCRIPTION: The project site is in Stratford at Russian Beach. There are many residential properties and roads that surround this site. York Street and Cove Place both run perpendicular to Park Boulevard which runs parallel to Russian Beach. The coastal bank at Russian Beach is undergoing severe erosion with limited protection in place. There is approximately 1000 feet of bank and beach that has been eroding. Most of the erosion occurred during Irene and Sandy. The residents of the area are concerned because several beach homes located on the opposite side of Park Boulevard are potentially at risk as is the immediately proximate Park Boulevard. Most of the sediment at the site is composed of sand and gravel with top soil and grass. There is some evidence that runoff from the Park Boulevard is enhancing the erosion along the backside of the bank. This project will consist of a bioengineered bank design either as a green infrastructure or hybrid solution that will further mitigate the erosion occurring along the bank of Russian Beach.

STRATFORD: Stratford Point Bank Protection (Map #12)

DESCRIPTION: Stratford Point is located at the most southern point of Stratford. The project area is near Lordship Point and Prospect Drive. Residential homes, neighborhoods, and businesses make up most of Stratford Point. The project area experienced major storm surge affects from both Sandy and Irene. There is a portion of the coastal bank that is undergoing some erosion with a variety of pre-existing protections in place. However, the erosion along the bank has escalated recently. Further bank protection or bank stabilization concepts would need to be implemented as either green infrastructure or hybrid solutions. Ideally, this would mitigate future erosion and provide further protection of homes and businesses situated in this residential area.

STRATFORD: Raymark Site Bank Protection (Map #12)



Credit: Milone and MacBroom

DESCRIPTION: This project site is situated southeast of the wastewater treatment plant along the greenway and in front of the Raymark parcel. The coastal bank is undergoing erosion with little to no protection in place leaving riprap and fill material exposed to further subsidence seaward. This project area did not experience any significant flooding or overtop from Sandy. Ideally, the project will consist of designing and installing a green infrastructure or hybrid protection system that will stabilize the bank and provide further protection of nearby critical facilities and residential neighborhoods. Similar treatments are recommended for the adjacent WPCF Bank Protection project.

STRATFORD: Oronoque Shore Condos Bank Protection (Map #9)

DESCRIPTION: This project is located off Ryders Lane just south and east of the Sikorski Estuary Walk and Route 15. The project area is comprised of a condominium complex with single-family homes that are positioned immediately along the bank of the Housatonic River. The bank of the Oronoque Shore Condos is currently eroding away with little to no protection in place. Some of area is contained within a FEMA flood zone due to its low-lying elevation. Ideally, restoring and enhancing bank protection would further stabilize the bank and mitigate any future erosion and potential flooding of the Oronoque Shore Condos.

STRATFORD: Raven Stream Bank Protection (Map #12)



Credit: TNC

DESCRIPTION: The Raven Stream is located along the southern portion of the Housatonic River. The stream weaves its way through a concrete weir on the west side of the road (Diane Terrace). After the stream passes through several culverts under the road, the stream enters a short tidal section that joins the southern portion of the Housatonic River. At low tide most of the bank is visible on both sides, however, at high tide most of the banks are under water. Bank erosion can be seen downstream from the road on both left and right sides. The banks that are near the culverts consist of concrete blocks that make up the headwall beneath the road. Most of them are uneven and in danger of collapsing. This project would consist of designing and installing bioengineered banks with possible new headwalls. Ideally, this will stabilize the bank and prevent further erosion. This would also provide further flood protection for surrounding residential neighborhoods and access roads along the southern portion of the Housatonic River Watershed.

MILFORD: Point Beach Drive Condos Bank Protection (Map #9, #12)



Credit: Milone and MacBroom

DESCRIPTION: The project site is located at the Point Beach Drive Condos. The Condos sits along a cul-de-sac that faces the Long Island Sound. The length of this section of beach and bank extends for about 700 ft. Towards the southern end, a 48" RCP stormwater pipe extends out from Point Beach Road and drains into the Sound. Along the steep embankment are two sections of broken up seawall consisting mostly of concrete blocks. At one time the blocks were used to hold up the bank but all sections have collapsed and fallen seaward due to significant erosion and scour. Many of the properties along this section of Milford's shoreline are at high risk. This project would consist of installing a bioengineered bank to ultimately stabilize the steep bank while protecting critical infrastructure.

NEW HAVEN: East Bank Protection at Mill River (Map #12)



Credit: Milone and MacBroom

DESCRIPTION: The Mill River is located immediately to the north of Interstate I-95 and Ball Island. The project area is adjacent to John Murphy W Drive. The bank along this portion of the Mill River is made up of shoreline vegetation with some riprap mixed alongside the bank at the water's edge. However, this site is extremely low-lying and is currently with FEMA's flood hazard zones. The surrounding area is mostly comprised of commercial and industrial sites with some residential homes and neighborhoods located to the east. This area has experienced flooding and erosion issues from past storm events due to a gap in the shoreline and along the bank. Ideally, this project would focus on installing green infrastructure, hybrid bank solutions, or other bank stabilization techniques to mitigate any future erosion and provide further flood protection measures for properties situated near this project site along the Mill River.

NEW HAVEN: East Shore Park Erosion Mitigation and Shoreline Enhancement (Map #9)



Credit: TNC

DESCRIPTION: East Shore Park is located along Woodward Avenue and just to the southeast of downtown New Haven. More specifically, the Park is on the eastern side of New Haven Harbor and just north of the United States Coast Guard Station. This vital public amenity contains a narrow beach, athletic fields, tennis courts, trails, and asphalt walkways within the park's 82-acres. Over the years, significant flooding and erosion has occurred with notable loss of shoreline partly due to Irene and Sandy. The Park does contain a high water table with some low-lying area currently within FEMA's flood hazard zones. A narrow sandy beach is located along the shoreline with thick vegetation along the steep eroded bank behind the beach. There are also two culverts (48" RCP) that discharge into the Harbor. The bank height is approximately five to seven feet (vertical) with limited public access to and from the water. This site does contain large riprap that was placed along the shoreline in 2006. Vegetation was planted in-between these sections of riprap but both the sediment and vegetation eroded away, potentially due to the riprap. Ideally, the city of New Haven is focused on a comprehensive green infrastructure or hybrid solution to mitigate the risk of further erosion and flooding. A bioengineered bank may be the best shoreline stabilization strategy in this area.

NEW HAVEN: Fire Training Academy Bank Protection (Map #9)



Credit: Milone and MacBroom

DESCRIPTION: This site is located along the West River just to the north of Interstate I-95 where the River empties into New Haven Harbor. The area did experience riverine and tidal flooding from both Irene and Sandy. Immediately behind the site are multiple parking lots and six large critical facilities that are used for fire training, emergency purposes, and storage. Upstream from the site lies a major rail line and bridge. Immediately south, the left bank of the tidal West River has experienced further erosion which has become progressively visible in recent years. Vegetation does exist along the site which could help stabilize the bank for future protection. However, there is evidence that the parking lot did extend further outward from the bank which has been eroded away and pieces of asphalt remain along the bank. The project consists of incorporating bank protection as either a green infrastructure or hybrid solution to reduce the risk of scour and erosion occurring along the bank of the West River at the Fire Training Academy.

EAST HAVEN: Victoria Beach Condominiums Bank Protection (Map #9, #12)



Credit: Milone and MacBroom

DESCRIPTION: The project is located off Cosey Avenue immediately adjacent to the condominium complex on the east side of East Haven's Town Beach. The condominium complex is situated on slightly higher ground than the Town Beach. However, most of the area is still low-lying and currently in FEMA's flood hazard zones. Armored riprap and/or revetment forms a bank along the front of the condo units. At certain sections of the engineered bank there appears to be some sand and beach grass that has been planted in-between. In front of the bank lies the condo's private beach with limited space available between the toe of bank and the water's edge. Ideally, due to the space available, this project would focus on re-designing and constructing a true bioengineered bank that would provide further flood protection for the complex and adjacent properties from future coastal storm systems.

BRANFORD: Howard Avenue Bank Protection (Map #12)

DESCRIPTION: The project is located along Howard Avenue, which intersects Rustic and Lamphiers Cove Road. The project area is situated in Lamphiers Cove just south of the Short Beach Preserve and northeast of Lindsay Cove. The site consists of shoreline homes that align this section of coast in a semicircle. Immediately in front of the homes is an eroded bank with a sewer main along Howard Ave at an immediate risk of collapsing seaward. Ideally, the project would focus on stabilizing the bank by incorporating either green infrastructure or hybrid solutions. The result would potentially mitigate future erosion and provide protection of the overall sewer system along this section of Branford's shoreline.

TYPE: Hard Infrastructure: (Map #13) STRATEGY: Road Abandonment and Removal

When roadways are abandoned, associated risk is eliminated. In many cases, road abandonment needs to be paired with increasing the level of service of another road, or creation of alternate access. Examples where roads are candidates for abandonment and removal include:

EAST HAVEN: Fairview Road and Brazos Road Abandonment and Removal

(Map #13; Section 5; Appendix E)

DESCRIPTION: Fairview road and Brazos Road in East Haven run parallel with each other from north to south. Fairview and Brazos cut across the tidal marsh and intersect Caroline road which runs parallel to the beach. Fairview Road is slightly higher in elevation causing Brazos to flood first. However, during Irene and Sandy, this entire area experienced a significant amount of flooding with both roads completely flooded and unpassable. An existing water main also runs underneath both Caroline and Brazos road. Ideally, this project represents an opportunity to either raise or abandon Brazos road and/or Fairview road. Allowing for improvement to tidal flushing, healthier marsh systems, open space for the advancement of salt marsh, and consequentially, enhanced flood protection and wave attenuation for nearby properties.

BRANFORD: Tabor Road Abandonment (Map #13)

DESCRIPTION: Tabor Drive is located immediately southeast of downtown Branford. The road intersects Montowese Street (Route 146) and Toole Drive at a three-way corner. Tabor Road then raps itself around the tidal marsh and intersects Tabor Drive toward the southern end of Branford. This entire road is extremely low-lying and experienced significant flooding during Sandy. The section of Tabor Drive that has the immediate risk is the area is encompassed by the marsh; located on the opposite side of the Tabor Lutheran Church. Ideally, this section of the road could be retired; providing more flood protection for many access roads, residential homes and neighborhoods within the town of Branford. The remaining portion of Tabor Drive would be accessed by Ark Road. Retiring this section of Tabor Drive would also restore hydrological flow for the watershed and improve drainage and storage during floods.

STRATEGY: Bridge Scour Reduction

Where scour has been observed or is posing risk to bridges, it may be possible to utilize hybrid solutions to stabilize the area subject to scour. Green or solely nature-based solutions may be more challenging to use in these areas, depending on the velocities found in the channels.

BRANFORD: Trolley Pedestrian Bridge Scour Mitigation (Map #13; Section 5; Appendix E)



Credit: TNC

DESCRIPTION: The Trolley Pedestrian Bridge project is located at 11 West Point Road. The project is east of the Pine Orchard Golf Course and just northeast of Pleasant Point. The onsite infrastructure consists of an old railroad bridge converted into a pedestrian walkway over the channel and marsh. Over the years, erosion has occurred along the front and bank portions of the abutments as well as areas underneath this important town-owned asset. The causes of erosion and scour appear to be a combination of stormwater runoff from the trail, pedestrian access where people walk from the trail down to the creek, hydrodynamic forces from the tidal flow, as well as other natural processes. Ideally, this coastal restoration project would focus on mitigating future erosion through the installation of green infrastructure techniques and potential bioengineered bank concepts or other hybrid approaches. The result would help protect this vital resource and point of public access for the town of Branford and residents of Pleasant Point. Hybrid approaches would be consistent with the Town's goal of preserving the Stony Creek estuary and its marshes.

Other Projects with Hard Infrastructure Requirements: (see Appendix C)

FAIRFIELD: Penfield Beach Pavilion Bulkhead

The Town's Penfield Beach bulkhead was reconstructed using CDBG-DR funds. The bulkhead can tie into a comprehensive flood protection system extending to the north (toward Fairfield Beach Club) and south (toward Shoal Point). This area was hit especially hard during storms Irene and Sandy so protecting the pavilion with a high level of protection is critical to the longevity of the structure.

BRIDGEPORT: Pleasure Beach Breakwater Repair

Repair of the breakwater, damaged by Sandy, was completed in 2015. The breakwaters are important to reducing wave energy in Bridgeport Harbor.

MILFORD: Gulf Beach "Breakwater" Repair/ Replacement

The City received a CDBG-DR grant to reconstruct the groin at Gulf Beach; restoring the 210-ft length. This project may stabilize sand migration at Gulf Beach.

MILFORD: Hillside Avenue Revetment Replacement

Some of the greatest storm damages in Milford occurred

along Hillside Avenue which is an entirely armored strip of shoreline. The granite block revetment is at a low elevation and the City is concerned about its condition. This project is a placeholder for future repairs.

MILFORD: Pelham Street Bank Protection

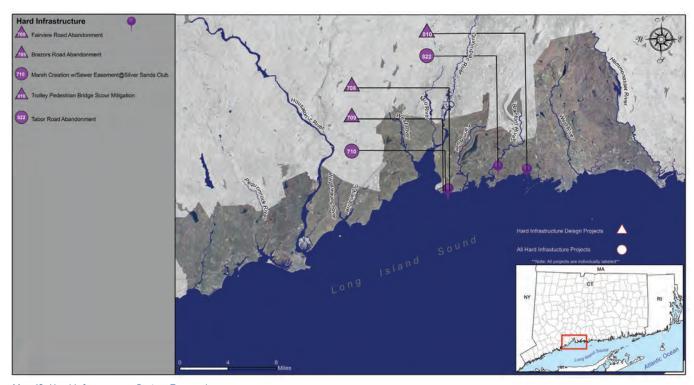
This project is an undermined seawall on municipal land with a bluff located behind. Design of a revetment has been funded. A revetment would provide a high level of protection to the homes along Pelham Street directly behind the structure.

WEST HAVEN: Bulkhead Replacement

Approximately 400 feet of bulkhead was replaced along Water Street by the City. This area is highly urbanized and built up. Fortifying this area protects the industrial building adjacent to Water Street as well as homes further inland from storm flooding.

WEST HAVEN: Old Kings Highway Revetment Repairs and Enhancement (Overall)

This project is part of the overall Old Kings Highway seawall resilience project which protects a sewer main. This project is a placeholder for future repairs to the revetment located in front of the seawall. Hard structures provide the highest level of protection for this area.



Map 13: Hard Infrastructure Project Type only

WEST HAVEN: Old Kings Highway Seawall Replacement (Small Section)

This project is part of the overall Old Kings Highway seawall resilience project which protects a sewer main. This small section of the seawall is slumping, risking collapse of the sewer main. Hard structures are required along this already armored stretch of coastline.

NEW HAVEN: Pardee Seawall Enhancement and Repair

The Pardee Seawall protects the Morris Cove neighborhood from direct coastal flooding from New Haven Harbor. The seawall also serves as a recreational hotspot for local residents. Green infrastructure or hybrid approaches could be considered in this area.

NEW HAVEN: Brewery Square Bulkhead Rehabilitation

This bulkhead protects a section of Fair Haven near the Ferry Street Bridge. CDBG-DR funds are being used to repair the bulkhead.

NEW HAVEN: River Street Bulkhead Completion

A portion of the River Street bulkhead has been replaced, but a section remains that has not been replaced. CD-BG-DR funds will be used to design this remaining section of a new bulkhead. This will stabilize the bank for the industrial properties.

NEW HAVEN: Mill River Shoreline Revetment

This project is a placeholder for revetment replacements or enhancements along Mill River. A study was funded by CDBG-DR and is currently underway to help determine how to address existing revetments.

EAST HAVEN: Shell Beach Road Condominiums

This seawall was reconstructed and protects the condominium complex from wave energy and storm surges. A seawall is necessary to protect these homes in their current location.

BRANFORD: Linden Avenue at Linden Shores Bank Protection

This portion of Linden Avenue was repaired after storms Irene and Sandy. Hard shoreline protections were used to stabilize the bank and reduce the risk of future erosion. Hard structures were used for this location in order to protect Linden Avenue from being undercut by erosion.

BRANFORD: Pine Orchard Revetment Replacement

A revetment was replaced in 2015-2016 by the owner of a property where a new home will be constructed. The entire stretch of shoreline in this area is armored with rock.

BRANFORD: Pine Orchard Bank Protection Seawall

New rock treatments have been placed on slopes above seawalls and revetments in front of the homes located along Ozone Road and Selden Avenue. This residential neighborhood has been further fortified to protect against future storms.

MADISON: Madison Surf Club Building Seawall Replacement

The Town's seawall at Madison Surf Club was replaced to elevation 11 feet to further increase resilience. Although this may provide additional protection to the building during future storm events, the seawall may need to be elevated even further in the future because this low-lying area has a FEMA base flood elevation of 13 feet.

MADISON: Middle Beach Road Shoreline Protection

Replacement or repair of the seawall at Middle Beach Road will protect property, homes, utilities, and egress along Middle Beach Road. Hard structures are necessary in this location to prevent Middle Beach Road from being undercut by erosional forces along this high wave-energy area.

MADISON: Madison Surf Club Picnic Area Shoreline Protection

Seawalls protecting the picnic area at Madison Surf Club may be repaired or replaced. Hard structures would best stabilize this shoreline along this headland.

MADISON: East Wharf Repair

Repairs to East Wharf were completed after storms Irene and Sandy. This shoreline-parallel structure breaks incoming wave energy and increases flood protection to homes behind the structure adjacent to Long Island Sound.

MADISON: West Wharf Repair

Repairs to West Wharf were completed after storms Irene and Sandy. This shoreline-parallel structure breaks incoming wave energy and increases flood protection to homes behind the structure adjacent to Long Island Sound.

TYPE: Inland Natural Infrastructure:

(Map #14)

STRATEGY: Inland Green Infrastructure

FAIRFIELD: Benson Road Parking Lot Green Infrastructure Retrofit (Map #15)

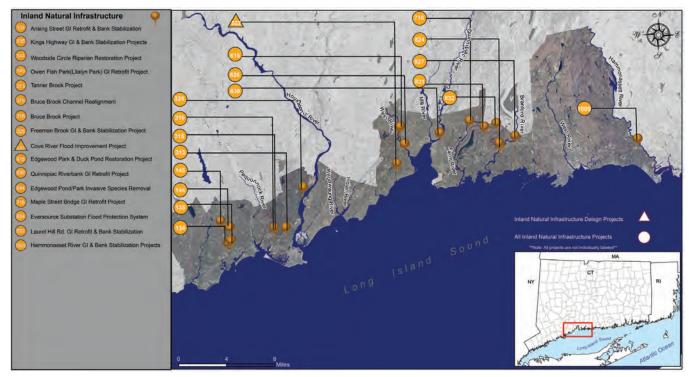
DESCRIPTION: South Benson Road runs parallel to Ash Creek with homes situated on either side. Two critical facilities are also located towards the southern end of South Benson Road right before entering the Jennings Beach parking lot. This entire area falls below the 100-year FEMA flood elevation. As a result, the area experienced significant storm surge from both Jennings Beach and Ash Creek. Unfortunately, Sandy's flood waters did not drain properly due to poor drainage along the road. There is a watercourse and drainage system that runs along the northwest side of the parking lot and underneath South Benson Road leading to Ask Creek, but most of the time it is clogged with debris. The project would retrofit the existing road with bioswales, curb bump-outs, pervious pavement, and other green street concepts to improve stormwater drainage and mitigate future flooding.

FAIRFIELD: Beach Road Green Infrastructure Retrofit (Map #15)

DESCRIPTION: The project area includes Beach Road which runs parallel to Penfield Beach and the parking lot. This entire area was inundated by Sandy. The area is contained in FEMA's flood hazard zones with some sections falling below the 100-year flood elevation. Penfield Beach Road is a major access route for residents that live along this portion of Fairfield's coastline. The project would incorporate green infrastructure to reduce stormwater runoff, erosion, and flooding along Penfield Beach Road. Some techniques would include bioswales, bioretention areas, curb bump-outs, pervious pavement, and other applications.

FAIRFIELD: Sturges Park Green Infrastructure Retrofit (Map #15)

DESCRIPTION: Sturges Park in Fairfield is located along Mill Pond Road. This park has seen significant ponding of the fields and along edges of the road during high rainfall events. The project would consist of retrofitting the park with green infrastructure techniques such as bioswales, tree box plantings, curb bump-outs and other green infrastructure applications. The outcome would be reduced flooding of the fields and improvements to the overall stormwater management throughout the Park.



Map 14: Inland Natural Infrastructure Project Type only

FAIRFIELD: Post Road Traffic Circle Green Infrastructure Retrofit (Map #15)

DESCRIPTION: This project site was recommended in the Rooster River Watershed Plan (2013). The project area is situated in the middle of a major rotary along Route 130 also known as the Post Road Traffic Circle. Immediately adjacent to the project site is a McDonalds. Adjacent to the McDonalds parking lot is a 1-acre, semi-circular grass area that contains several catch basins that discharge through an underground culvert. Turney Creek flows from north to south through this 865-foot culvert underneath Route 1 and towards the center of the grass area. The current topography is sloped toward the middle allowing runoff from the McDonald's parking lot to flow towards the middle and discharge underground. This green infrastructure retrofit project will primarily focus on improving the stormwater management system at this site by retrofitting the landscape with bioswales, rain gardens, tree box plantings, and other techniques to improve overall drainage.

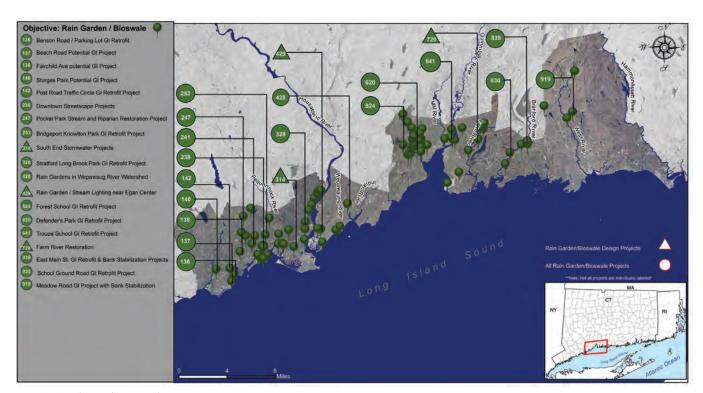
BRIDGEPORT: Downtown Streetscape Improvement Projects (Map #15)

DESCRIPTION: This project represents a suite of green infrastructure projects scattered throughout the city of Bridgeport. Over the years, the City has witnessed flooding and poor drainage issues due to its low topography and limited ways for runoff to drain. The main focus is to install

small to medium sized bioretention areas that are planned and under construction at various locations. Other green infrastructure and hybrid approaches will also be applied and further reviewed. Many of these projects will improve infiltration and reduce stormwater runoff. This will eventually improve the City's stormwater management system and overall aesthetics for Bridgeport.

STRATFORD: Long Brook Park Green Infrastructure Retrofit (Map #15)

DESCRIPTION: Long Brook Park is near Glendale Road. Charlton Street, and Prim Street in Stratford. Northwest of the project site is Brewster's Pond where a bio-filter basin was recently installed. The topography of this area is sloped toward the southeast portion of the park with most of the runoff flowing towards Brewster's Pond. The area is currently contained in FEMA's Flood Hazard Zones. As a result, it has experienced some flooding in certain locations around the Park. The surrounding area contains mostly residential homes and neighborhoods with a large athletic complex located across Glendale Road. Essentially, Long Brook Park would be retrofitted with green infrastructure such as rain gardens, bioretention areas, vegetated swales, tree box plantings, or other similar strategies. The outcome would reduce the potential for flooding and improve the parks stormwater management.



Map 15: Rain Garden/Bioswale Strategy Projects only

MILFORD: Wepawaug River Corridor Green Infrastructure Retrofit (Map #15)

DESCRIPTION: The Wepawaug River corridor extends from Eisenhower Park and flows along Route 121 until it empties out into Milford Harbor. There are certain sections surrounding this riparian corridor that are low-lying and within the FEMA flood hazard zones. Several streets are near the river bank allowing stormwater runoff to enter the river. The increase in stormwater runoff from rainfall events has certainly impacted many homes, neighborhoods, and access roads surrounding the river. The project would focus on installing rain gardens and bioswales along portions of the Wepawaug River to manage stormwater runoff, improve the corridor's hydrology, increase infiltration, and reduce the risk of flooding.

NEW HAVEN: Forest School Green Infrastructure Improvements (Map #15)

DESCRIPTION: The Forest Elementary School is located at 95 Burwell Road just north of Ralph F. Della Camera Stadium and the University of New Haven. This project was a recommended site in the West River Watershed Management Plan. A small parking area is located on the northwest corner of the lot containing 26 parking spaces. There are other designated parking areas located near the south side, closest to Burwell Road, and another on the east side, near Josephine Avenue. A playground exists on site and it is in the northeast corner immediately next to Josephine Avenue. The topography of the area is sloped toward the front entrance of the school where there are visible catch basins and a vegetated swale that captures the sites stormwater runoff. This is somewhat of a low-lying area and is currently within the FEMA flood hazard zones. Ideally, the school would like to focus on incorporating additional green infrastructure techniques onsite to increase infiltration. Some strategies would include, vegetated swales, tree box plantings, infiltration strips, and bioretention areas, to reduce stormwater runoff, alleviate flooding of school property, and improve the water quality within the West River.

NEW HAVEN: Troup School Green Infrastructure Improvements (Map #15)

DESCRIPTION: This project was identified as a recommended site in the West River Watershed Management Plan (2015). The Troup School is located at 298 Edgewood Ave just northwest of downtown New Haven. The project site is situated on an approximately 3 ¾ acre lot that lies north of the Yale-New Haven Hospital Saint Raphael Campus. Currently, the project site is not located within FEMA's flood hazard zones but it has experienced poor drainage issues during rainfall events. The site has one designated parking lot located in the rear, and a semi-circle round-about located in the front of the building. There is a

small fenced in playground and a grass field located at the rear of the school adjacent to the parking lot. The focus of this small project would be retrofitting the rear parking lot with permeable pavement and installing a bioretention or rain garden in the front of the school to capture runoff. Other green concepts that would be incorporated include tree box plantings and four curbside bioswales recently installed on Platt Street and Edgewood avenue adjacent to the Troup School to accommodate stormwater runoff and reduce flooding of the school's property. Save the Sound is leading the project with the City of New Haven's Engineering Department as a partner and using funding from a 319/ Clean Water Fund grant.

Strategy: Inland Green Infrastructure and Bank Stabilization

FAIRFIELD: Arising Street Potential Green Infrastructure Retrofit with Bank Stabilization (Map #14, #12)

DESCRIPTION: Arising Street is located immediately along the bank of the Rooster River and runs perpendicular to Route 1 (Kings Highway). The length of Arising Street is approximately 200 ft. with a col de sac at the end of the street that impedes the left bank of the Rooster River. Over the years, erosion and scour have occurred along this portion of the river bank. Arising Street and parts of Kings Highway are currently contained within FEMA's flood hazard zones. During Sandy, this area did experience some minor flooding due to its elevation and proximity to the river. Stormwater issues also exist along the street due to limited designated drainage areas. The focus of the project would be to retrofit the landscape with green infrastructure such as bioswales, tree box plantings, and curb bump-outs to improve the overall stormwater and drainage systems. Other possible techniques could be applied to stabilize the bank and provide further flood protection along this section of the Rooster River.

FAIRFIELD: Kings Highway Green Infrastructure and Bank Stabilization (Map #14, #12)

DESCRIPTION: Kings Highway, also known as Route 1, is a major access route in the town of Fairfield. The highway contains a few low-lying areas where flooding has previously occurred. During Sandy, sections of the road were flooded resulting in closures of major access routes. Kings Highway also have many sections with poor drainage and flood during heavy rainfall events. The project would incorporate green street strategies such as, bioswales, rain gardens, bioretention areas, tree box plantings, vegetation, curb bump-outs, and bank stabilization to mitigate future flooding and erosion along Route 1 in Fairfield.

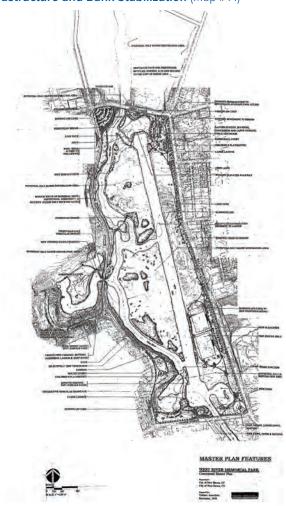
FAIRFIELD: Owen Fish Park Green Infrastructure and Bank Stabilization (Map #14)

DESCRIPTION: Owen Fish Park is currently located along the upper portion of Stratfield Road. The park has many public amenities with parking, recreational fields, playgrounds, trails, pond, and buildings. The parking area and playground are located at rear of the parcel, immediately adjacent to a tributary of London's Brook. The small stream runs through an open channel along the backside of the property and flows into a pond where a small dam-like structure discharges the water into London's Brook. Horse Tavern Brook and London's Brook merge toward the southern portion of the parcel and discharge into the Rooster River. The project consists of retrofitting the park and parking lot by restoring the riparian buffer with green infrastructure and bank stabilization strategies such as vegetated swales, rain gardens, bioretention cells, berms, floodplain benches, and other green infrastructure applications. The outcome would improve the water quality, alleviate flooding, and restore the open channel back to its natural state.

STRATFORD: Freeman Brook Green Infrastructure and Bank Stabilization (Map #12)

DESCRIPTION: Freeman Brook flows from north to south through three culverts; one underneath Tanglewood Road, Main Street, and River Road before discharging into the Housatonic River. The project site is located along the upper portion of the brook between 1 Tanglewood Road and 22 Medowmere Road. At this section, the open channel has been experiencing some erosion along the bank due to increase runoff flowing from upstream areas and into the brook. Ideally, this section of Freeman Brook would need to be further reviewed to incorporate bank stabilization techniques to restore this portion of the brook. Some bank stabilization strategies would include floodplain benches, berms, or vegetated swales to prevent further erosion along section of Freeman Brook.

NEW HAVEN: Edgewood Park and Duck Pond Green Infrastructure and Bank Stabilization (Map #14)



Credit: Milone and MacBroom

DESCRIPTION: The project is located along Whalley Avenue, Edgewood Avenue, and Chapel Street; all of which are immediately adjacent to the West River and just northwest of downtown New Haven. This is a large scale multi-faceted project. The surrounding area is comprised of residential homes and neighborhoods that are currently located in FEMA's flood hazard zones and flood consistently during rainfall events. This project involves the implementation of green and natural infrastructure elements designed to restore the park and the pond's natural landscape. The project focus in on green infrastructure, shoreline protection, bank stabilization/protection, lawn restoration, and marsh/ tidal restoration. The project is also designed to improve the overall aesthetics of Duck Pond and Edgewood Park. This project will reduce the amount of stormwater runoff and improved the water quality in the West River.

NEW HAVEN: Quinnipiac Riverbank Green Infrastructure and Bank Stabilization (MAP #14)



Credit: TNC

DESCRIPTION: Quinnipiac Riverbank project represents a multi-component project for the Quinnipiac Riverfront Park. The Park runs parallel to Front Street and is immediately along the left bank of the Quinnipiac River. The surrounding area is mostly residential homes and neighborhoods with commercial and industrial sites mixed in. The project site is east of downtown New Haven, south of Interstate I-91 and just to the north of Interstate I-95. The Park is a vital amenity to the city of New Haven and the surrounding area. The riverfront park contains walking paths, tree plantings, benches, and an open elongated field with grass surfaces. One component is to re-establish the riverbank where significant erosion has occurred along a section of the Park's bank. A cement concrete wall is situated along the northern portion of this bank that aligns approximately with Pierpont Street all the way north toward Exchange Street. At the other end, the bank is mostly composed of large riprap that has significantly eroded away. The project area is low-lying and is currently within FEMA's flood hazard zone. Ideally, the project would restore the riverbank along the southern portion using berms, floodplain benches, bioretention cells, and vegetated buffers along riverbank and walkway. The outcome would mitigate any future flooding and erosion. A second component includes using green infrastructure applications such as tree box plantings, curbside bioswales with bump-outs along Front Street, pervious pavement walkways, bioretention areas, and rain gardens. Ultimately, these strategies will improve infiltration and capture stormwater runoff while reducing the risk of flooding and improve the water quality within the Quinnipiac Watershed.

NEW HAVEN: Adult Education Center Green Infrastructure and Bank Stabilization (Map #12)

DESCRIPTION: This site was identified in the West River Watershed Plan as a top tier project. This large site is located at 580 Ella T. Grasso Boulevard immediately along the lower portion of the West River. The Adult Education Center is owned by the city of New Haven and currently sits on a large 3.5-acre commercial lot. The building itself is in the northeast corner of the lot with a parking area and several other occupied structures surrounding the building. The large parking lot of the Education Center runs right up against the edge of the West River with little or no vegetation aligning the bank. As a result, all stormwater runoff discharges directly into the West River. Due to the limited and outdated stormwater system, this entire area floods and currently lies within FEMA's flood hazard zones. The project would focus on several key components. The first would be retrofitting the parking lot with green street concepts such as bioretention areas, tree box plantings, and other strategies to naturally control stormwater runoff. The second would focus on restoring the riparian zone along the bank of the West River using techniques such as vegetated swales, berms or even floodplain benches. Ideally, the project would alleviate future flooding while restoring the riparian buffer along the West River.

MADISON: Hammonasset River Green Infrastructure and Bank Stabilization (Map #14, #12)



Credit: TNC

DESCRIPTION: The projects is situated north of the Town Hall Campus and immediately along the Hammonasset River. Most of the area is composed of a private homes and residential neighborhoods. Five Fields Road forms an oval shape and intersects High Field Lane just to the northwest. A large drainage basin exists onsite as a mowed grass area. The drainage system near the 140 properties goes underneath the road through a 36" RCP extending towards the back portion of the lot where it discharges into

the Hammonasset. This entire area of Five Fields Road acts like a bowl with stormwater runoff constantly collecting and flooding this section of the neighborhood during rainfall events. Due to past storm systems, a 60-foot-wide portion of the bank has completely eroded away into the Hammonasset River. The drainage pipe has completely split and collapsed along the bank. The project would focus on reconstructing the stormwater drainage system by installing a new catch basins and drainage pipes. The second phase of the project would focus on incorporating bioengineered bank strategies either as green infrastructure or hybrid solutions to restore the bank back to its original state. This multiphase project would reduce the constant flooding along Five Fields Road, improve water quality along the Hammonasset, and stabilize the riverbank to mitigate future erosion and protect adjacent properties.

Strategy: Riparian Restoration with Bank Stabilization

FAIRFIELD: Woodside Circle Riparian Restoration and Bank Stabilization (Map #14, #12)



Credit: TNC

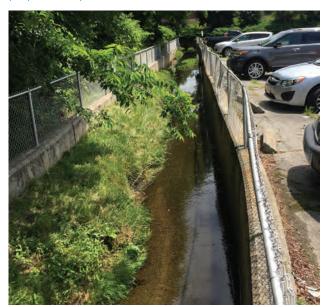
DESCRIPTION: This project site is identified in the Rooster River Watershed Based Plan (2013). Woodside Circle is located downstream of London's Brook and Horse Tavern Brook. It is immediately south of Our Lady of Assumption School and Church. The Rooster River flows through many neighborhoods in this area which has severely impacted abutting properties due to erosion and overflow. This project provides an opportunity to restore a good portion of the Rooster River. The large-scale riparian restoration project would focus on many bank stabilizations along the east and west banks of the Rooster River at Woodside Circle. Some of strategies would include plantings, biologs, riprap, or other green/hybrid approaches. The project would ultimately be mitigating future erosion and flooding of home

and businesses at Woodside Circle, but would also restore many of the natural ecosystems along this portion of the Rooster River.

BRIDGEPORT: Pocket Park Stream and Riparian Restoration (Map #15)

DESCRIPTION: This project is recommended in the Rooster River Watershed Plan (2013). The project site is at the intersection of Madison Avenue and Vincellette Street. Stop & Shop was located onsite with many parking areas encompassing the proposed park. The Pocket Park is small with dense vegetation and sits on approximately half an acre. The Horse Tavern Brook runs through the middle of the parcel providing residents with easy access. The park plan would consist of a short trail along the stream with picnic tables and benches. The focus for the project would be on restoring the riparian buffer along the brook, removing invasive species, and replanting along the banks of the brook. Further armoring would likely be needed to stabilize the banks along this portion of the brook. Other green infrastructure strategies, such as vegetated swales, rain gardens, berms, and tree box filters would be retrofitted within the landscape. The Pocket Park would provide signage describing the area's natural environment and ecological resources of the Rooster River Watershed. The project would ultimately help restore Horse Tavern Brook and revitalize the Pocket Park.

STRATFORD: Tanner Brook Stream Channel Restoration (Map #14, #12)



Credit: Milone and MacBroom

DESCRIPTION: The project is located near California Street and Broad Bridge Avenue. Tanner Brook is immediately behind the condominiums at this intersection. The channelized brook flows from north to south along the southeast portion of the condo's parking lot. Before reaching the parking lot, there is a significant bend in the brook which runs immediately against the Amtrak Rail line embankment. Frequent flooding occurs due to the areas low elevation and poor drainage. The project is currently undergoing permitting review with a design already in place. The project will consist of widening the channelized section of the brook by re-grading the entire left bank and installing berms, swales, and floodplain benches to stabilize the bank. The outcome will improve flood conveyance while protecting nearby properties, homes, roadways, and businesses throughout this section of Stratford.

STRATFORD: Bruce Brook Channel Realignment (Map #14)



Credit: Milone and MacBroom

DESCRIPTION: Bruce Brook is located just to the south of Route 1 along Bowe Avenue and perpendicular to Barnum Avenue. The channelized brook runs right along the Bridgeport and Stratford boundary. Bruce Brook is located towards the norther end of the Bowe Avenue confined to an open concrete channel. This entire area is currently contained in the FEMA's flood hazard zones and experiences numerous flooding events. However, most of the damage is confined to nearby properties and homes. The first component of this multiphase project consists of completely re-aligning the "S" turn in the channel of Bruce Brook at Bowe Avenue. This will create more open space in the channel for floodwaters to move through. The small driveway bridge from Bowe Avenue over the brook will also be removed. Homes that were originally located along the bank were acquired by the city of Bridgeport and left vacant. Ideally, this project will mitigate frequent flooding of Bruce Brook along Bowe Avenue and provide protection to nearby homes and properties. The second phase of the project focuses on a much larger scale. The plans include re-routing a culvert near the McDonalds at the intersection

of Bowe Avenue and Barnum Avenue. This portion also has experienced some past drainage problems. The overall long-term plan for this section of Bruce Brook will consist of widening and re-grading the right side of the open channel to install berms and a floodplain extending from the northern end of Bowe Avenue to McDonalds. The outcome will alleviate flooding of roadways, properties, businesses and any future development along the Strafford and Bridgeport boundary.

MILFORD: Egan Center Stream Channel Restoration and Green Infrastructure Retrofit

(Map #17; Section 5; Appendix E)



Credit: TNC

DESCRIPTION: The Margaret Egan Center is located at the end of Mathew Street which runs perpendicular to Naugatuck Avenue in the city of Milford. The community center contains a school/conference building with a large parking lot located at the rear of the building. Egan Center Park sits on a 3.7-acre lot just northwest of the building. Tidal marsh in the Housatonic River abuts the parking lot in southeast corner as well as properties along Mathew Street. The parking lot and park are contained within FEMA's flood hazard zones which has resulted in frequent flooding during storm events. An underground stream runs through the park and extends along the back portion of the parking lot where it discharges from a culvert into the marsh. Essentially, the stream would be restored as a small open channel along the backside of the parking lot. The parking lot would be re-graded to a higher elevation and retrofitted with berms, rain gardens, vegetated swales, bioretention areas, pervious pavement, or other green street concepts to improve infiltration and alleviate constant flooding of the park and parking lot at Margaret Egan Center.

WEST HAVEN: Cove River Stream Channel Flood Reduction (Map #14, #12)



Credit: TNC

DESCRIPTION: The Cove River project is located well inland from the coastline. The project site is focused on a large area along the Cove River at West Main Street that runs perpendicular to Painter Drive. This upper portion of the Cove River flows behind a school before wrapping around and flowing through an open channel underneath West Main Street. The river proceeds around several apartment complexes and large parking lots located on both sides of the river. Just to east lies a major intersection of Wagner Place, Main Street, and Kelsey Ave. This section of the Cove River flows through an open channel about 15 feet in width. The channel is comprised mostly rock and sediment with vegetation located along the banks of the river. There is about a 7 to 8-foot cement wall along the right side of the channel. The area is extremely low-lying and has experienced flooding and damage from previous storms. The city of West Haven would like to re-align and widen the existing channel on both sides; installing floodplain benches, berms, and vegetated swales along the banks of the Cove River to help improve channel flow and conveyance. Ideally, this would alleviate large scale flooding of critical infrastructure and prevent closures of major access routes.

EAST HAVEN: Maple Street Bridge Riparian Restoration and Bank Stabilization (Map #14)



Credit: TNC

DESCRIPTION: The project site is located toward the north end of Maple Street where it intersects with North High Street and Hunt Lane. The Farm River runs underneath a newly installed bridge flowing from north to the south through East Haven where it eventually discharges into Long Island Sound. The site has repeated flooded events resulting in a significant amount of erosion occurring along this section of the Farm River. Maple Street Bridge and surrounding landscape was reconstructed and redesigned in 2012 as a result of the repeated flooding. The project would retrofit the existing landscape and available open space to provide additional flood storage with temporary wetlands and bank stabilization elements. A component of the project would focus on re-aligning the upper portion of the Farm River to improve flood conveyance. Bank stabilization strategies would also be applied to mitigate future erosion along this section of the river. The final component of this project would focus on retrofitting a portion of the open space with two tier berms or floodplain benches that would provide further flood protection of adjacent and nearby properties along the Farm River.

BRANFORD: Laurel Hill Road Riparian Restoration and Bank Stabilization (Map #14)

DESCRIPTION: Laurel Hill Road intersects Bushy Plain Road to the south of Lidyhites Pond and north of the intersection between Laurel Hill and Richill Road. The site is located east of Lake Saltonstall and southwest of the Saltonstall Mountain preserve. The landscape is sloped toward Pisgah Brook with many properties abutting the south side of the stream's bank. The area surrounding the road is somewhat elevated, but most concerning is the erosion that is occurring beyond the back portion of properties that align Laurel Hill Road and Piscitello Drive. Ideally, the project would focus on incorporating a bioengineered bank either as a green infrastructure or hybrid solution. Some techniques that would be implemented include vegetated swales, floodplain benches, and berms. This would mitigate future erosion and provide bank protection for adjacent properties and homes in this section of Branford.

GUILFORD: Long Cove at Daniel Avenue Stream Channel Restoration (Map #17, #12)



Lia Marie Johnson

DESCRIPTION: The project is a component of a much large project focused on Long Cove Marsh. Daniel Avenue runs between a beach on the southern side of the road and a marsh immediately to the north. This stretch of Daniel Avenue is extremely low-lying and was greatly impacted by Sandy. The beach consists mostly of sand towards the eastern corner with some vegetation and riprap aligning the entire back section of the beach. The largest amount of riprap and vegetation is situated towards the western side where no beach exists. An open channel aligned with riprap runs directly underneath Daniel Avenue and into the tidal marsh. This project consists of enhancing and restoring this small open channel to mitigate future erosion and increase flood conveyance for the tidal creek at Daniel Avenue.

TYPE: Shoreline Infrastructure:

(Map #16)

STRATEGY: Berm/Dike Construction or Enhancement

FAIRFIELD: South Benson Road Flood Protection System (Map #16)



Lia Marie Johnson

DESCRIPTION: This project represents a critical gap along Ask Creek and South Benson Road. One of the major vulnerabilities is overtopping of storm surge at Jennings Beach and potential tidal flooding from Ash Creek. The elevation in this part of Fairfield is extremely low-lying. Many residential homes, neighborhoods, and critical facilities need further flood protection. This project would add to a comprehensive flood protection system by incorporating a high berm near the beach entrance that would meet the dunes toward the east end and extending along the south side of the Marina to the west. This would reduce the risk of storm surge traveling toward Baldwin Terrace from Ash Creek. Essentially, the project would tie in with Ash Creek/Jennings Beach flood protection system, reducing storm surge and inflow from the mouth of Ash Creek.

FAIRFIELD: Riverside Drive Open Space Dike Enhancement (Map #16)

DESCRIPTION: This project is located immediately south of Riverside Drive and along the Ash Creek Estuary. An earthen dike extends from the homes along Riverside Drive across a portion of the Ash Creek inlet. The elevation on top of the dike is below 10 feet which was completely overtopped by Sandy. This opening provided yet another pathway for the surge to inundate many of the neighborhoods and homes along and south of Route 1. The area surrounding the dike has a considerable amount of vegetative growth and natural habitat that protects many of the abutting properties. Town officials have explained that elevating this dike is a key component of the envisioned comprehensive flood protection system. This section would tie directly into the Ash Creek/Jennings Beach flood protection system designed to mitigate future flooding. This segment of the project would consist of raising the elevation of the dike nearest to Riverside Drive on an existing open space parcel.

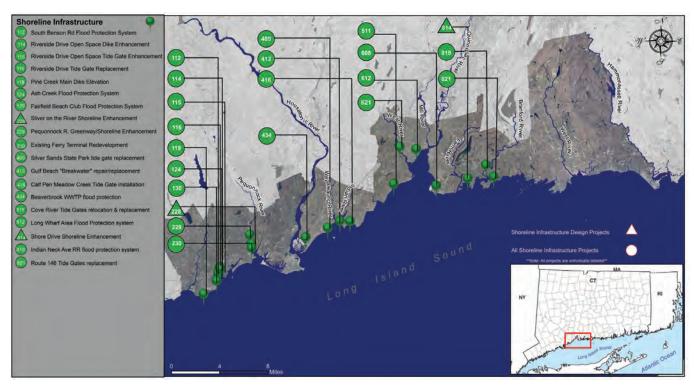
FAIRFIELD: Pine Creek Main Dike Enhancement (Map #16)

DESCRIPTION: Pine Creek Estuary is located toward the southern end of Fairfield's shoreline. This area is highly residential with homes and businesses located along a narrow peninsula that stretches out towards Pine Creek Point

and Long Island Sound. The peninsula runs parallel to the coastline with Pine Creek flowing in between with riprap along the landward side of the creek. Most of the area falls within FEMA's flood hazard areas and was heavily impacted by Sandy. Homes, neighborhoods, businesses, and critical facilities that surround Pine Creek were severely impacted. The project would focus on enhancing and increasing the elevation of the main dike and tie it into the overall flood protection system for Pine Creek. The outcome would provide further flood protection at a critical gap along this section of Fairfield's shoreline.

FAIRFIELD: Ash Creek Flood Protection System (Map #16)

DESCRIPTION: The Ash Creek Estuary is proximate to Riverside Drive. Many residential homes and neighborhoods reside to the west and northwest along this section of the Estuary. Significant flood damage has occurred from previous storm events due to its low elevation and proximity to the tidally influenced waterbody. The project would focus on developing the Ash Creek flood protection system that would include berms along sections of Riverside Drive. This segment of the project would eventually tie in with the Ash Creek/Jennings Beach flood protection system to provide protection for the entire area encompassing Ash Creek.



Map 16: Shoreline Infrastructure Projects only

FAIRFIELD: Fairfield Beach Club Flood Protection System (Map #16)



Credit: Milone and MacBroom

DESCRIPTION: The Penfield Beach and the Fairfield Beach Club is situated to the west of Jennings Beach. This section of beach experienced significant storm surge from Sandy that flooded out many homes, businesses and access roads. A good portion of dune and dense vegetation is situated behind the beach. However, there are a few gaps in the dune system that are lower than others along this section of beach. This segment of the overall project would address those low points by enhancing the dune system and generate a much higher flood protection system. Ultimately, this project would complement the Ash Creek Flood Protection System.

MILFORD: Beaverbrook Wastewater Treatment Plant Flood Protection (Map #16)

DESCRIPTION: The project is located along Deerwood Avenue east of the Housatonic River and the Charles E. Wheeler Wildlife Refuge. The landscape in front of the WWTP consists mostly of tidal salt marsh. Currently, the facility has little to no protection with its proximity to the extensive marsh and the Housatonic River. There are several residential homes, neighborhoods, and access roads that encompass this facility and along this section of shoreline. The topography of the area is extremely low-lying and contained in FEMA's flood hazard zones. The project would consist of installing a flood wall system to protect the facility from coastal flooding and storm surge, as well as adjacent properties, homes, and access roads.

NEW HAVEN: Long Wharf Flood Protection Project (Map #16)

DESCRIPTION: The project is located along Long Wharf Drive which extends landward from Long Wharf Park to areas around Interstate I-95, Sargent Drive, and Union

Station/railyard. HUD CDBG-DR funds are being utilized for portions of this project which consists of multiple phases. The first phase of the project is focused on a long-term study of flood and storm surge protection strategies for areas along Long Wharf and northwest from Long Wharf Drive to Union Avenue. In addition to the study, this project will also develop plans, designs, and solutions to be implemented to protect downtown New Haven. Located within this 270-acre area is Interstate I-95, Union Station, Metro North and Amtrak rail lines, New Haven Police Station, residential homes and neighborhoods, the US Post Office, Greater New Haven Water Pollution Control Authority, South Central CT Regional Water Authority, and major access roads in and out of downtown New Haven. Many of these areas experienced significant structural impacts and flooding from Sandy and are contained in FEMA's flood hazard areas. This project will improve public safety and reduce the risk of regional economic loss, while implementing significant shoreline protection measures and mitigating the future potential of flooding and storm surge and sea level rises.

STRATEGY: Tide Gate Replacement

FAIRFIELD: Riverside Drive Open Space Tide Gate Replacement (Map #16)



Credit: Milone and MacBroom

DESCRIPTION: This projects site is located near the Ash Creek Tributary in proximity to Riverside Drive. An operational tide gate was installed across the existing dike on the Riverside Drive open space that provides tidal flushing. However, additional flushing may be needed at this location for future storms. The project would either replace or enhance the tide gate to enhance flushing and reduce upstream flooding during major storm events. The replacement or enhancement of the tide gate would not be affected by whether the dike protection system is or is not installed.

MILFORD: Silver Sands State Park Tide Gate Replacement (Map #16)



Credit: Milone and MacBroom

DESCRIPTION: The tide gate is located towards the southern portion Silver Sands Park Way and northeast of a cul-de-sac. A small tidal channel runs along the backside of tide gate with many backyard properties abutting the channel and marsh along Pearl Street and Cooper Avenue. Currently, the state of Connecticut is in the process of replacing the tide gate at Silver Sands State Park. Ideally, this will improve tidal flushing and provide further flood protection of homes and properties to the east and northeast of the project site.

MILFORD: Calf Pen Meadows Creek Tide Gate Installation (Map #16)



Credit: Milone and MacBroom

DESCRIPTION: Calf Pen Meadow Creek Tide Gate would be located between 2 Bayshore Drive and 3 Melba Street. The Melba Street Bridge passes over Calf Meadow Creek as it flows underneath and into a channel with salt marsh located to the north. Many backyard properties along the left side Melba Street and right side of Summer Place extend into the marsh. Ideally, the tide gate would be installed before the tide flows underneath the bridge and abutting the properties on Bayshore Drive and Melba Street. The project would also restore and repair of both the left and right side embankments due to scour and erosion. A tide gate at this location would be beneficial to allow for tidal flushing and reduce the frequency of flooding and erosion of properties along Calf Pen Meadow Creek.

WEST HAVEN: Cove River Tide Gate Relocation and Replacement (Map #16)



Credit: Milone and MacBroom

Description: The project is located along Captain Thomas Boulevard and Ocean Avenue. The current Cove River tide gates are immediately adjacent to Bradley Point Park and Seabluff Beach. The tide gates are old one-way gates that do not allow sufficient flushing north of the road. They are located beneath Captain Thomas Boulevard and Ocean Avenue. The replacement with new tide gates is planned but not yet funded. The new gates would be placed at the failing pedestrian bridge that is currently closed and the entire bridge would be repaired. This would help increase tidal flushing and control invasive species for this portion of the Cove River as well as reduce flooding upstream.

STRATEGY: Shoreline Enhancement

BRIDGEPORT: Sliver by the River Shoreline Enhancement (Map #16)



Credit: TNC

DESCRIPTION: This project site is situated on a narrow strip of land located on the western bank of the Pequonnock River and immediately north of interstate I-95 and the Stratford Avenue Bridge. Just to the Northwest of the site lie critical facilities such as the Fire Station Headquarters, United Illuminating Substation, the GBT bus terminal, the elevated Metro-North rail line, and Peck Bridge. There are other major roads, residential neighborhoods and critical facilities that are located farther to the northwest that were all severely impacted by Sandy. This is an extremely low-lying area that floods frequently. The current elevation of the parcel is below 10 feet and lies below the 100-year flood elevation. The derelict site is composed of a parking lot containing rocks and soil with little to no vegetation. Riprap and concrete blocks line the edge of the parcel between the lot boundary and the riverbank. This provides little to no protection for nearby critical infrastructure and a compromised location for public leisure activities. This project will consist of implementing shoreline protection measures, either green infrastructure or hybrid solutions, to mitigate future storm surge and flood potential of nearby critical facilities and enhance the amenity for public use.

BRIDGEPORT: Existing Ferry Terminal Redevelopment (Map #16)

DESCRIPTION: The existing Bridgeport/Port Jefferson Ferry Terminal site is located immediately south of interstate I-95 and adjacent to the rail line which runs right behind the terminal building. The Ferry Terminal will eventually be relocated to the opposite side of the harbor. Currently, this

section of shoreline is protected by bulkheads. Green infrastructure or hybrid shoreline protection measures may be implemented when the site is redeveloped as mixed use.

BRANFORD: Shore Drive Shoreline Enhancement (MAP #16)



Credit: Milone and MacBroom

DESCRIPTION: The project is located along Shore Drive or otherwise known as Short Beach Road (Route 142). The project site is situated along Pages Cove which is just north of Green Island and immediately east of Stanley Point. The site contains a section of beach located in the eastern corner of the Cove with dune vegetation right against the road. A rock revetment extends from the corner of the beach all the way towards the western section of Pages Cove. There are some sections of vegetation imbedded along the upper portion of the revetment near the road. Towards the water edge most of the area contains rocks and smaller intertidal pools that are visible at low tide; at high tide most of them are completely submerged. This project would focus on replacing the rock with a more natural or bioengineered bank treatment as either a green infrastructure or hybrid solution. The outcome would mitigate future erosion, improve aesthetics, and provide further flood protection for nearby waterfront properties.

STRATEGY: Breakwater Repair/ Replacement/Enhancement

MILFORD: Gulf Beach Breakwater Repair/Replacement (Map #16)



Credit: Milone and MacBroom

DESCRIPTION: The Gulf Beach Breakwater is located southeast of Milford Harbor and Burns Point. Just to the north lies Gulf Pond and the tidal marshes. The Milford Yacht Club is right across the channel from Gulf Beach. This site is highly utilized by residents and out of town visitors. This low-lying area is currently contained in FEMA's flood hazard zones. As a result, the site experienced surge and flood impacts from Sandy. Restoring the 210-foot breakwater at Gulf Beach would provide further flood protection while reducing wave action for nearby residential neighborhoods and access roads. This would ultimately stabilize the ongoing scour and sand migration that is occurring along the breakwater and at Gulf Beach.

STRATEGY: Manual Flood Protection Measures

BRANFORD: Indian Neck Avenue Railroad Bridge Flood Protection Systems (Map #16)

DESCRIPTION: Indian Neck Avenue runs immediately parallel to the commuter rail line, a substation, and Meadow Street. There is a small crossing that goes underneath this section of rail line connecting Meadow Street with Indian Neck Avenue. This area experienced significant flooding from Sandy. The entire area is extremely low-lying with most contained in FEMA's flood hazard zones. Many critical facilities, access road, residential homes, neighborhoods, and parks were completely flooded out due to flood waters traveling through this low-lying underpass. This flood proof project focuses on incorporating some type of manual flood protection closure that would be able to close automatically during extreme storm events. The outcome would provide essential downtown flood protection and reduce the coastal flood risk for this vital section of Branford.

STRATEGY: Elevation of Coastal Structures

The elevation of structures is happening or anticipated as represented by the following, non-exhaustive list generated through discussion with the municipalities during Project Component #1.

FAIRFIELD: Penfield Beach Pavilion Repair

The Town's Penfield Beach building was elevated using CDBG-DR funds. Elevation of the building will reduce the potential for flood damage.

Fairfield: Home Elevations

Elevation of homes has occurred and will continue to be the preferred alternative for the section of Fairfield Beach Road outside of any other future flood protection system.

BRIDGEPORT: Marina Village Resilience Project

Elevation of the Marina Village apartments may be considered upon renovation or redevelopment. Although the apartments sit in the 12' AE base flood elevation zone, this area was partially flooded during Hurricane Sandy. Elevation of the apartments would help reduce risk from flooding during future storm events.

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BRIDGEPORT: P.T. Barnum Apartments Resilience Project

Elevation of the P.T. Barnum apartments may be considered upon renovation or redevelopment. Although the apartments sit in the 12' AE base flood elevation zone, this area was partially flooded during Hurricane Sandy. Elevation of the apartments would help reduce risk from flooding during future storm events.

STRATFORD: Home Elevations

Elevation of homes has occurred and will continue to be the preferred alternative for the section of Lordship located in the coastal AE and VE zone along West Beach Drive and Shoreline Drive. Elevating homes along this floodprone area will reduce damages incurred from future storm events.

MILFORD: Home Elevations

Elevation of homes has occurred and will continue to be the preferred alternative for the section of East Broadway east of Silver Sands State Park. This includes the 13 finger roads extending from East Broadway toward the tidal marsh. Elevating homes remains the best method to accommodate flooding, while providing protection to the properties.

EAST HAVEN: Cosey Beach Home Elevations

Elevation of homes has occurred and will continue to be the preferred alternative for homes along Cosey Beach. Elevating homes would significantly reduce the risk of flood damage from future storms.

EAST HAVEN: Home Elevation - 2nd Avenue

FEMA has obligated funding for acquisition of the property and conversion to open space near the beach. This reduces the overall amount of homes/infrastructure impacted and associated costs during future storm events.

BRANFORD: Home Elevation - Clark Avenue

FEMA has obligated funding for elevation of the house on Clark Avenue. Elevating the house would significantly reduce risk of flood damage from future storms.

STRATEGY: Removal of Coastal Structures

The removal of structures is happening or anticipated as represented by the following, non-exhaustive list generated through discussion with the municipalities during Project Component #1.

FAIRFIELD: Reef Road Property Acquisitions

This project represents one of several options for Reef Road. In this alternative, the properties along the road would be acquired and converted to open space, making space for a dike system.

MILFORD: Home Acquisition - Caroline Street

FEMA has obligated funding for acquisition of the property and conversion to open space adjacent to the tidal marsh. This will increase flood storage and reduce property damaged incurred during future storms.

MILFORD: Home Acquisition - Blair Street

FEMA has obligated funding for acquisition of the property and conversion to open space near the tidal marsh. This will increase flood storage and reduce property damaged incurred during future storms.

MILFORD: Home Acquisition – Melba Street

NRCS considered acquisition of this property with conversion to open space immediately adjacent to the creek. It is not currently funded, but the house is frequently flooded. It may be necessary to acquire this property and alleviate anticipated damage costs from future storms.

MILFORD: Home Acquisition – Cooper Avenue

NRCS has obligated funding for acquisition of the property and conversion to open space near the tidal marsh. This will increase flood storage and reduce property damaged incurred during future storms.

MILFORD: Home Acquisition – Tremont Street

NRCS has obligated funding for acquisition of the property and conversion to open space near the tidal marsh. This will increase flood storage and reduce property damaged incurred during future storms.

WEST HAVEN: Property Acquisitions – Phase 1 (13 homes), 3rd Avenue

This project is part of the overall Old Field Creek resilience framework. NRCS has obligated funding for acquisition of 13 properties and conversion to open space near the Old Field Creek tidal marsh. This will increase flood storage and reduce property damage incurred during future storms.

WEST HAVEN: Property Acquisitions – Phase 2 (15 homes), 3rd Avenue

This project is part of the overall Old Field Creek resilience framework. NRCS has obligated funding for acquisition of 15 properties and conversion to open space near the Old Field Creek tidal marsh. This will increase flood storage and reduce property damage incurred during future storms.

STRATEGY: Road Elevation

Examples where roads need to be elevated, where elevation is already underway or have been completed, include – based on discussions with the municipalities during Project Component #1 – the following:

FAIRFIELD: Reef Road Enhancement

This project represents one of several options for Reef Road. In this alternative, the road would be enhanced (widened and/or elevated) to provide better egress.

BRIDGEPORT: RBD #S1.2 Elevated Street and Floodwall Creation

This Rebuild by Design project includes elevation of the Singer Street alignment by three feet with an integrated 4' floodwall on the water side. This flood protection system would provide protection to the South End neighborhood.

BRIDGEPORT: RBD #B.2 Elevated Infrastructure Corridor Project

This Rebuild by Design project would raise Iranistan Avenue and its utilities 3 feet, with new stormwater drainage, and the potential for integration into the broader flood and storm surge protection system for Cedar Creek and the South End. Elevation of the road would provide egress to I-95 for the industrialized area.

MILFORD: Milford Point Road Elevation

Milford Point road is being elevated between 1st Avenue and Seaview Avenue. Funding was provided by CDBG-DR. Design was completed in 2015-2016. The elevated road will have lower risk of inundation during coastal flood events.

MILFORD: Beachland Avenue Road Elevation

The City will elevate Beachland Avenue from 1.5' to 2' above high tide elevation. This project was funded by CDBG-DR. Design was completed in 2015-2016. The road routinely floods during the highest monthly tide, and the new elevation will improve egress.

MILFORD: East Broadway Connection to Nettleton Road and Possible Flood Protection System

Nettleton Road could be restored and connected to the end of East Broadway for improved egress. If elevated, it could also serve as part of a flood protection system with new dunes.

WEST HAVEN: 1st Avenue/Beach Street Elevation

This project is part of the overall Old Field Creek resilience framework. CDBG-DR funds will be used to elevate a section of the road to improve egress for residents and access to the sewage treatment plant during coastal floods.

EAST HAVEN: Farview Road Elevation

Fairview Road crosses a tidal marsh close to the parallel Brazos Road. One road may be elevated to increase its resilience, allowing the other to be retired. This project represents elevation of the road.

EAST HAVEN: Brazos Road Elevation

Brazos Road crosses a tidal marsh near the parallel Farview Road. One road may be elevated to increase its resilience, allowing the other to be retired. This project represents elevation of the road.

EAST HAVEN: Hemingway and Coe Avenues Roadway Elevations

Hemingway and Coe Avenues are critical roads serving East Haven and Branford. The road will be elevated to improve egress during floods and connect Emergency Services with the shoreline area so that emergency vehicles have access during floods.

BRANFORD: Route 146 Elevation at Jarvis Creek

Elevation of Route 146 is necessary to reduce the risk of tidal and storm surge flooding at this low-lying crossing. CT DOT will need to be involved in this project. Flooding of this low-lying crossing cuts off many homes along southeast Branford and Guilford from access to I-95.

GUILFORD: Old Quarry Road Elevation

Elevation of Old Quarry Road was funded by municipal bonds and completed in 2014-2015. This reduced tidal flooding from adjacent marsh.

GUILFORD: Tuttles Point Road Elevation

Elevation of Tuttles Point Road was funded by municipal bonds. This reduced tidal flooding from Chittenden Park and reduces the risk of inundation from future storms.

GUILFORD: Chaffinch Island Road Elevation

Elevation of Chaffinch Island Road was funded by municipal bonds. This reduced tidal flooding from adjacent marsh and will provide better egress during future storms.

GUILFORD: Route 146 Elevation at West River

Elevation of Route 146 is necessary to reduce the risk of tidal and storm surge flooding at this low-lying crossing. CT DOT will need to be involved in this project.

GUILFORD: Route 146 Elevation at Long Cove

Elevation of Route 146 is necessary to reduce the risk of tidal and storm surge flooding at this low-lying crossing. CT DOT will need to be involved in this project.

GUILFORD: Route 146 Elevation at Leetes Marsh

Elevation of Route 146 is necessary to reduce the risk of tidal and storm surge flooding at this low-lying area. CT DOT will need to be involved in this project.

GUILFORD: Route 146 Elevation at Great Marsh

Elevation of Route 146 is necessary to reduce the risk of tidal and storm surge flooding at this low-lying crossing. CT DOT will need to be involved in this project.

GUILFORD: Long Hill Road Culvert Replacement

The Spinning Mill Brook culvert in Long Hill Road was replaced to increase capacity and reduce flood risk.

MADISON: Green Hill Road Elevation

Flooding from tidal wetlands occurs north and south of I-95 at Green Hill Road and Green Hill Place. Road flooding can be 2'-3' deep. Elevation of the roads may be a solution. Long-term, this area may be a candidate for property acquisitions.

STRATEGY: Utility Infrastructure Resilience

Examples where water, wastewater, and stormwater utilities will need to be strengthened, elevated, created, or relocated over time emerged during discussions with municipalities including the following:

FAIRFIELD: South Benson Road Stormwater Pumping Station

This pumping station would remove floodwaters that become trapped in low-lying land west of Jennings Beach. Removing floodwaters in a timely manner is critical because the duration of flooding experienced is relative to the cost of repair.

FAIRFIELD: WPCF Outfall Pipe Enhancement

The Town's sewage treatment plant outfall pipe was repaired using CDBG-DR funds. Specifically, a leaky joint was repaired. This will reduce discharging during future storm surge flooding.

BRIDGEPORT: RBD #B1 Offshore Outfall Park Development

This Rebuild by Design project would be designed to treat up to the 2-year rain event, and some of the raw sewage released each year, while cleaning the water flowing through Cedar Creek even during dry periods.

MILFORD: Bayview Beach Drainage Projects

Drainage systems among the Bayview Beach streets will be upgraded to prevent road flooding using a combination of bonds and CDBG-DR funds. This will serve as one component of resilience projects for the Bayview neighborhood.

MILFORD: Carmen Road Drainage Projects

The City will utilize bonds to fund drainage projects in this area near Calf Pen Meadow Creek. The drainage projects will reduce the frequency of road flooding.

MILFORD: Point Beach Drainage Projects

The City will utilize bonds to fund drainage projects in this area. The drainage projects will reduce the frequency of road flooding.

MILFORD: Rock Street Drainage Projects

The City will utilize bonds to fund drainage projects in this area. The drainage projects will reduce the frequency of road flooding.

MILFORD: Beaverbrook WWTP Flood Protection

A flood wall system is believed necessary to protect the Beaverbrook Wastewater Treatment Plant from Housatonic River flooding, as well as coastal flooding.

WEST HAVEN: Outfall Pipe Replacement

The traditional option for protection of the wastewater plant effluent outfall pipe is to maintain sand coverage by re-routing the mouth of Old Field Creek. This alternative considers replacing the pipe with a new, resilient alignment at a lower depth.

NEW HAVEN: Hill Neighborhood Drainage Improvements Study

This project is a feasibility study of new outlets, pump stations, or alternative improvements to supplement existing outfalls and increase protection from storm events. The study will consider development of an effective low-impact solution.

EAST HAVEN: Sewer Pumping Station Resilience

This project is a component of three potential resilience projects at this site. The sewer pumping station could be fortified or elevated to increase its resilience from storm surge and subsequent flooding.

BRANFORD: Branford Wastewater Treatment Plant Floodproofing

Floodproofing of various components of the wastewater treatment plant is desired by the Town. Floodproofing is needed to reduce the risk of flooding from Branford River.

TYPE: Stormwater Management:

(Map #17)

STRATEGY: Green Infrastructure Retrofits

FAIRFIELD: Fairchild Avenue Green Infrastructure Retrofit (Map #17)

DESCRIPTION: The Fairchild Avenue project site is situated perpendicular from Route 1 (Kings Highway). The Rooster River runs immediately behind the street with 3 to 5 homes abutting the river bank. This entire low-lying area contains a high water table with some sections along the street falling below the 100-year flood elevation. As a result, the area experienced flooding impacts from Sandy. The project would consist of retrofitting the street with bioswales, curb bump-outs, tree box plantings, bioretention areas, pervious pavement, or other green street strategies to improve drainage and mitigate future flooding of homes and businesses along Fairchild Avenue.

BRIDGEPORT: Knowlton Park Green Infrastructure Retrofit (Map #17)

DESCRIPTION: This project was highlighted in the Pequonnock River Watershed Based Plan (2013). The project site runs parallel with Knowlton Street and lies just to the north of East Washington Avenue. The park is approximately 10 acres, containing walkways, gardens, and playground activities. The project would focus on riparian buffer enhancements-restoration and living shoreline techniques using either green infrastructure or hybrid approaches. Some of these strategies include, rain gardens, bioswales, berms, vegetated buffers, bioretention areas, tree box filters, and pervious surfaces. This multiphase project will ultimately help with the rehabilitation of the Pequonnock River and its shoreline.

STRATFORD: Sikorsky Estuary Walk Green Infrastructure Retrofit (Map #17)



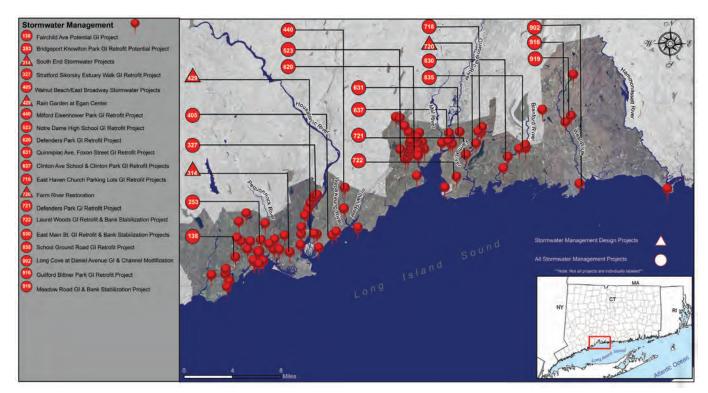
Credit: TNC

DESCRIPTION: Sikorsky Estuary Walk is near Ryder Lane and Main Street in Stratford adjacent to the Ryder Landing Plaza and the Oronoque Shore Condos. The Sikorsky walk extends from Ryder Lane along the bank of the Housatonic River and then travels underneath Route 15. A detention area is in the middle of the parcel with the Estuary Walk rapping around it. The topography of the land is sloped towards the detention area and the river. Many opportunities exist to retrofit the nature walk with additional green infrastructure strategies such as rain gardens, bioretention areas, vegetated swales, tree box plantings, berms, and more

signage. The outcome would improve the sites stormwater management and protect the adjacent Shore Condos, as well as improving the water quality within the watershed. In addition, the greenway would provide more educational opportunities and allow the walkway to connect with the waterfront along the Housatonic River.

STRATFORD: South End Stormwater Management (Map #17)

DESCRIPTION: The project site is between Sedgewick Avenue and Benton Street in the southern part of Stratford. The area is east of Interstate I-95 with commercial industries and residential neighborhoods encompassing the project area. A small culverted stream flows through this heavily residential area. The entire project site is low-lying and contained in FEMA's flood hazard zones. The topography is somewhat bowl-shaped resulting in frequent shallow flooding from the underground stream. Limited waterways exist onsite for runoff to drain therefore, installing and retrofitting green and natural infrastructure techniques such as vegetated swales, bioretention areas, infiltration strips, tree box filters, curbside bioswales or other techniques would reduce the constant flooding and provide means of capturing stormwater runoff within this urbanized area of Stratford.



Map 17: Stromwater Management Projects only

MILFORD: Walnut Beach/East Broadway Green Infrastructure Retrofit (Map #17)



Credit: Milone and MacBroom

DESCRIPTION: The City's Walnut Beach is located perpendicular to Viscount Drive and parallel to East Broadway. The main parking lot for the beach is located northwest from the site which is underutilized and somewhat oversized. Residents and visitors prefer to park closer along East Broadway. The road is relatively narrow and offers no emergency access. A small cul-de-sac is located at the end of the road and would need to be expanded to provide the appropriate radius for all types of vehicles to turn around. The rest of the road would be widened to accommodate parking and improve access for emergency vehicles. The city of Milford would like to take the parcel of land on the opposite side of the road and retrofit the existing landscape with green infrastructure such as rain gardens and bioswales. The outcome would reduce the amount of runoff and improve the sites stormwater management. The bioswale would remove silt and pollution from surface water runoff.

MILFORD: Eisenhower Park Green Infrastructure Retrofit (Map #17)

DESCRIPTION: The project site is situated along the upper portion of the Wepawaug River at 780 North Street along Route 121. The park itself contains a sport complex with athletic fields, tennis courts, and a building at the front of the entrance of the park. There is a gravel road that runs from the entrance to the back of the Park where there is a parking lot and more ball fields near Clark's pond. The Wepawaug River runs parallel with the back of the park and discharges into Clark's Pond before continuing downstream. This entire area of the park is extremely low-lying and contained in FEMA's flood hazard zones. The back pf the Park constantly floods during heavy rainfall events. Ideally, the town of Milford would like to retrofit this portion of the existing property with green infrastructure to improve flood protection, drainage, and water quality at Clark's

Pond and along the Wepawaug River. This multiphase project would focus on the removal of sediment at the pond, re-alignment of the Wepawaug River and channel, installment of floodplain benches, rain gardens, vegetated swales or wet meadow depressions to increase flood conveyance and storage. The outcome would restore and preserve the natural ecosystems throughout the Park and along the Wepawaug River.

WEST HAVEN: Notre Dame High School Green Infrastructure Retrofit (Map #17)

DESCRIPTION: Notre Dame High School is located at 24 Ricardo Street which encompasses Terrace Avenue, Zegmont Street, and Cook Avenue. The site contains a couple of designated parking areas with many parking spaces. The lot closest to Terrace Avenue is somewhat elevated and contains some vegetation and parking spaces. Both sides of the lot are graded towards the curb and near new catch basins. However, the area still experiences flooding during rainfall events, and as a result, the School would like to retrofit the existing landscape with more rain gardens, bioretention areas, vegetated swales, infiltration strips, tree box plantings, and other forms of green infrastructure. Ideally, these techniques would be installed around the School to improve its stormwater management system and to alleviate future flooding of the School's property.

NEW HAVEN: Defenders Park Green Infrastructure Retrofit (Map #17, #15)

DESCRIPTION: The project is a recommended site in the West River Watershed Management Plan. The project area is located on the western side of downtown New Haven and adjacent to the West River. The project site is a small triangular-shaped open space municipal park located in between Davenport Avenue, Columbus Avenue, and Congress Avenue. Currently, the Park is underutilized and contains mostly grass with trees aligning the Park along the street and trees within the Park, as well as monument located at the back center. The entire project area is low-lying and is currently within FEMA's flood hazard zones. Over the past years, the area has experienced its fair share of flooding from previous storm systems. In addition, stormwater runoff has also taken a toll with problems surrounding this project site. Ideally, a retrofit would occur that includes retrofitting the landscape and streets with green infrastructure such as rain gardens, curb bump-outs, infiltration strips, bioswales, tree box plantings, and possibly adding permeable pavement. Many of these green concepts would be designed and implemented to collect, store, and infiltrate or treat stormwater and reduce impervious runoff. Defenders Park would be revitalized to mitigate future flooding while improving New Haven's stormwater drainage system and the water quality along the West River.

NEW HAVEN: Quinnipiac Avenue/Foxon Street Green Infrastructure Retrofit (Map #17)

DESCRIPTION: The project is recommended in the Quinnipiac River Watershed Plan (2013). The project site is located at the intersection and along both Quinnipiac Ave and Foxon Street. This area is just east of the Quinnipiac River and southeast of Interstate I-91. This entire area is low-lying with most of the project situated within FEMA's flood hazard zones. The area has experienced flooding from past rainfall events. The project would involve retrofitting the landscape and streets with green infrastructure. This "greenstreet" approach would be incorporated along the side of the road and grassy surfaces between the curb and sidewalks. Some of the installations could include pervious pavement along with parking stalls to improve infiltration, curbside bioswales along intersections and before driveways to reduce peak flow rates, the installation of tree box plantings, bioretention areas, or narrow rain gardens to improve infiltration, collection, and storage of stormwater runoff. This large greenstreet project would improve the overall stormwater management system while reducing pollutants discharging into the river.

NEW HAVEN: Clinton Avenue School and Clinton Park Green Infrastructure Retrofit (Map #17)



Credit: TNC

DESCRIPTION: The project is a recommend in the Quinnipiac River Watershed Plan (2013). Both the Clinton Avenue School and Clinton Park are located at 293 Clinton Avenue. The entire project area is just west of the Quinnipiac River and near Interstate I-91. Currently, the city of New Haven and their Parks Department maintain the Park and some of the School's grounds. The focus of the project would be retrofitting the parking lot and landscape with green infrastructure to improve both infiltration and the water quality discharging into the Quinnipiac River. The area near the Park and School is somewhat low-lying and has poor drainage. Ideally, the existing parking lot along Clinton Avenue

would be retrofitted with bioretention areas and permeable pavement towards the end of the lot where stormwater runoff would infiltrate into the drainage system. The School's grounds and Park would then be retrofitted with rain gardens, tree box plantings, and other green infrastructure to improve the quality of the water discharging into the Quinnipiac River. The city of New Haven has awarded a project to provide traffic calming on Clinton Avenue in front of the school and park with some curb bump outs that will have green infrastructure (rain garden with subsurface infiltrators) incorporated into them.

EAST HAVEN: Farm River Restoration (Map #17, #15)



Credit: TNC

DESCRIPTION: The Farm River runs north to south through the town of East Haven and discharges into Long Island Sound. The Farm River Watershed contains many residential homes, businesses, and neighborhoods. Many of which fall within FEMA's flood hazard zones and have experienced flooding and damage during past rainfall events and other large coastal storms. The projects would focus on incorporating bioengineered banks, green infrastructure, and hybrid approaches along the Farm River's riparian corridor to improve the overall watershed health. Some strategies would focus on installing floodplain benches, berms, vegetated swales along the banks of the Farm River to help improve flood conveyance. Other green infrastructure techniques may include curbside bioswales, pervious pavement, tree box plantings, bioretention cells, rain gardens and other forms of green street concepts to reduce runoff and alleviate future flooding of critical infrastructure. The outcome of this projects would help restore many of the natural ecosystems while utilizing green solutions to improve stormwater management throughout the Farm River Watershed.

EAST HAVEN: Church Parking Lots Green Infrastructure Retrofit (Map #17)



Credit: TNC

DESCRIPTION: The Totoket Valley Church and Our Lady Valley Pompeii Church are located at 355 Foxon Road in East Haven. The entire project area is immediately in front of Foxon Pond and just northeast of North High Street. The churches are side by side and contain two extremely large parking lots that are connected in rear of the buildings. Our Lady of Pompeii parking lot is smaller in size and is in poor condition. The second parking area is the largest, located in the rear of Totoket Valley Church and extending toward a second entrance and exit off Bennett Road. This entire asphalt parking area takes up approximately 2 acres. Ideally, this potential project focuses on retrofitting the parking lot to reduce the amount of impervious cover. Some of these approaches would include the installation of parking stalls and curbside bioswales between the edge of the pavement and grass. Second, retrofit the existing parking lot with permeable pavement to improve infiltration and improve the quality of water along the Farm River. The outcome would help improve the overall aesthetics of the Church and provide potential future opportunities for green infrastructure.

EAST HAVEN: Laurel Woods Green Infrastructure Retrofit and Bank Stabilization (Map #17)



Credit: TNC

DESCRIPTION: The project is located at the Apple Rehabilitation Center at Laurel Woods - 451 North High Street along Route 100. The East Haven Police Station site is immediately to the north with Interstate I-95 located just to the south of the project area. Laurel Woods immediately abutting the west bank of the Farm River. The lot itself contains 1.2 acres of buildings and a 1,600-square foot parking lot, as well as a grass area, picnic tables, and walkways for residents. The project site is low-lying with most of the area sloped from the road to the Farm River. Currently, the site is within FEMA's flood hazard zones and experiences flooding during rainfall events. Ideally, this project would focus on incorporating a rain garden or bioretention area along the grass strip to reduce runoff from the adjacent parking lot. In addition, the project would incorporate bank stabilization techniques along the backside of the property like vegetated swales, floodplain benches or other concepts to control future erosion and provide further flood protection of adjacent properties and other critical infrastructure along this section of the Farm River.

BRANFORD: East Main Street Green Infrastructure Retrofit and Bank Stabilization (Map #17, #15)

DESCRIPTION: The project is near the downtown area of Branford along East Main Street. The area has had flooding concerns during past rainfall events and especially during Sandy. Ideally, the focus of this project would be to incorporate green infrastructure and greenstreet strategies with existing landscape to reduce impervious surface and stormwater runoff while also providing flood protection for nearby critical infrastructure. These approaches would include curb-bioswales to be installed between the edge of the road and the curb. Installing tree box plantings and impervious pavement along sidewalks and before driveways would also improve infiltration while reducing impervious

surfaces. Retrofitting would improve the overall stormwater system and help mitigate future flooding of vulnerable area along East Main Street.

BRANFORD: School Ground Road Green Infrastructure Retrofit and Bank Stabilization (Map #17, #15)

DESCRIPTION: The project is situated along School Ground Road which is located towards the northeast part of Branford just west of The Fairways Woods Driving Range and south of Route 139. There are multiple areas along this road that are extremely low-lying and are near the Branford River. In 2014, a bridge was rebuilt and a portion of the bank was restored with sections of bulkhead, riprap, and vegetation. There are many other sections along School Ground Road that are low-lying and are still vulnerable to future street flooding from rainfall events. Ideally, this project would focus on retrofitting with green infrastructure such as rain gardens, curbside bioswales, pervious pavement, and tree box planters to increase infiltration of stormwater runoff throughout this section of Branford. Bioengineered bank strategies could also be applied either as green infrastructure or hybrid solution in sections abutting the River. The project would improve the overall stormwater system and provide flood control measures for nearby critical infrastructure.

GUILFORD: Bittner Park Green Infrastructure Retrofit and Bank Stabilization (Map #17)

DESCRIPTION: Bittner Park is located along the western side of Durham Road (Route 77) and east of Long Hill Road. Currently, the West River flows through this area of Bittner Park and alongside Durham Road towards Interstate I-95. Bittner Park is relatively large area comprised of hiking trails, walkaways, ball fields, a playground (closest to riverbank), and more athletic fields situated along the far west side of the park. There are two facilities and two designated parking lots onsite. The topography of the park is somewhat low-lying with some areas sloped toward the river. The West River flows underneath the park entrance and around the backside of the ball fields before running parallel to Durham Road. This project would focus on retrofitting the existing landscape and parking lots with green infrastructure. Some strategies would include curbside bioswales, pervious pavement, and tree box filters. Bioengineered bank strategies would also be applied along the ball field banks as either green infrastructure or hybrid solutions to mitigate future erosion. The outcome of the project would improve both drainage and flood conveyance of the West River and Bittner Park.

GUILFORD: Meadow Road Green Infrastructure and Bank Stabilization (Map #17, Map #15)

DESCRIPTION: Meadow Road is located just south of Route 80 and northeast of Bittner Park. The landscape of the area is composed mostly of woods and dense vegetation with some homes and residential neighborhoods. The topography of the area is somewhat low-lying with areas sloped toward Little Meadow Brook. The Brook flows north to south through a small open channel and underneath Meadow Road via a box culvert beside a homeowner's property. Ideally, this project would focus on retrofitting this landscape with green infrastructure and bioengineered bank strategies or hybrid solutions. Some applications would include curbside bioswales, berms, native vegetation, and floodplain benches along the banks of the Brook to provide flood protection to adjacent homes and properties. This project would reduce stormwater runoff and improve flood conveyance for Little Meadow Brook at Meadow Road.

OVERALL LESSONS LEARNED: Planning and Design Phases

Numerous lessons were learned during the identification, planning, and design phases (Project Component #1, #2, #3) of this Regional Resilience Framework project as discussed below. These lessons as provided are intended as general guidance for stakeholders looking to advance community resilience building for municipalities and regions in Connecticut and beyond.

Nature-based solutions and green infrastructure will not be possible everywhere. Some coastal structures will remain and will need to be repaired and even elevated as needed (either in kind, or with modifications).

Hard coastal structures will be a part of Connecticut's developed shorefront for many years into the future. These structures presently include and will continue to include seawalls, bulkheads, revetments, groins, and breakwaters. These hard structures will protect many miles of shoreline roads, the State's numerous water-dependent uses, countless public amenities, and many thousands of private properties. In municipalities, such as West Haven, hard structures are the only barrier standing between open water and critical sewer mains in the southwestern part of the city. Similar situations with critical infrastructure can be found in many other municipalities.

While the regulatory climate will only rarely allow the construction of new hard structures in Connecticut, existing structures will need to be repaired or replaced as needed. Modifications may be prudent in some cases in response to changing site conditions due to sea level rise and intense precipitation events. However, opportunities for natural and green infrastructure are negligible in these settings. Likewise, hybrid solutions are unlikely to be pursued. Municipalities and property owners will continue to choose the methods that have been used for decades to define the coastal and riverine edges, prevent erosion, and directly deflect wave energy and flood waters. Some coastal structures will need to be enhanced, modified, or replaced over time. In limited instances, new hard structures may be necessary to protect infrastructure or people.

In certain situations, such as coastal and riverine bank protection, nature-based solutions may achieve the desired results of flood protection and/or erosion mitigation.

Where new coastal bank protection is needed or desired, **nature-based**, **green**, **or hybrid methods may be feasible**.

Coastal banks in Connecticut are not protected in a continuous uninterrupted manner. There are many locations where protection is absent and erosion is taking place. Some erosion may be tolerable; for example, where it is providing sand for the State's beaches. However, there are many locations where the unprotected banks occupy gaps (or risk) in otherwise protected shorefronts. Because hard structures are present updrift and downdrift from these gaps, they may be eroding at a different pace than they would naturally.

Unprotected coastal banks that are moderately eroding could be left untouched. However, unprotected coastal banks that are significantly eroding may represent some of our most interesting opportunities. Green and hybrid approaches should be considered for these settings; incorporating native vegetation and local earthen materials whenever possible.

Living edges or shorelines **may be feasible to establish** in the
intertidal zone where they are
not already present, and many
existing tidal wetland systems may
be feasible locations for marsh
enhancement.

There are many examples of tidal wetlands and natural shoreline features that are established and functioning without intervention. Small pockets of smooth cordgrass (Spartina alterniflora) can be found in many places along the Connecticut shoreline where wave energy is generally high, but outcrops or structures are providing some shelter. By replicating these conditions, tidal wetlands may establish in areas where they have recently been lost, or perhaps where they have been absent for many years.

Like hard structures, **tide gates will continue to exist** as part of Connecticut's coastal landscape.

Where possible, tide gates can be replaced to enhance tidal flushing and promote a healthier ecosystem, driving out invasive species. Flood protection benefits may also be improved, given the opportunity to replace aging infrastructure with new infrastructure.

Municipalities and their residents will continue to **rely on beaches** that are nourished regularly, occasionally, or infrequently.

Almost every shoreline municipality in Connecticut has at least one beach that is periodically nourished with sand. Examples include Penfield Beach in Fairfield, Seaside Park in Bridgeport, Short Beach in Stratford, Laurel Beach in Milford, Ocean Avenue Beach in West Haven, Town Beach in East Haven, Jacobs Beach in Guilford, and Hammonasset Beach in Madison.

Wide beaches provide relatively greater risk reduction than narrow beaches. This can be seen in the FEMA flood risk maps along the Connecticut shoreline. For example, Laurel Beach residents in Milford enjoy a slightly lower risk profile than adjacent Wildemere Beach residents, because Wildemere Beach is submerged (absent) at high tide whereas Laurel Beach is wider and higher due to regular beach nourishment under a DEEP permit.

Likewise, almost every shoreline municipality has a handful of beaches where nourishment is desired by municipal officials and/or residents.

Dunes can serve as parts of a flood protection system, and have done so in the past years. Dunes can be enhanced or created in some locations to help reduce flood risk, although they may not eliminate risk.

There are many examples in the literature (including studies mentioned in this report) of dune systems and dune ridges providing flood protection. Connecticut has several examples of locations where dunes previously provided flood risk (Madison Surf Club) and could again provide flood risk, or where new dunes could reduce flood risk.

True engineered flood protection systems such as walls, dikes, and berm systems are desired in some locations.

Notable flood protection systems are found in several inland locations in Connecticut such as the municipalities of Hartford, Torrington, Watertown, Ansonia, Derby, and Stonington. These flood protection systems were installed many decades ago to reduce risk of flooding in densely developed areas adjacent to rivers. However, coastal flood protection systems are rare in Connecticut.

FAIRFIELD:

Several segments of a dike system are presently located in Fairfield. Two segments were mentioned above in the context of hard structures that may be elevated. The Town's administration, Flood and Erosion Control Board, and many residents are in favor of extending the dike system to reduce the risk of flooding from the creek, from the shorefront, and from Ash Creek. Although recent public meetings of the Flood and Erosion Control Board (2015-2016) found some coastal residents speaking out in opposition, the U.S. Army Corps of Engineers continues to evaluate the cost effectiveness of flood protection systems near Pine Creek. The town of Fairfield also has a CDBG-DR grant to evaluate flood protection systems along Ash Creek, and the study is underway with anticipated completion in 2017.

BRIDGEPORT:

The Rebuild by Design and NDRC awards for Bridgeport support portions of a comprehensive flood protection system for the City. This part of the system would be comprised of several segments extending from the downtown area along the Pequonnock River, into the South End and along Seaside Park, crossing Cedar Creek as a hurricane barrier, and extending northwest to high ground (included in list of example flood protection systems). A flood protection system is not envisioned for the East Side or Steelpointe Harbor because ground surfaces tend to be higher. However, the Steelpointe Harbor development includes an elevation of the ground surface in lieu of a flood protection system.

NEW HAVEN:

In New Haven, CDBG-DR funds are being utilized to study long-term flood and storm surge protection strategies for the Long Wharf area which extends landward from Long Wharf Park. This critical area includes Interstate I-95, Sargent Drive businesses, and the railroad yard.

Although flood protection systems are not typically feasible to construct as natural or green infrastructure, several opportunities may exist to incorporate these features into some of the design elements. For example, New Haven is considering creation of flood protection at Long Wharf Park by tying elevated ground into park features, creating a dune system, and restoring salt marsh in front of this linear park. The flood protection would still be hard infrastructure at heart, but greener elements would soften the appearance and improve this public amenity.

Municipalities will acquire properties and owners will elevate buildings to reduce risk where flood protection systems or nature-based solutions cannot be created to eliminate risk. In other words, residual risk will continue to drive acquisitions and elevations

Numerous sections of **coastal roads will need to be elevated** to reduce the frequency of flooding, and therefore reduce the risk of flooding.

Some **coastal roads** and parking lots **may be candidates for abandonment** or a modification in how they are paved. Natural or green infrastructure could be placed in their footprints.

If a roadway were abandoned, risk would be eliminated. In many cases, road abandonment needs to be paired with increasing the level of service of another road, or creation of alternate access.

Scour is a problem in some coastal settings, **posing risk** to bridges.

Where scour has been observed, or is posing risk to bridges, it may be possible to utilize hybrid solutions to stabilize the area subject to scour. Green or solely nature-based solutions may be more challenging to use in these areas, depending on the velocities found in the channels.

Water, wastewater, and stormwater utility infrastructure will need to be strengthened, elevated, created, or relocated over time, either as a measure to solely increase resilience or reduce associated flooding.

Many of the municipalities recognize the **nexus between coastal resilience projects and stormwater management** using rain garden, bioswales, and other traditional inland green infrastructure projects.





Project Selection and Design

One high priority resilience project from each municipality was selected to advance through an iterative conceptual design process. The design documentation (Appendix E) comprises the record of the design criteria developed for each of the ten projects. In all cases, the projects are designed are intended to not impact public access, views, or nearby water-dependent uses.

Concept:

All ten projects are believed to be effective alternatives for reducing risks to ecosystems, people, and infrastructure. However, they are not all equal in this regard. For example, the Long Wharf living shoreline will reduce erosion and help directly reduce risk to infrastructure (Long Wharf Drive and its utilities) whereas the Chittenden Beach living shoreline will not directly reduce risks to infrastructure. Instead, it may help reduce the frequency of storm damage to Brown's Boat Yard (considered a critical facility in the Guilford Hazard Mitigation Plan) on the west side of the West River. These are two different infrastructure risk reduction profiles; direct and ancillary benefits. However, both projects could result in significant direct ecological benefits if marshes become more resilient to erosion from storm surge.

The summary sheets (Appendix E) also provide a brief discussion about how each project relates to future conditions as viewed using TNC's Coastal Resilience tool and web-based decision support system depicting future combinations of downscaled sea level rise projections for Connecticut and storms (1938 Cat-3, Cat-2, Sandy) in the 2020s, 2050s, and 2080s (Appendix I). Projects were either believed to be affected in their efficacy because they will be submerged more often (these are projects in the intertidal zone like Long Wharf) or because they will be overtopped more often (these are projects above the coastal jurisdiction line such as the dune ridge projects).

All ten designs were thoughtfully developed to ensure that the one-foot rise in sea level would not render them ineffective. In some cases, higher sea level rise projections will necessitate that projects be redesigned or otherwise enhanced. However, this timeframe would be beyond the life span of most natural and green infrastructure or hybrid designed and installed projects. More importantly, the ten projects could be modified to accommodate unforeseen changes in climate change progression given the regenerative and adaptable nature of natural and green infrastructure projects. This is in stark contrast to hard structures, which are often fixed and more difficult to adapt.

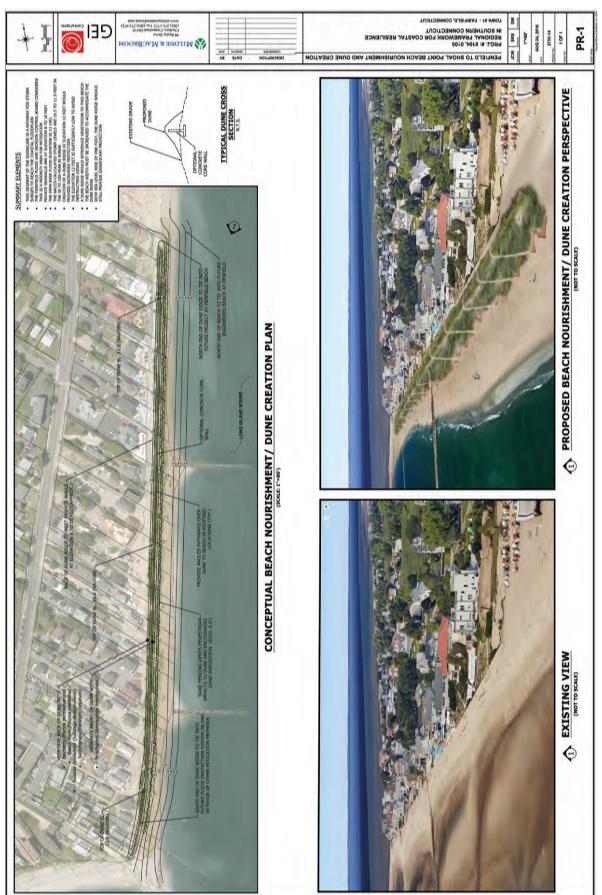
Conceptual Designs:

The projects selected to advance through a conceptual design process were arrived at through a detailed assessment, cataloguing, and prioritization process with a diverse suite of stakeholders (Project Component #2). While the conceptual designs represent high priority projects there are a few common "gradients of concern" that seek to address the challenges of risk and respond to the promise of resilient solutions in these vulnerable locations. The first resilient gradient common to most stretches of coastline around the world is the urban, suburban, and rural development challenges. The ten projects selected reflect development challenges in urban centers like Bridgeport and New Haven as well as less developed coastlines from suburban (West Haven, East Haven, Fairfield, Stratford, Milford) to more rural (Branford, Guilford, Madison). A second resilient gradient reflected in the conceptual designs is the transition from coastal areas to inland locations up into the watersheds – salt to fresh water flooding challenges. A third resilient gradient presented by the projects is one of socio-economic advantages and disadvantages ranging from the wealthiest communities in the United States to among the poorest.

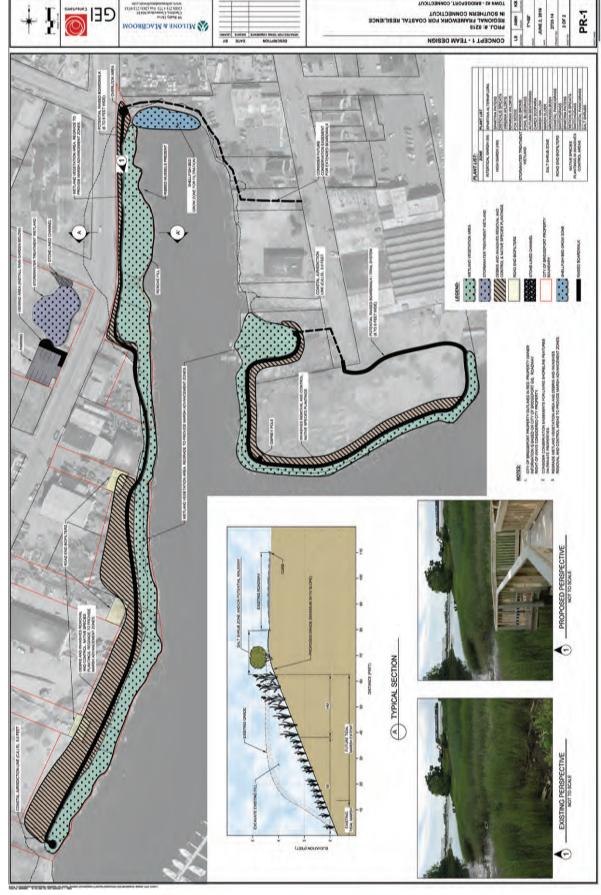
The conceptual designs also vary in levels of complexity as they attempt to portray strategies and ultimately outcomes that are net positives for more simplistic projects such as reducing flooding in a critical intersection to re-imaging an entire neighborhood or section of a municipality with multiple interconnected systems, simultaneously. Ultimately, the intended outcomes of all the conceptual designs is to take a perceived negative (i.e., reduction in property values and tax base due to sea level rise and flooding) and generate a net positive. In every case the conceptual designs try to adhere to a triple bottom line approach to community resilience building - reduce risk to people, property, and the environment; enhance a public amenity or quality of life for residents; and increase the viability and function of natural infrastructure and ecosystems.

Presented here are a sequential array of all ten of the conceptual designs for the high priority projects. Additional details on each of the ten projects are provided in a variety of maps as indicated below and in Appendix E.

Penfield Beach to Shoal Point Dune Creation (Map #9)



CONCEPTUAL DESIGNS 89



West Branch Johnson Creek Living Shoreline (Map #9, #11)

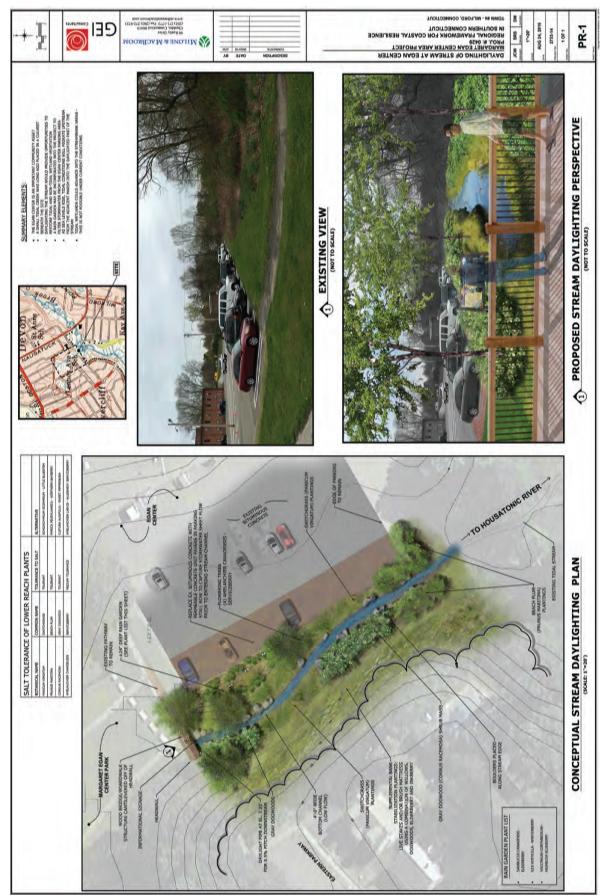
BRIDGEPORT:

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(201) 231-1222-2323 AS NOTED JUNE 2, 2016 PR-1 PROPOSED PERSPECTIVE • EXISTING PERSPECTIVE • TYPICAL SECTION
- LIVING SHORELINE DETAIL BOULDER STEPS

STRATFORD: Russian Beach Bank Protection (Map #9)

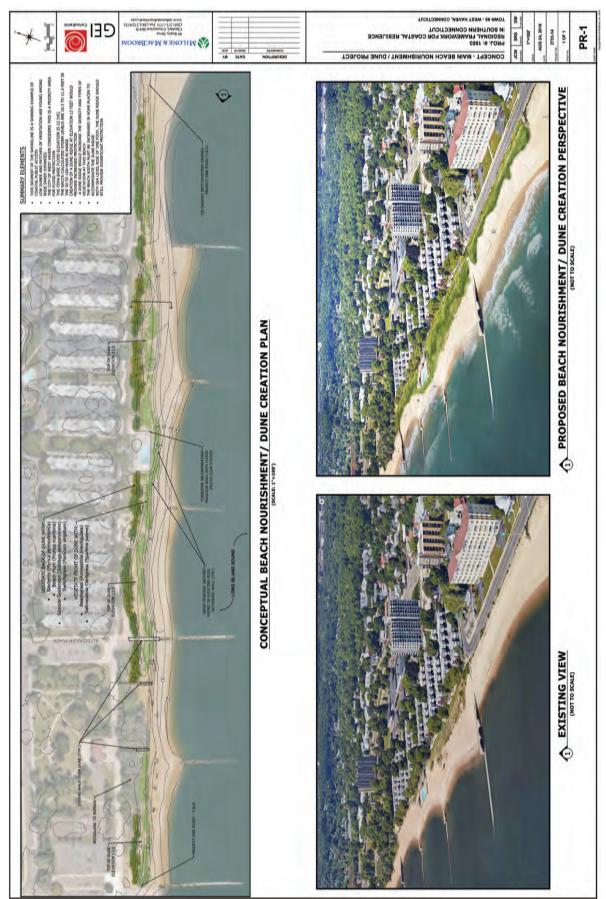
CONCEPTUAL DESIGNS 91

Egan Center Stream Channel Restoration and Green Infrastructure Retrofit (Map #17) MILFORD:



West Haven Beach Nourishment and Dune Creation (Map #9)

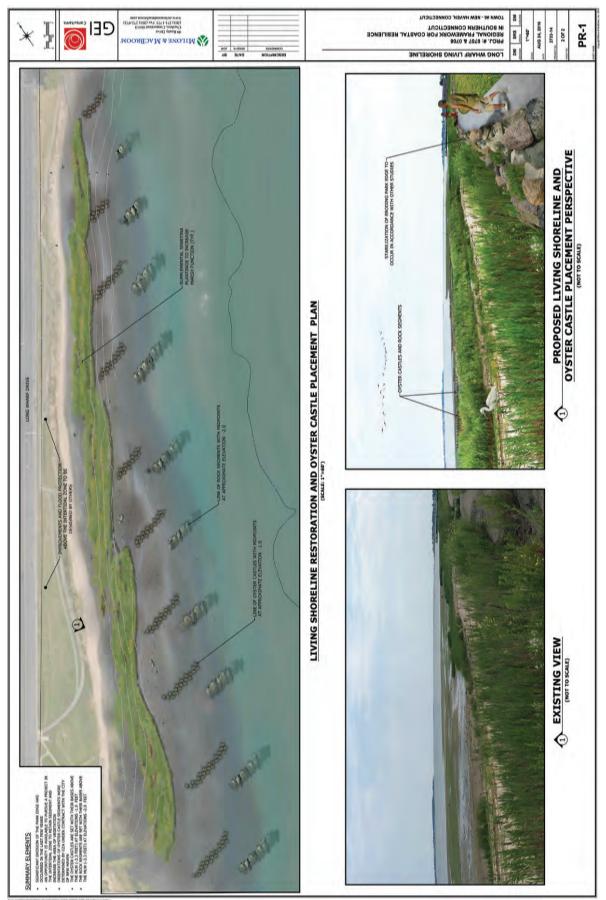
WEST HAVEN:

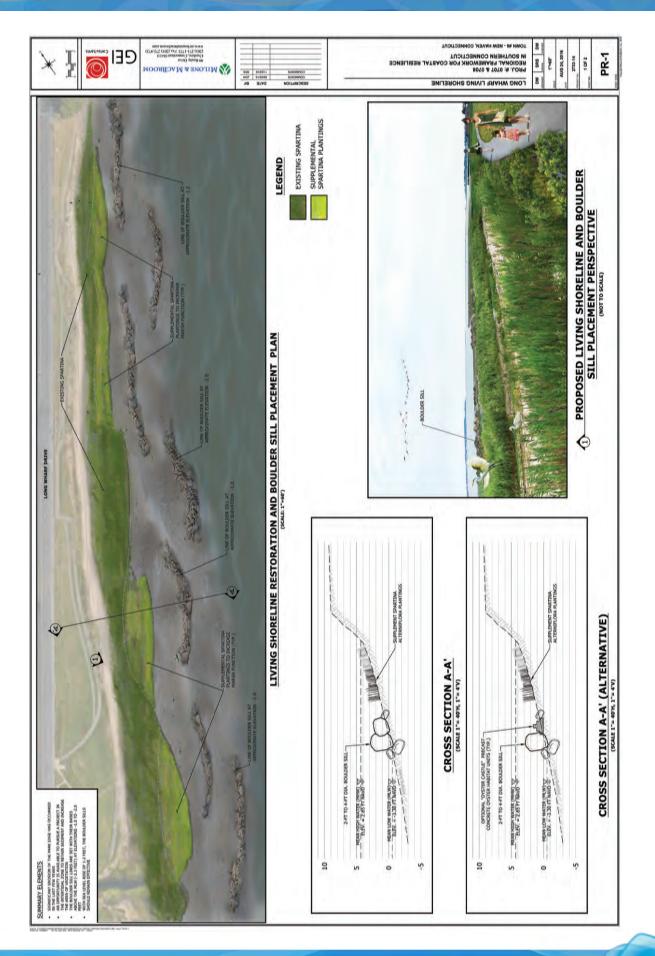


CONCEPTUAL DESIGNS 93

Long Wharf Park Erosion Mitigation and Shoreline Enhancement (Map #9)

NEW HAVEN:

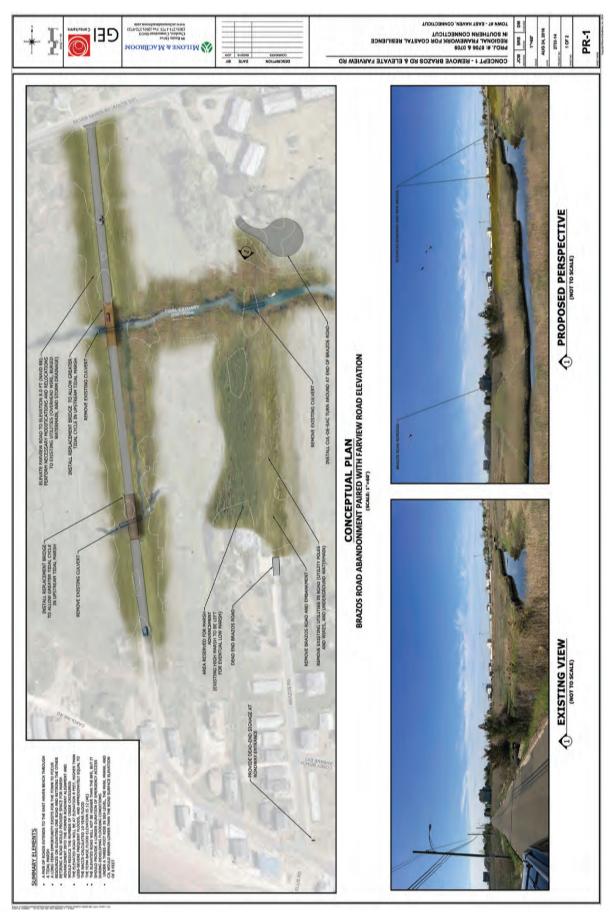


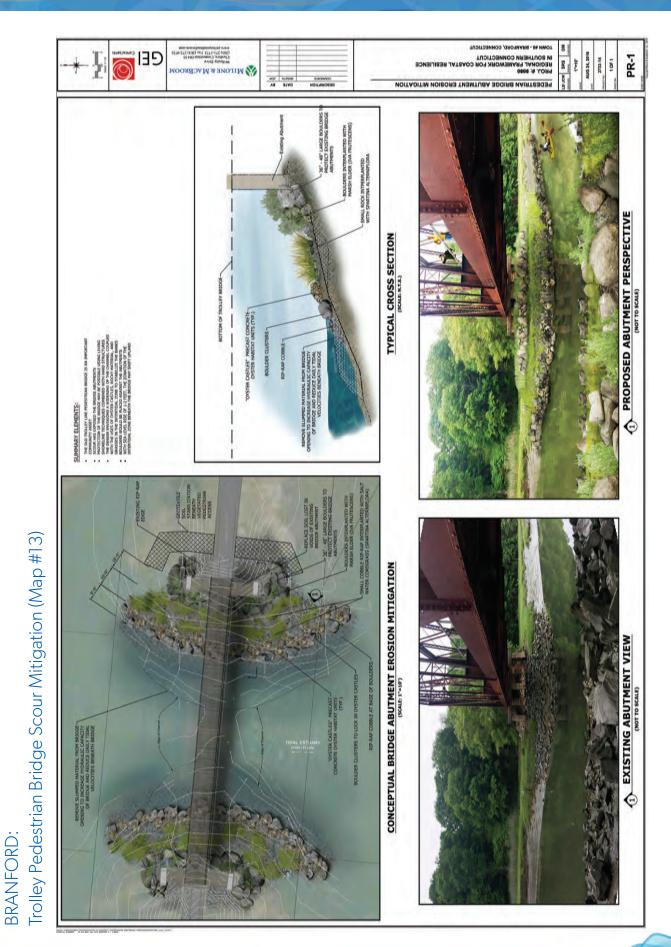


CONCEPTUAL DESIGNS 95

Fairview Road and Brazos Road Abandonment and Removal (Map #13)

EAST HAVEN:





CONCEPTUAL DESIGNS 97

PR-1 CONCEPT 1 - TEAM DESIGN PROPOSED PERSPECTIVE A TYPICAL SECTION EXISTING PERSPECTIVE NOT TO SOME

GUILFORD: Chittenden Beach Living Shoreline (Map #9, #11)

PROJ. #: 1003 REGIONAL, PRAMEWORK FOR COASTAL RESILIENCE IN SOUTHERN CONNECTICUT TOWN #19 - MADISON, GONNECTICUT MILONE & MACHROOM Graftle Concession (0410 (201) 21-173 Fee (201) 23-973) www.nibenendmackconn.com **CEI** PR-1 AUG 34, 2016 DUNE RESTORATION AT MADISON SURF CLUB SCALE 1"+40H 1"+8 V PROPOSED DUNE RESTORATION PERSPECTIVE (MOTTO SCALE) CONCEPTUAL DUNE RESTORATION PLAN (SQUE 1"-39") EXISTING BEACH VIEW

CONCEPTUAL DESIGNS 99

Madison Surf Club Dune Restoration (Map #9)

MADISON:



SECTION 6: Coastal Resilience Legal, Policy, Regulatory Opportunities

The "Regional Framework for Coastal Resilience in Southern Connecticut: Legal, Policy, Regulatory Assessment Identifying Options for Advancement of Natural/Green Infrastructure Projects and Improve Resilience in Coastal Municipalities" (referred to herein as the Assessment) has helped promote amongst the ten municipalities advanced planning and potential implementation of forward-looking land use, including natural/green infrastructure policies. A proactive planning process that integrates legal and policy considerations can overcome challenges that may reduce risk and seize opportunities to integrate coastal natural and green infrastructure across the region. The following is a summary of the opportunities chapter of the full assessment.

Coastal Land Use

The Connecticut shoreline is directly impacted by sea level rise and coastal flooding and is a critical component in coastal resiliency. Shorelines are dynamic systems in which erosion and avulsion are natural processes.

Coastal Zoning Districts

The content and direction of municipal approaches to coastal zoning districts depends on each municipality's vision and plan of its coastal areas. All municipalities face a dilemma in that shoreline areas are highly valuable real estate that can substantially contribute to the tax base, but those areas are highly vulnerable to flooding and erosion. This dilemma is most acute in more urbanized areas, where historic areas and downtown districts are often centered on the waterfront. Retaining and even densifying these areas may be not only a primary driver for city budgets but also a primary focus for redevelopment efforts.

All municipalities must balance the need to invigorate their downtown areas, activate their waterfronts, and the responsibility to limit vulnerable development. The assessment recommends several options for creating a balanced approach.

- Option 1: Erect flood walls or levees to remove highly-valuable areas from the flood zone.
- Option 2: Prohibit especially vulnerable uses or require applicants to receive a special permit or exemption for those uses.
- Option 3: Create special enhanced building and construction standards for use in coastal areas.
- Option 4: No action.

Theoretically, in most circumstances, the benefit of removing particularly high-value areas from the flood zone by erecting levees is the potential to eliminate flooding concerns. The limitations of this approach include the potential of high capital costs and expensive ongoing maintenance. This may require substantial participation and support from federal partners for permitting and design of the levee and to update the relevant flood insurance study. Additional caveats to consider are changes to flooding patterns in other locations and a development of a high barrier between protected locations and the waterfront, reducing the value of the amenity. Such levees may also fail, with disastrous consequences. This option may therefore be reasonable only in extremely valuable and dense locations.

In other locations, municipalities may wish to consider reducing the exposure of particularly vulnerable land uses to coastal flooding and erosion without prohibiting all uses. For example, hazardous uses or those that may release pollution during flooding (e.g., waste handling facilities) may not be appropriate to locate within the coastal zone.

To this end, the Coastal Management Act disallows certain facilities within the coastal boundary, including tank farms and other fuel and chemical storage facilities that can reasonably be located inland.²⁴ Municipalities without existing coastal districts may wish to consider developing one or more new coastal zoning districts or overlays as appropriate for this purpose. As a related option, municipalities may wish to consider using coastal zoning districts and overlays to require enhanced standards for buildings and structures.

Municipalities may determine that existing coastal zoning restrictions—in particular, the coastal site review process offer sufficient regulation of uses in coastal areas. With a strong coastal review process, uses and structures that are not appropriate for a site or that present substantial hazards may not be approved.

Coastal Site Plan Review

As required by state law, every municipality in the study area has developed a coastal site plan review process. The Connecticut Coastal Management Act allows municipalities to exempt certain activities from coastal site review, and each municipality has adopted these exemptions. In most cases, the exemptions apply regardless of how close they are to the shore, but a few municipalities have added coastal setback limits on these exemptions. As a result, activities must submit a coastal site plan if they are less than a set number of feet from the shore.

The use of setback limits for coastal site plan review exemptions ensures scrutiny of all activities in the most vulnerable areas along the coastline. Such scrutiny may be important, even for seemingly low-impact activities, due to the ecological sensitivity of the coast, the importance of natural features to flood and erosion control, and the vulnerability of structures located on the water. A potential caveat of a requirement to submit coastal site plans for these otherwise-exempt activities is financial.

Coastal Setbacks

Coastal setbacks can reduce the need for coastal protection projects by ensuring space between the shoreline and structures. Setbacks may be consistent with and support the use of coastal natural and green infrastructure, reduce casualty loss, and reduce threats to public safety by ensuring that developments are not placed on the shoreline. Connecticut has not established mandatory coastal setback requirements through the Coastal Management Act or other mechanisms. As a result, the use of these buffers is a function of municipal ordinances.

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Existing setback requirements are roughly consistent with Connecticut's past and legacy development patterns, which will pose a continuing limitation on the ability of the state and municipalities to require greater setbacks. Even where legacy structures are torn down and rebuilt, small lot sizes may not allow the footprint of the rebuilt structure to move substantially landward. Imposition of setback requirements for these properties could eliminate any redevelopment of nonconforming structures, which could raise concerns over takings and limit tax assessment increases if policies do not accommodate such issues through variances or other mechanisms. The state and/or municipalities could use new or modified authorities to require adequate and appropriate setbacks for new developments and redevelopments. Avenues for strengthening municipal setback requirements may include regional, voluntary efforts to harmonize municipal ordinances, or independent amendments to municipal ordinances to introduce or extend setbacks.

- Option 1: Develop consistent minimum setback and/or buffer regulations at the municipal level.
- Option 2: Amend Coastal Management Act to mandate setbacks and/or buffers in coastal site plans.
- Option 3: Amend Connecticut Conservation and Development Policies Plan to require coastal setbacks.
- Option 4: Establish coastal buffer requirements by state statute and/or municipal ordinance.
- · Option 5: No Action

Natural Protective Barriers

Legal authorities mandating retention of natural protective barriers, including dunes and coastal vegetation are a direct means of strengthening protections for coastal properties from exposure to flood and erosion hazards. While the current Coastal Management Act creates a policy "to preserve the dynamic form and integrity of natural beach systems in order to provide . . . a buffer for coastal flooding and erosion," ²⁵ municipal ordinances and regulations do not consistently and fully meet this policy.

Municipalities may wish to both expand the types of natural coastal landforms that are protected and bar their removal under any circumstances. Alternatively, municipalities can extend protection to "coastal resource areas" mentioned in the state Coastal Management Act, which include "tidal wetlands, coastal bluffs and escarpments and beaches and dunes." Protection for coastal vegetation may not be included in protections based on landforms. Municipalities may therefore wish to consider explicit protection for coastal vegetation, which serves important functions, including limiting erosion and capturing pollutants. From a state perspective, the Coastal Management Act could be modified to ensure or support consistent protection of all relevant forms of natural protective barriers.

Flood and Erosion Control Structures

Connecticut has created legal authorities supporting the use of living shorelines and other non-structural, natural infrastructure approaches to flood and erosion control. Connecticut's Coastal Management Act promotes non-structural mitigation measures to address the adverse effects of erosion and sedimentation on coastal land uses, and conversely provides that structural solutions are permissible when "necessary and unavoidable," such as to protect critical infrastructure, including access roadways. The Connecticut Department of Energy and Environmental Protection (DEEP) currently implements this state policy through case-by-case analysis. DEEP has not issued general guidance, general permits for dredge and fill for nonstructural approaches, or used other mechanisms to facilitate permitting of development projects focused on non-structural approaches. Flood and Erosion Control Structures (FECS) seaward of the Coastal Jurisdiction Line (CJL) are subject to DEEP permitting, while municipalities review and approve projects proposed landward of the CJL. The burden associated with DEEP review under current practice creates incentives to design projects to avoid DEEP oversight. One option for improving implementation is through issuance of DEEP guidance for natural infrastructure project design and permitting. Such guidance might assist municipalities and the regulated community in:

- a) understanding when hard structures are likely to be (dis)approved;
- b) identifying design considerations for development of non-structural and hybrid project proposals;
- c) streamlining and reducing the costs and uncertainty associated with DEEP permitting; and/or
- d) providing a resource to assist municipal authorities when reviewing FECS projects proposed landward of the CJL.

Interviews conducted as part of the assessment indicated that local government and nongovernmental stakeholders expressed a strong desire for streamlining and increasing the predictability of DEEP review, potentially through the issuance of guidance identifying types of non-structural projects or designs that DEEP would find acceptable.²⁷ Other stakeholders suggest that such guidance or general permits would be premature and/or inappropriate because FECS permitting requires a contextual, site-specific process where consideration is given to the geology, wave action, and other factors as well as the design of the FECS. A cooperative approach in which DEEP engages with stakeholders may be the most beneficial mechanism for overcoming current disparities.

A second option would be to modify the incentives for placing structures fully landward of the CJL by amending the Coastal Management Act. Such an amendment could require DEEP approval (or allow DEEP to veto) all FECS proposals, regardless of location. This change could result in an approval process for FECS that is consistent across both elevation and municipal boundaries, thereby encouraging placement of FECS, including living shorelines projects, in the locations where they are likely to be most effective and inexpensive rather than where they may avoid regulatory oversight. This approach would not address the existing dissatisfaction with DEEP permitting, and could in fact intensify issues experienced by stakeholders by exposing all FECS projects to DEEP oversight.

An additional option would seek to encourage the development of living shorelines by simplification of the permitting process for dredge and fill. This could entail the issuance of a general permit for certain qualifying projects or through use of certificates of permission for approval of qualifying projects. The stakeholder Interviews suggested that coastal natural/green infrastructure approaches remain relatively new in Connecticut, such that general permits and likely certificates of permission are not yet considered appropriate. On the contrary, full permit processing may currently provide useful opportunities for regulators and engineers to collaborate on modifying and improving proposals for maximum efficacy. It is likely that maturation of certain categories of living shorelines approaches and practices over time may become standardized, such that the advantages of full permitting are reduced in comparison to the costs to the department and regulated community, such that streamlined processes are both appropriate and desirable.

The state may wish to consider whether and how a grant and/or technical assistance program might be appropriate to support development and implementation of living shorelines projects. Such a program would likely require dedication of new or repurposed state grant and/or revolving loan funds, but could be offset in part by new or changed user fee requirements associated with other types of FECS.

- Option 1: Develop guidance on DEEP permitting of non-structural coastal erosion projects.
- Option 2: Amend Coastal Management Act to remove incentives for placement of FECS landward of the CJL.
- Option 3: Develop criteria for certain categories of living shorelines projects that may be appropriate for new general permit and/or approval through a certificate of permission.
- Option 4: Establish state-funded grant and technical assistance program for living shorelines projects.
- Option 5: No Action.

Open Space

Preserving existing open space in public ownership or under a perpetual easement and providing for the expansion of such protections, municipalities and the region can reduce and mitigate property exposure and casualty losses associated with climate change and storm activity. Conservation has the additional benefit of simplifying the implementation of coastal natural/green infrastructure and other resiliency projects. Many municipalities have protected substantial swathes of their shoreline as public parks. There are instances where private owners and municipalities have sold undeveloped shoreline areas to the federal government for inclusion in the Stewart B. McKinney National Wildlife Refuge. This option ensures permanent conservation with limited uses still allowed, and it allows landowners, including town governments, to receive onetime payments for their open space assets.

Financial Mechanisms

Financial incentive programs such as transfer of development rights (TDR) represent a second option for preserving privately-held shoreline open space. These programs offer mechanisms to encourage conservation of highly vulnerable locations while simultaneously promoting transit-oriented or other development in desirable locations. Municipalities may wish to consider the use of such ordinances, in both urban and suburban locations. Where adequate demand exists in a receiving area (e.g., transit-oriented development), TDR or similar incentive programs could be used to both preserve existing coastal open space and to convert legacy developed areas into open space, particularly in locations where coastal development is not the primary tax base for the community. Development impact fees provide one option that would allow municipalities to recover the costs associated with developments that are located in high-risk areas and may increase municipal costs. For example, development in a high-risk area could result in a need to build and maintain in perpetuity shoreline flood or erosion control systems (including coastal natural/green infrastructure), maintain new highways to ensure access, and otherwise ensure the ongoing safety of the residences or commercial enterprises in that area. Municipalities are currently barred from charging such fees, and state legislation would be required to enable use of this tool. The state may wish to consider the merits of such an approach; while it may enable funding for maintenance and conservation activities, such fees would increase the costs of new development in shoreline areas (as well as, potentially, infill development).

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Urban and Developed Shoreline Areas

In urban areas and other locations where the shoreline is fully developed under existing zoning, land is likely to require alternate mechanisms and programs if it is to be brought under public ownership or easements. This is especially true when urban shoreline properties are contaminated or have other complications. Development in urban coastal areas is also likely to include central business districts and historic areas where removal of legacy property development presents transactional difficulties and social equity considerations. Municipalities may wish to consider the extent to which they can use redevelopment authorities, brownfields authorities, and similar tools as a mechanism to fund and implement projects that will improve the resiliency of vulnerable urban areas. Both perpetual dedication of open space and developments located in vulnerable areas may present fiscal challenges to municipalities.

- Option 1: Amend municipal authorities to ensure strong minimum open space dedication requirements and cluster or open space developments.
- Option 2: Develop municipal TDR ordinances providing incentives to not develop in areas that are vulnerable and to encourage development in less vulnerable areas.
- Option 3: Consider the application of redevelopment and brownfields funding and authorities to remediate vulnerable urban lands and transfer them to low-vulnerability uses.
- Option 4: Enact state legislation authorizing the use of development impact fees for coastal development.
- Option 5: Explore sale of land to private owners or state or federal governments for perpetual protection.
- · Option 6: Continue existing policies.

Flood Hazard Mitigation

In most instances, municipal requirements for flood damage mitigation echo the minimum requirements necessary for a community to participate in the National Flood Insurance Program. Municipalities can exceed these requirements, and in some cases the towns and cities in the study area have done so. For example, some municipalities require that residences be elevated to one foot above the Base Flood Elevation (BFE), rather than simply to the BFE as minimally required. The ability to exceed the minimum requirements for participation in the NFIP opens up a range of potential policy options that municipalities can consider to increase their resiliency. These can be divided into the following categories:

- Preventing construction on lands subject to flooding and erosion;
- Expanding geographic areas where construction must

- meet flood standards: and
- Requiring construction to comply with heightened building requirements.

Suitability for Building

Determination of where buildings can be located and restricting building in areas subject to inundation or erosion risks in long-term projections is a primary method for decreasing flood hazard risks in a community. Municipalities and the region as a whole may wish to support expansion and standardization of building lot suitability requirements. Municipalities without suitability requirements may benefit from creating such requirements, which could potentially be written to apply to infill development as well as subdivisions to ensure that they are useful in practice along the shore. In addition, municipalities could consider explicitly incorporating erosion risk and projected future hazards as reasons supporting an unsuitability finding. In weighing the retention, expansion, and alteration of suitability determinations, municipalities may wish to consider the potential legal issues associated with prohibitions on development. If not carefully delineated and implemented, limitations on where buildings can be placed that result in an inability to build on a property could result in a judicial challenge under a takings theory. As currently deployed, municipalities have not faced such challenges, in part due to provisions allowing construction if the hazard is removed. Similar provisions could enable construction in coastal areas that are protected by living shorelines or other natural/green infrastructure solutions designed to mitigate erosion or

- Option 1: Modify municipal ordinances to require review of building lots for suitability in all municipalities.
- Option 2: Expand new and proposed suitability analysis to include coastal erosion and projections that consider sea level rise and other climate-related hazards.
- · Option 3: No action.

Defining Flood-Prone Areas

The minimum geographic area for Special Flood Hazard Area (SFHA) and/or Coastal High Hazard Area (CHHA) is set based on the Flood Insurance Rate Maps (FIRMs) and includes A, AE, and V zones for SFHAs and V zones for CHHAs. All of the municipalities in the study area use these default zone designations. FEMA designates flood zones on the basis of historical studies of flooding during past flood and storm events. The resulting zones are conservative, based on historic data rather than projections, and underestimate current and future flood risk. This retrospective analysis does not fully account for projected sea level rise, and structures may have a higher actual flood risk than indicated on the FIRM. Structures at high risk of flooding in the future despite having little past history of inundation are

unlikely to be covered by flood insurance. These structures therefore present a risk of casualty loss to homeowners and coastal communities, as well as a risk of harm to inhabitants during storm events particularly in areas that may be subject to storm velocities (wind and wave impacts) but which are not required to be built to withstand such impacts.

State legislation could address the issue across the entire region. A state-led approach could potentially avoid market impacts from town to town caused by differential municipal standards. Statewide legislation could also promote a regional approach to flood zone reform. On the other hand, state action may be politically difficult and would insert the state in an area (flood zone construction standards) that it currently leaves largely to the federal government and municipalities. While not currently regulating flood zone construction, however, Connecticut has established uniform statewide building standards. Flood zone requirements (e.g., establishment of minimum freeboard requirements) could be incorporated into the existing building code framework. Connecticut has adopted NOAA generated sea level risk projections into state law in numerous contexts, including hazard mitigation planning, state and municipal plans of conservation and development, civil preparedness planning, the Long Island Sound Blue Plan, and DEEP water quality projects.²⁸ These requirements have been applied to both state and municipal processes and similar language could be used to set a standard definition of the flood zone in the state. Care would be needed to ensure that such a definition does not cause conflict with federal requirements, but could ensure that construction in coastal areas is based in a realistic risk profile.

Municipalities can independently reduce their exposure to flood risk by amending existing local flood zone ordinances. These ordinances currently define the SFHA and CHHA for each municipality. These definitions can be modified by changing the zones included in each definition. These amendments could redefine SFHAs to include additional zones (e.g., B or C Zones) and/or redefine CHHAs to include A Zones. These changes could increase construction costs but would not affect flood insurance requirements or other types of costs, and casualty losses in the event of a disaster would be dramatically reduced.

- Option 1: Modify municipal ordinances to define the SFHA to include B zones, thereby requiring new construction and substantial renovation in B zones to meet specific construction standards currently applicable in A zones.
- Option 2: Modify municipal ordinances to require new construction and substantial renovation in A zones to comply with specific standards for CHHAs, with or without allowance for exceptions in locations unlikely to be subjected to velocity.

- Option 3: Modify state law to require compliance with flood zone requirements in B Zones and/or with CHHA standards in A Zones.
- Option 4: Modify FEMA methodologies and update FIRMs to adopt precautionary projections that include enhanced threats posed by sea level rise and coastal flooding.
- · Option 5: No Action.

Enhanced Building Requirements in Flood Areas

The risk of flood damage can be mitigated by increasing the stringency of flood standards that apply to new and renovated structures in the SFHA. These standards currently are established at the municipal level and typically, the requirements are set at the federal minimum. Enhanced building standards are important for reducing the property damage and human toll associated with flood events. As is the case for flood zone definition, federal minimum requirements are conservative and may not adequately reflect the projected flood impacts arising from climate change. For example, BFE is used as the index for elevation requirements but is based on historical flood levels rather than projections; thus, freeboard requirements may be more accurate reflections of future flood elevations and may enhance resiliency. Additionally, building requirements such as increased structural elements can increase resiliency. For example, the Insurance Institute for Building and Home Safety has created the FORTIFIED program, which provides building standards to reduce property damage resulting from hurricanes.²⁹ The FORTIFIED program is designed to be an improvement on minimum building codes, and thus is currently applied by property owners independently or through a certification program, which may reduce losses and may yield reductions in insurance costs. The state and municipalities could consider adoption of these or similar standards in the state building code or requirements applicable to construction in CHHAs. Alternatively, the state or municipalities could develop incentive programs to encourage voluntary uptake of these existing programs. Incentive programs could take the form of a capital outlay by the government, such as a cost share or property tax offset, or could enable modification of zoning requirements (e.g., lot size) for compliant structures. Either approach would require the development or modification of legal authority, which could include state legislation, municipal ordinances, and/or zoning regulations.

- Option 1: Modify federal minimum requirements to reduce flood risk.
- Option 2: Modify state building code to require compliance with enhanced construction standards such as those produced by the FORTIFIED program in SFHAs and CHHAs.

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- Option 3: Modify municipal flood ordinances to require new and renovated structures to meet enhanced construction standards such as those produced by the FORTIFIED program in SFHAs and CHHAs.
- Option 4: Develop state or municipal incentives for property owners to incorporate enhanced building standards.
- · Option 5: No Action

Stormwater and Low-Impact Development

Stormwater management is an important tool for mitigating flood hazards. The state is an important player in stormwater management under both water pollution control law governing nonpoint source pollution and by the publication of manuals for stormwater management. Other options to strengthen stormwater management for coastal resiliency across the region are available to municipalities directly, and may be applied alone or in combination. These options include:

- Option 1: Ensure that stormwater management requirements apply broadly within coastal areas.
- Option 2: Require and explicitly support the use of low-impact development approaches where safe and appropriate.
- Option 3: Ensure adequate minimum standards for peak flow, retention, and impervious cover.

Stormwater management requirements generally apply only to a subset of development activities—generally those requiring some form of zoning approval or those larger than minimum thresholds. Municipalities may wish to consider requiring stormwater management plans more consistently for activities requiring coastal site plan review in order to ensure that these activities do not increase the strain on existing storm sewer systems or contribute to coastal flooding. In addition, consideration should be given to requiring or explicitly supporting the use of low-impact development (LID) approaches. This approach may provide support to developers and encourage inclusion of natural/green infrastructure in stormwater management plans.

Finally, municipalities may wish to consider whether existing specific standards for stormwater infrastructure are sufficient and appropriate. Impervious surface minimums could work with LID techniques and other forms of natural or green infrastructure to mitigate runoff, increase on-site retention, and provide other services that may mitigate the effects of coastal flooding. LID requirements and minimum stormwater management design standards both apply most directly to new construction and often are located in subdivision regulations rather than general zoning regulations. As subdivision activity in the coastal area is limited, these requirements may not substantially influence coastal

resiliency as currently implemented. Municipalities therefore may wish to consider whether and how to modify existing standards to cover redevelopment activity as well as new development.

Transportation Resiliency

Transportation systems are critical to coastal resiliency. State and municipal highway systems are subject to periodic inundation in coastal areas and may be damaged or destroyed by sea level rise, erosion, or other hazards. This infrastructure is also essential for access to coastal properties and serves as a means of egress during storm and flood events. If designed or redesigned with resilience in mind, transportation infrastructure can continue to provide access with reduced exposure to inundation, while also providing ancillary benefits related to flood defense and ecosystem services. Resilient approaches include designing highway systems to reduce strain on storm sewer systems; and protecting vulnerable coastal highways from hazards including flooding and erosion. Both of these approaches can include natural and green infrastructure. Successful implementation of resilient roadway systems requires coordination and planning among municipalities, council of governments, and the Connecticut Department of Transportation (CTDOT).

- Municipal highway system requirements differ but in general are defined most clearly for new streets laid out in subdivisions, and thus are largely inapplicable in coastal areas with existing infrastructure. In some municipalities, both new and existing roadways must meet generally applicable design standards, which may include green infrastructure approaches.
- The parallel state highway system is managed and maintained by CTDOT, which uses different design and construction criteria which may not match local needs or desires.
- COGs also play an important role if designated as MPOs. MPOs are responsible for developing longrange transportation plans and transportation improvement programs used to plan projects that are eligible for federal funding. These activities offer an opportunity to think holistically about the transportation system and proactively address sea level rise, emergency management, and other needs associated with coastal resiliency.

Highways and Stormwater Management

Failure to design highway systems to carry adequate stormwater flows can result in flooding during periodic high tide events or storms. Storm sewers carry stormwater along highway rights-of-way. Green infrastructure approaches, such as swales and rain gardens, can increase permeability along roadways and reduce surface flows that the sewer system must carry. The requirements for stormwater sewer capacity differ from town to town but are generally based on both a minimum diameter specification and a carrying capacity specification, the latter of which is based on statistical storm frequency. The adequacy of these design requirements may be in question under sea level rise scenarios in coastal areas, particularly if storm severity and frequency increase over time. As sewer systems are long-lasting forms of infrastructure, inadequately specified pipe sizes will remain in place for decades. Therefore, municipalities may wish to ensure that their specifications for new and substantially repaired roadways are adequate to carry projected levels of storm water runoff. CTDOT also may wish to consider whether updates to its design standards are needed, as municipal ordinances do not affect state highways, but often do refer to CTDOT design guidance. Concerns regarding the adequacy of storm sewer systems may be mitigated by designing roadways to absorb runoff before it enters the sewer system. Natural and green infrastructure solutions may reduce flooding along roadways where sewers cannot handle loads; reduce sewer overflow events; and mitigate impacts on water quality during and after storm events.

The state has not adopted policies favoring natural/green infrastructure approaches within state rights-of-way. The adoption of policies or legal authority that endorses and/ or creates design standards for natural/green infrastructure in roadway rights-of-way may be an important step in the increased implementation of rain gardens, swales, and other types of green infrastructure. Such policies will be most effective where they address both new roadways and renovation of existing roadways in suburban and urban settings where permeability is limited and surface flows may present a continuing challenge. This option would likely require many municipalities to adopt highway standards as generally applicable ordinances rather than as elements of subdivision regulations.

In addition to the endorsement of such systems, municipalities and the state may wish to consider whether, and the extent to which, it may be sensible to create design standards for particular natural or green infrastructure projects whose designs are mature and which it is possible to define as a best practice. Such a requirement could reduce downstream infrastructure costs by allowing the use of

smaller pipes and catch basins as well as reduced treatment costs particularly in locations relying on legacy combined sanitary and storm sewer systems. Mandatory natural/green infrastructure requirements may raise concerns that mandated systems could be unsafe or ineffective in certain situations. Existing municipal ordinances endorsing these approaches address this concern through provisions noting that natural/green infrastructure is supported only where appropriate. Similar language, a design review, or a variance procedure could allieviate safety fears. A second argument against mandatory standards may arise if mandated systems result in increased capital or maintenance costs. A thorough life-cycle review of costs avoided (e.g., through reduced sewer treatment needs) and incurred may assist authorities in evaluating whether and how cost concerns should influence their design requirements.

- Option 1: Modify municipal and/or state ordinances, regulations, and design standards to ensure that new and reconstructed highways include adequate stormwater carriage capacity under projected future scenarios.
- Option 2: Modify municipal and/or state ordinances, regulations, and design standards to endorse the use of natural/green infrastructure approaches such as bioswales and rain gardens.
- Option 3: Modify municipal and/or state ordinances, regulations, and design standards to require the use of natural/green infrastructure approaches such as bioswales and rain gardens unless such approaches would be unsafe or otherwise unreasonable.
- · Option 4: No action.

Protection of Vulnerable Highways

Coastal highways are uniquely vulnerable to inundation as a result of erosion and flooding.

As a function of exposure to wave action, erosion can be addressed not only by hard infrastructure such as seawalls, but also through non-structural approaches such as living shorelines and dune or marsh restoration, which may reduce wave impacts. While hard stabilization may occur solely within the highway right-of-way, natural and green infrastructure approaches will typically extend beyond the right-of-way. Municipalities may be limited in their ability to influence or carry out projects in these areas without the support and participation of state agencies. Both seawalls and marsh restoration would likely require permits for fill activity from both Department of Energy and Environmental Protection and the U.S. Army Corps of Engineers (USACE). Projects seeking federal funds through a Metropolitan Planning Organization would also need to be consistent with the applicable Transportation Improvement Program (TIP) and Long Range Transportation Plan (LRTP). As natural and

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green infrastructure models remain relatively new, plans may not incorporate these models, and permitting may be difficult. While coastal natural/green infrastructure approaches may be complex, they may nonetheless be highly desirable given the importance of transportation infrastructure and the ancillary benefits and ecosystem services that such projects can provide.

- Option 1: Review TIPs and LRTPs for integration of coastal natural/green infrastructure approaches and needs and to identify projects that may be good candidates for coastal natural/green infrastructure approaches.
- Option 2: Include coastal natural/green infrastructure approaches for highway resiliency in ongoing revisions of DEEP and USACE general permits for fill, particularly in tidal wetlands.
- Option 3: Incorporate natural/green infrastructure and erosion control mechanisms into projects on a caseby-case basis as needed and desired by states and municipalities.
- · Option 4: No action.

Elevation of roadways can protect against overwash in the present and future conditions, but elevation projects must be planned, designed, and implemented to achieve these goals. Not all highways are suitable for elevation as they may be vulnerable to other forces (e.g., erosion), service too few residences or other critical infrastructure, or carry insufficient traffic to warrant investment in elevation. Where a roadway is vulnerable but does not warrant elevation, it may be subjected to degradation and rising maintenance costs to keep it serviceable. This may pose particular issues for smaller roadways that are the sole access for coastal communities. Municipal and state authorities may need to determine whether and how these roadways should be discontinued or otherwise addressed. Consideration for roadway elevation may be warranted, both for how existing roadways will be managed in years to come and to ensure that new highways are designed to accommodate future conditions. This planning may be carried out at the municipal, regional, and/or state scale, and ideally will incorporate a range of stakeholders to ensure a wide range of viewpoints. A successful plan of this type may be part of a larger effort, such as a regional plan, or may be tightly focused on transportation. Regardless, results related to transportation can be integrated into TIPs and LRTPs that serve as the basis for federal funding or regional transportation projects.

Many municipalities lack formal processes for discontinuance of streets, though some have established procedures for abandonment, which could be used to convey public streets to neighborhood associations. Privatization of public ways may be viewed critically, but such concerns may arise primarily due to potential loss of shoreline access. Municipalities may be able to address these concerns through contracting approaches (e.g., retaining an easement for access) or inclusion of mandatory conditions for abandonment in ordinances. Advantages of abandonment would include shifting maintenance responsibility and costs to the neighborhoods that are most reliant on the roads and allowing those roads to continue without conformity to mandatory roadway standards that apply to public ways.

- Option 1: Develop interagency and regional transportation resiliency plan(s) (which may be parts of larger hazard mitigation or resiliency plans), with or without new legislative authority, to consider transportation system vulnerability under future scenarios and identify long-range solutions to ensure continuing, safe access to coastal areas. Incorporate findings into state and regional TIPs and LRTPs.
- Option 2: Review municipal subdivision and zoning regulations to ensure that mandated street designs maintain access to key elevated evacuation routes.
- Option 3: Review municipal and state highways to identify key evacuation routes and other highways suitable for increased elevation or those that may warrant abandonment or decommissioning in the future. Incorporate these findings into state and regional transportation plans and/or hazard mitigation plans.
- Option 4: Amend municipal ordinances and/or state design standards to require elevation of roadways within the coastal area as projected under sea level rise scenarios.
- Option 5: Amend municipal ordinances to create processes for abandonment and/or decommissioning of public ways subject to inundation.
- · Option 5: No action

Development of a regional framework for coastal resilience in southern Connecticut is a challenge requiring the cooperation and collaboration of federal, state, and local governments, the public, and private sector and non-governmental organizations. Only by working together in an interdisciplinary manner can the region overcome the complex legal, policy and regulatory challenges associated with resilience.





Regional Resilience Framework Leverage

Due to the unique scope and creative elements of this Regional Resilience Framework project several opportunities have arose that have and are helping to secure and leverage the work across the project area. The following is a bulleted account of a growing list of advancements originating from this Southern Connecticut Regional Framework for Coastal Resilience Project:

- Additional funding secured to bring on Yale University

 School of Architecture and Urban Ecology Design
 Laboratory to complete an additional ten conceptual designs from amongst the high priority resilience projects identified by the participating municipalities.
 This additional effort effectively doubled the number of project receiving conceptual designs. The additional designs were conducted in accord with the project funded conceptuals and integrated into the final community design open house.
- Additional funding was secured by MetroCOG via a state grant to move the conceptual design for West Branch Johnson Creek Living Shoreline Project to completion.
- SCRCOG, in partnership with the Yale Urban Ecology Design Laboratory, received a state grant to complete a project titled Design and Technical Guide for Implementing Innovative Municipal Scale Coastal Resilience in Southern Connecticut. The two pilot locations (Old Field Creek in West Haven and Cosey Beach in East Haven) were selected because of the of the conceptual designs developed for the Southern Connecticut Regional Framework for Coastal Resilience project. These two sites will be used to develop and utilize a decision-making toolkit. The project team will use the decision-making tool to prioritize green infrastructure projects in areas with differing typologies. The final product is intended to help transition towns away from using hard infrastructure as a means of coastal adaptation.
- The geospatial database developed for the Southern Connecticut Regional Framework for Coastal Resilience was provided to the U.S. Army Corps of Engineers, New England District to assist in the scoping phase of a New Haven County/Fairfield County Storm Risk Management Study. A Feasibility Cost Sharing Agreement was signed with DEEP (June 2016) which is designed to explore opportunities to address flood risk and coastal storm risk management, and related activities.

Conclusion

Southern Connecticut is a collection of communities each with its own individual identity and history. However, the fate of each community is closely tied to the social, environmental, and economic health of the whole region. Therefore, the challenges facing southern coastal Connecticut are best tackled collectively with multiple towns, organizations, associations, institutions, foundations, and businesses working together across the Southern Connecticut Regional Framework for Coastal Resilience project area. Our sincere hope is that this regional resilience framework process and Final Report helps communities build greater clarity on the common challenges they face while providing a positive vision for continued dialogue, resource sharing, and forward thinking leadership needed for community resilience building here in Connecticut and beyond.

Footnotes

Section 2

- 1. To evaluate a community's social vulnerability, this report uses variables identified by the North Atlantic Coast Comprehensive Study's (NACCS) Social Vulnerability Characterization Index (United States Army Corp of Engineers, 2015). More information on the study and index can be found at http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS_Appendix_B.pdf. Social Vulnerability Indexes visually for this project area are also available at http://maps.coast-alresilience.org/connecticut/.
- 2. Joel Johnson, Coastal Hazards in Connecticut (Connecticut Department of Environmental Protection, Office of Long Island Sound Program, 2009).
- 3. Connecticut Department of Energy and Environment Protection (CT DEEP)
- 4. Johnson, 2009
- 5. Natural Hazard Mitigation Plan (Greater Bridgeport Regional Council, 2014).
- 6. Ralph Lewis, Geologic History of Long Island Sound (Connecticut Department of Environmental Protection Tidal Wetlands Program, 1997)
- 7. Ron Rozsa, "Human Impacts on Tidal Wetlands: History and Regulations" in Tidal Marshes of Connecticut ed. Glenn Dreyer and William
- 8. Niering (Connecticut College, 1995).
- 9. NHMP, 2014
- 10. Rozsa, 1995
- 11. Rozsa, 1995
- 12. Rozsa, 1995
- 13. Rozsa, 1995
- 14. NHMP, 2014
- 15. Rozsa, 1995
- 16. Kevin O'Brein, Joel Stocker, Juliana Barrett, and Bruce Hyde Analysis of Shoreline Change in Connecticut (Connecticut Department of Energy & Environmental Protection, the Connecticut Sea Grant, and the University of Connecticut Center for Land Use Education and Research, 2014).

- 17. O'Brien, 2014
- 18. O'Brien, 2014
- 19. Johnson, 2009
- 20. Johnson, 2009
- 21. NHMP. 2014
- 22. Johnson, 2009
- 23. State of Connecticut in North Atlantic Coast Comprehensive Study (United States Army Corp of Engineers, 2015)
- 24. NACCS 2015

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- 25. Conn. Gen. Stat. § 22a-92(b)(2)
- 26. Conn. Gen. Stat. § 22a-109.
- 27. See A.W. Whelchel et al., Workshop Summary of Findings: Report on Non-Structural and Natural Infrastructure Alternatives: Current Opportunities and Constraints for Connecticut's Coast, The Nature Conservancy Coastal Resilience Program Publication 15-1, at 13-14 (2015) (noting obstacles to deployment of non-structural approaches including the need for guidance and clarity in DEEP permitting process).
- 28. Conn. Gen. Stat. §§ 8-23 (municipal POCD); 16a-27(h) (state POCD); 22a-92 93 (defining "rise in sea level" for coastal planning); 22a-478 (water quality project priority determination); 25-157t (Blue Plan); 25-680 (municipal evacuation or hazard mitigation plans); 28-5 (state civil preparedness plan).
- 29. See Insurance Institute for Business & Home Safety, Build Strong. Build FORTIFIED (2016), at http://disastersafety.org/fortified/ (last visited Aug. 31, 2016).

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APPENDICES:

- A. SITE ASSESSMENTS: Project Component #1
- B. REGIONAL FRAMEWORK PROJECTS: Summary Spreadsheets
- C. REGIONAL FRAMEWORK PROJECTS: Municipal-based Maps
- D. REGIONAL FRAMEWORK PROJECTS: Watershed-based Maps
- E. REGIONAL FRAMEWORK PROJECTS: Conceptual Designs
- F. Meeting Documents
- G.DOI Internal Project Review
- H. Natural/Green Infrastructure Resource Guides
- I. REGIONAL RESILIENCE FRAMEWORK PROJECT: Application Guidance





Municipal Scoping Meetings and Field Reconnaissance Memos (Fairfield east to Madison)

FAIRFIELD SCOPING

Introduction

Steps taken in advance of an initial scoping meeting with Fairfield included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Farfield already contains a number of successful tide gate systems. The gates allow twice daily high tides to penetrate salt marshes to keep them viable; providing protection of habitats, mosquito control, limits invasive species (phragmites), flushing of sediments, regulates entering waters. Fairfield is usually protected from tide surges by barrier beach, dikes and tide gates (multiple locations along Ash Creek and Pine Creek).

Hazard Mitigation Plan (HMP)

The Town of Fairfield (the Town) is covered under the 2014 Natural Hazard Mitigation Plan Update by the Greater Bridgeport Regional Council. The regional plan offers a number of recommended actions to respond to potential hazards in the region. Those recommendations that would fall under the Coastal Resiliency Program goals have been summarized below:

Prevention

- Develop a comprehensive protective infrastructure analysis of the Town's coast and waterways that incorporates natural infrastructure (salt marsh, beaches, dunes and floodplains) and existing engineered infrastructure.
- Reassess the viability and cost-benefit of direct future capital investment in the coastal floodplain as an immediate and longer-term, proactive risk reduction action.
- Increase design standards for tidal flood control structures and improve inspection and maintenance requirements to avoid failures during future coastal storm events.
- Develop a better debris management plan with designated lead for flood control structures before and after extreme
 events, particularly for the 28 town-owned and three state-owned tide gates in Fairfield.
- · Assess the safety and viability of existing water and sewer infrastructure in the coastal flood zone.
- Prepare an action plan to reduce the susceptibility of the low lying Fairfield Beach area to storm surges from Long Island Sound. Specifically the Plan should address the feasibility of installing a "hurricane barrier" and a storm water pump station.
- Reassess long-term viability of the wastewater treatment facility and determine the feasibility of hardening and flood proofing the existing structure versus siting a new facility in a lower risk area.
- Reassess the capacity of existing flood control structures (berms/dikes, tide gates, culverts, dams, reservoirs) in light of accelerating rates of sea level rise and likelihood of more significant precipitation events.

• Factor sea level rise into all critical infrastructure, development plans, and public amenity improvements and consider planning for a worse-case scenario based on 0.2% storm event or flood or a Category-3 Hurricane.

Property Protection

- Strategically consider the acquisition of chronically flood prone and repetitive loss properties, as well as those properties
 that can assist in the implementation of flood drainage improvements to protect against storm surge or to allow flood waters to recede after a flood event.
- Promote elevating private properties in the flood hazard zones to the required base flood elevations plus a 2-to-3 foot freeboard above the base levels.
- Ensure that the design criteria for future structures in the coastal floodplain include a determination of the probable factors of obsolescence during the structure's lifespan so that the design-service-life and value of a structure approximate the time when sea level rise or other factors would render the structure obsolete.

Structural

- Install flood protection and harden existing berms to protect critical municipal facilities, including the wastewater treatment plant and pump station.
- · Raise the berm around the wastewater treatment plant.
- Install storm water pump stations and upgrading storm systems to keep up with rising sea levels, especially in the area bounded by Old Post Road, Fairfield Beach Road, Reef Road and South Benson Road.
- Increase the height of the dike along Pine Creek by 2' to 3' to provide additional protection for several hundred homes, the sanitary sewer pump station, the municipal athletic complex, and Town roads. This project will also reduce potential flooding from a FEMA-defined 1% storm.
- Consider increasing beach nourishment
- Improve and elevate tide gates and dikes to keep up with rising sea levels.
- Address the continued periodic tidal flooding of streets and properties in the coastal flood plain by making concerted
 efforts to design, construct, and maintain flood relief and drainage structures (e.g., dikes, tide gates, detention and natural
 marsh basins, storm sewers and natural channels) to ensure the discharge of flood waters during the receding tidal cycles
 immediately following the flood event.
- Relocate the sanitary sewer transmission trunk line from the flood prone Rooster River and Ash Creek corridor.
- Encourage green development and rehabilitation of existing impervious structures to reduce runoff generated in urbanized areas.
- Explore building modifications, use of pervious road materials and green infrastructure designs to improve on-site storm water retention and reduce storm water inflows into Fairfield's wastewater treatment system.
- · Prior to a storm, lower the volume of water in the wastewater treatment plant to increase capacity.
- Design culverts for a 50-year or 100-year storm in the Rooster River, Ash Creek/Royal Avenue and Camden Street areas.
- Consider improving the culvert at Merwins Lane.
- Evaluate methods to increase storage or improve drainage to alleviate flooding downstream of the Fairchild Wheeler golf course.

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- Install on site detention, relay new storm lines, incorporate bioswales and/or rain gardens in developed areas to help reduce or redirect runoff that contributes to flooding. For example, in the Fairfield Center and Railroad parking lot.
- · Continue to maintain/improve critical culverts and associated outlets/swales to remove debris, especially in advance of storms.
- Elevate Fairfield Beach Road as needed to keep up with rising sea levels.
- Extend the dike system along the shoreline from the Riverside Drive and Post Road area to Sasco Hill. Obtain easements to extend and complete the system in areas where it does not presently exist.
- Extend the dike in Southport along Harbor Road in the AE flood zone.
- · Improve the drainage system in the Downtown area, along Sanford and Reef Roads
- · Incorporate drainage improvements and best management practices to the Grasmere Brook watershed to reduce flooding.
- · Consider acquisition of properties where it is prudent and feasible to extend and construct the dike system.
- · Install pump stations to address flooding in the underpasses of New Haven rail line bridges
- · Expand and repair flood gates along the Mill River.
- · Consider increasing the approved bulkhead elevation along Pine Creek to account for sea level rise.
- Consider elevating all roads within the AE and VE flood zones, including Fairfield Beach Road and surrounding neighborhoods
- · Implement a dike system in the Rooster River, Holland Street, Ash Creek/Royal Avenue and Camden Street areas.
- · Consider elevating Merwins Lane. This would require the abutting property owner's permission and permits.
- Reconstruct New Haven rail line bridges over town streets to prevent flooding, including at North Pine Creek Road, Mill Plain Road, and Round Hill Road.
- Reconstruct and expand the culvert conveying Ash Creek and Rooster River under I-95 to reduce flooding in the Camden Street and Royal Avenue neighborhoods and to meet a 1% storm event. Include other local bridges on Rooster River in this project, so as to increase hydraulic capacity and reduce flooding.
- Improve and install flood control outlet pipes and tide gates along Pine Creek and Ash Creek to increase the removal of flood waters.

Natural Systems Protection

- Incorporate improvements listed in Rooster River Watershed based Plan.
- Protect and restore natural systems (salt marshes, beaches, dunes, floodplains/riparian areas, forested lands) on both watershed and full coastline scales, as well as diked and isolated wetlands to better withstand and absorb storm surges and flooding.
- Renourish engineered beaches, Town and private beaches after storm events, including Fairfield Beach, Jennings Beach, Sasco Hill Beach and Southport Beach.
- Restore upland stormwater discharges in Pine Creek to their historical locations around the marsh and thereby utilize the large acre-foot-volume of storage capacity of the diked marshes with tide gates closed during storms to detain floodwaters during a high tide and heavy rain.

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Emergency Services

- Enhance flood protection at the DPW (immediate and surrounding areas) garage or consider feasibility of moving garage to an alternate location Study/explore how to evacuate water and relocate equipment prior to a threatening event.
- Conduct a study to identify the highest risk locations for prioritized mitigation and emergency response efforts before, during and/ or after an extreme event during a variety of hazard scenarios.

Flood and Erosion Control Board Flood Control Plan

Fairfield's Flood and Erosion Control Board Flood Control Plan is dated January 8, 2015. The plan suggests installing 3.5 miles of earthen dikes and improve 6,700 feet of dike along coastal areas including: Riverside Drive, Fairfield Beach Road, and around the sewage treatment plant on One Road Highway/Richard White Way. Existing dikes would be raised and a total of 7 new tide gates would be installed. Metal culverts would be replaced. The improvements would allow an increase in tidal flow to 10-15 acres of salt water-starved marshes.

Most of the land required for the project is Town property; some minor land acquisition would be required to construct a berm along Turney Creek and Riverside Drive. Easements would be required through 4 private properties to construct a concrete flood wall. Residents may not agree with the location of the earthen berm along the beach. The annual cost to maintain the structure would be a burden to the town. The installation of tide gates would provide for a level of tidal marsh restoration, thus falling under the grant requirements. However, the installation of the levees/wall/dikes may not be as easily fitted into the grant restrictions.

Fairfield Initial Scoping Meeting

DATE:	May 20, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Jason Williams, LA, MMI
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	Matt Fulda, GBRC Joe Michelangelo, Public Works Director Laura Pulie, Town Engineer Brian Carey, Conservation Director Members of the Flood and Erosion Control Board: • Rick Grauer, Chair • Dick Dmochowski, Vice Chair • Don Lamberty • Steve Stearns
SUBJECT:	Fairfield Coordination	
LOCATION:	Independence Hall	

A project coordination discussion was held on May 20, 2015 during the regular meeting of the Fairfield Flood and Erosion Control Board as agenda item #2 from approximately 9 PM to 10 PM. David Murphy and Jason Williams were present from Milone & MacBroom, Inc. David Murphy presented the regional coastal resilience project, utilizing a power point slide show as the basis for the presentation.

The Fairfield shoreline was discussed in the context of all resilience projects. A comprehensive flood protection system is strongly desired for Fairfield, and parts of the system will be pursued as funds become available. The options for siting a flood protection system are essentially as follows: in front of beaches, behind them, or some combination. Attendees inquired about what the design criteria should be for various components of a flood protection system. David indicated that the desired objective would drive the design criteria. For example, does the town want to lessen the frequency of minor flooding, stop future severe floods, or re-map the FEMA floodplain to reduce insurance premiums? One member of the Flood and Erosion Control Board indicated that elevating some of the beaches only 1-2 feet could be significant, and that the town would accomplish a lot by getting the ground surface to elevation 13 along berms and dikes.

Potential green infrastructure projects were discussed:

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- The Flood and Erosion Control Board identified the span of shorefront from Beach Road to Reef Road as the area that could
 most benefit from coastal resilience projects that may fit into the green and hybrid context of the regional coastal resilience
 project. Hard structures currently do not exist in this span of beach, and surging over the beach toward Reef Road was a
 significant problem during Sandy.
 - The segment west of Penfield Beach is a very narrow beach. Here, the approach could include beach nourishment followed by creation of dunes. However, this segment consists of private properties. Without making the beach wider, there likely would not be space for dunes to be created as a berm.
 - The segment east of Penfield Beach is mostly owned by the Fairfield Beach Club. A similar approach could be taken
 here, with some potential ease because of the limited number of property owners, and because the beach is somewhat wider.
 - The dunes at Jennings Beach could provide a model for the above approach. These dunes were reportedly not
 breached by the surges from Irene and Sandy, and therefore provided localized flood protection (although floodwaters
 reached around from behind).
- One member of the Flood and Erosion Control Board identified the Jennings Beach parking lot as a potential location of a
 green infrastructure project. The parking lot is reportedly oversized for most days of the year and therefore partly underutilized. Areas of pavement could be replaced by open space available for marsh advancement or less pervious surfaces that
 could infiltrate stormwater.
- Several members of the Flood and Erosion Control Board believe that opportunities for green infrastructure and hybrid
 resilience project may be located along Ash Creek and the lower Rooster River. This would extend the areas of green infrastructure opportunities upstream into more traditional riverine settings, which is consistent with The Nature Conservancy
 looking at riverine projects as part of this grant. Locations of potential projects include:
 - · Tidal flat south of Kenwood Avenue
 - · Tidal wetland west of Turney Road
 - Spit of land located between Ash Creek and the South Benson Marina
 - St. Mary's site (which is reportedly being studied by the City of Bridgeport)
- · Joe might have some information about some of these sites, and will forward as appropriate.
- Green infrastructure opportunities may also be present at the Riverside Drive bridge/culverts and tide gates adjacent to Ash Creek, as this infrastructure needs attention.
- · There may be some potential for tidal wetland projects between Veterans Park and Field Point Road.
- Laura suggested that removal of groins may be something that fits into the regional coastal resilience project. This would be considered if there was a benefit. This is something to look at further.

David asked if there were any locations that may be feasible in the long-term for acquisitions of private properties to make space for marsh advancement and a flood protection system. One potential typology for this kind of project would be Reef Road south of One Rod Highway. The homes on the west side of the road could be removed and this land could be set aside for marsh advancement while the road could be converted into a dike. This could also be done elsewhere along the margins of the Pine Creek tidal marshes and tributary tidal marshes.

David asked about the coastal flood risk areas west of Sasco Hill Road. Attendees from Fairfield indicated that these areas were not in need of extensive resilience projects, in part because elevations rise steeply from the shoreline.

Field reconnaissance was not scheduled during the meeting. David will contact Laura and Joe to discuss potential dates.

A6 APPENDIX A

STRATFORD SCOPING

Introduction

Steps taken in advance of an initial scoping meeting with Stratford included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan (HMP)

The Town of Stratford (the Town) is covered under the 2014 Natural Hazard Mitigation Plan Update by the Greater Bridgeport Regional Council. The regional plan offers a number of recommended actions to respond to potential hazards in the region. Those recommendations that would fall under the Coastal Resiliency Program goals have been summarized below:

Property Protection

• Consider acquiring properties that have experienced repetitive loss from storms and flooding and maintain a list of properties with owner interest for future acquisition, and as NRCS funding becomes available.

Structural

- Proceed with roadway reconstruction on the Lordship Boulevard/ State Route 113. The Connecticut Department of Transportation has initiated a project to elevate Route 113 in the vicinity of Sikorsky Airport.
- Continue to clean catch basins on a regular basis.
- · Complete the elevation of Route 113 in the vicinity of Sikorsky Airport.
- Address recurring flooding on Surf Avenue at the I-95 overpass.
- Complete the design phase and initiate construction to replace multiple culverts and channels at Barnum Avenue between Sage Avenue and Bowe Avenue to alleviate flooding of Barnum Avenue and West Avenue.
- Maintain the project to replace and enlarge the structured channel and culverts conveying Tanners Brook from the ball fields at Stratford High School, from Broadbridge Avenue and King Street and along the New Haven rail line
- Develop a maintenance protocol with the US EPA to address flood mitigation strategies at the Raymark (Superfund) site.
 Work with the Raymark waste site at Ferry Creek and Lockwood Avenue to ensure planting and stabilization of land to prevent mobilization during events.
- Assess feasibility of elevating Main Street from 5 1/2' to 7'.
- Coordinate a full scale survey of Short Beach with the Army Corp of Engineers so that it may meet FEMA's definition of an
 engineered beach.
- · Increase protection around the wastewater treatment plant by raising the existing flood control berm.

2017 SOUTHERN CONNECTICUT REGIONAL FRAMEWORK FOR COASTAL RESILIENCE

- In the South End neighborhood, evaluate installing twin 6' X 8' box culvert with regulating tide gate to allow tidal flushing while preventing tidal flooding up to elevation 9' on Lordship Boulevard.
- Continue with the project to increase the width of the channelized stream downstream of Broadbridge Ave. to reduce flooding at a condominium parking lot. The replacement and enlargement of the structured channel and natural channel that conveys Tanners Brook from Broadbridge Avenue South to King Street has been designed and is in the permitting phase. Funds have been allocated for construction.
- Complete the bridge project to elevate Broad Street over Ferry Creek.
- · Increase the capacity of the wastewater treatment system by reducing inflows, such as with flood proofed manhole covers.
- Complete the design phase for a 36" relief pipe to Long Brook and proceed to construction.
- Complete the bridge project to elevate Broad Street over Ferry Creek.
- Complete the West Broad railroad viaduct renovation project. Assess the feasibility of other locations in need (Bruce Avenue, King Street, East Main). Utilize green infrastructure to reduce drainage "upstream" from viaducts (catchment basins, swales, stormwater gardens, etc...).
- Consider a quantitative study to determine which manhole covers within the existing or new flood zones to waterproof to prevent inundation of flood waters into the sanitary sewer system, and secure funding for this project.
- Drainage improvements on Lordship Boulevard/State Route 113.
- Respond to future needs as appropriate at Oronoque Village.
- · Harden sewage pump stations against flooding.
- · Complete the replacement of storm water culverts under Old Spring Road with new box culverts.
- The Town has selected a consultant to design a 7X3 culvert as part of the West Broad St roadway improvements. This will alleviate flooding at the West Broad St RR underpass at Tanner's Brook.
- Proceed with increasing the size of the culvert at Reed St. to 500' of 12' X 4' box culvert. The town had started property acquisition procedures.
- An assessment of drainage system components through specific areas of Oronoque Village is underway. Continue to monitor improvements to the drainage system completed by Association in 2004.
- Consider installing twin 6' X 8' box culverts on Lordship Boulevard with regulating tide gate to allow tidal movement while preventing flooding in the South End neighborhood.
- Consider replacing the storm water culverts under Quail Street with new box culverts. Due to the status of an adjacent Superfund site, the Town has been unable to proceed with this project.
- Flood proof structures and construct drainage improvements in the vicinity of Masarik Avenue, Benton Street and Harding Avenue.
- Conduct an investigation to examine the implications of various flooding scenarios on the wastewater treatment plant and identify appropriate and feasible responses, such as raising the berm.
- Assess approaches to maintain the functionality of the Birdseye boat docks and ramp under flooded conditions to ensure continued use during disasters.

- Structural flood proofing on Massarik Avenue/ Benton Street.
- Evaluate a flood control structure at Stratford High School ball field on King St. to create 2.5 MG of flood storage for a 1% storm event
- · Consider bank erosion protection east of Diane Terrace.
- Reconstruct New Haven rail line bridges over Town streets to prevent flooding, including at Bruce Avenue, West Broad Street, Route 113 and Route 110
- Consider integrating the animal shelter into improvements at the wastewater treatment plant, such as by extending the
 protective berm around the shelter.
- · Strengthen and extend the Lordship Beach seawall.
- Assess and scope the feasibility of hardening facilities associated with 2 pump stations; assess impact of temporary loss of multiple pump stations; consider alternative sites for relocation of vulnerable stations longer term

Natural Systems Protection

- Protect and maintain Long Beach as an effective barrier beach.
- Protect and maintain Short Beach, including replenishing the beach (engineered beach) after a major event. Coordinate with federal agencies to conduct a cost/benefit analysis for Short Beach replenishment over time.
- Assess the impacts on Long Beach/Pleasure Beach and adjoining National Wildlife refuge and built structures (roads, commercial/ industrial, residential, airport) from breach of barrier island during future extreme weather events; cost/benefit analysis of beach restoration/replenishment over time.
- Renourish and replenish beaches and regenerate dunes after major events.
- Assess the impacts of hazards on natural areas: Roosevelt Forest, Booth Memorial Park, Far Mill River, and Wooster Park; identify ways to enhance defensive/protective features for additional flood protection longer-term.
- Work with private land owners to understand the importance and benefits of maintaining and leaving vegetation in place to stabilize riverbanks
- Consider a "Living Shoreline Plan" for the Stratford coastline.
- At Russian Beach, assess the ongoing and longer-term impacts from hazards towards developing a sustainable course of action.

The hazard mitigation plan includes an action "Consider a "Living Shoreline Plan." David asked if this pertained to any particular areas. At this time, this does not pertain to any particular areas; the town would like to evaluate where they may be appropriate.

Additional inland issues are listed in the hazard mitigation plan. These three actions include:

- "Work with private land owners to understand the importance and benefits of maintaining and leaving vegetation in place to stabilize riverbanks"
- "Complete the West Broad railroad viaduct renovation project. Assess the feasibility of other locations in need (Bruce Avenue, King Street, East Main); Utilize green infrastructure to reduce drainage "upstream" from viaducts (catchment basins, swales, stormwater gardens, etc...)"

• "Maintain the project to replace and enlarge the structured channel and culverts conveying Tanners Brook from the ball fields at Stratford High School from Broadbridge Ave and King St along the rail line"

Stratford Initial Scoping Meeting

DATE:	May 27, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI Matt Fulda, GBRC John Casey, Town Engineer Raynae Serra, Operations Coordinator, DPW Gary Lorentson, Planning and Zoning Administrator
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	
SUBJECT:	Stratford Coordination	
LOCATION:	Stratford Town Hall	

A project coordination meeting was held on May 27, 2015 at the Town Hall. David Murphy and Kim Bradley were present from Milone & MacBroom, Inc. and GEI Consultants, respectively. David Murphy presented the project, utilizing a power point slide show as the basis for the presentation. The Stratford shoreline was discussed in the context of all resilience projects. Two main areas of potential green infrastructure approaches were discussed:

- The town greenway currently ends near the WPCF. The shoreline is eroding at this location. Green infrastructure erosion control methods should be explored at this site.
- Long Beach extending from Lordship to the Bridgeport city line suffered extensive damage from Sandy. FEMA assistance
 is not available in this area because it is a coastal barrier. The town is interested in making improvements along the barrier
 beach to reduce future wash over and erosion. The jetties along the beach are vintage 1950s/1960s and were reportedly
 installed in response to hurricane damage from those decades. Creation of dunes along Long Beach might be a project
 that fits the regional coastal resilience approach. Access to the Bridgeport part of the barrier beach is not available from
 Stratford, and this would not be part of any project.

The hazard mitigation plan includes an action "Consider a "Living Shoreline Plan." David asked if this pertained to any particular areas. At this time, it does not; the Town would like to evaluate where they may be appropriate.

Other areas of potential coastal resilience projects were discussed:

- · Erosion is occurring at the Oronoque Shore Condos which are located along Jamestown Road south of the Merritt Parkway.
- Erosion is a concern near Diane Terrace along Raven Stream near its end at the Housatonic River. The hazard mitigation plan action is "Consider bank erosion protection east of Diane Terrace."
- Erosion of private properties is occurring at Stratford Point in Lordship.
- Dune and bluff erosion has occurred on the south side of Park Blvd in Lordship. This land is owned by the Lordship Association.
- Russian Beach in Lordship has experienced erosion. A seawall is present here, but the ground below the seawall is mostly rocky without much beach.

The West Beach Drive and Shoreline Drive cottages in Lordship did not suffer extensive damage during Sandy. Many of these cottages are elevated, and some were removed after Storm Beth in 1992.

David asked about the various Raymark properties, spurred by the identification of one of the Raymark sites in the hazard mitigation plan ("Develop a maintenance protocol with EPA to address flood mitigation strategies at the Raymark site; Work with the

Raymark to ensure planting and stabilization of land to prevent mobilization during events"). There is a Raymark site near Ferry Creek which may be at risk of erosion, as well as another site near Shore Road. Raymark waste is located in the old landfill near Short Beach; erosion would be undesirable here.

The Shore Road area was discussed. The greenway will run through this area, and the POCD speaks of this area being a focus for waterfront access and economic development, possibly associated with the theatre.

Short Beach is annually nourished by the town, thus preserving its status as a maintained beach. None of the other beaches in Stratford are nourished.

David asked about Route 113, the airport, and the large tidal wetland system in the context of resilience projects. Route 113 is being elevated slightly. Lordship Blvd serves as a dike during some coastal storm events, with the various culverts under the road helping to reduce landward flooding to the north of the road. This is one reason why the Sandy inundation mapping for the South End may not be entirely accurate. In the 1960s, the Army Corps of Engineers evaluated diking the commercial area in the South End, but this was never advanced to a project phase.

David also asked about more inland issues, including some listed in the hazard mitigation plan. These three actions, in particular, were mentioned:

- "Work with private land owners to understand the importance and benefits of maintaining and leaving vegetation in place to stabilize riverbanks"
- "Complete the West Broad railroad viaduct renovation project. Assess the feasibility of other locations in need (Bruce Avenue, King Street, East Main); Utilize green infrastructure to reduce drainage "upstream" from viaducts (catchment basins, swales, stormwater gardens, etc...)"
- "Maintain the project to replace and enlarge the structured channel and culverts conveying Tanners Brook from the ball fields at Stratford High School from Broadbridge Ave and King St along the rail line"

Tanners Brook near King Street suffers from flooding and some bank erosion. At one point, the town was evaluating the option of constructing detention at the high school ball fields. However, the high school expansion will now be using this land. Raven Brook near Reed Street is another area where bank erosion might be occurring. John can provide a drainage study for the Raven Brook watershed if this would be helpful.

The final area of concern with regard to stormwater or inland flooding is the South End, generally speaking, which occupies a topographic bowl associated with a stream that flows entirely within culverts. If there was a way to help reduce the frequent stormwater-related flooding in the South End using green infrastructure, this would be something to consider as part of the project.

Gary asked about low impact development (LID) in regulations, and inquired whether any Connecticut towns might serve as good examples of incorporating LID into regulations. David mentioned Guilford's approach as an overlay, and Kim mentioned Old Saybrook.

Field reconnaissance was set for July 9 or 14 at 9 AM. The date will be confirmed soon.

MILFORD SCOPING

Introduction

Steps taken in advance of an initial scoping meeting with Milford included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan

The City of Milford's (the City) effective Hazard Mitigation Plan Upate is dated August 12, 2013. The Plan identifies 31 severe repetitive loss (SRL) properties following Tropical Storm Irene, located predominantly in the Field Court, Point Beach, and Hillside neighborhoods. Post-Sandy, the number of SRL properties increased to 46. Following Storm Irene, the number of repetitive loss properties was 164, located in some of the same neighborhoods as that SRL properties, as well as in the Melba Street, Broadway and East Broadway neighborhoods. Following Storm Sandy, the number of repetitive loss properties increased to 519 structures, including six commercial properties, three of which are subject to riverine flooding along the Wepawaug River and the other three subject to coastal damage.

As noted in the Plan, the history of coastal flooding in Milford has led to a series of flood prevention and property protection projects to be completed along the City's coastline. These projects have included revetments, groins, jetties and beach nourishment projects.

Section IV.C identifies potential hazard mitigation projects according to hazard type. The initial 2008 Plan identified broader areas for projects, while the 2013 update provided more detailed descriptions of the projects. For this review, we have focused on the flooding hazards and those projects which are not yet completed, designed or funded. Following is a summary of these potential projects:

- Beach Erosion, Drainpipe Replacement, Sand Replenishment: Study and investigate erosion control, repair/replacement of shoreline storm drains and sand replenishment. Currently development of design studies is on-going. High priority project, funded by bonds.
- Eisenhower Park Environmental/Existing Renovations: Environmental reclamation, natural resource improvement, flood plain and water quality improvement, park maintenance and park security. No new facilities or amenities are contemplated. The renovations are on hold pending funding. The project is low priority and will be funded through the City Budget.
- Tumble Brook Flood Control Study: Commission study to control flooding along Tumble Brook which flows approximately 3,000 linear feet from the Orange town line to Route 1 (Boston Post Road). The watershed encompasses over 500 acres of densely developed and populated area. Flooding occurs in heavy rains affecting many homes and flooding on Route 1. The project is on hold due to lack of funding, and is a medium priority. Funding is anticipated to come from the city budget.
- Wepawaug River Pond Dredging/Dam and shore Rehabilitation: Dredge Wepawaug River Ponds (Eisenhower Park, North St. (upper) Duck Pond, City Hall (lower) Duck Pond, and Prospect Street
- Pond). Repair dams and shore walls. The ponds have been filled with silt and debris which threatens wildlife and habitats. Dredging, dam and shore repair has not been done in several decades. The study has been completed and a committee has been formed subject to funding, project will proceed. Funding is anticipated through the city budget.

- Study-Shoreline Beach Erosion, Drainpipe Replacement Sand Replenishment: Milford has approximately 17 miles of coast-line. Many low lying shoreline neighborhoods are prone to flooding and shoreline erosion. Many drainpipes are decades old and should be repaired or replaced and possibly fitted with "fishmouth or "flapper" valves. Study has been authorized and received; phased construction is under separately entered project(s).
- Silver Beach area: New sand replenishment project resulting from Sandy and Irene storm damage. The work is being done in cooperation with the Army Corps of Engineers. It is high priority, with federal funding.
- Silver Sands State Park: Rebuilding training walls and flood gate to alter erosion patterns. The project is approved by the State for funding, and is submitted to bonding for funding. A design is pending for this medium priority project.
- · Gulf Beach: High priority, annual sand replenishment project to be funded through the City budget.
- Milford Harbor: Federal channel dredging project. Low priority project funded by a combination of City budget, state and federal funds.
- Melba Street and Calf Pen Meadow Creek: Melba Street area was impacted by rain and wave action from Long Island Sound, but also by the Calf Pen Meadow Creek overflowing. Mitigation efforts would include cleaning the silt and debris out of the creek, allowing the water to flow into Long Island Sound.
- South Street/Hillside Avenue: The revetment at South Street/Hillside Avenue was damaged during the storm and a FEMA rebuilding project has been proposed for funding. Identified eligible for 75% funding by FEMA and 25% City New project resulting from Sandy and Irene storm Damage.
- Wildemere Beach: sand replenishment. New project resulting from Sandy and Irene. Storm damage work in cooperation with the Army Corps of engineers. High priority project.
- Gulf Street bluff: The natural earth bluff was eroded by the storm. If it continues to erode, it will expose the underground utilities and endanger the asphalt road. Pending approval of funding. High priority project.
- Bayview Beach drainage design: Engineering design project to improve storm drainage system and outfalls to alleviate flooding. Medium priority project.
- Beachland Avenue elevate road: Elevate roadways at Beachland Ave to alleviate flooding. Elevation of some private property area may be required. Medium priority project.
- City Beach/Shoreline Mitigation Projects: Identify flood prone properties and develop flood mitigation projects including structural elevation, property acquisition and roadway/storm drain reconstruction. Includes construction which is under separately entered project(s). Some grants may require private funding match. High priority project.
- Wastewater Facilities Upgrade: Design and construction for upgrades of Housatonic and Beaver Brook Wastewater Treatment Plants and sanitary sewer collection systems. The project has already been financed by an appropriation of the Board of Aldermen.
- Naugatuck/Bridgeport Avenues Drainage: Alleviate flooding along Bridgeport Avenue and Naugatuck Avenue in the Devon Center Area. This will be achieved through a joint city and state project to increase the number of catch basins and to increase the size (capacity) of the drain pipes. Flooding has occurred for many years in the Devon center area as far as Church Street.
- Town Dock (High St.) Repair and Renovate: Repair, shore up and renovate the existing town dock which sits at the end of High Street at the Harbor.
- Flax Mill Lane Bridge Repair: Rehabilitation and repairs to the deck, piers and abutments to the Flax Mill Lane Bridge over
 the Wepawaug River. The bridge was constructed in 1935 and has been identified as requiring work to maintain its structural integrity and aesthetic charm.

- · Lisman Landing: Post Sandy reconstruction and repair of Lisman Landing, elevation of utilities.
- · Helwig St. Sewer Damage: Replacement of the Helwig St. manhole pump outside of the Flotilla Bldg.
- Creeland Avenue drainage design: Engineering design project to improve storm drainage system to alleviate flooding from city street onto private property
- · Great Creek: Sediment removal in Great Creek.
- · Morningside Dr Pump Station: Repair of Morningside Dr pump station and flood mitigation improvements.

Milford Initial Scoping Meeting

DATE:	May 19, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI Chris Rappa, SCRCOG Ben Blake, Mayor Chris Saley, Director of Public Works Joe Griffith, Director of Permitting and Land Use Steve Fournier, Office of the Mayor
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	
SUBJECT:	Milford Coordination	
LOCATION:	Milford City Hall	

A project coordination meeting was held on May 19, 2015 at the City Hall. David Murphy and Kim Bradley were present from Milone & MacBroom, Inc. and GEI Consultants, respectively. David Murphy presented the project, utilizing a power point slide show as the basis for the presentation. The Milford shoreline was discussed in the context of all resilience projects. Potential green infrastructure projects were noted as discussed.

- Mayor Blake believes that Silver Sands State Park and the vicinity should be the focus for resilience project development in
 connection with the NFWF grant. He believes this is the location for the best potential for incorporating green infrastructure,
 with benefits to ecosystems and people. He mentioned berming of new roads in the park as potential means of reducing
 flooding, and noted that the west end of the park has not received as much attention with regard to planning as other
 areas.
- All attendees agree that the CDBG-DR funded projects are probably not good candidates for green infrastructure or hybrid approaches, as they have very rapid timetables with designs that are underway.
- The Gulf Beach breakwater is one of the CDBG-DR projects. Sand re-nourishment is needed frequently here, as it migrates
 into the harbor and elsewhere. The City will not begin design of the breakwater until they believe DEEP has bought into the
 project.
- Wildemere Beach might be a candidate for beach nourishment and dune restoration. This beach is located between Silver Sands State Park and Milford Point Road.
- \$600,000 was reportedly spent after Irene to re-nourish the Woodmont and Hawley Road beaches. Additional work was completed after Sandy. Sand from this area reportedly migrates to the mouth of the Oyster River and clogs its tidal flushing. The crescent in Woodmont is lined with hardened structures.
- Homes along Hillside Avenue were damaged in Irene and Sandy, and many are being elevated. An old granite block revetment is partially submerged and believed to be somewhat ineffective. David mentioned that this might be the type of situation that offers opportunities for incorporating green infrastructure or hybrid solutions.

- The Army Corps' revetment along Morningside Drive, immediately adjacent to the Hillside Avenue area to the south, is from the 1960s and reportedly very effective.
- David asked about the condo complex with the failing seawalls at the end of Point Beach Drive. Chris noted that the failure
 may be due partly to water getting behind the wall. David mentioned that this is another example that may offer opportunities for incorporating green infrastructure or hybrid solutions.
- The Point Beach area in general is not a good fit for green infrastructure.
- · Bayview Beach is somewhat natural and could benefit from nourishment.
- Calf Pen Meadow Creek causes significant tidal flooding. NRCS was initially on board to conduct sediment removal, but has
 since reduced the scope of the work and it has not been completed.
- Beach nourishment and dune creation might be beneficial in many locations.
- "The Berm" at Walnut Beach may be an area with a potential project. Apartments are located behind this area.

David asked about flooding and risks from the back sides of the tidal marshes. City attendees explained that Nettleton Creek and Calf Pen Meadow Creek are two areas that this happens, as well as the Silver Sands area. The tide gates at Silver Sands are reportedly being replaced, which should help reduce lower-intensity flooding from the marsh side.

David also asked about more inland issues, such as the Wepawaug River. The City has plans to conduct several projects in this watershed. MaryRose Palumbo and Gary Wassmer have information about these. The City would like to reduce peak flows, ad a weir in one location to facilitate sediment removal, and construct rain gardens in the watershed.

The City recently completed a \$100,000 rain garden and would be interested in more. A rain garden is desired behind the Egan Center off Naugatuck Avenue. This would fit in with the ongoing drainage projects in that area. However, City attendees are concerned about diluting the focus on shoreline projects.

The City inquired about the overall goals of the NFWF grant and raised concerns about competing with the other communities and not having suitable projects. David and Kim explained that this initial inventory should cast a wide net, and then the consultants would help filter the candidates for consistency with the grant. The Mayor noted that the recent RPA report might have some ideas.

Field reconnaissance was set for June 12 at 9 AM. Participants will meet at Milford Point Road.

WEST HAVEN SCOPING

Introduction

Steps taken in advance of an initial scoping meeting with West Haven included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan and Other Planning Documents

The City of West Haven (the City) is covered under the SCRCOG Multi-Jurisdiction Hazard Mitigation Plan (April 24, 2014; Jamie Caplan Consulting/AECOM). West Haven has had multiple past hazard occurrences, such as impassable roadway flooding at the Morgan Lane Underpass that resulted in the drowning of an individual. They have given considerable thought to the allocation of hazard mitigation funding, including projects that address coastal erosion and the transfer station located in a floodplain. In addition, HMP Mitigation Action #6 calls for raising the roadway from Monahan Place to Second Avenue to provide access to Water Pollution Control Plant.

Section IV of the 2004 Plan of Conservation and Development deals with Natural Resources that include West, Oyster, and Cove Rivers and identifies that tidal wetlands make up nearly 25% of West Haven's total wetlands. Section V deals with Coastal Resources and identifies the following recommended mitigation actions:

- Property Buyout 3rd Avenue Extension. Buy properties on 3rd Avenue Extension, Blohm Street in the Old Field Creek Floodplain and demolish houses.
- Beach Sand Nourishment and Dune Restoration
- · Bridge and Channel Improvement Improve bridge and channel on Cove River at Painter Drive and West Main Street.
- Cove River Channel Study Study, design and construct Cove River Channel and retention basins to reduce flooding at Greta Street & West Spring Street.
- Mechanized Tide Gate Install mechanized tide gates at Captain Thomas Blvd. on Cove River.
- Raise Beach Street Raise roadway from Monahan Place to Second Avenue to provide access to Water Pollution Control
 Plant
- Additional development near Savin Rock Expiration of waterfront redevelopment plan for Savin Rock area in 2006, City
 must formulate a specific strategy for managing future land uses in this area. Current zoning regulations for the land encompassing the redevelopment area are more restrictive than the redevelopment plan itself.
- Comprehensive Flood Control Study Along the entire Cove River corridor to identify the most critical places for improvement; continue the non-structural rehabilitation of Wet Haven's beachfront through beach nourishment, dune reestablishment and natural vegetation plantings, and mitigate shorefront erosion problems by non-structural means where possible.

The 2004 POCD notes that there is an ongoing problem of shoreline erosion continues to be an issue and has led to sand replenishment efforts executed by the United States Army Corp of Engineers (USACE). The City believes that some harvesting of sand from Sandy Point might be approvable. Sand may also be available near the mouth of Cove River where sandbars are continuously forming down-drift from the beach that is nourished by the USACE.

A condominium at the east end of Main Street is located on a bluff or cliff and there is potential risk of erosion. However, the City would be unlikely to participate in mitigation at this site, as it is private property. Nearby, the City repaired 400 feet of bulkhead. In general, this part of the shoreline (to the east facing New Haven Harbor) is occupied by private properties.

The Haven South Municipal Development Plan (2015)

A developer has expressed interest and committed resources to revitalize the Project Area (24.24 acres of The Haven South) including environmental investigations at waterfront site; pre-development historic/archaeological resource and environmental evaluation studies; and demolition activities for road and parking improvements. Development associated with parks and infrastructure improvements would not fall under ecological restoration/habitat restoration. The environmental investigations may lead to activities that qualify for the State's Brownfield Remediation and Revitalization Program.

All of the Haven South MDP area falls within the Coastal Area Management District of the City of West Haven, and portions along the West River are located within the coastal flood hazard area (FEMA 100-year zone). The West River shoreline is primarily developed shorefront with small areas of tidal wetlands and intertidal flats.

The redevelopment plan includes waterfront improvements such as retail/dining complex, public waterfront promenade, community amphitheater and parking facilities. It is not anticipated that any state grants or loans will be used as part of the MDP activities. If state funding is used, the development must demonstrate compliance with floodplain management and stormwater management standards.

Projects applied for CDBG-DR Grant Funding

2014 CDBG-DR Grant Application: Raise 2,210 feet of 1st Avenue and Beach Street and First Avenue by an average of 3 feet, adjust storm sewer system. The City has committed \$1.65M to complete this, and requested a CDBG-DR Grant for the additional funds to meet the required \$2.2M project cost.

2014 CDBG-DR Grant Application: Old Field Creek Dredging. The City has committed \$175,000 to complete this, and requested a CDBG-DR Grant for the additional funds to meet the required \$700,000 project cost. The project is tied to the 2013 NRCS floodplain easement program for residents in low-lying flood zones and aims to improve the health and resiliency of the Old Field Creek while improving the natural ecosystem. The 2004 Plan of Conservation and Development identifies that the restoration fo Old Field Creek salt marsh is underway. Sediment removal and dredging along Old Field Creek and Cove River may not be eligible resilience projects, as they may not provide benefits unless the dredging allows better flushing. It is possible that managing sand along the shorefront will lower the movement of sand into the channels. Additionally, there are ways that sand can be captured before it enters the watercourses. For example, the City would like to build a plunge pool near the headwaters of Old Field Creek. This plunge pool should be reviewed as a possible resilience project.

April 28, 2014 CDBG-DR Grant Application (and HMP Mitigation Action #1): Property acquisitions of 12 homes on Beach Street, Blohm Street, and Third Avenue Extension; floodplain easements on 34 acres in Old Field Creek salt marsh. This was funded by NRCS.

2014 CDBG-DR Grant Application: Front Avenue culvert reconstruction. Demolish old culvert and install new precast concrete box culvert over steel pilings and reconstruct 70 feet of road. The City has committed \$350,000 to complete this, and requested a CDBG-DR Grant for the additional funds to meet the required \$1.4M project cost. Infrastructure repair, but does not enhance natural systems.

West Haven Initial Scoping Meeting

DATE:	May 11, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI Abdul Quadir, P.E. City Engineer Gregory Pidluski, P.E., RLS, Assistant City Engineer
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	
SUBJECT:	West Haven Coordination	
LOCATION:	West Haven City Hall	

A project coordination meeting was held on May 11, 2015 at the City Hall. David Murphy and Kim Bradley were present from Milone & MacBroom, Inc. and GEI Consultants, respectively. David Murphy presented the project, utilizing a power point slide show as the basis for the presentation. Potential resilience projects were described as follows:

- Beach and dune restoration along 3,000 feet of shorefront (refer to the City's NFWF application for details): This area located along Savin Rock Trail may have been nourished in the 1960s or 1970s, but not since then. Erosion has occurred. The project would provide ecosystem benefits if designed as such, and risk reduction benefits to people and structures. The City does not own the land, but retains an easement for access and management of this strip of beach.
- Cove River tide gates and pedestrian bridge (refer to the City's NFWF application for details): The tide gates originating from the 1930s and bridge are both structurally failing. Coincidentally, the failing tide gates are helping increase flushing and reducing the occurrence on invasive wetland plants, but eventual complete collapse will prevent flushing. The gates were formerly located at the pedestrian bridge. The best solution may be to remove the failing tide gates and then place the new gates at the pedestrian bridge's location, thus restoring the original location and providing an opportunity to maintain pedestrian access. The current tide gate location on Captain Thomas Blvd would then revert to normal ebb and flood tide through the four box culverts that are already present. Sand from the nearby nourished beach has consistently drifted to the east and built sandbars off the mouth of the Cove River.
- The WPCF outfall pipe replacement: This may be a potential resilience project if multiple benefits can be worked into the project. A long section is currently exposed, and maintenance is disruptive to the nearby Sandy Point area. The 2,000' length is not optimal, and tidal flushing is less than desired, restricting the flow of saline surface water. It is important to note that the Sandy Point area is an Important Bird Area, providing nesting habitats for many migratory shoreline bird species, many of which are protected by the State of Connecticut.
- New bridge at Cove River: This project is from the hazard mitigation plan. The bridge opening is believed too constricted.
 CT DOT reportedly designed a new bridge in 1986 but it was not funded because DOT would have required the City to enlarge the channel downstream of the bridge.
- City-Owned Seawall: The seawall is in various stages of disrepair and residents are very interested in improvements in this area. Part of this includes a revetment. The City may consider incorporating elements of green infrastructure here. The City would like to reduce wave energy offshore, and a reef may be considered. A paper street runs along this seawall and the City can gain access.

The City indicated that the above projects have been discussed with DEEP OLISP, and that OLISP personnel (specifically, Krista Ramero) were not opposed.

Sediment removal and dredging are desired along Old Field Creek and Cove River. These may not be eligible resilience projects, as they may not provide benefits unless the dredging allows better flushing. It is possible that managing sand along the shorefront will lower the movement of sand into the channels. Additionally, there are ways that sand can be captured before it enters the watercourses. For example, the City would like to build a plunge pool near the headwaters of Old Field Creek. This plunge pool should be reviewed as a possible resilience project.

The City believes that some harvesting of sand from Sandy Point might be approvable. Sand may also be available near the mouth of Cove River where sandbars are continuously forming down-drift from the beach that is nourished by the Corps.

A condominium at the east end of Main Street is located on a bluff or cliff and there is potential risk of erosion. However, the City would be unlikely to participate in mitigation at this site, as it is private property. Nearby, the City repaired 400 feet of bulkhead. In general, this part of the shoreline (to the east facing New Haven Harbor) is occupied by private properties.

Mr. Pidluski asked if projects would need to be designed to the FEMA BFE (100-year elevation). Mr. Murphy stated that this would not be necessary unless buildings or critical facilities were part of the projects, which is unlikely. For example, the beach/dune project would not need to be designed to that height, although it could be if desired.

Field reconnaissance was scheduled for June 19 at 9 AM. This date and time were selected, in part, based on the low tide at 8 AM.

NEW HAVEN SCOPING

Initial Scoping Meeting

DATE:	June 10, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI Kevin Deneault, TNC Karyn Gilvarg, City Plan Department Susmitha Attota, City Plan Department Donna Hall, City Plan Department Giovanni Zinn, City Engineer
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	
SUBJECT:	New Haven Coordination	
LOCATION:	City Plan Department	

A project coordination meeting was held on June 10, 2015 at the City Plan Department office in City Hall. David Murphy and Kim Bradley were present from Milone & MacBroom, Inc. and GEI Consultants, respectively. David Murphy presented the project, utilizing a power point slide show as the basis for the presentation. Potential resilience projects were discussed. The City offered two potential green infrastructure projects:

- Long Wharf: Erosion of this area has been progressive and it was mentioned in the initial hazard mitigation plan in 2005. Significant erosion occurred during storms Irene and Sandy, removing the remaining buffer that previously existed and damaging sections of a paved walkway. Damage assessment reports with photographs are available in the City Plan Department. The next significant event like Irene or Sandy could cause unacceptable damage. Several important sections of infrastructure are in the path of additional erosion including the City's road, a critical sewer force main below the road, and the interstate further landward. David mentioned that the presence of the critical infrastructure could make a project here into a good candidate for a FEMA mitigation grant. Attendees from the City Plan Department explained that a partial design for stabilization was completed many years ago along with a cost estimate, and the project was initially going to be funded by DOT but then the funding was not allocated to the project. Donna has information about the design. Looking forward, the Long Wharf shoreline could be an ideal candidate for hybrid approaches that include some hard structures along with beach nourishment and vegetation.
- East Shore Park: Like Long Wharf, erosion of this area has been progressive and it was mentioned in the initial hazard mitigation plan in 2005. Significant erosion occurred during storms Irene and Sandy, and damage assessment reports with photographs are available in the City Plan Department. Ocean & Coastal Consultants Inc. in conjunction with StanTec/Vollmer Associates and Land Tech Consultants Inc. developed a "Waterfront Rehabilitation Wave Analysis, Shoreline Stabilization and Conceptual Design Report" in 2006. The conceptual design recommended alternating vegetated dunes and riprap protection areas, and was partially implemented along the shoreline. The vegetated dune sections had failed. Kim explained GEI Consultants' prior involvement (supporting Save the Sound) included a site visit and visual assessment of the erosion issues and preparation of a white paper for hybrid/living shoreline approaches to stabilize the shoreline. Donna asked about the hazard mitigation plan action for East Shore Park which speaks of considering options such as "retreat," which was addressed by David and Susmitha given their involvement with the initial hazard mitigation plan and its update, respectively. Attendees agreed that retreat is no longer an appropriate option for this park. A "fresh look" is desired.

Attendees discussed the importance of the shoreline parks and public access to the shoreline in the city. The presence of these parks is one reason why risks to people are relatively low along the shoreline, and they provide critical green space in the city. Despite the urban nature of New Haven, the importance of the parks is a key reason why the regional framework for coastal resilience grant may be a good fit for New Haven.

Other coastal vulnerabilities were discussed. Their potential for inclusion as green infrastructure projects is uncertain at this time:

- Fire Training Academy: Little information has been gathered for this section of shoreline since it was discussed in the hazard mitigation plan. The status of the shoreline is not known. This will be checked during the field reconnaissance. A section of the West River estuary shoreline further upstream should also be checked.
- East bank of Mill River upstream of Grand Avenue: The riverbank upstream of Grand Avenue is not hardened like the section downstream of Grand Avenue. There may be some vulnerability in this area. One specific issue in this area is that the City has permitted non water-dependent uses and obtained shoreline easements in the process, but the widths of the easements are at risk due to continued erosion. If an easement is only six feet and two feet are lost, for example, the remaining width is unacceptable.
- Morris Creek berms near tide gates: the ground surface near the tide gates is elevated and helps reduce the risk for flooding upstream of the tide gates during less frequent, larger events. However, the high ground water short-circuited by the surge from Sandy. This area should be reviewed for potential green infrastructure or hybrid solutions.

Inland flooding areas were discussed. Significant work has been done in the West Rock neighborhood including reconstruction of housing and drainage improvements. Giovanni reported that bank erosion may be occurring along Wintergreen Brook. David remarked that inland bank stabilization projects may be reviewed as part of the grant if bioengineered approaches are considered.

David asked about Belle Dock. This shoreline is reportedly stable and recent dredging has been completed. David also asked about Lighthouse Point. Information about shoreline risks is not known; the Parks Department should be consulted. Kim noted that GEI Consultants and Save the Sound visited Lighthouse Point and found that the near-shore areas are primarily composed of rocky outcroppings; therefore, the potential need for living shoreline/green infrastructure resilience measures may be limited.

Clarification was sought about some of the CDBG-DR projects. The drainage improvement project (green infrastructure systems) will help reduce runoff from a 600-acre storm sewershed. The green infrastructure systems will be designed using best available designs in recent literature, and these designs can be applied throughout the City. In the future, another area of interest for green infrastructure systems could include Fair Haven. David and Kevin explained that this regional coastal resilience project could potentially help design green infrastructure systems for stormwater management, but there is not a compelling reason to advance any particular green infrastructure system into the compilation of projects at this time.

The callout for the Brewery Square bulkhead on the large map used during the meeting was incorrect. The site is closer to the Ferry Street Bridge. The blue line representing the River Street bulkhead should be discontinuous, as there is a pocket of tidal wetlands near the end of Lloyd Street.

David and Kim will circulate potential July dates for the field reconnaissance. Giovanni will like attend along with David Moser and perhaps someone else from the City Plan Department. Kevin will obtain digital files from the City Plan Department and post them to the project ftp site. Maggie Targrove may have additional information related to storm response and cleanup.

BRANFORD SCOPING

Introduction

Steps taken in advance of an initial scoping meeting with Branford included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan (HMP)

The Town of Branford (the Town) is covered under the SCRCOG Multi-Jurisdiction Hazard Mitigation Plan (April 24, 2014; Jamie Caplan Consulting/AECOM). The HMP identified assets that are vulnerable to hurricane/tropical storm and nor-easters including 13,207 parcels, 26,414 buildings and 19 critical facilities. There is no identification of coastal erosion vulnerability in Branford. Some shelters exist in flood areas and they are working with The Nature Conservancy on issues emerging from sea-level rise and coastal erosion. The plan notes that 18 properties were repetitive loss properties and 1 was a severe repetitive loss. The HMP identifies sea level rise preparation, stormwater management and flooding as opportunities to integrate mitigation plan.

Plan of Conservation and Development (POCD)

Section 4: Natural Resources of the POCD describes the goals of protecting water quality, protecting biological resources, utilizing utilize green energy, and reducing light pollution. To continue to address stormwater pollution, the POCD recommends the continuation of public education about the impacts of stormwater run-off, providing stormwater treatment and restricting run-off from new development.

The POCD also identifies a goal of enhancing wetlands and watercourses buffers, including streams, lakes, ponds and rivers, Lake Saltonstall, and the Branford River. Implementation would be via strict regulations for activities that may affect them and continued monitoring and evaluating additional opportunities to enhance buffers via regulations, land use agency coordination and enforcement.

The POCD also calls for the implementation of the 2005 Open Space Plan, which includes the improvement of open space acquisition tools, managing town open space, and enhancing coastal access. The plan notes that the town must prepare for sea level rise.

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Branford Initial Scoping Meeting

DATE:	May 14, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	Jamie Cosgrove, First Selectman Janice Plaziak, Town Engineer Diana Ross, Inland Wetlands
SUBJECT:	Branford Coordination	Rich Stoecker, Planning and Zoning Bill Horne, Open Space Acquisition Committe
LOCATION:	Branford Town Hall	Karyl Lee Hall, Conservation Commission

A project coordination meeting was held on May 14, 2015 at the Town Hall. David Murphy and Kim Bradley were present from Milone & MacBroom, Inc. and GEI Consultants, respectively. David Murphy presented the project, utilizing a power point slide show as the basis for the presentation. The Branford shoreline was discussed from east to west, starting near the Guilford town line:

- Flooding of Route 146 occurs at Jarvis Creek. Tide gates are present at the mouth of the creek. An obvious solution to flooding is not apparent at this time. The road and a farm are both vulnerable to flooding. Saltmarsh dieback reportedly has occurred in this estuary, too. It is not clear whether erosion of the marsh front is occurring; the loss of vegetation appears to be dieback rather than erosion.
- The town beach at Stony Creek (Stony Creek Beach) could benefit from beach nourishment. Town-owned dredge material was available but not of appropriate sandy quality. Stony Creek floods, but the tidal marshes here are reportedly healthy.
- Upstream, erosion has occurred near and at the old trolley line. Marsh erosion is reportedly severe here. The Trolley line is
 a regional resource of importance as it is now used as an important recreational trail providing public access to high value
 natural resources. It may be part of a shoreline greenway trail. These are factors that should be taken into account when
 reviewing potential resilience projects.
- The Pine Creek estuary has seen some marsh dieback.
- Seawalls in the Pine Orchard area are suffering from disrepair. The beach in front of the seawalls is very narrow. This could be a potential beach nourishment project area. However, it is not a town-owned beach.
- Limewood Beach is located along Route 146. Irene caused erosion and the response was to dump concrete and riprap along the road/beach. Jersey barriers are also located along the road. The land is owned by DOT and private owners. This is an area that could possibly benefit from a naturalized/green infrastructure approach. Important local shellfish beds are located offshore.
- Linden Avenue is an area of priority interest. The town would like to study the corridor and determine the appropriate approach to save the road. This is the only means of access to 400 homes. Hard structures will likely be part of the solution. However, the town needs something better than mafia block walls. The Linden Shores District owns some of the land. The town submitted an HMGP application and never heard a response from DEMHS.
- The tide gates at Route 146 at Sybil Creek are reportedly going to be replaced.
- Tabor Drive near Ark Road is a potential candidate for road abandonment. It is at risk of flooding and may not be a critical road
- Flooding occurs north of Damascus Road in marshes that are tributary to the Branford River. This area is reportedly affected by invasive Phragmites australis of more than 50 acres. There is potentially space for marsh advancement here.
- A large CL&P sub station on East Main Street (Route 1) is located in a bend in the Branford River. This property is at risk for flooding, and Eversource will be taking actions to protect it, currently with proposed hard infrastructure solutions.

- Meadow Street might be a good location for a flood protection system. The area north of the road between Church Street and Roger Street is vulnerable to flooding through an opening in the dike (the railroad line). However, this opening may serve as a conduit for drainage.
- Significant erosion of private land has occurred near Howard Avenue. An old Trolley way is located here. The town's sewer line in the road will be vulnerable one day.
- A revetment is located along Shore Drive/Short Beach Road (Route 142). This is town-owned land that was deeded to the town as open space in connection with a subdivision. Residents may have added rock to the revetment.
- · Beckett Avenue is lined with homes protected by a seawall and a beach in front of the wall.
- There is a small town beach nearby at the Clark Avenue causeway. Is something could be done to reduce the risks to Clark Avenue, that would be desired.
- · Not much is known about risks along the Farm River estuary (East Haven town line).

The sites that could be modified to include green infrastructure include Linden Avenue, Limewood Beach, the revetment near Short Beach, and areas of tidal marsh erosion near the trolley line. However, all areas discussed will be considered going forward.

Field reconnaissance was scheduled for June 9 at 9 AM meeting at the Branford Town Hall prior to the coastal tour of potential project areas.

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GUILFORD SCOPING

Introduction

Steps taken in advance of an initial scoping meeting with Guilford included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan (HMP)

The Town of Guilford (the Town) Natural Hazard Mitigation Plan was adopted June 4, 2012. The Plan identifies existing vulnerabilities and presents recommendations for addressing inland and coastal flooding issues experienced by the Town. Section 4 deals specifically with Coastal Flooding and Shoreline Change. The Plan references Section 7.1 of the Harbor Management Plan for its combination of hard and soft methods for mitigation of tidal marsh erosion at Jacobs Beach, Chittenden Beach, and Chaffinch Island. Specific reocmmendations include structural projects focused on the elevation of roadways in flood prone and low-lying areas; raising the bulkhead and seawall in the marina area; and numerous erosion control projects as summarized below:

INLAND FLOODING: Structural Projects

- Developing a hydrologic and hydraulic model of the West River watershed as a way to prioritize mitigation activities such as culvert and bridge upgrades, property acquisitions and elevations, and retention/detention.
- Upgrade bridges and culverts along West River south of Lake Quonnipaug.
- Upgrade the Route 1 bridge at West River.
- Stabilize slopes and lake edge along Route 77 to prevent further erosion of the road.
- Upgrade culverts along and under Route 77 southwest of the Fire Station to prevent flooding and washout along a tributary
 of West River.
- · Conduct culvert maintenance along Sucker Brook near Lake Drive; work with private property owners as needed.
- · Work with the CT DEEP to control beaver activity at the north end of Lake Quonnipaug and prevent flooding of Route 77.
- · Install culverts to reduce flooding from a hillside near County Road and Route 77.
- Upgrade culverts to reduce flooding associated with the outlet stream from the Menuckatuck Reservoir near 3300 Route 77.
- · Upgrade culverts to reduce flooding along Race Hill Road associated with Hall Lot Brook or a West River tributary.
- Improve drainage and West River flood conveyance near Bittner Park.
- Improve drainage and Spinning Hill Brook flood conveyance in the area that floods near Martin Bishop Field and Long Hill Road.
- · Determine whether flooding still occurs at the new bridge over Little Meadow Brook at Little Meadow Road.
- · Improve drainage and Munger Brook flood conveyance in the area that floods between County Road and Route 80.

COASTAL FLOODING: Property Protection – General

- Ensure that transit-oriented development around the railroad station is flood disaster resistant and practical under sea level rise scenarios.
- Implement a comprehensive review of all shore protection features in the Harbor Sector to mitigate repeated loss of the damage that was typical of Tropical Storm Irene.
- Property Protection for Repetitive Loss Properties
- Provide technical assistance to RLP owners (and other owners of structures that suffer flood damage) regarding floodproofing measures or pursue elevation or acquisition/demolition of these properties for open space.

COASTAL FLOODING: Public Education

• Develop and implement a program of data collection at key locations along the shoreline to document sea level rise and characterize the rate of sea level rise.

COASTAL FLOODING: Natural Resource Protection

· Pursue the acquisition of additional municipal open space in coastal flood areas and hurricane surge zones.

COASTAL FLOODING: Structural Projects

- Elevate Route 146 at West River; upgrade bridge.
- Elevate Route 146 at Long Cove provided that clearance below the railroad bridge is not jeopardized; upgrade culverts.
- Elevate Route 146 at Great Harbor/Hidden Lake; upgrade culverts.
- Elevate Route 146 at Leetes Island; upgrade culverts.
- · Elevate Whitfield Street from Seaview Terrace to the entrance of the marina to minimize flooding and improve drainage.
- Elevate Daniel Avenue or West Lane to provide multiple modes of egress for Indian Cove residents.
- Elevate Tuttles Point Road to provide egress for Tuttles Point residents.
- Elevate selected locations along Old Quarry Road.
- Elevate low spots on Chimney Corner Road.
- · Elevate Chaffinch Island Road as needed as long as Brown's Boat Yard remains a critical facility.
- Elevate selected locations along Seaside Avenue.
- Upgrade stormwater collection and discharge systems along Whitfield Street and in Guilford Center to keep up with rising sea level.
- · Raise the entire bulkhead and seawall in the marina area.

COASTAL FLOODING: Frosion Control

- Conduct beach nourishment at Jacob's Beach.
- Consider extension of the breakwater near Jacob's Beach.
- Conduct a study of alternatives for erosion control at Jacobs Beach, Chittenden Beach, Grass Island, and near Chaffinch Island and implement feasible and prudent alternatives.
- Consider construction of a new groin at Grass Island.
- · Consider replacing the old submerged groin at the east side of the mouth of the West River.
- · Consider the use of wave attenuation structures offshore.
- Consider the use of dredged sediment for stabilizing marsh fronts such as those near Grass Island, Chittenden, and Chaffinch Island.
- Consider the construction of a groin at Chaffinch Island point.
- · Construct pile-supported walkways where foot traffic is exacerbating erosion.
- Maintain existing hard structures in good condition.
- Set aside sufficient land for landward migration of tidal wetlands.

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Guilford Harbor Management Plan

The Guilford Harbor Management Plan (revised 2012) offers additional suggestions and insights into vulnerable tidal areas within Guilford. Rapid erosion is occurring to the marshes and to the margins of Grass Island, Jacobs Beach, Chittenden Beach and Chaffinch Island. The eroded material is transported northward and into the river channels and mouths, filling the rivers with sediment and restricting navigation.

Findings from the "Scientific and Engineering Studies – 1985" by DiCeasare-Bentley Engineers which are related to potential coastal resiliency plans include:

- a. The wave climate for the inner harbor is one of moderate to rough water conditions, esp. in the approaches to the Town Marina and the anchorage area. The low surrounding land topography allows the full force of the LIS wind systems to act on docked, moored and anchored boats.
- b. Wave erosion of the shoreline tidal marshes and beach areas is a problem. The sediment transport fills the river mouths and causes recession of the shore. Chittenden Beach at the mouth of the West River is of particular concern. For over a century a hand laid groin controlled erosion from severe nor-easterly storms. The groin was made of small stones, and combined with sea level rise over the last 50 years almost 500 feet of beach and marsh has been lost. The eroded material ends up in the West River Channel and Guilford Yacht Club Basin requiring frequent dredging. The erosion now exposes the historic Browns Boat Yard and residence to direct wave action.
- c. Boat wake due to harbor traffic has been presented as a problem, esp. along the mouth of the East River. Boat wakes have been suggested as a cause of bank erosion. However, a greater problem may be the win-created short-period, steep-crested wave fields which attack the tidal marshes at the mouths of both the East and West Rivers.
- d. Shellfish management is being carried out in both the East and West Rivers.

Guilford Initial Scoping Meeting

DATE:	June 9, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	George Kral, Town Planner Kevin Magee, Environmental Planner John Henningson, Hazard Mitigation
SUBJECT:	Fairfield Coordination	Commission
LOCATION:	Independence Hall	

A project coordination meeting was held on June 9, 2015 at the Town Hall Annex. David Murphy and Kim Bradley were present from Milone & MacBroom, Inc. and GEI Consultants, respectively. David Murphy presented the project, utilizing a hard copy of a power point slide show as the basis for the presentation. Potential resilience projects were discussed. Numerous potential resilience projects were discussed. In particular, three projects were the subject of the town's NFWF grant application:

• West River/Chittenden Beach living shoreline: This project is still desired. The continued marsh front erosion in this area remains a concern. John believes that the loss of marsh in this area has contributed to easterly currents or circulation that heads directly west into the vicinity of Brown's Boat Yard, where marsh erosion has been occurring on the south side of the property. John believes there may be utility in breaking the project into phases. For example, the West River groin can be pursued first because restoration of this piece of the project will reduce erosion and facilitate sedimentation in the eroded area south of Chittenden Beach, where the living shoreline could later be established. This living shoreline project is a potentially good candidate for the regional coastal resilience design.

- Long Cove: A new/restored channel at Daniel Avenue is still desired. The surge from Sandy disrupted work that was occurring at this location. Further upstream, the diagonal trolley grade may be impeding drainage because culverts may be clogged. Options here may include clearing the culverts, replacing the culverts, or removing the grade associated with the trolley line. Projects associated with Long Cove are potentially good candidates for the regional coastal resilience design.
- Leetes Marsh: Tide gate design for the Shell Beach Road culvert is underway with DEEP involvement. Due to timing and logistics of this project (a permit condition required by DEEP), potential design as part of the regional coastal resilience grant is not appropriate.

David asked about the road elevation projects, understanding that Old Quarry Road is complete. Chaffinch Island Road is scheduled for 2015 and Tuttles Point Road is scheduled for 2016. Low spots along Route 146 continue to be floodprone and the town is ultimately interested in addressing these spots using appropriate methods to reduce the frequency of flooding.

David asked about Sachems Head. Numerous private structures will continue to be used in this area.

David asked about Vineyard Point Road. The edge of the road has been repaired and the approach will be to allow flooding. This topic sparked a discussion about the "room for the river" approach that allows floodwaters to rise and fall near occupied areas.

David asked about the Trolley Road area. Erosion is still a concern at the opening to Great Marsh where water velocities can be significant. The town and the State both own small patches of coastal public access along Trolley Road, and green infrastructure projects may be possible in these areas. Further evaluation is needed.

David asked about potential projects for Grass Island. John explained that Grass Island marsh and beach restoration is appropriate as part of a larger effort related to protection of the harbor and marina. Ideally, groins, beach restoration, and marsh restoration east and west of the harbor would help reduce long term risks to the harbor. Jacob's Beach Park was recently renovated and the beach is a nourished/managed beach.

Inland flooding areas were discussed. The road elevation and culvert replacement projects at Spinning Mill Brook are planned or pending.

David asked about progress relative to hazard mitigation at the Public Works facility. There are currently no plans to relocate the facility. Potential green infrastructure projects that reduce risks are not apparent for this site. It would be difficult to reduce flood risks for the entire property.

Field reconnaissance was scheduled for July 9 at 11:30 AM.

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MADISON SCOPING

Introduction

Steps taken in advance of an initial scoping meeting with Madison included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan

The Town of Madison (the Town) is included in the SCRCOG Multi-Jurisdiction Hazard Mitigation Plan (HMP) dated April 24, 2014 by Jamie Caplan Consulting/AECOM.

Chapter 4 of the regional HMP addresses potential threats, including urban, riverine, and coastal flooding. The plan identifies 573 flood damage claims in Madison, as of December 31, 2012, noting that the most severe coastal flooding in the region has occurred as a result of high tides and storm surge caused by hurricanes, tropical storms and nor'easters. The potential for damage resulting from future flooding and storm events is increased due to the predicted sea level rise along the Connecticut shoreline, anticipated to be as much as 23 inches by the end of the century.

Table 4.57 of the HMP summarizes problem statements for Madison, identifying coastal flooding, coastal erosion, and sea level rise. As noted, hurricanes and tropical storm hazards pose significant issues for the Town related to coastal flood damages (to homes and infrastructure, including seawalls). Chapter 6 of the SCRCOG HMP identifies a number of potential mitigation actions that could be implemented in Madison. The following actions are specific to addressing flood and coastal hazards:

- Circle Beach Road numerous homes at risk to regular coastal/tidal flooding and storm surge. Many have been damaged
 or destroyed in past storms, and most of those remaining or that were rebuilt are elevated with breakaway walls in accordance with FEMA standards.
- Middle Beach Road (HMP Mitigation Action #1) area susceptible to coastal flooding and storm surge. Protected by 800 foot armored stone wall that was heavily damaged following Hurricane Irene in 2011. The Town is applying for repair/redesign and reconstruction of revetment through FEMA grants (Public Assistance).
- Garvin Point Bulkhead (HMP Mitigation Action #2) Rehabilitate an approximate 280 foot long steel sheet pile bulkhead at Garvin Point.
- East River (HMP Mitigation Action #3 and #4) Property acquisition of five residential homes north of I 95 / Elevation of buildings and roadway on south side.
- East River Roadway and Flood Control Structure (HMP Mitigation Action #5) Roadway reconstruction and flood control structure construction adjacent to the East River.
- Surf Club Dune Restoration (HMP Mitigation Action #8) Restoration of coastal dune at Surf Club Recreation Facility. The park is vulnerable to coastal flooding and storm surge. Failure of seawall and loss of primary frontal dunes during Irene.
- Hartford Avenue significant erosion concern for bluffs along the Sound
- Low-lying neighborhoods that frequently become isolated by tidal/coastal flooding occurrences include areas along Neck Road, the west end of Green Hill Road, Harbor Avenue, and Circle Beach Road.

• Town Campus (Town Hall, Police, EOC, community shelter, etc.) is a critical lifeline for the continuity of government for the Town. Area is in proximity to special flood hazard area for Hammonasset River and is downstream from Lake Hammonasset Dam (high hazard dam, owned by RWA). Should be considered for possible mitigation actions.

Madison Initial Scoping Meeting

DATE:	May 13, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	David Anderson Michael Ott, P.E.
SUBJECT:	Madison Coordination	
LOCATION:	Madison Town Hall	

A project coordination meeting was held on May 13, 2015 at the Town Hall. David Murphy and Kim Bradley were present from Milone & MacBroom, Inc. and GEI Consultants, respectively. David Murphy presented the project, utilizing a power point slide show as the basis for the presentation. Potential resilience projects were discussed. The town offered two potential green infrastructure projects:

- Surf Club dune restoration: This is town-owned property that was damaged in Irene and Sandy. The storms breached the dunes and sand was deposited in the tidal wetlands to the rear. This left a significant quantity of sand in the wetlands, and also contributed to more frequent tidal flooding of the Parker Avenue homes to the east because water could still pass through the breach. The town placed sand into the breach to block tidal flows and prevent continued tidal flooding. However, the gap is still vulnerable to future breaches and the town would like to restore the dune with a higher elevation than previous. The distance is about 300 feet. The shoreline to the east and west of this gap is lined with seawalls and bulkheads, so the gap is a real vulnerability. Design has not been attempted for this area. The tidal wetlands behind the breach are normally drained by a culvert than runs from the Parker Avenue area to the sound; this pipe is from the 1990s (designed by Roberge) and does not have tide gates, so it restricts tidal flooding via its reduced capacity. As a point of clarification, the Garvin Point sheetpile seawall repair (mentioned in the hazard mitigation plan) is also located at the Surf Club. Representatives of the Town identified this as a priority project.
- Seaview Avenue beach: This beach is owned by an association. Tidal wetlands are located behind the beach. The beach is not nourished, and it experienced erosion during Irene and Sandy. After the flood from Irene, water could not drain from the residential area. The solution here is not obvious but there may be a project that fits this grant.
- Other coastal vulnerabilities were discussed. Their potential for inclusion as green infrastructure projects is uncertain at this time:
 - Middle Beach Road: the road is supported by a masonry seawall that, in turn, is supported by a revetment. The revetment protects the seawall. This is a high energy area. Damage during Irene caused parts of the wall and road to collapse. Roberge has done some work here, and OLISP has reportedly stated that DEEP could permit the repair with a COP.
 - Green Hill Road: Green Hill Road and Green Hill Place were formed when I-95 was constructed and cut off the end of
 the colonial Green Hill Road. Flooding in the tidal wetlands occurs north and south of I-95. Several of the affected properties are rental homes. Road flooding can be 2-3 feet deep and is therefore a public safety issue. One of the property
 owners has sued the town. Elevation of the roads is probably one of the solutions here, but only a few properties
 would benefit. This area would be a good candidate for acquisitions and creation of a park.
 - South of Neck Road: the roads extending south from Neck Road (Twin Coves Road to Shorelands Road) are lined with homes. The southern ends are vulnerable to flooding, and were flooded by Irene. However, no solutions are apparent with green infrastructure.

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- Somewhat "inland" flooding areas were discussed:
 - Flooding at intersection of Middle Beach Road West and Island Avenue: this stream begins near the Stop and Shop and flows southwest toward the Madison Beach Hotel. There probably isn't incentive to do much here.
 - Bailey Creek: this neighborhood west of Mungertown Road and south of I-95 was likely developed in a floodplain. An SCS study in the 1980s evaluated flood control options.

The group briefly discussed the State of Connecticut Hammonasset Beach State Park Master Plan, which includes some resiliency components including retreat in areas of the park and nourishment of other area. The town has not applied for any HMGP or CDBG-DR grants. Roberge has looked at many of the areas described above.

Field reconnaissance was scheduled for June 10 at 9 AM at the Surf Club property. The date was not scheduled base on tidal ranges as it is not anticipated that candidate project areas require review at specific tidal levels.

FARIFIELD RECONNAISANCE

Fairfield Field Reconnaissance

DATE:	July 15, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	Adam Whelchel, TNC Kevin Deneault, TNC Kathy McLeod, TNC
SUBJECT:	Fairfield Field Reconnaissance	Laura Pulie, Engineering Department
LOCATION:	Fairfield	Bill Hurley, Engineering Department Brian Carey, Conservation Director Rick Grauer, Chair, FECB

Field reconnaissance of potential resilience projects was conducted on July 15, 2015. The team started at the Town Hall and progressed to the shoreline, working in a south-to-north direction. The tide was midway between high and low.

- Penfield Beach: Attendees parked at Penfield Beach and viewed the two pavilions and adjoining areas. The larger building will be elevated above the base flood elevation in the near future (bid were due this week). As part of the project, the existing timber bulkheads will be armored with riprap and the area inside (beneath the building) will be elevated. The smaller pavilion to the south is already on pilings and was not damaged by Irene and Sandy.
- From Penfield Beach to Reef Road Alignment (Shoal Point): The section of beach located south of Penfield Beach to the approximate alignment of Reef Road is low-lying without any significant patches of ground surface above 10 feet, which is in stark contrast to the section of beach further south of Reef Road (beyond Shoal Point) where the ground surface is slightly higher and above 10 feet in several places. This low-lying section of beach was reportedly one of the primary pathways of storm surge to wash over the barrier beach and flood the marshes and densely developed neighborhoods to the west and northwest. Although the FECB and the Town favor the larger comprehensive flood protection system described in its Flood Mitigation Plan, they recognize an opportunity to reduce the risk of storm surge overwash through this area by building dunes and raising the elevations of the few dune-like systems located here.

In general, this particular stretch of beach located south of Penfield Beach to the approximate alignment of Reef Road is divided into two sections: a northerly section (approximately 11 properties wide) with many private seawalls and a southerly section without seawalls. One groin is located where these two sections meet, and another groin lies midway along the southern section. The Town reports that a homeowners' association is not present here. The southerly section of the beach is wider and has a higher sand buildup than the northerly section with the seawalls, but this appears to be a function of the groin spacing more than the presence of the seawalls. True dunes are not present in either section of beach, although some dune-like patches of beach were visible. Two lots at the northern end, adjacent to Penfield Beach, are vacant and new structures are proposed.

A public access alley aligned with Rowland Road has a very low elevation and was likened to a "Class 3 rapids" when storm tides surge through the alley. When standing at the low concrete flashboard opening at the beach end of the alley, one can see straight through to the neighborhoods beyond Fairfield Beach Road without any ridge or rise in the ground surface to mitigate the movement of water.

The FECB and Town report that the section of Fairfield Beach Road here is quickly flooded before other sections, and the logical evacuation route (Reef Road) is insufficient due to its narrow width. As a result, residents along the southern section of Fairfield Beach Road, beyond Reed Road, must evacuate from their neighborhood before the section of Fairfield Beach Road here is flooded.

Given the particular observations described above, attendees discussed the possibility of increasing the width of the beach (especially the northerly section in front of the seawalls) and creating dunes with elevations of 10+ feet that could stop or slow down the storm surge through this area. Attendees understand that flooding beyond Fairfield Beach Road could still occur, but addressing this section of beach could give residents more time to evacuate. In addition to creating dunes along this beach,

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specific vulnerable pathways for flooding such as the alley could be retrofitted with small dune systems and undulating topography with vegetation that could slow the flood surge if the new frontal dunes were to be breached.

- Rickards Beach: The small beach immediate north of Penfield Pavilion is town-owned and backed by a wide vegetated
 and wooded area with elevation exceeding 10 feet. The surge from Sandy did not breach Rickards Beach because of this
 higher vegetated area. This could provide a model for other areas. The three private properties north of Rickards Beach are
 fronted by dunes that have elevations exceeding 10 feet, and they also were not breached. Town staff and FECB members
 stated that it is possible that the dunes here and at Jennings Beach (see below) have a hardened core structure because
 they were created in the 1960s-1970s.
- Fairfield Beach Club: Attendees viewed this area from the town's beaches and then drove by the club. The tennis court area is low-lying and was another primary pathway for storm surges to cross Fairfield Beach Road and reach neighborhoods to the west and northwest.
- Jennings Beach: Attendees viewed the low-lying parking lot behind the dunes and noted the area that is typically underutilized for parking. It was mentioned back in May at the data collection meeting as a potential location for replacing asphalt with natural conditions or pervious surfaces. However, this part of the parking lot is typically used about 12 times per year for specific functions such as a carnival. Additionally, it is used for snow storage. The parking lot is so close to the water table that it may not encourage infiltration even if made pervious. For several days after the flood from Sandy, waist-high water was trapped in the area of the parking lot because there are few pathways for it to drain. A watercourse or drainage system is located on the northwest side of the parking lot (along the south and east sides of properties on Craig Place, Baldwin Terrace, and Craig Court) and reportedly flows into the boat basin at Ash Creek. A non-tidal wetland is located near Myren Street, and a low hill is located between the parking lot and Beach Road to the south.

Attendees walked over the dunes and observed wooded conditions on the back sides and beach grass on the front sides. The beach is relatively wide in this area, and it was reportedly re-nourished with sand that was dredged from Ash Creek. The dunes exceed elevation 10 feet and were an effective barrier from storm surge flooding, and therefore could provide a model for other areas.

However, the north end of Jennings Beach at Ash Creek is one of the major vulnerabilities for storm surge flooding because the elevations are low. Homes along Newell Place had five to six feet of water from Sandy. One of the components of the desired flood protection system would be to create a high berm in the vicinity of the beach entrance, meeting the dunes at its east end and extending along the south side of the boat basin to the west. This would reduce the risk of storm surge traveling toward Baldwin Terrace from Ash Creek.

- Dike near Riverside Drive: Attendees viewed the earthen dike extending from homes on the south side of Riverside Drive across a tributary of Ash Creek. The top of the dike is below elevation 10 feet and it was overtopped by the storm surge from Sandy, providing yet another pathway into the densely developed neighborhoods south of Route 1. A small SRT is functional in this dike. At 12 noon, the water surface on the upstream side of the dike appeared to be at its maximum level, and although tidal flushing is occurring, invasive Phragmites are visible in the upstream marsh. The town has hypothesized that perhaps an additional one foot (vertical) allowed in the tidal level upstream might be sufficient to kill the reed. However, could the additional day-to-day increase of one foot cause flooding nearby? The FECB members explained that elevating this dike is a key component of the envisioned flood protection system, as it would prevent the storm surges from overtopping the dike. The SRT would continue to function as designed or as modified. Green infrastructure projects were not apparent in this area.
- Bridge at Riverside Drive: Attendees viewed the bridge just south of Route 1. The bridge consists of a box culvert type opening that is directly beneath the paved part of the road; three culverts extending to the east (toward Ash Creek) that are fitted with flap gates; and twin culverts on the north side of the bridge that bypass the bridge and the three culverts with flap gates. The twin culverts are both meant to have SRTs, but only one does at the present time. The Town would like to repair/retrofit this entire system to allow proper tidal flushing while maintaining optimal conditions for residents. Green infrastructure projects were not apparent in this area.
- Ash Creek upstream of Route 1: Attendants parked on the Bridgeport side of Ash Creek and viewed the reach of the creek upstream of Route 1. At the current tide level, the expansive mud flats were not visible. These flats are potentially contami-

nated, but many people would like them to be dredged. Engineering staff noted that the concrete wall located between the creek and homes on Grassmere Avenue was overtopped by the flood from Sandy. Green infrastructure projects were not apparent in this area.

• Kenard Street: Attendees completed their tour at the new wetland and marsh system located east of Kenard Street. This system consists of three wetlands (high/fresh, middle/brackish, and low/tidal) that were restored/constructed as mitigation for nearby actions. The land to the northeast is available for development and a hotel has been mentioned as a potential occupant of this parcel. Green infrastructure projects were not apparent in this area.

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BRIDGEPORT RECONNAISSANCE

Introduction

Steps taken in advance of an initial scoping meeting with Bridgeport included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan (HMP)

Bridgeport (The City) is covered under the 2014 Natural Hazard Mitigation Plan Update by the Greater Bridgeport Regional Council. The regional plan offers a number of recommended actions to respond to potential hazards in the region. Those recommendations that would fall under the Coastal Resiliency Program goals have been summarized below:

Prevention

- · Encourage low impact development techniques and green infrastructure for new developments.
- · Conduct a study to assess and prioritize the highest risk locations across the City

Structural

- · Consider moving sediment to preserve hydrologic function of Ash Creek.
- Expand the separation of sanitary and storm drainage sewers. Implement and install green infrastructure and building modifications to improve on-site storm water management, retention and infiltration
- Improve ability of drinking water supply reservoirs to accommodate high intensity, short duration rain events.
- Continue to utilize low impact development techniques and green infrastructure for new developments and continue to
 work with the Office of Planning and Economic Development and the WPCA to coordinate development and sewer separation projects
- Consider retreat from the Cedar Creek shoreline where vacant properties have little probability of expansive redevelopment. The City is currently considering a conservation easement for a site located at the NE terminus of Brewster Ave.
- Continue to implement the recommendations from the Pleasure Beach Master Plan (June 27, 2012). Phase I work is in construction. The City is seeking funding for Phase II and hopes to build in more resilience measures into plans.
- Implement recommendations made by the Seaside Park flood control study.
- · Initiate a waterfront recapture program and consider waterfront easements. Proceed with Knowlton Park Phase III.
- Integrate the Complete Streets Policy (Greater Bridgeport Regional Council) into the annual paving regiment, to improve drainage as part of road improvement projects. A key element of a "complete street" is green infrastructure.
- Initiate strategically placed green infrastructure and roof leader and other building modification projects to improve on-site stormwater runoff retention and infiltration. Continue to work to find physical locations for 'green solutions' called for in the WPCA Long Term Control Plan (LTCP).

- Continue using a mix of hard and soft beach protection measures at Seaside Park.
- · Continue to frequently clean the racks at Bowe Street
- · Aggressively maintain culverts and remove debris from channels along Ash Creek/ Rooster River;
- Johnson Creek; Pequonnock River, and Yellow Mill.
- · Improve beach protection in the Black Rock Area
- Proceed with creation of a stormwater detention area at the north end of Roger's Park. The design phase of the project has been bonded. The project's scope and fee negotiation for design is anticipated to be complete by the end of 2013.
- Systematically replace culverts and bridges and upgrade drainage systems.
- Repair/replace the State Street Ext/ Commerce Drive Bridge and upgrade the catch basins and drainage system.
- Protect the Cedar Creek bank with bulkheads or other creative hard solutions. The City is currently considering construction of a hurricane barrier (similar to Stamford) to address surge-related flooding in Cedar Creek.
- Raise the height of two harbor breakwaters to protect the inner harbor, St. Mary's at Ash Creek and the Fayerweather
 lighthouse breakwater from the reach of higher waves and to reduce damage from wave action. The City is actively seeking
 funding for breakwater improvements. Hope to tie into comprehensive resilience barrier: Pleasure Beach pier wave fence,
 seawall/ jetty improvements, Seaside Park berm (see below), Cedar Creek hurricane barrier. This is a potential USACE project
- Implement physical enhancements of beach protection infrastructure, including breakwaters, groins, and hardscape along Seaside Park, in the Black Rock neighborhood and in the lower East Side, as necessary and appropriate. This project is anticipated to be included in the project above.
- Acquire additional land as needed for the creation of a detention area. The City is in ongoing discussions with property
 owners regarding land acquisition.
- Implement Flood Control Project to divert 400 cfs from Island Brook at Old Town Road to Ox Brook at Roger's Park. This flow is to be diverted back to Island Brook at Fairview Avenue through a large detention basin at Shriva Park. The final phase of the Ox Brook project will address this issue.
- In the Northeast section, continue with the Feasibility/Flood Control Study that takes the downstream constriction at the GE Property into consideration, and implement recommendations as appropriate. The environmental study and preliminary design for this project has been completed.
- Remove existing bridges at Feroleto Steel and Scofield Avenue and replace with new bridge that increases the base height of the structure and minimizes flood impacts.
- Build in extra flood storage at Island Brook, Bruce Brook and Rooster River/Ash Creek.
- · Replace or maintain the culverts along the Ox Brook to adequately handle the flow of water.
- Increase, and in some cases introduce, bank protection along the Yellow Mill Channel.
- Allow Barnum Boulevard to be submerged during storm surge. The City conducted an initial conceptual design of a berm in Seaside Park. The City is currently looking for funding sources, as FEMA did not fund the berm during the 2012 round of grants.

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- Consider elevating the road and parking lots in the Cedar Creek area, especially in connection with redevelopment projects.
- Elevate low-lying roads, including the south end of Seaview Avenue, Waterview Avenue, Seabright Avenue and Gilman Street
- Protect the banks along Cedar Creek and upstream of Black Rock Harbor with construction of a hurricane barrier, bulk-heads and other hardscape and elevated streets and parking lots in vicinity of or adjacent to Cedar Creek.
- · Upgrade the Bridgeport Harbor Seawall and continue the process of researching funding sources.
- Upgrade improvements along Ash Creek/ Rooster River from 50-year storm to 100-year storm.
- Encourage the owner of the rail line to raise the grade of the railroad.
- · Replace the Charcoal Pond dam (private).
- Construct culvert improvements on Barnum Avenue to realign Bruce Brook and soften the bends from Sage Street to Bowe Street.
- · Create dike and pumping system for low-lying areas along Ash Creek/Rooster River.
- · Install a hurricane barrier to connect Black Rock to Seaside Park to minimize storm surge and act as a flood control gate.
- Reconstruct New Haven rail line bridges over city streets to prevent flooding.

Natural Systems Protection

- Preserve open space and wetlands in high risk areas.
- Protect and restore natural buffers, natural systems on the watershed and full coastline scales; replant Remington Woods Riparian Zone, Pleasure Beach, inland wetlands, tidal wetlands (East End\Johnson's Creek, Stratford Great Meadows, Harbor areas, Ash Creek).
- Acquire open space in high risk areas. Identify and seek further conservation through acquisition of marsh "Advancement Zones" and riparian corridor restoration projects throughout the City.
- Implement the recommendations from the Pequonnock River Watershed Plan to improve water quality and alleviate flooding. The September 2011 plan was developed by Fuss & O'Neill and identified a number of green infrastructure options for the City of Bridgeport including:
 - Bridgeport City Hall LID Retrofits (green roof, rain gardens, pervious pavement, and bioretention basins)
 - Green Streets (bioretention basins, pervious pavement at intersections) as constructed along Park Avenue and slated for the Park Avenue/Railroad Avenue areas of the City
 - Knowlton Park redevelopment (LID stormwater management and riverbank restoration)
 - Green stormwater treatment at the proposed Water Street transportation center
- Implement the recommendations from the Rooster River Watershed Plan to improve water quality and alleviate flooding.

 This plan was developed by Fuss & O'Neill and approved by the CT DEEP in September 2013. The plan identifies a number of green infrastructure options for the City of Bridgeport including:
 - · Bridgeport Public Library LID Retrofit (infiltration trenches, bioretention islands and tree boxes, rain garden).
 - Eliminate the last remaining CSO discharge location in the watershed, located at State Street and Dewey Street in the upper portion of Ash Creek.
 - · Blackham School LID Retrofit (bioretention areas, permeable pavers, subsurface infiltration, and green roof).
 - · Pocket Park at Madison Avenue and Vincellette Street (includes riparian buffer restoration)
 - Rooster River stream restoration between North Avenue Bridge and Brewster Street Bridge

- Small-scale residential LID retrofits along Laurel Avenue between Hughes and Capital Avenues
- · Sediment removal from Rooster River upstream of I-95 road crossing, restore floodplain and tidal wetland habitat.
- Daylight Horse Tavern Brook at the Brookside Shopping Center.
- Restore Ox Brook stream buffer and daylight stream.
- · John Winthrop Middle School LID retrofits.
- St. Mary's Sand Spit dune restoration following T.S. Sandy damage.
- Improve tidal gate flow along Turney Creek and Riverside Creek.
- · Address eroding bridge abutments at Park Avenue near Plankton Street.
- · Plan for beach nourishment at Seaside Park.
- · Implement dune restoration projects.
- Promote conservation and management of open spaces and wetlands within sea level rise areas. Restore and protect natural systems in Bridgeport including replanting the Remington Woods riparian zone, Pleasure Beach, along Ash Creek.
- Identify parcels within the marsh advancement zone that could be acquired, including properties along Cedar Creek that have low potential for redevelopment.
- · Introduce land forms to minimize vulnerability to storm surge in the South End community.
- · Mitigate erosion from flooding at Ash Creek.

Emergency Services

In coastal and low-lying areas, raise/repair bridges for evacuation routes, viaducts for pumping stations and backup generators.

Green Infrastructure Feasibility Study

This feasibility study was completed by Hazen and Sawyer and Save the Sound for Bridgeport and New Haven in August 2006. The study evaluated the feasibility of utilizing green infrastructure for combined sewer overflow (CSO) abatement in Bridgeport and New Haven, Connecticut. The study addressed the feasibility of green infrastructure implementation throughout Bridgeport and New Haven, development of a framework for implementation, cost-benefit analyses, and consideration of the effect green infrastructure implementation could have on job creation. A variety of green infrastructure source controls were evaluated during the course of the feasibility study, including various bioretention configurations, subsurface infiltration, blue roofs, green roofs, permeable pavement, rainwater harvesting, infiltration basins, and pocket wetlands. Special emphasis was placed on identifying and evaluating opportunities where green infrastructure could be utilized synergistically with other efforts within these cities, such as incorporating permeable pavement into repaving operations or utilizing enhanced tree pits and other vegetated practices for beautification efforts.

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Bridgeport Field Reconnaissance

DATE:	July 21, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Becky Meyer, P.E., MMI
PROJECT:	Regional Framework for Coastal Resilience in Sothern Connecticut	Laura Schwanof, GEI Kevin Deneault, TNC Matt Fulda, GBRC
SUBJECT:	Bridgeport Field Reconnaissance	Scott Appleby, CEM, Director, Emergency
LOCATION:	Bridgeport	Management Terron Jones, MPH, Assistant Director, Emergency Management Jay Habansky, Assistant Special Projects Manager, Office of Planning & Economic Development Rep. Ezequiel Santiago, Office of Sustainability Jacob Robinson, Office of Sustainability Stephen Tyliszczak, Bridgeport Landing Development (present at Steel Point only)

Field reconnaissance of potential resilience projects was conducted on July 21, 2015. The team started at the East End Yacht Club and progressed along Johnsons Creek, Yellow Mill Pond, the Pequonnock River, Long Island Sounds, Cedar Creek, and Ash Creek, stopping at various sites that included active development and potential sites for coastal resilience implementation. The tide was low in the morning and was incoming throughout the day. While there is (and will be) significant development along Bridgeport's shoreline that will require continuned use of bulkheads, there may be some opportunities to incorporate green infrastructure.

- Johnsons Creek Shoreline (Stratford side): Prior to beginning the field reconnaissance, the existing eastern bank of Johnson's Creek in Stratford was observed. The upper end of the creek is fed by numerous storm drains and stream channels. Bruce Brook enters Johnson Creek via a tide gate structure at the north end of the creek. An unnamed tributary enters at the northeast corner, also through a tide gate. An existing storm drain flared end discharges to a vegetated channel into the northeast section. There is a healthy stand of marsh grass in this section, located waterward of the existing riprap along the Motiva Enterprises oil storage site. Phragmites are located between the spartina and the existing riprap. The remains of an old wooden barge structure are located on the Bridgeport side of this channel, just north of the boat slips.
- Johnsons Creek: City officials explained that the City intends to create a greenway extending from PC Metals, on the west side of Johnson Creek, and wrapping up around the spit of land that separates the two sections of Johnsons Creek, eventually connecting to the East End Yacht Club. The City has acquired a land bank of parcels on the west side of the inlet and has or is working to obtain easements along the remainder of the parcels the that extend around the industrial developments on Webster Avenue. GEI developed a living shoreline concept for this area, and NOVIS is assisting the City with site testing and permitting.

The area was fist viewed from the southern end of Union Avenue. Evaluation of the existing shoreline along this proposed greenway section revealed a variety of shoreline treatments and conditions. An existing timber bulkhead located at the southeast bank behind Lecog Cuisine Corporation is in poor condition, nearly two feet away from the eroding bank behind it. Attendees then viewed the inlet from the intersection of Central Avenue and Trowel Street. Various revetment types including riprap and concrete blocks are located on the northeast side of the inlet. One section of bank located behind the solitary residential house is not armored, and the sandy soil appears to be subject to erosion. The bank along the western side of the inlet has a mix of bituminous scraps and stone, and is exhibiting some evidence of scour from roadway runoff. Marsh grasses are present in front of sloped and eroding sections of shoreline and also in front of riprap, but are less prevalent in front of timber bulkheads and concrete blocks.

- Johnsons Creek to Bridgeport Harbor: This area was viewed during transit to the next stop. Hard structure such as riprap
 and bulkheads will continue to be used around the point with the oil terminals, past the Pleasure Beach ferry terminal, and
 along the private establishments located between the Pleasure Beach ferry terminal and the area south of the end of Newfield Avenue.
- Newfield Avenue Boat Ramp: The existing City boat launch located at the south end of Newfield Avenue at Seaview Avenue was severely damaged during Hurricane Sandy and T.S. Irene. The City has acquired approximately \$40,000 of FEMA funds to repair this launch. A month prior to the field reconnaissance, a truck with jetskis and quad went into the water and had to be lifted out. Several small marina and boat yard businesses are located on each side of the City's boat launch. These adjacent properties are armored with concrete retaining walls and/or are built on piles over a sandy beach. There is very little opportunity here for green infrastructure, as a hardened surface is necessary for the various water-dependent uses.
- Cooks Point: The area west of the Newfield Avenue boat basin and extending to the Yellow Mill Channel on the south side of Seaview Avenue is an extension of the Steel Point development. The new Port Jefferson ferry terminal will be developed at the bend in Seaview Avenue, and the parcel between the new ferry terminal and the WPCF will be developed with an undetermined use. Directors Shipyard is located between the WPCF and the vacant parcel on the east side of Yellow Mill that is currently undergoing environmental remediation and is slated for use by Bass Pro Shop and a 150,000 square foot mixed used residential and commercial development. This relatively large vacant parcel will have an environmental land use restrictio (ELUR) but currently has a long, relatively uniform established riprap bank at the water's edge. The developer's intent is to maintain and enhance this riprap as necessary. Mr. Murphy explained to all attendees that this is an example of an area that could provide the City an opportunity to incorporate green infrastructure along this coastline, because design of the shoreline has not yet been completed (unlike the Steel Point shoreline to the west, described below). Here at Cooks Point, the existing riprap revetment could be enhanced with vegetation. Mr. Tyliszczak indicated that his organization would not be opposed to this type of opportnity. He explained that there is a small part of the site that will be enhanced as wetlands to mitigate for adjacent activities.
- Steel Point Development: The Steel Point Development is a massive redevelopment project extending from Bridgeport's Yellow Mill Channel to the Pequonnock River that includes commercial sites, mixed-use residential facilities, and an extensive boardwalk/bulkhead system. The majority of the project at Mather Point, on the point that separates the Pequonnock River and Yellow Mill will be armored with bulkhead and elevated to 14 feet, to allow for finished floor elevations at elevation 15 feet. Existing pilings in the harbor will be removed and a public boardwalk will be installed that will extend around the perimeter of the development. A new slip for 150 boats will be constructed. There will be little opportunity to incorporate green infrastructure at this portion of Steel Point. Mr. Tyliszczak explained the extents of the Steel Point project and his goals for additional redevelopment upstream of the Stratford Avenue bridge. The developer currently owns 348 Waterview Avenue, located north of I-95 and a marina and yacht club.
- Bass Pro Shop: While most of Steel Point is south of Stratford Avenue, the new Bass Pro Shop building is north of the road.

 The armored bank adjacent to the new Bass Pro shop on the west side of Yellow Mill Channel at the Stratford Avenue bridge may be a potential site for additional plantings, given that the shoreline's construction does not appear complete.
- Yellow Mill Channel: The existing banks at Water View Park, located at the north end of Yellow Mill, were viewed to determine feasilibity for green infrascture in this area. The large Crescent Crossing residential development is located just to the west of Water View Park, along with two elementary schools, and additional city-owned property along the western banks. The park shoreline contains multiple spartina pockets and is adjacent to a relatively sheltered area of watercourse. The removal of the upstream GE dam may establish additional fish passage and ecological enhancement. There is an opportunity for green bank treatments to be installed along with fishing access points, though the site is already located above the base flood elevation. Improvements to the park may be more of an aesthetic goal to accompany the new development, rather than a coastal resiliency armorment.

The eastern side of Yellow Mill is primarily industrial, with most parcels paved all the way up to existing vertical bulkheads. From Deacon Street to the south, the bank treatments are riprap then stacked rock wall; and then further south along the O&G property they are timber bulkhead, steel bulkhead, and riprap. However, north of Deacon Street and extending all the way to the head of the channel, spartina marsh grass is found along the shoreline where the bank treatments are less hard and sometimes lacking.

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The western banks of the Yellow Mill Channel are lower and offer a sloped shoreline conducive to grasses and plants, unlike the eastern banks that offer little to no habitat area south of Deacon Street. The City-owned parcel located to the north of 348 Waterview Avenue is exhibiting undercutting, despite the heavily riprapped outfall and stands of marsh grass. Continued erosion of this bank could eventually threaten Waterview Avenue, as the lateral distance from the top of eroding bank to the edge of paved road is only 22 feet.

• "Sliver by the River": A narrow strip of land located on the western bank of the Pequonnock River, the "Sliver by the River" is currently used as a parking lot and a public access point for fishing. The parcel is located just north of the Stratford Avenue bridge. Mr. Appleby explained that this parcel was completely indundated during Hurricane Sandy. Although the parcel itself is undeveloped, it is the critical facilities located just beyond the site and the elevated railroad tracks which are at risk during storm events. A large substation that powers all of downtown Bridgeport and up to Trumbull was forced to shut down during the Hurricane Sandy surge inundation. This left 45,000 residents without power. The bus terminal located just to the south of the substation is critical for emergency evacuation, but becomes unreachable when this area is inundated. Finally, the Fire Department Headquarters located adjacent to the substation is another critical facility that should be protected during storm events and emergency situations.

The existing Sliver by the River shoreline is armored with riprap and old concrete blocks, but is not elevated much above the water surface and is in fact below the 100-year flood elevation. The entire site is located below elevation 10 feet, and is mapped within the FEMA AE Zone, as are the three facilities noted above. Stratford Avenue is mapped at elevation 10 feet as well, giving the City little option for the construction of any type of dyke or berm along the water's edge of the sliver to keep flood waters from overtopping. The existing elevated railroad is currently open underneath. There is a possibility that flood barriers could be constructed in this openings to prevent storm surge from reaching the substation located on the opposite side of the tracks. However, the substation is also located on an inside bend of the Pequonnock River, so downgradient surge protection would not prohibit overtopping of upstream floodwaters.

On the opposite side of the river, the shoreline is armored with riprap from the railroad bridge downstream nearly to the Stratford Avenue bridge, except for a small section of river frontage consisting of stacked rock walls and a short section of steel bulkhead.

- Other River Sites: City officials explained that an area upstream of East Washington Avenue along Knowlton Avenue will
 eventually be developed as a greenway. Downstream, the current Port Jefferson Ferry Terminal will be redeveloped with an
 undetermined use, likely a mixed-use project.
- Seaside Park at Remington Site: Several attendees had obligations and departed from the reconnaissance. Remaining
 attendees visited Seaside Park beginning at the east end of the park adjacent to the old Remington site. This site will be redeveloped into some type of mixed-use project. A crescent shaped beach is located in front of the Remington site, extending to Seaside Park. Some low dune vegetation and beach grass was visible at this beach.
- Seaside Park: Stantec has developed an extensive plan for Seaside Park that includes elevating Soundview Drive along the entirety of the main park's perimeter from the old southern end of Main Street to Barnum Dike, reinstalling cross culverts that drain floodwaters under the drive into Long Island Sound, and utilizing the park as a large flood containment area to protect adjacent areas from storm surge. The proposal for these modifications was prompted by the prior storm events that flooded Sikorsky, the fuel storage areas, Bridgeport University, and low-moderate income housing.

The City has recently completed the repairs to breakwaters near the eastern end of Seaside Park. The breakwaters protect the existing beach and create significantly calmer area that is conducive to marsh grass growth (several small pockets were visible in front of the riprap). The section of the park that faces due south towards Long Island Sound is subject to significant fetch and is only armored by the large boulders adjacent to Soundview Drive. Only a small pocket of marsh grasses were observed on the western side of Park Point, where the spit of land offers some protection from wave action. A wide sandy beach is located at the bend from Soundview Drive to Barnum Dike; this beach is bracketed by walls.

Seaside Park near Fayerweather Island: The western portion of the park is located on a barrier beach that connects to
Fayerweather Island, where the Black Rock Lighthouse is located. Although three fishing piers that were located on the
western side of this spit of land were destroyed during the storms, the back side of the point (near the furthest damaged
pier) provides a potential example of a functioning living shoreline where marsh vegetation has established between rocky

material and edges of the park amenities.

- Cedar Creek at Wordin Avenue: There is very limited public access to the banks of Cedar Creek. One entry point is located
 off Wordin Avenue on the western bank, where an empty lot is located adjacent to a dilapidated building that is built out
 over the water. The eastern banks are predominantly steel sheet pile bulkhead adjacent to Sikorsky facilities and other industrial developments. The small parcel on the western bank is experiencing bank erosion. Installing armorment or a hybrid
 approach along this shoreline could potentially stabilize erosion and offer surge protection to the adjacent industrial uses.
- Cedar Creek: Other stops on the field reconnaissance trip included the Captain's Cove Seaport at the end of Bostwick
 Avenue, the end of Ferris Street, and the boat ramp at the end of Brewster Street. Captain's Cove Seaport is a developed
 shorefront and will remain as such. The shoreline at the ends of Ferris Street and Arthur Street is partly riprapped but
 marshes are present. Marsh grasses line the perimeter of the embayment located south of Ferris Street and east of Ellsworth Street, indicating a low-energy environment.
- Seabright Avenue Beach: A small beach is located on the east side of Seabridge Avenue. The high beach contains beach
 grass and marsh grasses are located beyond the low part of the beach. Other types of vegetation are also present, characterizing dune-like conditions.
- South of Beacon Street: A very narrow beach is located in front of a concrete seawall extending from Beacon Street past a condominium complex. Marsh grasses have established in front of the seawall, which is atypical but demonstrates a sufficiently low wave energy that the seawall has not encouraged downward erosion. The wall appears to demarcate the high water mark.
- Eames Boulevard: This road skirts the perimeter of Battery Point. Attendees parked near the intersection of Armitage Drive. A pink granite block riprap revetment was identified along the Battery Point coastline, as has been observed at other towns such as Milford and West Haven. According to City representatives, the Black Rock Yacht Club and its seawall at Grovers Avenue were destroyed during Hurricane Sandy, but have since been rebuilt.
- Ash Creek: The Black Rock area is located adjacent to Ash Creek, which was a flooding source for Faifield during Hurricane Sandy. The Bridgeport side of Ash Creek is at a higher elevation than parcels in Fairfield, however City representatives indicates that the Black Rock area at Gilman Street becomes a flooded bowl during storm events. The area was isolated for two days following Hurricane Sandy due to waist deep water. The tidal marshes in Ash Creek are well developed, and the adjacent area has been well maintained as park facilities with walkways, educational signage and lighting. Kayakers were observed within the marsh area on the day of the field reconnaissance.

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STRATFORD RECONNAISANCE

Stratford Field Reconnaissance

DATE:	July 14, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Jason Williams, LA, MMI
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	Kim Bradley, GEI Adam Whelchel, TNC Kevin Deneault, TNC
SUBJECT:	Stratford Field Reconnaissance	John Casey, Town Engineer Christina Batoh, Conservation Administrator
LOCATION:	Stratford	Matt Fulda, GBRC

Field reconnaissance of potential resilience projects was conducted on July 14, 2015. The team started at Tannery Brook and progressed to the pier at the Housatonic River, observing inland and shoreline sites, before ending at Raven Stream. For the shoreline sites, the tide was relatively low.

- Tanners Brook: Tanners Brook flows north to south and then makes a hard turn to the northeast behind the California Street condominiums. The brook is channelized here with a concrete basin and fenced banks. A precipitation event of four inches in one storm will reportedly flood the parking lot. A project has been designed, and is undergoing a regulatory permit review at DEEP, to widen the channelized section by re-grading the left bank (east bank) to make a floodplain bench. The goal is to reduce frequent flooding such as the 10-year flood. The 12'x5' culvert under the Amtrak line reportedly conveys the 10-year storm, so any floods greater than that would presumably be backed up by the railroad grade and still cause flooding. A 48" RCP culvert previously conveyed the brook under the Amtrak line. During the site visit, attendees observed that gravel had cascaded down the railroad embankment and across the channel, blocked low flows in the stream channel, causing a slight backwater condition.
- Bruce Brook: Bruce Brook is channelized with wall of stone masonry and concrete sides and channel at the north end of Bowe Avenue. During storm events, water jumps out of the channel and flows down Bowe Avenue. A project has been designed to leave the wall against the road but remove the wall on the right bank and generally reduce the sharp "S" turn in the channel, thereby reducing frequent flooding. The small driveway bridge from Bowe Avenue will be removed. Homes on the right bank were taken by the City of Bridgeport and the land is now vacant; a small triangle of this land is in Stratford. This comprehensive project also includes re-routing of a culvert in the vicinity of the McDonalds on Barnum Avenue. The long-term plan for this section of Bruce Brook is to widen the channel from the north end of Bowe Avenue to the vicinity of McDonalds possibly incorporating a section of the brook onf wooded private land south of McDonald's.
- Long Beach: All attendees of the site visit to Long Beach met in the public parking lot. The background of Long Beach was discussed briefly. Town representatives described the fact that the town discontinued the leases on several cottages on Long Beach. In 2009, the Trust for Public Lands began raising funds for habitat restoration through removal of vacant cottages, which occurred in 2011. Additionally, in 2011 the Town of Stratford received a Long Island Sound Futures Fund grant to develop a management plan and implement invasive species control which resulted in the development of a Habitat Management Plan for Long Beach, was developed by Ken Metzler & Ron Roza in January 2013. Kim Bradley noted that when reviewing the plan there was a recommendation to evaluate the current benefit and liability associated with the ACOE groins on Long Beach.

The dunes located along the north side of the parking lot and the Sound-side dunes located between the parking lot and the entrance gate were reportedly enhanced or created by the town over the years. Jersey barriers placed between the parking lot and beachfront have reduced movement of sand into the parking area. The dunes located west of the end of the parking lot extending on to the barrier beach are a natural part of the landscape. The barrier beach was washed over by the surges from Irene and Sandy, and the surge from Irene reportedly reduced the height of dunes in this area. Sand from the dunes is still visible on the north side of the dune ridge, extending toward the marsh. Attendees discussed the fact that overall, this beach and dune system appears to be functioning as a natural barrier beach and dune system (aside from the groins) and new green infrastruc-

ture projects are not apparent. However, dunes could be enhanced in some locations to speed up the process of restoring previous heights, if there was consensus to do so.

- Seawall and Revetment at Beach Drive: Attendees briefly viewed the seawall and revetment at Beach Drive/Lordship Beach Road between Washington Parkway and Jefferson Street. These structures appear to be in good condition without any opportunities to incorporate green infrastructure.
- Russian Beach: Attendees viewed Russian Beach to the east from the end of Jefferson Street. John reported that this
 western part of the beach had undergone significant sand accretion over the last few years. This part of the beach lies in
 front of a wide vegetated buffer that is located between the beach and the homes off Ocean Drive; this area is all privately-owned. Attendees then parked at the intersection of Lordship Road and Park Blvd and walked across the wide vegetated
 section to the beach to view the area where Christmas trees had been deposited. Green infrastructure projects are not
 apparent although invasive species control in the vegetated buffer could be beneficial.
- Coastal Bank Erosion at Russian Beach: Attendees parked at the intersection of York Street and Park Blvd to view the eroding bank that extends to the east toward the Cove Place alignment. Severe erosion appears to have taken place, and the bank is comprised of unconsolidated sand and gravel with only a thin topsoil and turf grass layer at the top. A resident approached the group and reported that storms Irene and Sandy heightened the erosion that was occurring. Evidence of sheet flow toward the top of the bank (from the storm that passed through while attendees were at Long Beach) was noted. This eroding bank provides an opportunity for stabilization via bioengineered bank designs. Although at present there does not appear to be any strong consensus to address the erosion, the town roadway will be at risk in the future.
- WPCF: Attendees viewed the eroding bank at the southeast corner of the WPCF. The eroding section appears to extend from the Raymark property to the south, possible midway to the dike at the Army Engine site (thus the eroding section is entirely south of the old breakwater that is visible at low tide). The surge from Sandy did not overtop this bank, nor did it flood the WPCF. This eroding bank could potentially be stabilized with bioengineered bank designs, as there appears to be consensus to address the erosion. During the visit, attendees discussed the reports that sediment in this area contains PCBs, metals, and other contaminants; the fact that the dike protecting the Army Engine site has an elevation of 10 feet; the challenges associated with redevelopment of the Army Engine site; and the challenges associated with the Raymark site located at the north end of the eroding bank.
- Public Pier at end of Birdseye Street: This was the final stop with John Casey, as he needed to leave and prepare for an evening meeting. Attendees viewed the piers, the stream channel emanating from the streets to the west, and the marshes adjacent to the nearby apartment buildings. Green infrastructure needs were not evident.
- Raven Stream at Diane Terrace: The stream is impounded by a concrete weir on the west side of the road. Immediately after passing through culverts under the road, the stream enters a short tidal section that joins the Housatonic River. This section was observed at low tide, such that the banks were visible. Some bank erosion has taken place on both sides (left and right) immediately downstream of the road. At high tide, water is likely in contact with these banks. Concrete blocks in the headwall beneath the road are misaligned and appear to be in partial collapse. A collapse could cause loss of areas of the town road upgradient of the bank and bridge. Bioengineered banks incorporating a new headwall might be a potential project in this area.
- Raven Stream Headwaters: Raven Stream appears to begin at a small impoundment located off Elmhurst Avenue. Although
 municipal attendees reported back in May (during the data collection meeting) that erosion was occurring downstream
 of this area, the stream was not visible downstream of the impoundment. The impoundment is formed by a dam and the
 stream flows out from a wide concrete spillway. Green infrastructure projects are not apparent.

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MILFORD RECONNAISANCE

Milford Field Reconnaissance

DATE:	June 12, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	Adam Whelchel, TNC Kevin Deneault, TNC Chris Saley, Public Works Director
SUBJECT:	Milford Field Reconnaissance	Ben Blake, Mayor
LOCATION:	Milford	

Field reconnaissance of potential resilience projects was conducted on June 12, 2015. David distributed a copy of the May 19, 2015 meeting notes with a suggested sequence of stops for the field reconnaissance. The team started at Milford Point and progressed to the northeast, ending at Hillside Avenue. Chris Saley and Mayor Blake were present through the stop at Walnut Beach. Before their departure, David explained which other stops were anticipated in the next two hours.

- Wildemere Beach: This beach was viewed from the end of Bittersweet Avenue, which is an point of public access to the shoreline. The Laurel Beach Association beach is a nourished beach located to the southwest. Unlike Laurel Beach, this section of Wildemere Beach is not replenished with sand. Very little beach is available at high tide. The City has reportedly gained some consensus with the residents that beach nourishment could be pursued with the understanding that public access would need to be available in front of homes where the beach would be nourished. Chris noted that groins may need to be part of the project. A beach nourishment project here could have dual benefits of increasing resilience to waves while enhancing public access.
- · Walnut Beach: The City's Walnut Beach was viewed from the linear parking area along East Broadway. Chris explained that the main parking lot immediately to the west is poorly utilized and therefore somewhat oversized because people prefer to park along East Broadway. However, East Broadway is relatively narrow and offers poor emergency egress when cars are parking along the roadway. A wider road is desired. The cul-de-sac at the end needs to be enlarged to provide the appropriate radius for vehicles to turn around, and the City has entertained the idea of re-establishing a connection from the end of East Broadway to Nettleton Avenue. If East Broadway were widened to allow continued parking with improved egress, a bioswale could be established along the east side (boardwal side) of the road. The City would also like to enhance the undeveloped vegetated area on the landward side of the road, but it is understood that condominium residents to the west are generally opposed to projects in this area because they do not wish to be visible from the boardwalk along East Broadway. The condominiums are at elevation 10' (approximately) and lie within the FEMA flood zone. There may be opportunities to create an elongated dune on this undeveloped land to serve as a berm or buffer between storm surges and the condominiums. David noted that one component of making major changes in this area could be looking at ways to reduce the paved area of the underutilized parking lot, similar to an idea that was raised in Fairfield. He also noted that many of the ideas discussed were more appropriately handled in the context of park master planning/improvement projects and therefore may not fit into green infrastructure project designs, but they should be captured in the database as potential coastal resilience projects.
- East Broadway: Attendees drove along the section of East Broadway located northeast of Silver Sands State Park, noting the very low elevations and viewing homes along Caroline Street and Cooper Avenue. David pointed out the pending HMGP-funded home acquisition at the end of Caroline Street. Marsh grasses are beginning to merge into the lawn of this property, as they are on many other properties in this area. David shared his opinion that one of the challenges found in this neighborhood is that homes on the east and west ends of the "finger roads" have been investing in mitigation measures (elevating) whereas those in the midsections have not, which will ultimately make it harder to step back from the tidal marshes and abandon the west ends of these roads. Green infrastructure projects were not evident in this neighborhood, except that the pending and future home acquisitions could allow for marsh advancement onto previously developed lots.
- · Gulf Beach: David pointed out the site of the CDBG-DR funded breakwater restoration project.

- Bayview Beach: This beach was viewed from the end of Deerfield Avenue. The City reported that there is some interest
 in beach nourishment here, but the residents are not open to the potential for increased public access like they are at
 Wildemere Beach. David pointed out the much wider section of sandy beach in the adjoining area to the northeast along
 Bayshore Drive.
- Calf Pen Meadow Creek outlet: The bridge abutments were viewed at Melba Street. Areas of erosion were noted. Bioengineered solutions to erosion mitigation may be possible in this area.
- Point Beach: While driving through, David explained that homes in this area (Morehouse Avenue and Richard Street) were elevated after Winter Storm Beth in the 1990s and remarked that many of the elevated homes had maintained their charm after being elevated.
- End of Point Beach Drive: A seawall consisting of stacked concrete blocks is failing, resulting in significant erosion at the top of bank in front of a small condominium complex. Two sections of the bank have eroded further than other sections. A new fence was evident, replacing a fence that was viewed in spring 2014 but located several feet landward away from the eroding bank. The location of the CDBG-DR-funded "Morningside revetment" is four lot widths northeast of this failing wall. Between the failing wall and the site of the future Morningside revetment, several bank erosion control treatments were visible in front of the four houses. Two of the residents from these four homes approached the team and requested that the City help reduce the erosion in front of the condominiums, as their properties were at risk. Properties in the other direction, to the southwest, are protected by a variety of private seawalls. Most of the failing wall appears to be above the coastal jurisdiction line, although the base appears to be in contact with water which is likely contributing to the slumping of loose sand behind the concrete blocks. Gully erosion from the top of the bank may also be a factor. This is a potentially strong candidate for a bioengineered bank treatment that could resist erosion while reducing deflection of wave energy. The team noted that further evaluation is warranted.
- Hillside Avenue: The granite block revetment was viewed from the ends of South Street and Burwells Court, which both
 appeared to be points of public access. These points are the approximate limits of the granite block revetment. The Army
 Corps' seawall starts southwest of South Street toward Morningside Drive, and private seawalls are located northeast of
 Burwells Court. Green infrastructure projects are not evident in this area. There does not appear to be an obvious reason to
 replace the revetment.

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WEST HAVEN RECONNAISANCE

West Haven Field Reconnaissance

DATE:	June 19, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Laura Schwanoff, GEI
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	Adam Whelchel, TNC Kevin Deneault, TNC Abdul Quadir, City Engineer
SUBJECT:	West Haven Field Reconnaissance	
LOCATION:	West Haven	

Field reconnaissance of potential resilience projects was conducted on June 19, 2015.

On the way to the meeting, David stopped briefly at the small condominium complex on Bayview Place near the east end of Main Street. Considerable erosion of the bank was visible. The top of the bank is in very close proximity to the easternmost unit of the complex. A green infrastructure in this location would need to consist of a steeply-sloping bioengineered bank; very few other options would be feasible without unacceptable loss of land or filling of land that may be below the coastal jurisdiction line. However, urgent action may be needed.

Upon meeting with the other attendees, David distributed a copy of the May 12, 2015 meeting notes with a suggested sequence of stops for the field reconnaissance. The team started at the water pollution control facility (WPCF) (wastewater treatment plant) and progressed to the southwest along the shoreline before viewing the non-tidal, somewhat inland sections of two watercourses.

- WPCF outfall: Attendees walked the extent of the outfall pipe from the point that it passes beneath tidal wetlands adjacent to the WPCF to the point that the current low tide channel of Old Field Creek crosses the pipe. Much of this route is inundated at high tide. Abdul explained that the tidal wetlands immediately south of the WPCF were enhanced as mitigation for a small loss of wetlands when the WPCF was upgraded. He pointed out the location of the breach caused by Irene (which was subsequently filled in June 2012 prior to Hurricane Sandy), riprap placed by the Army Corps in 1994, the previous outlet of Old Field Creek across the southern barrier beach spit, the remains of a jetty that demarcated this prior outlet, and finally the current area of concern where the creek flows over (and in direct contact with) the outfall pipe. The City is very concerned that the pipe will fail where the creek flows over the pipe. One of the possible solutions is to install a new outfall at an angle of about 45 degrees to the south of the current pipe. The new pipe would likely be shorter if it were installed more directly to the southeast. Attendees discussed the lack of a traditional green infrastructure project here; there is no means of avoiding the need for a resilient outfall pipe, and the WPCF benefits the entire city. They key to developing ecological benefits in connection with a new outfall pipe would be the actions that are completed at the same time, such as restoring marshes or sandy areas used by birds.
- Morse Beach/Savin Rock Beach: Attendees parked at Chick's Restaurant and viewed the beach across the street while discussing the Beach Street road elevation project that is currently in the design phase. Laura and Adam pointed to a number of opportunities to incorporate green infrastructure into the roadway project to manage stormwater and improve the area. Abdul explained that the beach at this location will be replenished with 20,000 cubic yards of sand in September of 2015. The beach nourishment will extend from the alignment of Morse Avenue to the east toward the public parking lot near the alignment of Third Avenue. He also explained that the section of beach to the west (from Washington Avenue to Morse Avenue) was nourished with sand in 1994. Due to the pace of the road elevation project and the imminent beach nourishment project, there are probably not any opportunities to incorporate green infrastructure under the regional framework for coastal resilience grant.
- West Haven Beach/Altschuler Plaza: Attendees parked at the lot at the end of Altschuler Place and walked eastward along
 the public walkway, viewing the beach in several locations west and east of the pool. The City holds an easement for public
 access along the walkway and to the beach. This easement also obligates the City to maintain the beach. The beach here
 was last replenished in the 1970s, and was 300 feet wide when that work was completed. The beach is narrower at this

time, but the many groins have reportedly held much of the sand in place. Beach and dune vegetation can be found in various areas, but turfgrass is found along most of the walkway. The dunes are somewhat higher and wider east of the pool. There may be many opportunities to enhance dunes and beach vegetation. Abdul noted that the condominiums were flooded by Irene and Sandy, and David noted that these buildings would be difficult to mitigate because they could not be elevated easily; instead, first floor living space would need to be converted to storage and parking that is floodable. The project team should evaluate creating continuous dunes that are sufficiently high to mitigate or prevent storm surge flooding, recognizing that the goal would not be to remove the buildings from the FEMA flood zone. Abdul explained that the City owns the beach to the west of Altschuler Place, extending slightly past Oak Street, and then has another access easement in front of the Jimmie's Restaurant.

- Cove River: Attendees parked on the gravel lot adjacent to the Cove River off Captain Thomas Blvd. The tide gates at the
 road are old one-way gates and do not allow sufficient flushing north of the road. Abdul indicated that the tidal range is
 only about one foot upstream of the road. Phragmites are controlled using chemical methods, but the last time was 2012.
 Increased tidal flushing will help control invasive species. New tide gates are planned but not yet funded. This was one of
 the NFWF grant applications submitted by the City. Ideally, the new gates would be placed at the failing pedestrian bridge
 that is currently closed, and this bridge would be repaired.
- Ocean Avenue near South Street: Attendees parked at the unpaved parking lot off Ocean Avenue near South Street to view the ongoing repair of the east end of the seawall that continues to the west toward Milford. Abdul explained that this seawall is City-owned and protects a sanitary sewer that is located immediately behind it. The seawall and sewer are approximately coincident with a road, Old Kings Highway, that existed many years ago. Over the years, residents have increased the height of the seawall in various locations, but the City still owns the structure. David noted that the granite block revetment in front of the wall is very similar to the revetment observed in the Hillside Avenue section of Milford. After viewing the repair, attendees walked slightly northeast (past the privately-owned section of the parking lot) to the next public section of the low where seawall repairs were completed in May 2015. David noted that opportunities for green infrastructure coastal resilience projects were not evident, as the seawall is likely needed to protect the sanitary sewer. This observation differs from the discussion at the initial meeting on May 12 when David and Kim Bradley noted the possibility of incorporating green infrastructure when revetments and seawalls were repaired.
- Woodruff Street: Attendees parked at the end of Woodruff Street and viewed the seawall and granite block revetment at
 this location. A section of the wall is slumping immediately northeast of the end of the road. David noted again that opportunities for green infrastructure coastal resilience projects were not evident, as the seawall is likely needed to protect the
 sanitary sewer.
- Cove River at West Main Street: Attendees parked at the school on West Main Street and viewed the channel of Cove River
 at West Main Street. The bridge/culvert is undersized. Abdul explained that a 20-foot bridge is desired here. Flooding occurs if the City receives 3-4 inches of rain, and water will flow down Painter Drive. David noted that an ideal solution beyond
 the new bridge would be to acquire land from the parking lot and construct a floodplain bench to reduce the constriction
 that has occurred. However, removing all flood risk here is unlikely or impossible, and the area will remain in the FEMA
 flood zone.
- Old Field Creek at Peck Avenue: Attendees viewed the head of the Old Field Creek estuary from Peck Avenue. Ul had
 just completed tree trimming and conditions were not ideal for observing the stream channel. However, the stream did not
 appear to be flowing at this location, and the channel appeared to be significantly filled with leaf litter and other debris.
 During the meeting of May 12, attendees had discussed the possibility of constructing a plunge pool or basin here to collect
 sediment before it flows into the estuary downstream.

While driving back to the WPCF, David pointed out the area of home buyouts in the vicinity of Third Avenue and Blohm Street.

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NEW HAVEN RECONNAISANCE

New Haven Field Reconnaissance

DATE:	July 13, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Jason Williams, LA, MMI
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	Kim Bradley, GEI Kristen Ponack, GEI Adam Whelchel, TNC
SUBJECT:	New Haven Field Reconnaissance	Kevin Deneault, TNC
LOCATION:	New Haven	Giovanni Zinn, City Engineer David Moser, City Plan Department Susmitha Attota, City Plan Department Dawn Henning, Engineering Department

Field reconnaissance of potential resilience projects was conducted on July 13, 2015. The team started at East Shore Park and progressed to Long Wharf Park, observing both sites at low tide.

• East Shore Park: East Shore Park has reportedly experienced significant erosion over the years, with notable loss of shoreline over the last ten years including storms Irene and Sandy. David Moser provided an overview of studies and efforts over
the last ten years. He indicated that Ocean and Coastal Consultants conducted a wave analysis and provided a conceptual
design with alternating areas of riprap and proposed vegetative planting approaches. This design was a result of CTDEEP
reluctance to approve of hard structures, in this case, continuous riprap along the park shoreline. Kim described her knowledge of the site, and the fact that several site visits and condition reviews have taken place with organizations such as Save
the Sound, Connecticut Sea Grant, UCONN and CTDEEP. Kim communicated the comments from Maryland's living shoreline expert Bhaskar Subramanian, whom attended a site walk organized through the Connecticut Sea Grant/UCONN CLEAR
Living Shoreline Workshop Series on June 15, 2015. He noted that per his observations at the site, existing vegetation,
although dominated by the invasive common reed (Phragmites australis) was representative of a current living shoreline

Attendees walked from south to north along the shoreline of the park, noting pockets of Spartina marsh grasses located in several areas below the high water wrack line. A narrow sandy beach appears to be located along the entire shoreline, backing up to a steep eroded nearly vertical bank that is difficult to observe due to the thick brushy and dominant invasive common reed (Phragmites australis) vegetation. The bank height is approximately five to seven feet (vertical). Attendees noted that very little public access to the water was practical because of the thick shrubby vegetation lining the steep bank between the narrow beach and the grassy park. David Moser explained that Phragmites stands located along the eroded bank are relatively new, appearing only in the last couple years. David Murphy noted that the species was present in 2004-2005 when the initial hazard mitigation plan was developed, which could mean that the bank has eroded landward and then the reed re-populated the shoreline.

David Moser provided information about the sites where very large riprap had been placed on the shoreline and vegetation had been planted between the sections of riprap in approximately 2006. In the southerly location of this approach, the vegetation and its substrate were quickly eroded. Kim explained that the riprap may have contributed to the rapid erosion of the material located between the sections of riprap due to deflected wave energy. Attendees noted that the park substrate consists mainly of fill material; this material is somewhat visible in the eroding banks. David Murphy noted the arkose sandstone exposed in the high beach sand below the eroded banks and collected a piece for subsequent determination about its origin and potential for bedrock outcrops.

Long Wharf Park: Long Wharf Park has reportedly experienced erosion over the years, with notable loss of shoreline over
the last ten years including storms Irene and Sandy. David Moser provided an overview of studies and efforts over the last
ten years. The conceptual design prepared by Langan Engineers is reliant primarily on extending and connecting the limited sections of riprap placed at a low slope angle, with alternate approaches using sheet pile. David Moser explained that
this solution lost its chances for funding as resources were directed elsewhere. At the present time, the City is expecting to
utilize FEMA funding to replace park amenities that were damaged, such as walkways.

Attendees walked from south to north beginning at the watercourse that drains from two concrete culverts within a concrete bulkhead. The Long Wharf Nature Preserve located south of this watercourse is not part of the park but may serve as a good reference site for how the park could evolve. A future visit to this nature preserve may be warranted.

The most severe erosion along the banks of the park begins at the north edge of the riprap located in front of the Veteran's Memorial "V" sculpture. It extends to the north, ending at the southern extent of the long riprap section near the food vendors and visitors center. The asphalt walkway has eroded and collapsed in several sections along the eroded reach of the shoreline. Although the eroded bank displays vertical erosion characteristics similar to East Shore Park, the total vertical drop is minimal here (one to maximum of three feet) and therefore the overall slope is gentle as compared to East Shore Park. The shortest distance between the edge of the eroded bank and the paved edge of Long Wharf Drive is 22 feet south of the Interstate 95 exit and entrance ramps, and 21 feet north of the Interstate 95 ramps. These distances therefore represent the approximate lateral distance between the eroded bank and the critically important sewer main. City staff reminded all attendees that damage to the sewer main is unacceptable.

David Murphy and Kim Bradley noted that the diversity and quality and density of vegetation visually appeared higher in front of the eroded bank areas as compared to the vegetation in front of the riprap section located to the north. Furthermore, the high beach is missing in front of the riprap such that the riprap gives way directly to low mud flats with minimal pockets of Spartina marsh grass, which is quite different than the transition zones located between the eroded bank and the mud flats. They explained that the riprap is likely causing this somewhat degraded condition and the edge of riprap areas could be increasing adjacent erosion due to wave diffraction. Attendees agreed that the protection provided by riprap is desired along with the quality of the vegetation located in front of the eroded bank. This is a considerable challenge to any green or hybrid design for the park.

Following the two visits described above, David Murphy stated that the Fire Training Academy on the east bank of the West River was the remaining site that was meant to be visited. The City staff present indicated that East Shore Park and Long Wharf Park were the primary locations to emphasize for shoreline projects in the context of the regional coastal resilience plan. David Murphy reminded the group that the planning phase should characterize all possible sites. David Moser and the engineering staff returned to their offices while Susmitha accompanied the remaining attendees to the Fire Training Academy. This site was mentioned in the initial hazard mitigation plan and/or municipal coastal program as a location of bank erosion. While erosion has clearly occurred here, it was not evident if erosion has been recent or has become progressively severe over the 10-11 years since the initial hazard mitigation plan was developed. The site is immediately downstream of the railroad bridge, and it is possible that the erosion is related to bridge scour caused by the relatively narrow opening at the bridge. Adam pointed out the layers of asphalt exposed in the eroded bank, indicating that the parking lot formerly extended waterward of the existing parking lot.

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EAST HAVEN SCOPING AND RECONNAISANCE

East Haven Scoping Meeting and Field Recon

Steps taken in advance of an initial scoping meeting with East Haven included evaluation of exisiting flooding problems and potential projects that would both address these damages while advancing the use of green infrastructure and hybrid living shoreline approaches to enhance coastal resilience.

The first task within this evaluation included a review of existing studies, plans, and community documents to identify problem areas and any previously proposed projects. Milone & MacBroom, Inc. (MMI) and GEI Consultants (GEI) then met with each of the ten municipalities to develop a list of potential projects/plans from the past ten years, as well as existing and proposed projects/plans. Following this evaluation, MMI and GEI conducted on-site assessments of locations that represent opportunities for natural/green infrastructure risk reduction and resilience projects. The intent of this memoradnum is to summarize the findings of each of these evaluations and assessments, and to develop a comprehensive list of projects that could feasibly be implemented using funding from the Hurricane Sandy Coastal Resiliency Competitive Grant program.

Hazard Mitigation Plan

The Town of East Haven's (the Town) Hazard Mitigaton Plan was updated and adopted May 1, 2012. Section 4 of the Plan addresses Coastal Flooding and Shoreline Change, identifying existing vulnerabilities and potential mitigation measures. The Plan identifies the damage caused by Tropical Storm Irene in August 2011, noting that the waves from the storm washed over Cosey Beach and other low-lying coastal areas, aided by the elevation of the storm surge. Coastal flooding from Irene inundated the following streets with a water depth of several feet:

- · Cosey Beach Avenue
- · Palmetto Trail, Catherine Street, Phillip Street, and Hobson Street at their intersections with Cosey Beach Avenue
- · Cosey Beach Extension, Ellis Road, and Caroline Road
- · Fairview Road and Brazos Road
- Jamaica Court
- · Seaview Avenue and First Avenue

A total of 17 homes were completely destroyed by the storm surge and waves. A total of 32 homes were classified as substantially damaged per the NFIP regulations and FEMA guidance, and another 49 homes were damaged but total costs fell below the threshold of substantially damaged. Based on this recorded damage and the evaluation of existing vulnerabilities, the HMP offers a number of mitigation measures, strategies and alternatives. Those recommendations are summarized below, prioritized according to category:

Property Protection

• Pursue acquisition/demolition of floodprone residential properties for open space as noted below under "Natural Resource Protection." Properties may be classified as repetitive loss or not classified as repetitive loss, but RLPs should be prioritized as the Town has done in the past.

Natural Resource Protection

- Pursue the acquisition of additional municipal open space in SFHAs.
- · Selectively pursue conservation recommendations listed in the Plan of Conservation and Development.
- Identify new funding sources for open space acquisition.
- · Continue to regulate development in protected and sensitive areas, including steep slopes, wetlands, and floodplains
- Continue to aggressively pursue wetlands protection through existing wetlands regulations. Incorporate performance standards into subdivision reviews to include additional protective measures such as conservation easement areas around wetlands and watercourses.

Structural Projects

- Continue to maintain a dialog with regulatory agencies, FEMA, and other entities regarding the possibilities for flood control structures such as a dam in North Branford.
- Continue to use modeling techniques to evaluate different flood mitigation options along the Farm River including floodplain storage, channel clearing, diversions, berms, dikes, bridge replacement, and culvert replacement as well as home elevations and acquisitions.
- Investigate funding sources and feasibility of improvements to the Coe Avenue, Hemingway Road, and Short Beach Road intersection to mitigate frequent and repeated flooding problems. Improvements could include elevation of roads and replacement of storm drainage systems. Work with CTDOT to facilitate these actions, as State roads are involved.
- Investigate funding sources and feasibility of elevating portions of Town-owned roads with an emphasis on those needed for inland evacuation, including Old Town Highway, Minor Road, Fairview Road, Brazos Road, and Silver Sands Road at Fairview Road.
- Upgrade stormwater collection and discharge systems in downtown and coastal East Haven to keep up with rising sea level.

Erosion Control

- Conduct beach nourishment along Cosey Beach as needed to keep up with erosion.
- · Maintain existing hard structures in good condition.

East Haven Scoping Meeting and Field Reconnaissance

DATE:	July 9, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	Adam Whelchel, TNC Kevin Deneault, TNC Douglas Jackson, Chief, East Haven Fire
SUBJECT:	East Haven Field Reconnaissance	Department
LOCATION:	East Haven	

A brief meeting with Fire Chief Douglas Jackson was convened at 2:15 PM on July 9, 2015. Immediately following the meeting, field reconnaissance of potential resilience projects was conducted.

During the meeting portion of the afternoon, David asked Chief Jackson to update the group on the status of many initiatives that had taken place such as home acquisitions, flood mitigation projects along the Farm River, and reconstruction and repairs along Cosey Beach.

- Acquisitions have not occurred in the last few years, and the hazard mitigation plan summarizes those that had occurred as
 of 2012.
- Many of the bridges over the Farm River have been replaced.
- The only remaining Farm River actions that are planned include clearing of various locations that have trees and other debris. Home elevations are continuing along Cosey Beach.
- Only one HMGP-funded elevation is pending (37 2nd Avenue).
- The status of the CDBG-DR grant to elevate Hemingway and Coe Avenues was uncertain. The town engineer or finance director might have more information.

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The Town Beach was visited first. The existing groins are unchanged since storms Irene and Sandy. However, sand was replenished on the beach after Irene and Sandy. This beach does not currently have any obvious resilience needs. However, a rear section of the beach along Cosey Beach Road is low-lying and adjacent to a new wall that was constructed along the south side of the road. This area could be a potential candidate for creation of low dunes. If dunes were located here, they not only could add a naturalized beach condition to a maintained and urbanized facility but could help reduce the risk of storm surge directly impacted the new wall and the road behind it.

The condominium complex located on the east side of the Town Beach was visited next. The condo units appear to be located as a slightly higher elevation that the Town Beach, and the bank in front of the units is armored with riprap/revetment. In some locations, loose beach sand has been deposited on the riprap and beach grass has been planted in the loose sand. The complex's private beach is located in front of this sandy riprap. This site is a potential candidate for a re-designed bioengineered bank, rather than a somewhat informally constructed sandy/grassy riprap bank.

The mouth of Caroline Creek at the end of Cosey Beach Road was viewed next. Chief Jackson pointed out some of the homes that were damaged or destroyed by Irene and Sandy. The mouth of the creek is lined with riprap on both sides (east and west) and erosion is not evident. Sanitary sewer manholes are located in the banks and the sewer passes beneath the creek bed. Green infrastructure or hybrid projects are not evident at this location.

The Farview Road and Brazos Road area was visited next. New houses have been constructed west of Farview Road and north of the Caroline Creek high marshes. Chief Jackson explained that Farview Road is slightly higher than Brazos Road, and therefore Brazos Road is inundated first. However, both roads were flooded by Irene and Sandy. David remarked that the roads were somewhat redundant and the hazard mitigation plans raises the concept of eventually retiring one of the roads to focus resources on maintaining the other and allowing the marsh to advance into the path of the other.

An unpaved access road covered with gravel including broken asphalt is located connecting the beach club to Farview Road trending northwest-southeast and parallel to Caroline Road. This unpaved road is very low-lying and similar in elevation to the marsh grasses lining the road on both sides. A sewer pumping station is located on the west side of Farview Road. Based on the presence of sewer manholes, it appears that the road lies over the sanitary sewer and is likely a sewer easement, and with abutting roads does not serve an important use for transportation/emergency access. There also appears to be a vacant residential lot between the unpaved road/sewer easement and Caroline Road. Although there does not appear to be an urgent need for a resilience project in this location, this is a good example of a site where multiple objectives could be met. For example, the vacant residential lot could be acquired and regraded to facilitate advancement of marsh grasses while the unpaved road/easement could be planted with marsh grasses to support restoration of high marsh. In connection with these projects, the sewer pumping station could be fortified or elevated to increase its resilience. Additional ideas could be generated for this area.

After Chief Jackson returned to the office, the remaining attendees viewed the new seawall at the condominium complex west of Old Town Highway. This appears to be a heavily armored low concrete footing wall in that is partially reinforced with sheet pile, and a tall concrete wall behind.

The final stop was the New Haven city line at Morris Creek. It is understood that a tide gate is present downstream of the bridge which can be regulated remotely from the airport. There were no urgent flooded concerns within this area.

BRANFORD RECONNAISANCE

Branford Field Reconnaissance

DATE:	June 9, 2015	ATTENDEES:
MMI #:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	Jason Williams, LA, MMI Kevin Deneault, TNC Janice Plaziak, P.E., Town Engineer
SUBJECT:	Branford Field Reconnaissance	Bill Horne, Open Space Acquisition Committee (present for most of the stops)
LOCATION:	Branford	(present for most of the stops)

Field reconnaissance of potential resilience projects was conducted on June 9, 2015. David distributed a copy of the May 14, 2015 meeting notes with a suggested sequence of stops for the field reconnaissance. The team started at the Jarvis Creek estuary and progressed to the west, ending at the small beach at Clark Avenue.

- Jarvis Creek: Janice provided a map of the Jarvis Creek estuary and pointed out the farm pond and the area that is flooded.
 The estuary was viewed from Route 146. Roadway elevation will eventually be necessary to reduce the frequency of road
 flooding, and this is a resilience project that will be captured by the regional coastal resilience plan, but this is not an appropriate project for the regional coastal resilience design phase. Bill has a significant amount of information about the Jarvis
 Creek estuary, which should be reviewed as part of this project.
- Stony Creek Beach: Stony Creek Beach is a key location of public access to the shoreline. The beach is relatively small but adjoining areas are also used for public access. During the May 14 meeting, this beach was discussed in the context of nourishment. However, sufficient sand appears to be present. A patch of tidal vegetation is located immediately north of the old wharf or wall that demarcates the north edge of the beach. A grassy park is located on the south side of the wall that demarcates the south edge of the beach. At low tide, sufficient flats are exposed that a person can walk along the base of these walls. Vegetation is not present on the flats in front of the walls. There may be opportunities to incorporate vegetation into the areas in front of the walls north and south of the beach, using the vegetation located north of the beach as a model or reference. This could have dual benefits of reducing erosion in front of the walls (if it is occurring) and enhancing the ecological value of the area.
- Trolley Pedestrian Bridge: Erosion has occurred at the abutments of this important town-owned asset. The erosion has
 occurred in front of the abutments and behind them, as well. Causes appear to be a combination of stormwater runoff from
 the trail, pedestrian access where people walk from the trail down to the creek, and hydrodynamic forces from the tidal
 flow. Erosion appears to be worse at the downstream (southern) parts of the abutments rather than the upstream (northern)
 parts. Mitigation of this erosion through green infrastructure projects could help protect this important resource and point of
 public access.
- Pine Orchard: From the point at the east end of Island View Road, attendees viewed the long beach associated with the Pine Orchard association. Many repaired seawalls with the curved top wave defectors were visible in the foreground. The beach is very narrow at high tide. In the distance, attendees could see a revetment in the process of being replaced by the owner of a property where a new home will be constructed. Attendees then viewed additional sections of Pine Orchard from the end of Spring Rock Road. New rock placements were visible to the west, in front of the homes located along Ozone Road and Selden Avenue. Green infrastructure projects are not apparent in Pine Orchard.
- Hotchkiss Grove: West of the Pine Orchard association boundary, the Hotchkiss Grove association has recently increased
 the height of its seawall. The beach here is wider, with more sand, than the Pine Orchard Beach. Attendees did not closely
 view the Hotchkiss Grove area; it was partly visible from Pine Orchard. Green infrastructure projects are not apparent in
 Hotchkiss Grove.

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- Limewood Beach: Attendees viewed Limewood Beach from the intersection of Waverly Lane and Route 146 (Limewood Avenue). As described in the May 14 meeting, DOT has deposited rocks and concrete along the edge of the roadway and positioned jersey barriers along the edge of pavement. The coastal jurisdiction line (CJL) appears to be the base of the rock and concrete. Small dunes and beach vegetation are present east of the Waverly Lane intersection. Replacement of the rock and concrete with a more natural or bioengineered bank treatment would be an appropriate project for this area. Incorporation of a living shoreline below a new bank could be considered, depending on the space available and the wave energy.
- Linden Avenue: The section of Linden Avenue in front of Linden Shores Road failed during Irene, exploiting a vulnerability that could be traced back to the damage from Hurricane Gloria. This section of the road is supported by a sloping rock treatment with a half-height sheet pile wall at its base. A section of sandy beach is located in front of the sheet pile wall. A stairway to the beach is located at the west end of the rock slope and sheet pile wall. Stone and concrete walls are located at the base of the rock in the vicinity of the stairway (rather than the sheet pile wall), but the sandy beach is present in this location. West of the stairway, the conditions are highly variable; this is the area of immediate concern. The sand beach gives way to rocky outcrops and small pockets of tidal wetlands, and the bank below the road is largely unprotected and has been subject to continued erosion. Further west, mafia block walls line the road bank, but there is evidence that they are unstable. This variable area is a potentially good candidate for a more natural or bioengineered bank treatment. Perhaps the tidal wetlands at the base could be incorporated and enhanced. Janice explained that a conceptual design and cost estimate were prepared and an application was submitted to DEMHS for a FEMA mitigation grant through HMGP. David asked Janice for traffic counts for Linden Avenue, which could be used to check the benefit-cost ratio and better support a FEMA mitigation grant.
- Linden Avenue near Bayview Lane: This section of Linden Avenue is also vulnerable to failure, but was not directly viewed by attendees. A future site visit may be appropriate.
- Howard Avenue: Due to road utility construction, this area could not be accessed and viewed. Attendees will revisit this
 topic later.
- Shore Drive (Route 142) Revetment: A rock revetment extends along a short section of beach (perhaps 4-5 lot widths), separating the road from the beach. This is town-owned open space. A triangular patch of beach and beach grass is located at the east end of the revetment. Replacement of the rock with a more natural or bioengineered bank treatment would be an appropriate project for this area.
- Clark Avenue Beach and Beckett Avenue Beach: Attendees parked on Clark Avenue and viewed the beach. This is a low
 section of road that is at risk of inundation. One of the residential properties on the landward side of the road is a pending
 elevation project. A small pocket of tidal wetlands is located between the beach and the marina. From this beach, the Beckett Avenue homes were viewed to the northeast. After leaving Clark Avenue, attendees drove along Beckett Avenue where
 low-lying areas are floodprone. Green infrastructure projects are not apparent at the Clark Avenue or Beckett Avenue
 beaches.

Subsequent to the field reconnaissance, attendees drove along Meadow Street and Janice explained how the surge from Sandy passed beneath the railroad grade at the opening and flooded the ball fields.

GUILFORD RECONNAISANCE

Guilford Field Reconnaissance

DATE:	July 9, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Jason Williams, LA, MMI
PROJECT:	Regional Framework for Costal Resilience in Sothern Connecticut	Kim Bradley, GEI Adam Whelchel, TNC Kevin Deneault, TNC
SUBJECT:	Guilford Field Reconnaissance	George Kral, Town Planner
LOCATION:	Guilford	Kevin Magee, Environmental Planner John Henningson, Hazard Mitigation Commission

Field reconnaissance of potential resilience projects was conducted on July 9, 2015. The team started at Chittenden Park and progressed to Long Cove followed by Trolley Road.

- Chittenden Park: A living shoreline at Chittenden Beach is the Town's primary candidate for a shoreline project. The team viewed the eroding shorefront from the end of the boardwalk and walked westward toward the mouth of the West River. The mid-to-low tide status allowed observation of the full beach, marsh front, and tombolo-like areas that have developed due to the severe erosion. Town representatives noted that erosion had gotten worse in the midpoint of the project area. Adam remarked that sand built up along the western part of the project site could have originated elsewhere and been transported to the beach here. Town representatives noted that erosion appeared to have worsened on the far side (right bank) of the West River just below Brown's Boat Yard.
- Long Cove: The team viewed the Long Cove area from Route 146 and discussed the potential issues associated with drainage from Long Cove. The Daniel Avenue area was not observed.
- Trolley Road: Based on the discussion during the June 9 meeting, the team briefly visited Trolley Road to view the town and State coastal access areas. A small patch of marsh grass was observed at the Town-owned beach. The Great Marsh channel opening was observed. The velocities are likely too high here for a green infrastructure project.

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MADISON RECONNAISANCE

Madison Field Reconnaissance

DATE:	June 10, 2015	ATTENDEES:
MMI#:	2733-14	David Murphy, P.E., CFM, MMI Kim Bradley, GEI
PROJECT:	Regional Framework for Coastal Resilience in Southern Connecticut	Jason Williams, LA, MMI Kevin Deneault, TNC Michael Ott, P.E., Town Engineer
SUBJECT:	Madison Field Reconnaissance	3
LOCATION:	Madison	

Field reconnaissance of potential resilience projects was conducted on June 10, 2015. The team started at Madison Surf Club and progressed to the east, ending at the ballfields at the former Griswold Airport.

The Surf Club dune restoration project, discussed in detail at the May 13 coordination meeting, was viewed by all attendees. Mike explained that the initial breach was caused by Tropical Storm Irene. During this event, significant quantities of sand were deposited in the marsh. Temporary measures had been taken when Hurricane Sandy re-opened the breach. In the days after Sandy, the daily highest high tide regularly allowed water to enter the tidal creek system and cause nuisance flooding of homes to the east. This continued until the town placed sand in the breach. Deposition of sand in the wetland behind the dune area was visually apparent and invasive common reed has colonized this portion of the wetland. Mike indicated that the CTDEEP had denied the town's interest in removing the sand of this area. Irene also damaged the seawall in front of the building, and this wall has been repaired with a top elevation of approximately 11 feet. Low dunes are present west of the breach; these are good examples of the dunes that were present in the current position of the breach. Boulders are present east of the breach adjacent to the private seawall. These boulders once extended to the west into the midsection of the breach, but Mike was not certain whether they were present for many years prior to the breach. Attendees believe that this site is a good candidate for consideration as a green infrastructure project.

Attendees discussed the area of dead-end roads and homes located south of Neck Road to the west of the Surf Club. Although the southern ends of these roads are vulnerable to flooding, and were flooded by Irene, no solutions are apparent with green infrastructure. This area was not viewed.

East Wharf and West Wharf were viewed. Mike explained that FEMA assisted with repairs to these historic structures. The damage from Irene was worse than the damage from Sandy at these sites.

Middle Beach Road was traversed during this tour. It was re-iterated that OLISP has reportedly stated that CTDEEP could permit the repair of the revetment and sea wall supporting the road with a COP. Michael Ott did note that if there were strategies to implement green infrastructure as a hybrid design the town could be interested in exploring options.

Attendees stopped at Fence Creek to view the Seaview Beach area. This area was discussed at the May 13 coordination meeting. However, upon further discussion during this reconnaissance, there does not appear to be a need for resilience measures here. Most of the homes are above the FEMA base flood elevation, and they are separated from the edge of water by a sandy beach, small dune area transitioning into a relatively wide zone of vegetation located behind the beach (which includes either some tidal marshes and/or higher non-wetland vegetation). Attendees discussed the possibility of using the Seaview Beach area may serve as a positive example of how the built environment can be separated from the edge of water.

Lastly, the town park and ballfields at the former Griswold Airport were visited. Mike pointed out various features of the park including the native coastal grass restoration areas and coastal forest trail system.

Municipal Watershed Assessments

The comprehensive natural/green infrastructure assessment for the entire coastline from Fairfield to Madison incorporated an evaluation of project sites within the coastal Connecticut HUC 12 watersheds. Many existing or potential priority projects focused on flooding and erosion control using green infrastructure and hybrid approaches. As part of Project Component #1, a review of existing studies, plans, and community documents were completed to identify problematic areas and previously proposed projects within the coastal catchments. The Nature Conservancy then met and spoke with municipality representatives to develop a list of existing and potential projects. During this evaluation TNC conducted on-site reviews at locations that best represented opportunities for natural/green infrastructure and risk reduction across all watersheds. All coastal priority watershed projects where then merged into the Access/ArcGIS database to represent the full suite of the Regional Resilience Framework projects. The technical procedures are described in detail below.

Review of Existing Reports, Studies, Plans, and Assessments

The resources listed below were reviewed to compile an initial list of potential or existing coastal watershed projects. Priority projects were then identified by the municipality representatives.

The following categories were used to sort the coastal watershed projects derived from various sources: rain gardens/bioswale (vareity of green Infrastructure techniques and strategies); bank protection (stabilizing riparian zone and buffer); stormwater management (drainage and runoff improvements); sewer infrastructure (replace, remove, and retrofit existing structures); and stream channel improvements (re-alignment and restoring channel).

Watershed and Subwatershed Management Plans.

Pequonnock River Watershed Management Plan (2011)

West River Watershed Management Plan (2015)

Rooster River Watershed Based Plan (2013)

Housatonic Housatonic River Basin, Final Natural Resources Restoration Plan, Environmental Assessment & Environmental Impact Evaluation for Connecticut (2009)

Farm River Watershed and Summary (2012)

Quinnipiac Watershed Based Plan (2013)

Other Green Infrastructure Studies, Reports and Asssements:

Green Stormwater Infrastructure Projects (City of Bridgeport - 2015)

Hazen and Sawyer Green Infrastructure Feasibility Scan for Birdgeport/New Haven, CT. (2016)

Baseline Watershed Assessment Pequonnock River Watershed (2010)

Watershed Field Assessment Report Pequonnock River Watershed City of Bridgeport (2011)

West River Watershed Green Infrastructure Retrofit Screening Report (Fuss & ONeill, Save the Sound - 2015)

Green Infrastructure Suitability Pilot Study (Greater New Haven Water Pollution Control Authroity & CH2MHILL - 2014)

Rooster River Technical Memorandum #2: Low Impact Development and Green Infrastructure Assessment (2013)

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West River Watershed Technical Memoramdum #1: State of the Watershed (2015)

Stormwater Managementt Pilot Program Study (City of New Haven -2010)

Foxon Boulevard (Route 80) Corridor Study City of New Haven and Town of East Haven (RBA Group of Connecticut, LLC – 2012)

Eisenhower Park Revitalization – Milford, Connecticut (2010)

Bridgeport Parks Report – City of Bridgeport (2011)

Single jurisdiction or multi jurisdiction hazard mitigation plans:

South Central Region Multi-Jurisdiction Hazard Mitigation Plan (SCRCOG - 2014)

Greater Bridgeport 2014 Natural HazardMitigation Plan Update (GBRC - 2014)

New Haven Natural Hazard Mitigation Plan Update (City of New Haven - 2011)

Milford Hazard Mitigation Plan Update (City of Milford - 2013)

East Haven Hazard Mitigation Plan Update (Town of East Haven - 2012)

Guilford Hazard Mitigation Plan (Town of Guilford - 2012)

Plan of Conservation and Development (POCD):

Fairfield Plan of Conservation and Development (Town of Fairfield - 2000)

Bridgeport Plan of Conservation and Development (City of Bridgeport - 2008)

Stratford Plan of Conservation and Development (Town of Stratford - 2014)

Milford Plan of Conservation and Development (City of Milford - 2012)

West Haven Plan of Conservation and Development (City of West Haven - 2004)

New Haven Plan of Conservation and Development (City of New Haven - 2015)

East Haven Plan of Conservation and Development (Town of East Haven - 2007)

Branford Plan of Conservation and Development (Town of Branford - 2008)

Guilford Plan of Conservation and Development (Town of Guilford - 2015)

Madison Plan of Conservation and Development (Town of Madison - 2013)

Community Resilience Building Workshops and other Municipal Plans:

Fairfield Flood Mitigation Plan (Flood and Erosion Control Board - 2015)

Guilford Community Coastal Resilience Plan (Town of Guilford - 2013; adopted 2015)

Bridgeport Community Resilience Building Workshops - Summary of Findings (The Nature Conservancy, METROCOG, Clean Air – Cool Planet - 2011)

Fairfield Community Resilience Building Workshops - Summary of Findings (The Nature Conservancy, MetroCOG – 2013)

Madison Community Resilience Building Workshops - Summary of Findings (The Nature Conservancy – 2013)

Stratford Community Resilience Building Workshops - Summary of Findings (The Nature Conservancy, METROCOG – 2013)

Watershed Field Reconnaissance

Field reconnaissance for existing and potential watershed projects were conducted from June through September of 2015. The goal of each field reconnaissance was to connect and collaborate with municipality representatives and others to discuss potential sites or areas of concerns that could potentially be addressed as either green infrastructure or hybrid approaches. The main criteria that helped narrow down the viewable sites was their potential use for green and natural infrastructure.

Most of the field notes were recorded directly on paper maps. Site maps were prepared beforehand in the office using ESRI ArcGIS products. Town and watershed data layers with aerial photography and imagery were used as base layers for generating map books for each of the town's coastal watershed sites. Site observations and town's future goal for that particular site as well as the previous accounts of flooding, erosion, drainage, repairs, projects, and other studies or associated hazardous site risks were captured.

Photo documentation was also incorporated into the database to document the potential project site and current condition. Additional photographs were taken to document specific vegetation, structures and evidence of damage from prior storms.

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GIS Database Development

All 95 coastal watershed projects were (a) gathered from reports, studies, plans, and assessments, then (b) discussed with municipality representatives and (c) further reviewed and entered into an Excel spreadsheet and converted to an Access database for use with ArcGIS. The entire list of non-tidal, freshwater, stormwater, and watershed-related projects were then added to the Regional Resilience Framework project database. The merged database currently contains 320+ records. The database fields were initially set as follows for all the projects:

IDENTIFICATION NUMBER – a number simply assigned in sequence

PROJECT KEY – a 4-digit number with the municipality embedded as follows:

Fairfield 01

Bridgeport 02

Stratford 03

Milford 04

West Haven 05

New Haven 06

East Haven 07

Branford 08

Guilford 09

Madison 10

PROJECT NAME

Address – typically just the street name

Town

Description – limited to a set number of characters

Primary Category*

Secondary Category*

Action*

Funding Source

Project Started?

Project Completed?

Primary Plan of Reference

Other Plan of Reference

Primary Risks Reduced

Secondary Risks Reduced

Green Infrastructure - Yes, No, or Hybrid

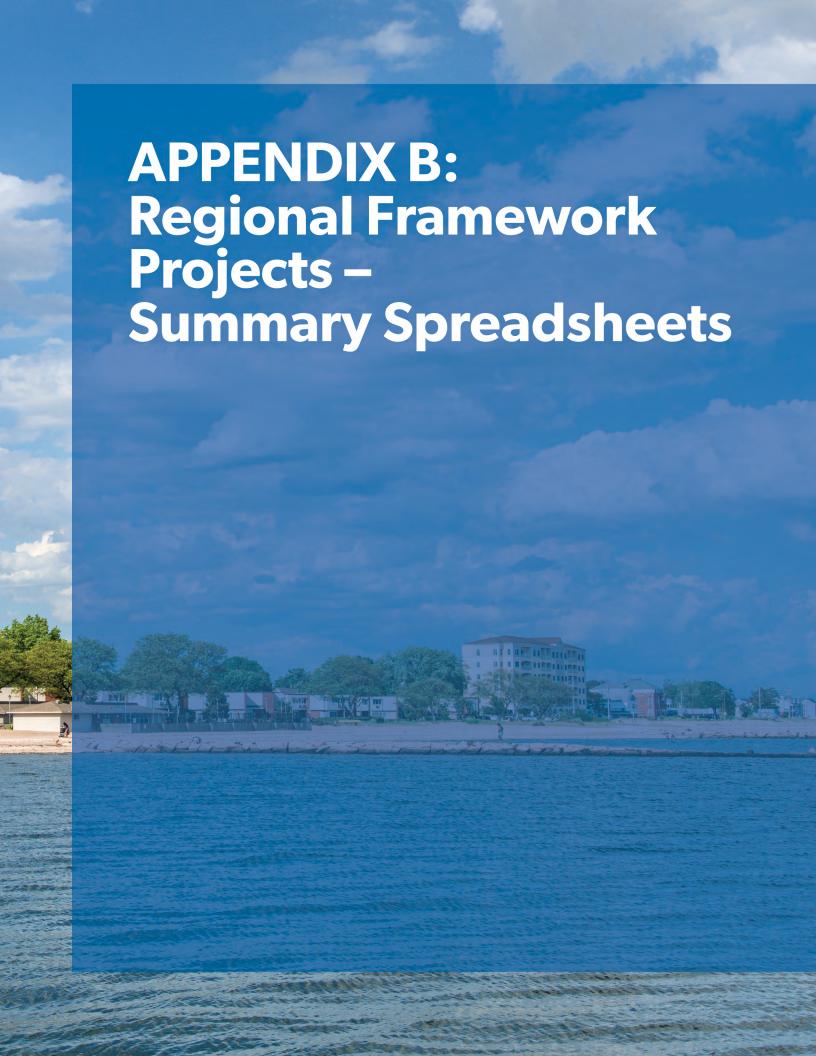
Natural Diversity Database - Yes or No

FEMA Base Flood Elevation

Coastal Jurisdiction Line

Drainage Basin/Watershed





FAIRFIELD

				Fairfield S	ummaı	у						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12
Penfield Beach Nourishment	CNI	Beach	Nourish (Managed)	Fairfield Beach Rd	NHMP	Public Access	Town Property	VE	13	5.2	22	Stratford Point to Cedar Point
Penfield Beach to Shoal Point Nourishment	CNI	Beach	Nourish (New)	Fairfield Beach Rd	NHMP	Private Property	Build- ings	VE	15	5.2	22	Stratford Point to Cedar Point
Penfield Beach to Shoal Point Dune Creation	CNI	Dune	Create	Fairfield Beach Rd	NHMP	Build- ings	Roads	VE	13	5.2	22	Stratford Point to Cedar Point
Rowland Road Alley Dune Creation	CNI	Dune	Create	Fairfield Beach Rd		Build- ings	Roads	VE	13	5.2	22	Stratford Point to Cedar Point
Reef Road Proper- ty Acquisitions	CNI	Building	Acquire-De- molish	Reef Rd	NHMP	Build- ings	Ecosys- tems	AE	13	5.2	23	Stratford Point to Cedar Point
Fairfield Beach Club Dune Cre- ation	CNI	Dune	Create	Fairfield Beach Rd	NHMP	Build- ings	Private Property	VE	13	5.2	22	Stratford Point to Cedar Point
Jennings Beach Nourishment	CNI	Beach	Nourish (Managed)	South Ben- son Rd	NHMP	Public Access	Town Property	VE	15	5.2	5	Stratford Point to Cedar Point
Jennings Beach Parking Lot Reconstruction	CNI	Road	Abandon	South Ben- son Rd		Ecosys- tems	Town Property	AE	11	5.2	5	Stratford Point to Cedar Point
Jennings Beach/ South Benson Road Flood Pro- tection System	SI	Flood Protection System	Create	South Benson Rd	FECB	Build- ings	Private Property	VE	13	5.2	19	Stratford Point to Cedar Point
Riverside Drive Open Space Dike Enhancement	SI	Flood Protection System	Enhance	Riverside Dr	FECB	Build- ings	Private Property	VE	15	5.2	19	Stratford Point to Cedar Point
Riverside Drive Open Space Tide Gate Enhance- ment	SI	Tide Gate	Enhance	Riverside Dr		Ecosys- tems	Town Property	VE	15	5.2	19	Stratford Point to Cedar Point
Riverside Drive Tide Gate Replacement	SI	Tide Gate	Replace in Kind	Riverside Dr		Ecosys- tems	Town Property	VE	15	5.2	19	Stratford Point to Cedar Point
Ash Creek Sediment Removal	Oth- er	Sediment Removal	New Area	Dalewood Ave		Town Property	Roads	AE	10	5.2	39	Stratford Point to Cedar Point

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	Fairfield Summary													
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) FMI	HUC12		
Pine Creek Main Dike Elevation	SI	Flood Protection System	Enhance	Pine Creek Ave	FECB	Build- ings	Private Property	VE	15	5.2	17	Stratford Point to Cedar Point		
Ash Creek Flood Protection System	Si	Flood Protection System	Create	Riverside Dr	FECB	Build- ings	Private Property	VE	15	5.2	19	Stratford Point to Cedar Point		
Penfield to Fair- field Beach Club Flood Protection System	SI	Flood Protection System	Enhance	Fairfield Beach Rd	FECB	Build- ings	Private Property	VE	13	5.2	22	Stratford Point to Cedar Point		
Jennings Beach Existing Dune Enhancement	CNI	Dune	Enhance	Beach Rd	FECB	Build- ings	Private Property	VE	13	5.2	5	Stratford Point to Cedar Point		
Arising Street Potential GI Retrofit with Bank Stabilization Projects	INI	Bank Protection	Create	Arising St	NHMP	Private Property	Roads	AE	16	5.2	36	Stratford Point to Cedar Point		
Kings Highway Potential GI with Bank Stabilization	INI	Bank Protection	Create	35 Kings Highway	NHMP	Private Property	Roads	AE	16	5.2	19	Stratford Point to Cedar Point		
Benson Road / Beach Parking Lot GI Retrofit	SM	Rain Garden/ Bioswale	Create	Benson Rd	NHMP	Public Access	Town Property	AE	10	5.2	19	Stratford Point to Cedar Point		
Beach Road GI Retrofit	SM	Rain Garden: Bioswale	Create	323 Fairfield Beach Road		Roads	Private Property	AE	10	5.2	23	Stratford Point to Cedar Point		
Fairchild Ave Gl	SM	Rain Garden: Bioswale	Create	Fairchild Ave	NHMP	Roads	Private Property	AE	16	5.2	36	Stratford Point to Cedar Point		
Brooklawn Ave Gl	SM	Rain Garden: Bioswale	Create	Brooklawn Ave	NHMP	Roads	private property	AE	37	5.2	5	Stratford Point to Cedar Point		
Sturges Park GI	SM	Rain Garden: Bioswale	Create	Sturges Park	Rooster River WP	Public Access	Town Property	AE	14	5.2	20	Mill River		
Our Lady of the Assumption Church GI Retrofit with Bank Stabilization	SM	Rain Garden: Bioswale	Create	605 Strat- field Rd	Rooster River WP	Private Property	Build- ings	AE	58	5.2	5	Stratford Point to Cedar Point		

				Fairfield S	ummai	У						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	LMI (%)	HUC12
Post Road Traffic Circle(Route 130) GI Retrofit	SM	Rain Garden: Bioswale	Create	536 Post Rd	Rooster River WP	Roads	Town Property	AE	10	5.2	39	Stratford Point to Cedar Point
Handy and Harman GI Retrofit	SM	Infiltration Galleries	Create	Grasmere Ave and Kings High- way	Rooster River WP	Ecosys- tems	Private Property	AE	10	5.2	26	Stratford Point to Cedar Point
Woodside Circle Riparian Restoration/Bank Stabilization	INI	Bank Protection	Enhance: Modify	Woodside Circle	Rooster River WP	Private Property	Roads	AE	49	5.2	5	Stratford Point to Cedar Point
Owen Fish Park (Lilalyn Park) GI Retrofit	INI	Infiltration Galleries	Create	1443 Strat- field Rd	Rooster River WP	Public Access	Town Property	AE	104	5.2	32	Stratford Point to Cedar Point

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BRIDGEPORT

	Bridgeport Summary													
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	ГМІ (%)	HUC12		
Public Access Erosion Control Measures	CNI	Bulkhead	Replace with Other	Union Ave		Public Access	Private Property	AE	13	5	71	Stratford Point to Cedar Point		
Private Home Bank Protection	CNI	Bank Protection	Create	Webster St		Private Property	Build- ings	AE	13	5	82	Stratford Point to Cedar Point		
West Branch Johnson Creek Living Shoreline	CNI	Living Shoreline	Create	Central Ave		Ecosys- tems	Public Access	AE	13	5	82	Stratford Point to Cedar Point		
New Ferry Ter- minal Shoreline Enhancement	CNI	Bulkhead	Replace with Other	Seaview Ave		Critical Facility	Build- ings	VE	14	5	82	Stratford Point to Cedar Point		
Cooks Point Bass Pro Shop/Mixed Use Site Shoreline Enhancement	CNI	Revetment	Replace with Other	Seaview Ave		Private Property	Build- ings	AE	14	5	82	Stratford Point to Cedar Point		
Bass Pro Shop Store Shoreline Enhancement	CNI	Bank Protection	Enhance	Waterview Ave		Private Property	Build- ings	AE	14	5	68	Stratford Point to Cedar Point		
Yellow Mill Channel Bank Protection - North	CNI	Bank Protection	Create	Waterview Ave		Town Property	Public Access	AE	14	5	68	Stratford Point to Cedar Point		
Yellow Mill Channel Bank Protection - South	CNI	Bank Protection	Create	Waterview Ave		Roads	Public Access	AE	14	5	68	Stratford Point to Cedar Point		
Sliver by the River	SI	Revetment	Replace with Other	Stratford Ave		Town Property	Public Access	AE	12	5	84	Pequon- nock River		
Pequonnock River Greenway/Knowl- ton Park Shore- line Enhancement	SI	Revetment	Replace with Other	Knowlton St		Public Access	Town Property	AE	10	5	72	Pequon- nock River		
Existing Ferry Terminal Redevelopment Shoreline Enhancement	SI	Bulkhead	Replace with Other	Ferry Access Rd		Private Property	Build- ings	AE	14	5	50	Pequon- nock River		
Remington Site Redevelopment Shoreline Enhancement	CNI	Bank Protection	Replace with Other	Main St		Private Property	Build- ings	VE	14	5	50	Stratford Point to Cedar Point		

	Bridgeport Summary													
PROJECT	ТҮРЕ	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12		
Vacant Lot Bank Protection	CNI	Bank Protection	Create	Wordin Ave	NHMP	Private Property	Ecosys- tems	AE	12	5	100	Stratford Point to Cedar Point		
Seaside Village Bioretention Project	SM	Rain Garden: Bioswale	Create	Connecticut Ave	NHMP	Ecosys- tems	Town Property	AE	12	5	50	Stratford Point to Cedar Point		
Pervious Pavers and Trees - Iranistan Avenue	SM	Rain Garden: Bioswale	Create	Iranistan Ave	NHMP	Ecosys- tems	Roads	VE	14	5	50	Stratford Point to Cedar Point		
Pervious Pavers and Trees - South Avenue	SM	Rain Garden: Bioswale	Create	South Ave	NHMP	Ecosys- tems	Roads	AE	12	5	50	Stratford Point to Cedar Point		
Downtown Streetscape Projects	SM	Rain Garden: Bioswale	Create	Bridgeport	NHMP	Ecosys- tems	Roads	Χ	N/A	5	84	Pequon- nock River		
Downtown Demonstration Projects	SM	Rain Garden: Bioswale	Create	Bridgeport	NHMP	Ecosys- tems	Roads	Χ	N/A	5	73	Stratford Point to Cedar Point		
Central High School Rain Garden	SM	Rain Garden: Bioswale	Create	1 Lincoln Blvd	NHMP	Ecosys- tems	Town Property	Χ	N/A	5	58	Stratford Point to Cedar Point		
Classical Studies Magnet Academy	SM	Rain Garden: Bioswale	Create	240 Lin- wood Ave	NHMP	Ecosys- tems	Town Property	X	N/A	5	66	Stratford Point to Cedar Point		
Harding High School	SM	Rain Garden: Bioswale	Create	1734 Central Ave	NHMP	Ecosys- tems	Town Property	Χ	N/A	5	73	Stratford Point to Cedar Point		
Groundwork Tree Nursery Rain Gardens	SM	Rain Garden: Bioswale	Create	Stratford Ave	NHMP	Ecosys- tems	Private Property	X	N/A	5	78	Stratford Point to Cedar Point		
Beardsley Zoo Parking Lot Retrofit	SM	Rain Garden: Bioswale	Create	1875 Noble Ave	NHMP	Ecosys- tems	Roads	AE	N/A	5	44	Stratford Point to Cedar Point		
Johnson Oak Park Jettie S. Tisdale School GI	SM	Rain Garden: Bioswale	Create	Johnson Oak Park	NHMP	Ecosys- tems	Town Property	X	N/A	5	66	Stratford Point to Cedar Point		

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	Bridgeport Summary													
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) IWI	HUC12		
Lafayette Circle GI	SM	Rain Garden: Bioswale	Create	Lafayette Circle	BGreen 2020	Ecosys- tems	Roads	Χ	N/A	5	84	Pequon- nock River		
Pocket Park Stream Resto- ration/Riparian GI	SM	Rain Garden: Bioswale	Create	Madison Ave - Vincel- lette St	Rooster River WP	Ecosys- tems	Build- ings	AE	153	5	25	Stratford Point to Cedar Point		
Crescent Crossing GI	SM	Raise Ground Surface	Create	252 Hallett St	POCD	Ecosys- tems	Build- ings	X	N/A	5	64	Stratford Point to Cedar Point		
Westport Developer Waterfront Development GI	SM	Rain Garden: Bioswale	Create	60 Main St	POCD	Ecosys- tems	Private Property	AE	N/A	5	50	Stratford Point to Cedar Point		
Housatonic Community College GI	SM	Rain Garden: Bioswale	Create	900 Lafay- ette Blvd	NHMP	Ecosys- tems	Town Property	Χ	N/A	5	84	Pequon- nock River		
Ox Brook Flood Control GI	SM	Rain Garden: Bioswale	Create	Elton G. Rogers Park	NHMP	Ecosys- tems	Prviate Property	Х	N/A	5	48	Pequon- nock River		
Seaside Park GI Retrofit	SM	Rain Garden: Bioswale	Create	1 Barnum Dyke	NHMP	Ecosys- tems	Private Property	VE	10	5	50	Stratford Point to Cedar Point		
Knowlton Park GI Retrofit	SM	Rain Garden: Bioswale	Create	Knowlton St	Pe- quon- nock River WP	Ecosys- tems	Town Property	AE	10	5	72	Pequon- nock River		

STRATFORD

	Stratford Summary													
PROJECT	ТҮРЕ	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	ГМІ (%)	HUC12		
Long Beach Dune Restoration	CNI	Dune	Restore	Oak Bluff Ave	NHMP	Public Access	Private Property	VE	16	4.8	27	Stratford Point to Cedar Point		
Russian Beach Bank Protection	CNI	Bank Protection	Create	Park Blvd	NHMP	Roads	Private Property	VE	14	4.8	21	Stratford Point to Cedar Point		
Stratford Point Bank Protection	CNI	Bank Protection	Create	Prospect Dr		Private Property	Build- ings	VE	14	4.8	27	Stratford Point to Cedar Point		
Short Beach Nourishment	CNI	Beach	Nourish (Managed)	Short Beach Rd	NHMP	Public Access	Town Property	VE	14	4.8	27	Housatonic - Naugatuck River to mouth		
WPCF Bank Protection	CNI	Bank Protection	Create	Birdseye St Ext		Sewer System	Town Property	VE	14	5	41	Housatonic - Naugatuck River to mouth		
Raymark Site Bank Protection	CNI	Bank Protection	Create	Birdseye St Ext	NHMP	Private Property	Ecosys- tems	VE	14	5	41	Housatonic - Naugatuck River to mouth		
Raven Stream Bank Protection	CNI	Bank Protection	Create	Diane Terrace	NHMP	Private Property	Build- ings	AE	10	5	5	Housatonic - Naugatuck River to mouth		
Oronoque Shore Condos Bank Protection	CNI	Bank Protection	Create	James- town Rd		Private Property	Build- ings	AE	N/A	5	19	Housatonic - Naugatuck River to mouth		
Tanner Brook Restoration	INI	Stream Channel	Create Floodplain Bench	Broad- bridge Ave	NHMP	Ecosys- tems	Town Property	AE	18	5	32	Housatonic - Naugatuck River to mouth		
South End Stormwater Gl	SM	Rain Garden: Bioswale	Create	Benton St		Private Property	Ecosys- tems	AE	12	5	62	Housatonic - Naugatuck River to mouth		
Bruce Brook Channel Realignment	INI	Stream Channel	Re-align	Bowe Ave		Private Property	Roads	AE	N/A	5	45	Housatonic - Naugatuck River to mouth		

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	Stratford Summary													
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	LMI (%)	HUC12		
Bruce Brook Restoration	INI	Stream Channel	Create Floodplain	Barnum Ave		Ecosys- tems	Town Property	AE	26	5	45	Housatonic - Naugatuck River to mouth		
Stratford Square GI	SM	Rain Gar- den-Bioswale	Create	Avery St (Parking Lot)	Housa- tonic River Basin NRRP	Build- ings	Roads	X	9	4.8	48	Housatonic - Naugatuck River to mouth		
Bruce Brook Park Gl	SM	Rain Garden: Bioswale	Enhance: Modify	Clover St	NHMP	Public Access	Ecosys- tems	AE	44	5	32	Housatonic - Naugatuck River to mouth		
Route 110 GI Retrofit	SM	Rain Garden: Bioswale	Create	5099 Main St	Housa- tonic River NRRP	Town property	Roads	AE	25	5	19	Housatonic - Naugatuck River to mouth		
Boothe Parking lot GI Retrofit	SM	Rain Garden: Bioswale	Create	5800 Main St	Housa- tonic River NRRP	Town Property	Ecosys- tems	Х	N/A	5	19	Housatonic - Naugatuck River to mouth		
River Road GI Retrofit	SM	Rain Garden: Bioswale	Create	5821 River Rd	Housa- tonic River NRRP	Roads	Ecosys- tems	Х	N/A	5	19	Housatonic - Naugatuck River to mouth		
Roger Sherman Baldwin Park Gl Retrofit	SM	Rain Garden: Bioswale	Create	Roger Sherman Baldwin Park	Housa- tonic River NRRP	Public Access	Town Property	Х	N/A	4.8	19	Housatonic - Naugatuck River to mouth		
Freeman Brook Gl/Bank Stabili- zation	INI	Bank Protection	Enhance: Modify	1 Tangle- wood Rd	Housa- tonic River NRRP	Ecosys- tems	Town Property	Х	N/A	5	19	Housatonic - Naugatuck River to mouth		
Main St. Parking Lot GI Retrofit	SM	Rain Garden: Bioswale	Create	6427 Main St	Housa- tonic River NRRP	Town Property	Roads	Х	N/A	5	19	Housatonic - Naugatuck River to mouth		
Sikorsky Estuary Walk Gl Retrofit	SM	Rain Garden: Bioswale	Create	Sikorsky Estuary Walk	Housa- tonic River NRRP	Public Access	Town Property	AE	N/A	5	19	Housatonic - Naugatuck River to mouth		

				Stratfor	d Sumi	mary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	(_")	LMI (%)	HUC12
Long Brook Park Gl Retrofit	SM	Rain Garden: Bioswale	Create	Long Brook Park	Housa- tonic River NRRP	Public Access	Town Property	Х	N/A	5	26	Housatonic - Naugatuck River to mouth
American Shakespeare Park GI Retrofit	SM	Rain Garden: Bioswale	Create	American Shake- speare Park	Housa- tonic River NRRP	Public Access	Town Property	AE	10	5	41	Housatonic - Naugatuck River to mouth

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MILFORD

				Milford	l Sumn	nary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12
Laurel Beach Nourishment	CNI	Beach	Nourish (Managed)	Grant St		Private Property	Build- ings	VE	15	5	76	Housatonic - Naugatuck River to mouth
Wildemere Beach Nourishment	CNI	Beach	Nourish (New)	Bitter- sweet Ave	NHMP	Private Property	Build- ings	VE	15	4.7	27	Housatonic - Naugatuck River to mouth
Walnut Beach/ East Broadway GI	SM	Rain Garden: Bioswale	Create	East Broadway		Ecosys- tems	Roads	VE	14	4.7	67	Housatonic - Naugatuck River to mouth
Walnut Beach Dune Creation	CNI	Dune	Create	East Broadway		Private Property	Town Property	AE	13	4.7	38	Housatonic - Naugatuck River to mouth
Silver Sands State Park Flood Protection	CNI	Flood Protection System	Create	Samuel Smith Lane		Build- ings	Private Property	VE	14	4.7	34	Milford Harbor - Wepawaug and Indian R.
Silver Sands State Park Tide Gate Replacement	SI	Tide Gate	Replace with Other	Samuel Smith Lane		Ecosys- tems	Town Property	VE	14	4.7	34	Milford Harbor - Wepawaug and Indian R.
Home Acquisition - Caroline St	CNI	Building	Acquire: Demolish	23 Caro- line St	NHMP	Build- ings	Ecosys- tems	AE	12	4.7	34	Milford Harbor - Wepawaug and Indian R.
Home Acquisition - Blair St	CNI	Building	Acquire: Demolish	15 Blair St	NHMP	Build- ings	Ecosys- tems	AE	13	4.7	34	Milford Harbor - Wepawaug and Indian R.
Gulf Beach "Breakwater" Repairt	SI	Groin	Replace in Kind	Gulf St		Town Property	Roads	VE	13	4.7	14	Milford Harbor - Wepawaug and Indian R.
Bayview Beach Nourishment	CNI	Beach	Nourish (New)	Deerfield Ave		Private Property	Build- ings	VE	13	4.7	13	Quinnipiac River to Welches Point

	Milford Summary													
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) IWI	HUC12		
Bayview Beach Drainage	SM	Stormwater Infrastructure	Enhance: Modify	Deerfield Ave	NHMP	Roads	Private Property	VE	13	4.7	13	Quinnipiac River to Welches Point		
Calf Pen Meadow Creek Restoration	Oth- er	Sediment Removal	New Area	Melba St	NHMP	Roads	Private Property	AE	12	4.7	13	Housatonic - Naugatuck River to mouth		
Calf Pen Meadow Creek Tide Gate	SI	Tide Gate	Create	Melba St		Build- ings	Private Property	AE	11	4.7	13	Quinnipiac River to Welches Point		
Point Beach Drive Condos Bank Protection	CNI	Bank Protection	Replace with Other	Point Beach Dr		Private Property	Build- ings	VE	20	4.7	9	Quinnipiac River to Welches Point		
Morningside "Revetment" Bank Protection	CNI	Bank Protection	Create	Hilldale Court		Private Property	Build- ings	VE	20	4.7	9	Quinnipiac River to Welches Point		
Woodmont Beach Nourishment	CNI	Beach	Nourish (Managed)	Beach Ave		Private Property	Build- ings	VE	14	4.7	23	Quinnipiac River to Welches Point		
Wepawaug River Sediment Removal	Oth- er	Sediment Removal	New Area	Various roads	NHMP	Town Property	Private Property	AE	N/A	4.7	27	Milford Harbor - Wepawaug and Indian R.		
Rain Gardens Installation	SM	Rain Garden: Bioswale	Create	Various roads		Ecosys- tems	Town Property	AE	N/A	4.7	27	Milford Harbor - Wepawaug and Indian R.		
Rain Garden Near Egan Center	SM	Rain Garden: Bioswale	Create	Mathew St		Ecosys- tems	Town Property	AE	11	4.7	36	Housatonic - Naugatuck River to mouth		
Home Acquisition	CNI	Building	Acquire: Demolish	Melba St		Build- ings	Ecosys- tems	VE	13	4.7	13	Quinnipiac River to Welches Point		

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				Milford	l Sumn	nary						
PROJECT	ТҮРЕ	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12
Calf Pen Meadow Creek -Sediment Removal	Oth- er	Sediment Removal	New Area	Melba St	NRCS	Roads	Private Property	AE	12	4.7	13	Quinnipiac River to Welches Point
Calf Pen Meadow Creek Marsh Restoration	CNI	Tidal Marsh	Restore (Direct Repair)		NRCS	Ecosys- tems	Private Property	AE	12	4.7	15	Quinnipiac River to Welches Point
Calf Pen Meadow Creek Marsh Acquisition	CNI	Tidal Marsh	Undeter- mined		NRCS	Ecosys- tems	Private Property	AE	12	4.7	15	Quinnipiac River to Welches Point
Beaverbrook WWTP Flood Protection	SI	Flood Protection System	Create	Deer- wood Ave	NHMP	Critical Facility	Town Property	VE	13	4.7	36	Housatonic - Naugatuck River to mouth
Beaverbrook WWTP Land Acquisition	CNI	Tidal Marsh	Undeter- mined	Deer- wood Ave		Ecosys- tems	Town Property	VE	13	4.7	36	Housatonic - Naugatuck River to mouth
Crescent Beach Nourishment	CNI	Beach	Nourish (Managed)	Beach Ave		Roads	Public Access	VE	14	4.7	23	Quinnipiac River to Welches Point
Home Acquisition - Cooper Ave	CNI	Building	Acquire: Demolish	84 Coo- per Ave	NRCS	Build- ings	Ecosys- tems	AE	11	4.7	34	Milford Harbor - Wepawaug and Indian R.
Home Acquisition - Tremont St	CNI	Building	Acquire: Demolish	21 Tremont St	NRCS	Build- ings	Ecosys- tems	AE	13	4.7	34	Milford Harbor - Wepawaug and Indian R.
Eisenhower Park GI Retrofit	SM	Infiltration Galleries	Create	Eisen- hower Park	NHMP	Ecosys- tems	Town Property	AE	54	4.7	13	Milford Harbor - Wepawaug and Indian R.
Edgemont Road & Grove Circle Park Gl Retrofit	SM	Rain Garden: Bioswale	Create	Edge- mont Rd	NHMP	Build- ings	Town Property	AE	9	4.7	32	Milford Harbor - Wepawaug and Indian R.

				Milford	l Sumn	nary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) FWI	HUC12
Point Road GI Retrofit	SM	Rain Garden: Bioswale	Create	Milford Point Rd	NHMP	Roads	Town Property	VE	10	4.6	19	Milford Harbor - Wepawaug and Indian R.
Silver Sands State Park GI Retrofit	SM	Rain Garden: Bioswale	Create	Silver Sands State Park	NHMP	Public Access	Ecosys- tems	AE	9	4.6	34	Milford Harbor - Wepawaug and Indian R.

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WEST HAVEN

			,	West Hav	en Sur	nmary						
PROJECT	ТҮРЕ	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12
Condominium Erosion Protection	CNI	Bank Protection	Create	Bayview Place		Private Property	Build- ings	VE	12	4.6	43	Quinnipiac River to Welches Point
Property Acquisitions - Phase I (13 homes)	CNI	Building	Acquire: Demolish	Third Ave	NHMP	Build- ings	Ecosys- tems	AE	10	4.6	73	Quinnipiac River to Welches Point
Property Acquisitions - Phase II (15 homes)	CNI	Building	Acquire: Demolish	Third Ave	NHMP	Build- ings	Ecosys- tems	AE	12	4.6	73	Quinnipiac River to Welches Point
Old Field Creek Sediment Removal	Oth- er	Sediment Removal	New Area	Blohm St		Private Property	Ecosys- tems	AE	11	4.6	73	Quinnipiac River to Welches Point
Old Field Creek Headwaters Plunge Pool Creation	SM	Stormwater Infrastructure	Create	Peck Ave		Private Property	Ecosys- tems	AE	10	4.6	43	Quinnipiac River to Welches Point
Morse Beach/ Savin Rock Beach Nourishment	CNI	Beach	Nourish (New)	Beach St	NHMP	Public Access	Private Property	VE	12	4.6	73	Quinnipiac River to Welches Point
Morse Beach Nourishment	CNI	Beach	Nourish (Managed)	Beach St	NHMP	Public Access	Private Property	VE	12	4.6	73	Quinnipiac River to Welches Point
West Haven Beach Nourish- ment and Dune Creation	CNI	Dune	Restore	Altschuler Plaza	NHMP	Build- ings	Private Property	VE	12	4.6	48	Quinnipiac River to Welches Point
Cove River Tide Gates Replace- ment	SI	Tide Gate	Replace with Other	Captain Thomas Blvd/ Ocean Avenue	NHMP	Ecosys- tems	Roads	VE	13	4.6	48	Quinnipiac River to Welches Point
Cove River Sediment Removal	Oth- er	Sediment Removal	New Area	Educa- tional Way		Private Property	Ecosys- tems	AE	11	4.6	31	Quinnipiac River to Welches Point

			,	West Hav	en Sur	nmary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) IWI	HUC12
Ocean Avenue Beach Nourishment	CNI	Beach	Nourish (Managed)	Ocean Ave	NHMP	Public Access	Town Property	VE	13	4.6	20	Quinnipiac River to Welches Point
Cove River Flood Control	INI	Stream Channel	Enhance: Modify	432 Paint- er Dr & 594 West Main St	NHMP	Ecosys- tems	Roads	AE	10	4.6	31	Quinnipiac River to Welches Point
Notre Dame High School GI Retrofit	SM	Rain Garden: Bioswale	Create	24 Ricar- do St	West River WP	Build- ings	Town Property	AE	127	4.6	53	West River
Forest School GI	SM	Rain Garden: Bioswale	Create	95 Bur- well Rd	West River WP	Build- ings	Town Property	AE	N/A	4.6	65	West River
North End Field GI Retrofit	SM	Rain Garden: Bioswale	Create	1101 Campbell Ave	West River WP	Public Access	Ecosys- tems	AE	N/A	4.6	44	West River
Quigley Field GI Retrofit	SM	Rain Garden: Bioswale	Create	364 Front Ave	West River WP	Public Access	Ecosys- tems	AE	N/A	4.6	44	West River
West River Memo- rial Park GI	SM	Rain Garden: Bioswale	Create	West River Memorial Park	West River WP	Ecosys- tems	Town Property	AE	10	4.6	84	West River

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NEW HAVEN

				New Hav	en Sun	nmary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) FMI	HUC12
East Shore Park Enhancement	CNI	Bank Protection	Create	Wood- ward Ave	NHMP	Public Access	Town Property	VE	14	4.6	25	Tuttles Point to Quinnipiac River
Long Wharf Park Enhancement	CNI	Bank Protection	Create	Long Wharf Dr	NHMP	Roads	Sewer System	VE	13	4.6	89	Quinnipiac River to Welches Point
Fire Training Academy Bank Protection	CNI	Bank Protection	Create	230 Ella Grasso Blvd	NHMP	Town Property	Build- ings	AE	10	4.6	59	West River
East Bank Protection at Mill River Upstream of Grand Ave	CNI	Bank Protection	Create	John Mur- phy Dr	NHMP	Private Property	Build- ings	AE	12	4.6	76	Mill River
Morris Creek Tide Gates	SI	Flood Protection System	Create	Cart Rd	NHMP	Private Property	Build- ings	AE	12	4.6	11	Mill River
Hill-to-Downtown/ Union Avenue GI System	SM	Rain Garden: Bioswale	Create	Various roads		Ecosys- tems	Private Property	AE	11	4.6	63	Quinnipiac River to Welches Point
Long Wharf Area Flood Protection	SI	Flood Protection System	Create	Various roads		Private Property	Roads	AE	12	4.6	89	Quinnipiac River to Welches Point
Hill Neighbor- hood Drainage Improvements Study	SM	Stormwater Infrastructure	Enhance	Various roads		Private Property	Roads	AE	11	4.6	54	Quinnipiac River to Welches Point
West River Water- shed Restoration & New Haven GI Projects	SM	Rain Garden: Bioswale	Create	West Park Ave - Edge- wood School	West River WP	Ecosys- tems	Town Property	AE	N/A	4.6	26	West River
Edgewood Park & Duck Pond Restoration	INI	Bank Protection	Replace in Kind	Edge- wood Park and Duck Pond	West River WP	Ecosys- tems	Private Property	AE	10	4.6	44	West River
New Haven Stormwater and Sewer Overflow GI Scan	SM	Rain Garden: Bioswale	Create	City of New Haven	Hazen and Saw- yer	Roads	Build- ings	X	N/A	4.6	71	West River

				New Hav	en Sur	nmary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) FWI	HUC12
Post Office & Fire Station GI Retrofit	SM	Rain Garden: Bioswale	Create	95 Foun- tain St	West River WP	Build- ings	Town Property	Х	N/A	4.6	50	West River
Hydraulic/Flood Analysis of West River - Pond Lily to Konolds Pond	SM	Sewer Infrastructure	Modify	Whalley Ave	West River WP	Ecosys- tems	Build- ings	Х	N/A	4.6	66	West River
Malcolm Stormwater Management Pilot Program Study	SM	Sewer Infrastructure	Create	City of New Haven	West River WP	Public Access	Ecosys- tems	X	N/A	4.6	45	West River
Defender's Park GI Retrofit	SM	Rain Garden: Bioswale	Create	Columbus Ave and Congress Ave	West River WP	Ecosys- tems	Public Access	AE	10	4.6	80	West River
West River Tide Gate	SI	Tide Gate	Create	Boston Post Rd	West River WP	Roads	Private Property	VE	10	4.6	67	Mill River
GNHWPC Green Infrastructure Suitability Pilot Study	SM	Sewer Infrastructure	Create	City of New Haven	West River WP	Public Access	Town Property	Х	N/A	4.6	45	West River
West River Memorial Park Restoration	SM	Rain Garden: Bioswale	Create	West River Memorial Park	West River WP	Roads	Town Property	AE	10	4.6	86	West River
West River Watershed Green Infrastructure Retrofit Screening Study	SM	Rain Garden: Bioswale	Create	West River Wa- tershed	West River WP	Build- ings	Town Property	Х	N/A	4.6	86	West River
Adult Education Center GI Retrofit and Riparian Restoration	INI	Bank Protection	Create	580 Elle T Grasso Blvd	West River WP	Build- ings	Town Property	AE	10	4.6	67	West River
Ann Street Playground GI	SM	Rain Garden: Bioswale	Create	Ann St	West River WP	Ecosys- tems	Town Property	Χ	N/A	4.6	89	West River
Monitor Square GI Retrofit	SM	Rain Garden: Bioswale	Create	Monitor Square	West River WP	Build- ings	Town Property	X	N/A	4.6	86	West River

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				New Hav	en Sur	nmary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	ГМІ (%)	HUC12
Quinnipiac River Park GI Retrofit	SM	Rain Garden: Bioswale	Create	Front St	Quin- nipiac WP	Build- ings	Town Property	AE	10	4.6	76	Quinnipi- ac-Hanover Pond Dam to mouth
Quinnipiac Riverbank Gl Retrofit	INI	Bank Protection	Create	Front St	Quin- nipiac WP	Build- ings	Town Property	AE	10	4.6	76	Quinnipiac River to Welches Point
Quinnipiac Ave, Foxon Street GI Retrofit	SM	Rain Garden: Bioswale	Create	Foxon St	Quin- nipiac WP	Ecosys- tems	Public Access	AE	10	4.6	57	Quinnipi- ac-Hanover Pond Dam to mouth
James Hillhouse High School GI	SM	Rain Garden: Bioswale	Create	480 Sherman Pkwy	West River WP	Public Access	Town Property	X	N/A	4.6	93	Quinnipi- ac-Hanover Pond Dam to mouth
Hilltop Playground GI and Green Streets	SM	Rain Garden: Bioswale	Create	23 Hilltop Rd	West River WP	Roads	Build- ings	Χ	N/A	4.6	13	West River
Lenox Street & Aner Street GI Streetscapes	SM	Rain Garden: Bioswale	Create	Lenox St and Aner St	Quin- nipiac WP	Ecosys- tems	Public Access	X	N/A	4.6	69	Quinnipi- ac-Hanover Pond Dam to mouth
Hill Regional Career High School Potential GI and Streetscapes	SM	Rain Garden: Bioswale	Create	140 Le- gion Ave	West River WP	Roads	Build- ings	X	N/A	4.6	77	West River
Strong School GI Retrofit	SM	Rain Garden: Bioswale	Create	130 Or- chard St	West River WP	Roads	Build- ings	Χ	N/A	4.6	75	West River
Clinton Ave School & Clinton Park GI Retrofit	SM	Rain Garden: Bioswale	Create	293 Clin- ton Ave	Quin- nipiac WP	Roads	Build- ings	Х	N/A	4.6	69	Quinnipi- ac-Hanover Pond Dam to mouth
Lighthouse Rd, and Light House Point Park GI Retrofit	SM	Rain Garden: Bioswale	Create	21 Light- house Rd	NHMP	Roads	Build- ings	AE	11	4.6	11	Tuttles Point to Quinnipiac River

				New Hav	en Sur	nmary						
PROJECT	ТҮРЕ	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) FWI	HUC12
Barnard School GI Retrofit	SM	Rain Garden: Bioswale	Create	170 Derby Ave	West River WP	Ecosys- tems	Public Access	Х	N/A	4.6	81	West River
Troupe School GI Retrofit	SM	Rain Garden: Bioswale	Create	Edge- wood Ave	West River WP	Roads	Build- ings	Χ	N/A	4.6	79	West River
Fair Haven Middle School GI Retrofit	SM	Rain Garden: Bioswale	Create	164 Grand Ave	Quin- nipiac WP	Roads	Build- ings	Х	N/A	4.6	76	Quinnipi- ac-Hanover Pond Dam to mouth
MLK Peace Garden GI Retrofit	SM	Rain Garden: Bioswale	Create	24 Ade- line St	West River WP	Roads	Build- ings	Χ	N/A	4.6	80	West River
McClain Park GI Retrofit	SM	Rain Garden: Bioswale	Create	Washing- ton Ave	West River WP	Build- ings	Private Property	Χ	N/A	4.6	67	West River
Edgewood Pond & Park Invasive Species Removal	INI	Bank Protection	Restore (Direct Repair)	Edge- wood Park Pond	West River WP	Roads	Town Property	AE	10	4.6	44	West River

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EAST HAVEN

				East Hav	en Sun	nmary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12
Home Elevation - 2nd Avenue	CNI	Building	Acquire: Demolish	37 2nd Ave	NHMP	Build- ings	Private Property	AE	12	4.5	36	Tuttles Point to Quinnipiac River
Town Beach Nourishment	CNI	Beach	Nourish (Managed)	Cosey Beach Ave	NHMP	Public Access	Town Property	VE	14	4.5	33	Tuttles Point to Quinnipiac River
Town Beach Dune Creation	CNI	Dune	Create	Cosey Beach Ave		Roads	Build- ings	VE	14	4.5	33	Tuttles Point to Quinnipiac River
Victoria Beach Condominiums Bank Enhancement	CNI	Bank Protection	Enhance	2nd Ave		Build- ings	Private Property	VE	14	4.5	33	Tuttles Point to Quinnipiac River
Farview Road Abandonment	НІ	Road	Abandon	Farview Rd		Roads	Ecosys- tems	AE	12	4.5	20	Tuttles Point to Quinnipiac River
Brazos Road Abandonment	НІ	Road	Abandon	Brazos Rd		Roads	Ecosys- tems	AE	12	4.5	20	Tuttles Point to Quinnipiac River
Marsh Creation -Unpaved Sewer Easement to Silver Sands Club	НІ	Road	Create	Farview Rd		Ecosys- tems	Roads	AE	12	4.5	20	Tuttles Point to Quinnipiac River
Vacant Lot Acquisition on Caroline Road	CNI	Building	Create	Caroline Rd		Ecosys- tems	Build- ings	AE	12	4.5	20	Tuttles Point to Quinnipiac River
Maple Street Bridge GI Retrofit	INI	Bank Protection	Create	Maple Street Bridge	NHMP	Public Access	Town Property	AE	10	4.5	37	Farm River
Kennedy Memori- al Field GI Retrofit	SM	Rain Garden: Bioswale	Create	Kennedy Memorial Field	NHMP	Ecosys- tems	Town Property	Χ	N/A	4.5	37	Farm River
Church Parking Lots GI Retrofit	SM	Rain Garden: Bioswale	Create	355 Fox- on Rd	NHMP	Ecosys- tems	Town Property	Х	N/A	4.5	38	Farm River
Parking Lot GI Retrofit and Bank Stabilization	SM	Rain Garden: Bioswale	Create	1215 N High St	NHMP	Roads	Town Property	AE	35	4.5	72	Farm River
Open Space and Bank Stabilization	SM	Rain Garden: Bioswale	Create	1 Van Horn Dr & 20 Hellis- trom	NHMP	Build- ings	Private Property	AE	27	4.5	45	Farm River

				East Hav	en Sun	nmary						
PROJECT	ТҮРЕ	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) IWI	HUC12
Laurel Woods GI and Bank Stabilization	SM	Rain Garden: Bioswale	Create	Apple Rehab Laurel Woods	NHMP	Roads	Town Property	AE	22	4.5	42	Farm River
Roads - GI with Green Street Concepts	SM	Rain Garden: Bioswale	Create	Waldo St, Edgar St, Burgess St, Memo- rial Field	NHMP	Ecosys- tems	Private Property	AE	10	4.5	53	Farm River

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BRANFORD

				Branfor	d Sum	mary						
PROJECT	ТҮРЕ	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12
Linden Avenue at Bayberry Lane Bank Protection	CNI	Bank Protection	Create	Linden Ave	NHMP	Roads	Sewer System	VE	14	4.3	16	Tuttles Point to Quinnipiac River
Linden Avenue at Old Pawson Road Replacement - Collapsing Wall	CNI	Bank Protection	Replace with Other	Linden Ave	NHMP	Roads	Sewer System	VE	14	4.3	16	Tuttles Point to Quinnipiac River
Linden Avenue at Old Pawson Road Bank Protection	CNI	Bank Protection	Create	Linden Ave	NHMP	Roads	Sewer System	VE	14	4.3	16	Tuttles Point to Quinnipiac River
Linden Avenue at Linden Shores Bank Protection	CNI	Bank Protection	Replace with Other	Linden Ave	NHMP	Roads	Sewer System	VE	14	4.3	17	Tuttles Point to Quinnipiac River
Limewood Beach Roadway Protection and Beach Enhancement	CNI	Bank Protection	Replace with Other	Lime- wood Ave		Roads	Sewer System	VE	15	4.3	17	Tuttles Point to Quinnipiac River
Pine Orchard Bank Protection	CNI	Bank Protection	Create	Ozone Rd		Private Property	Build- ings	VE	15	4.3	14	Tuttles Point to Quinnipiac River
Stony Creek Beach Living Shoreline	CNI	Living Shoreline	Create	Thimble Island Rd		Public Access	Town Property	VE	12	4.3	14	Tuttles Point to Quinnipiac River
Howard Avenue Bank Protection	CNI	Bank Protection	Create	Howard Ave		Roads	Sewer System	VE	21	4.3	23	Tuttles Point to Quinnipiac River
Shore Drive Town Open Space Shoreline Enhancement	SI	Revetment	Replace with Other	Shore Dr		Roads	Town Property	VE	14	4.3	23	Tuttles Point to Quinnipiac River
Beckett Avenue Beach Resilience	Oth- er	Undeter- mined	Undeter- mined	Beckett Ave		Build- ings	Private Property	VE	14	4.3	29	Tuttles Point to Quinnipiac River
Clark Avenue Beach Resilience	Oth- er	Undeter- mined	Undeter- mined	Clark Ave		Roads	Build- ings	VE	14	4.3	29	Tuttles Point to Quinnipiac River
Indian Neck Avenue RR Underpass Flood System	SI	Flood Protection System	Create	Meadow St	NHMP	Critical Facility	Build- ings	AE	12	4.3	34	Tuttles Point to Quinnipiac River

				Branfor	d Sum	mary						
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	LMI (%)	HUC12
Jarvis Creek Es- tuary Tidal Marsh Restoration	CNI	Tidal Marsh	Restore (Direct Repair)			Ecosys- tems	Town Property	VE	13	4.3	14	Tuttles Point to Quinnipiac River
Pine Orchard Beach Nourishment	CNI	Beach	Nourish (New)	Island View Rd		Build- ings	Private Property	VE	15	4.3	14	Tuttles Point to Quinnipiac River
Route 146 Tide Gates Replace- ment	SI	Tide Gate	Replace in Kind	Route 146		Ecosys- tems	Town Property	AE	12	4.3	16	Tuttles Point to Quinnipiac River
Tabor Road Aban- donment	HI	Road	Abandon	Tabor Rd		Roads	Ecosys- tems	AE	12	4.3	17	Branford River
Pine Creek Estuary Marsh Restoration	CNI	Tidal Marsh	Restore (Direct Repair)			Ecosys- tems	Town Property	VE	12	4.3	14	Tuttles Point to Quinnipiac River
Eversource Energy Substation Flood System	INI	Flood Protection System	Create	East Main St		Critical Facility	Private Property	AE	N/A	4.3	20	Branford River
Branford Atlantic Wire Develop- ment	SM	Rain Garden: Bioswale	Enhance: Modify	Meadow St	NHMP	Ecosys- tems	Town Property	AE	10	4.3	51	Branford River
75 School Ground Road GI Retrofit	INI	Bank Protection	Enhance: Modify	75 School Ground Rd	NHMP	Ecosys- tems	Private Property	AE	26	4.3	20	Branford River
Mill Plain Road Gl Retrofit	INI	Bank Protection	Create	49 Mill Plain Rd	NHMP	Roads	Build- ings	AE	13	4.3	20	Branford River
East Main Street GI Retrofit	SM	Rain Garden: Bioswale	Create	East Main St	NHMP	Ecosys- tems	Roads	AE	11	4.3	45	Branford River
Brushy Plain Road Gl Retrofit	INI	Bank Protection	Create	Brushy Plain Rd	NHMP	Ecosys- tems	Private Property	Χ	N/A	4.3	23	Branford River
Laurel Hill Road GI Retrofit	INI	Bank Protection	Create	Laurel Hill Rd	NHMP	Ecosys- tems	Private Property	Χ	N/A	4.3	23	Branford River
North Branford Road GI Retrofit	SM	Rain Garden: Bioswale	Create	137 North Branford Rd	NHMP	Build- ings	Private Property	AE	22	4.3	20	Branford River
NE Industrial Road GI Retrofit	SM	Rain Garden: Bioswale	Create	20 NE Industrial Rd	NHMP	Build- ings	Ecosys- tems	AE	23	4.3	20	Branford River
School Ground Road GI Retrofit	SM	Rain Garden: Bioswale	Create	School Ground Rd	NHMP	Roads	Ecosys- tems	AE	26	4.3	20	Branford River

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GUILFORD

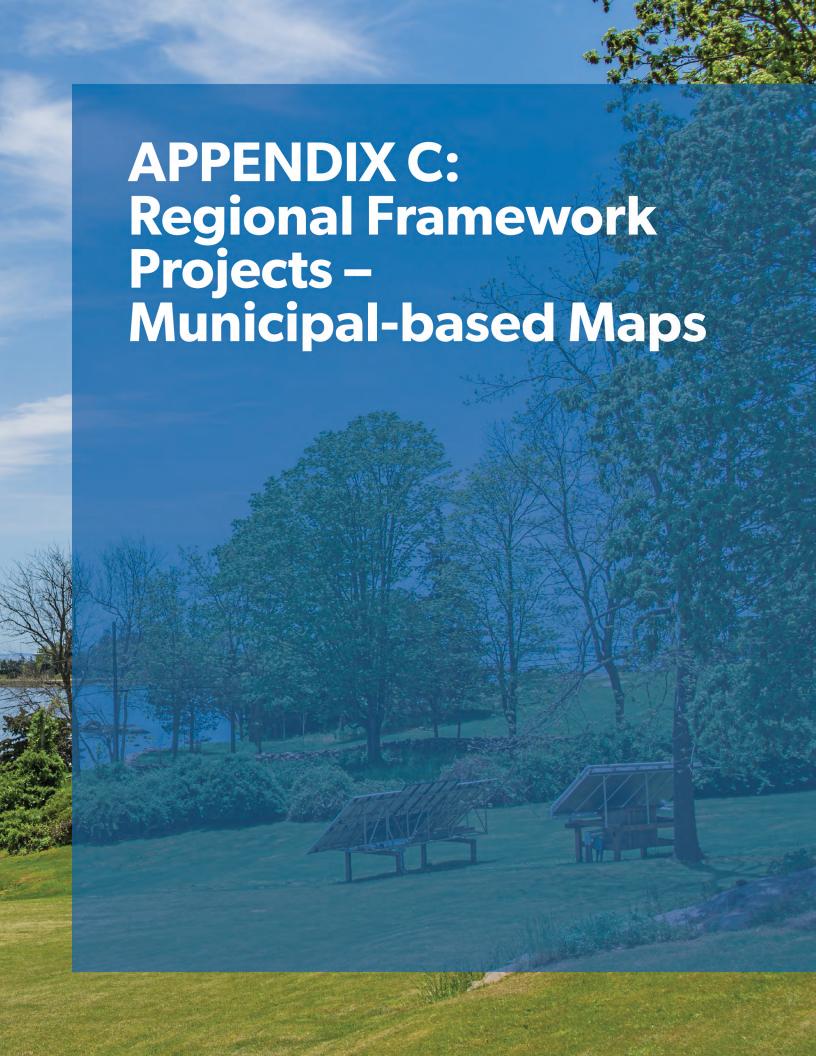
Guilford Summary												
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%)	HUC12
Chittenden Beach Living Shoreline	CNI	Living Shoreline	Create	Seaside Ave	DOI/ NFWF	Ecosys- tems	Town Property	VE	14	4	19	West River
Long Cove at Daniel Avenue Stream Channel Modification	SM	Stream Channel	Enhance: Modify	Danel Ave	DOI/ NFWF	Ecosys- tems	Roads	VE	14	4	29	Tuttles Point to Quinnipiac River
Long Cove Up- stream Hydrologic Restoration	CNI	Tidal Marsh	Remove Obstruc- tion	Sachem Head Rd - Mulberry Point Rd	DOI/ NFWF	Roads	Ecosys- tems	VE	14	4	29	Tuttles Point to Quinnipiac River
Leetes Marsh Restoration	CNI	Tidal Marsh	Restore (Tidal Flow)	Shell Beach Rd	DOI/ NFWF	Ecosys- tems	Roads	AE	12	4	8	Tuttles Point to Quinnipiac River
Jacobs Beach Nourishment	CNI	Beach	Nourish (Managed)	Seaside Ave	NHMP	Public Access	Town Property	VE	14	4	19	East River
Grass Island Living Shoreline	CNI	Living Shoreline	Create	Circle Beach Rd	NHMP	Critical Facility	Ecosys- tems	VE	13	4	25	Tuttles Point to Quinnipiac River
Lake Dr. Gl	SM	Rain Garden: Bioswale	Create	Lake Dr	NHMP	Public Access	Town Property	AE	N/A	4	10	West River
Bittner Park GI Retrofit	SM	Rain Garden: Bioswale	Create	Bittner Park	NHMP	Public Access	Town Property	AE	78	4	13	West River
West Street GI	SM	Rain Garden: Bioswale	Create	West St & County Rd	NHMP	Roads	Private Property	X	N/A	4	13	Branford River
Meadow Road GI	SM	Rain Garden: Bioswale	Create	Meadow Rd	NHMP	Roads	Private Property	AE	82	4	14	East River

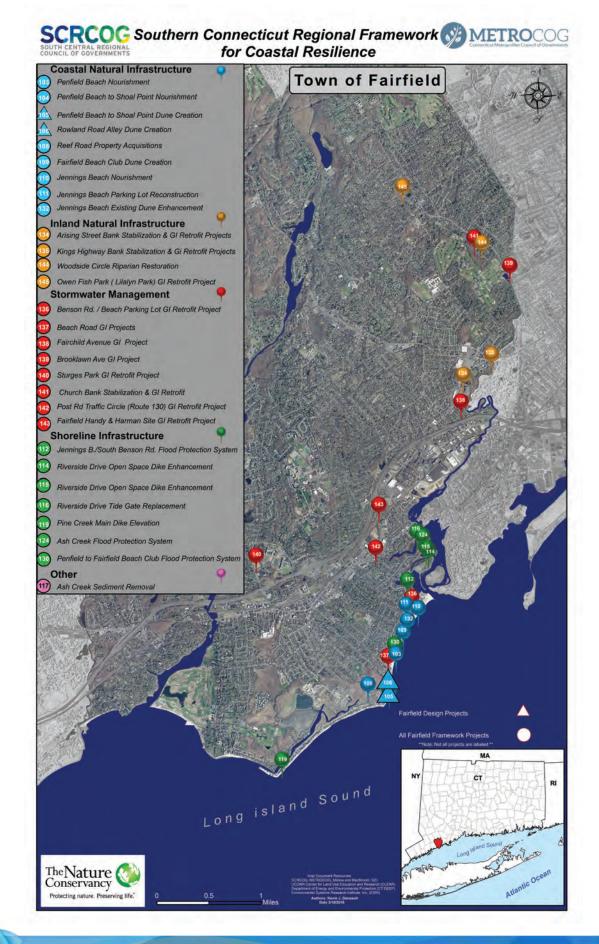
MADISON

Madison Summary												
PROJECT	TYPE	STRATEGY	ACTION	ADDRESS	PLAN REFERENCE	RISK - PRIMARY	RISK - SECOND	FLOOD ZONE	BASE FLOOD ELV (")	CJL (")	(%) FWI	HUC12
Smith Bay Flood Risk Reduction	Oth- er	Undeter- mined	Undeter- mined	Twin Coves Rd - Shore- lands Dr		Build- ings	Private Property	VE	14	3.7	25	Cedar to Hogshead Point Drain- ages
Madison Surf Club Dune Restoration	CNI	Dune	Restore	Surf Club Rd	NHMP	Private Property	Town Property	VE	14	3.7	6	Cedar to Hogshead Point Drain- ages
Five Field Road - Hammonasset River Gl	INI	Bank Protection	Enhance: Modify	143 Five Field Rd	NHMP	Ecosys- tems	Public Access	VE	14	5	14	Hammonas- set River
New Meigs Point Nature Center Gl Retrofit	SM	Rain Garden: Bioswale	Restore (Direct Repair)	Meigs Point Nature Center	POCD	Ecosys- tems	Private Property	VE	10	5	16	Cedar to Hogshead Point Drain- ages
Seaview Ave Shoreline En- hancement	CNI	Dune	Enhance: Modify	Seaview Ave		Public Access	Private Property	VE	11	3.7	16	Cedar to Hogshead Point Drain- ages

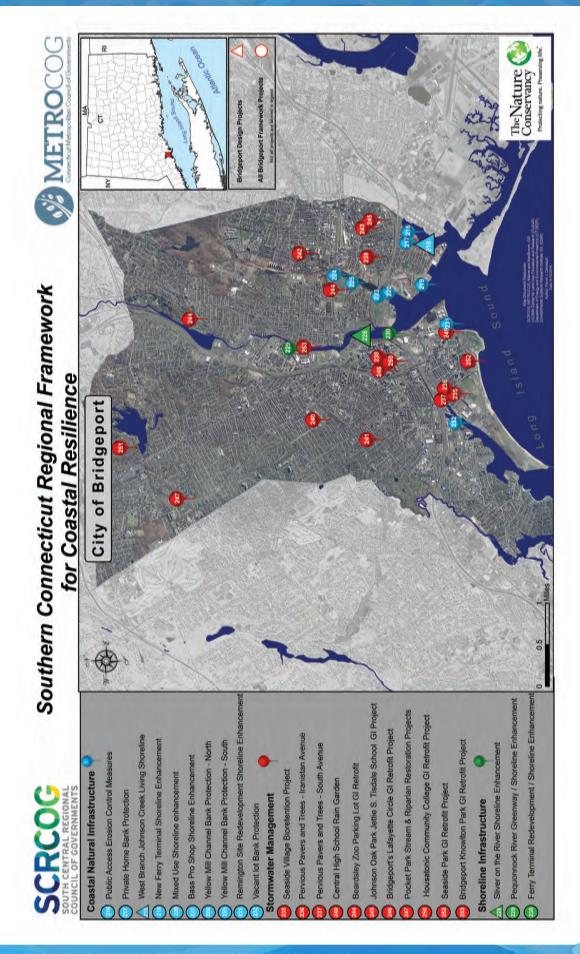
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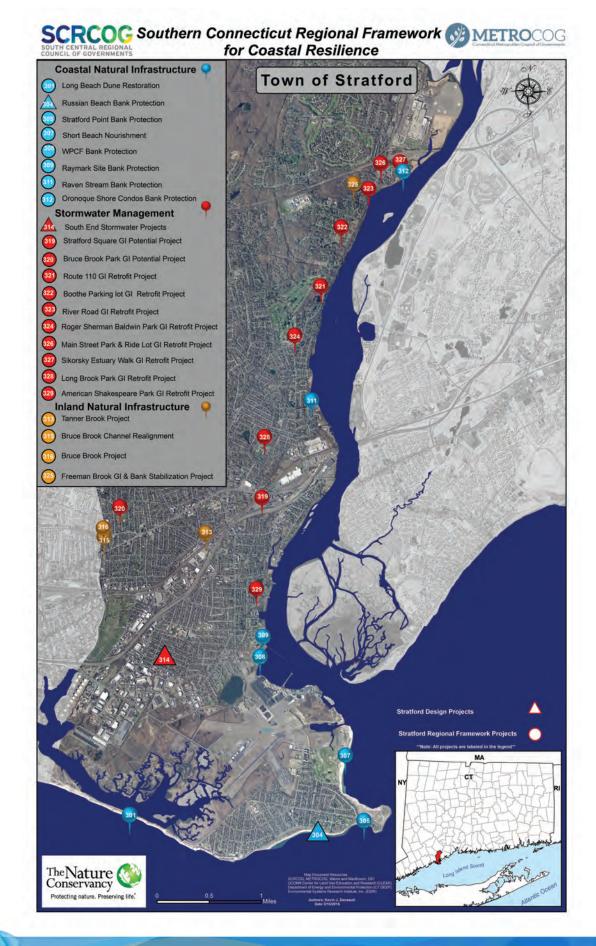




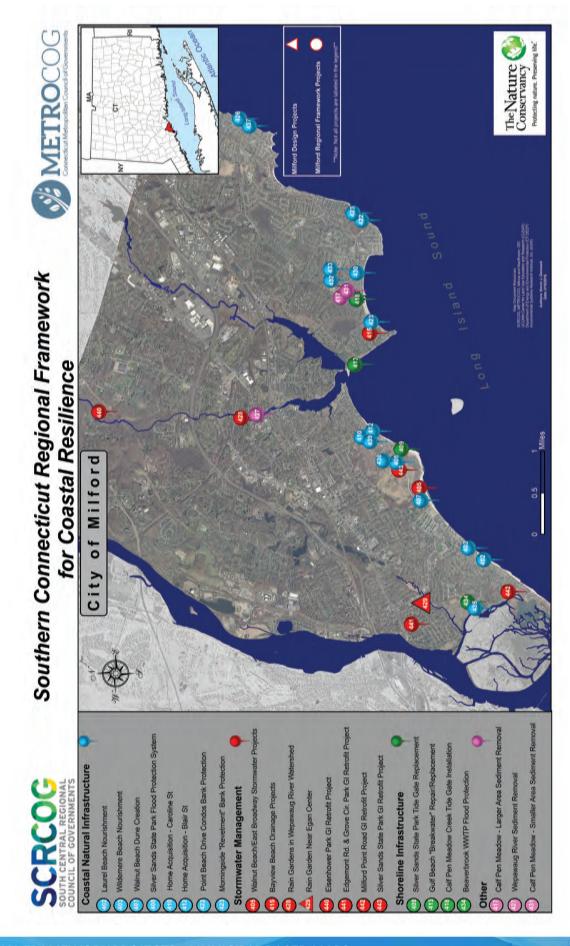


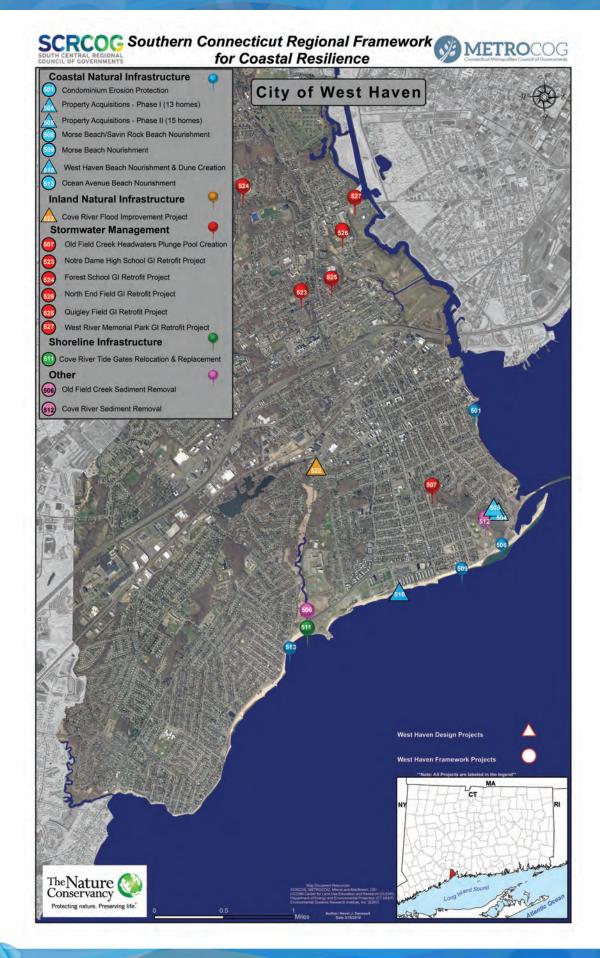
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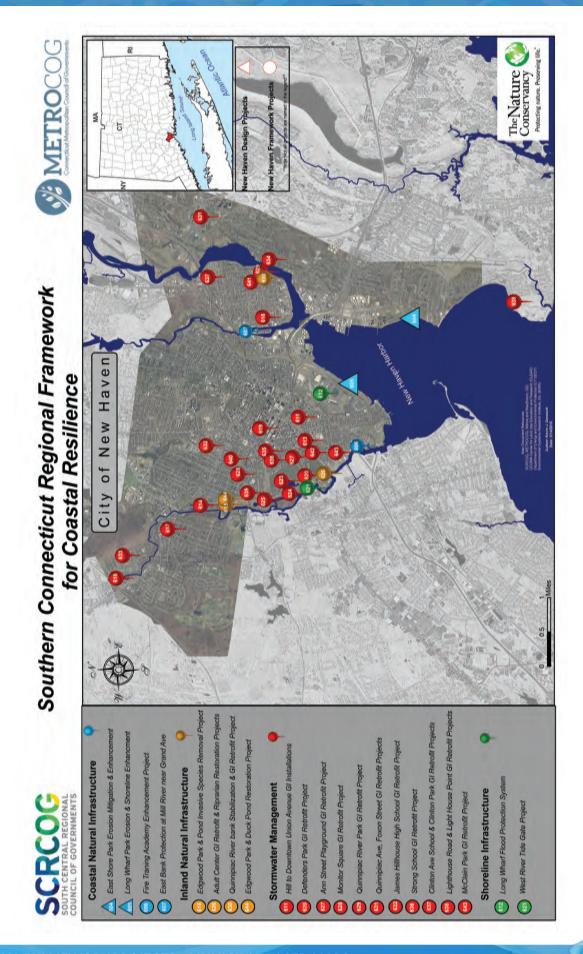


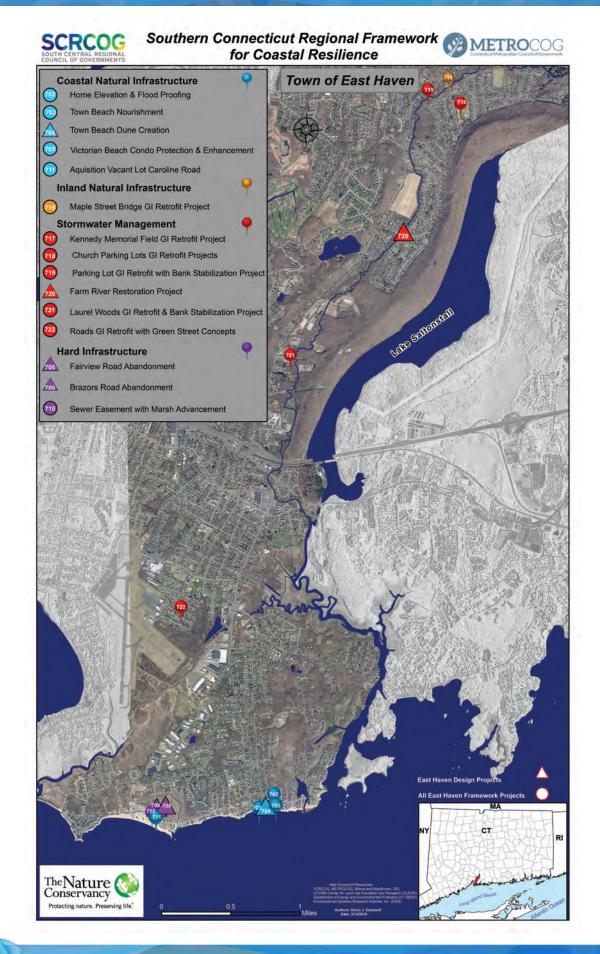
APPENDIX C



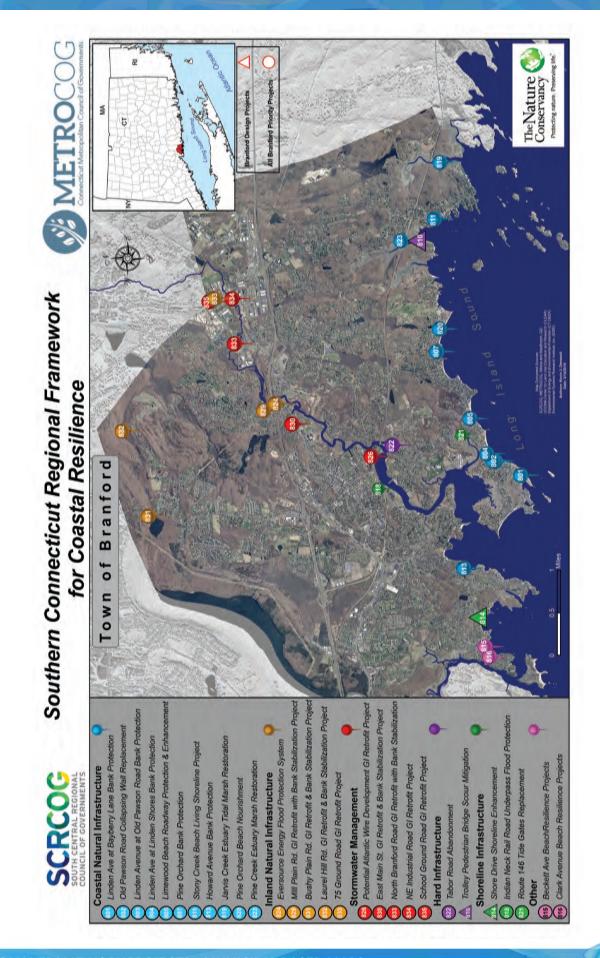


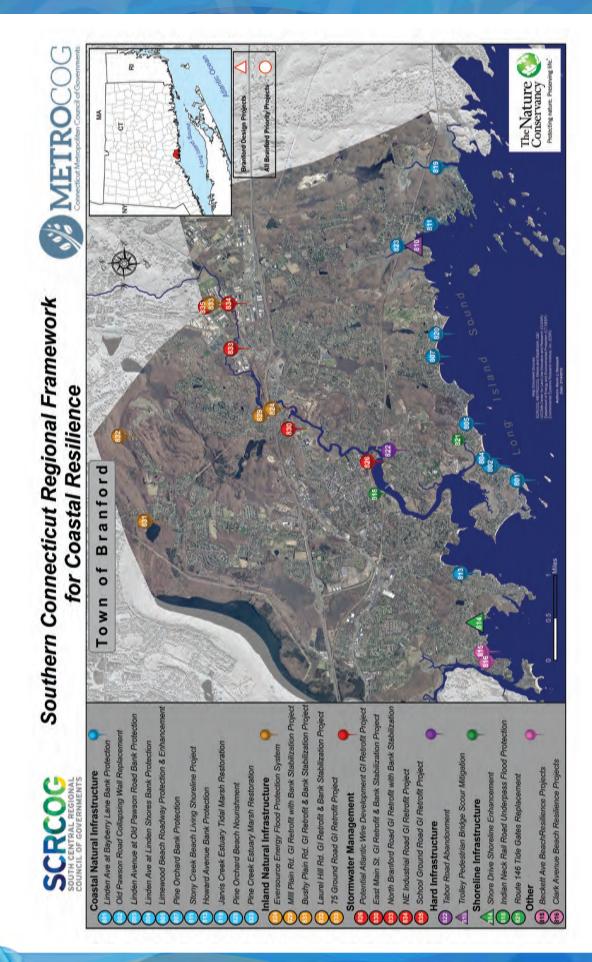
A68 APPENDIX C



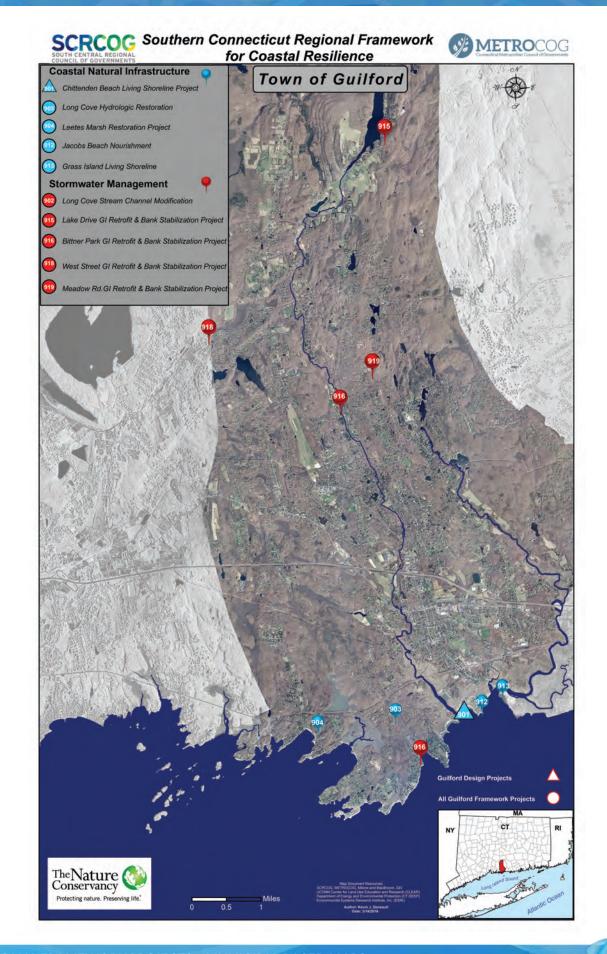


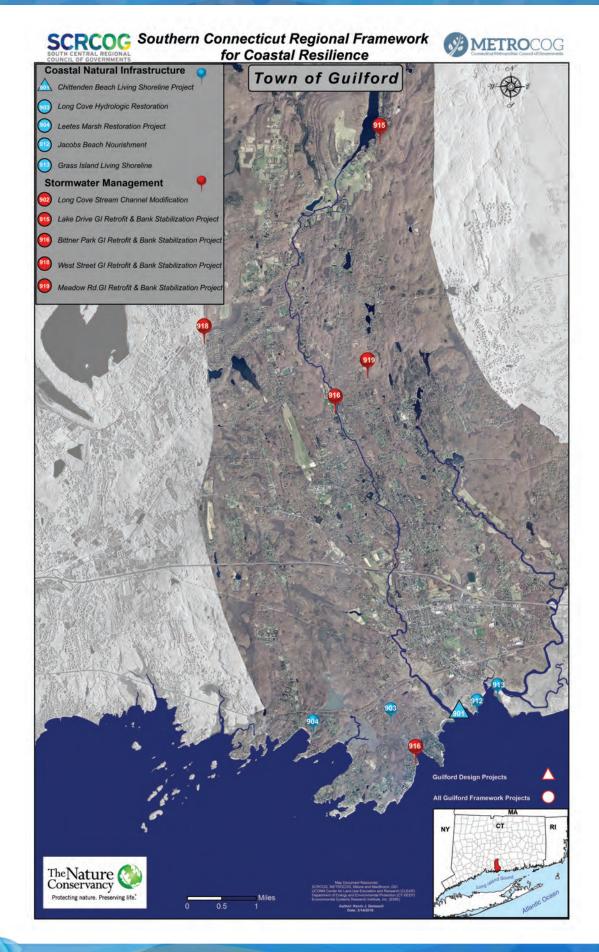
A70 APPENDIX C





A72 APPENDIX C

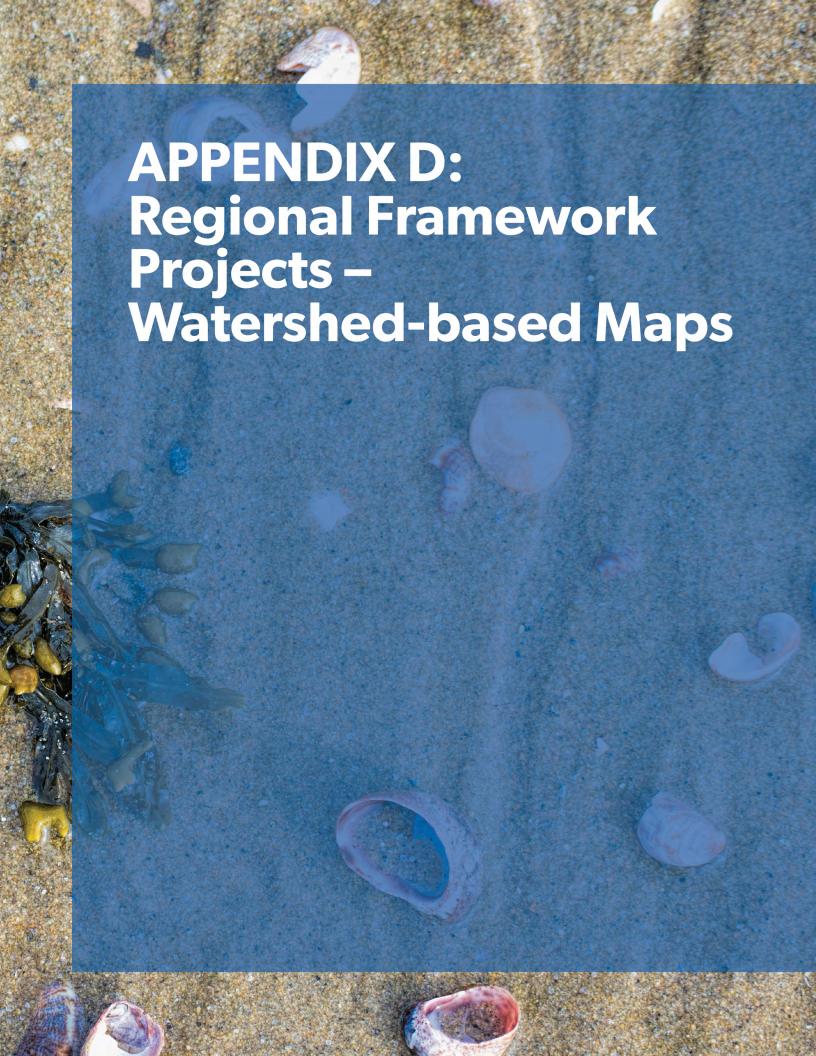


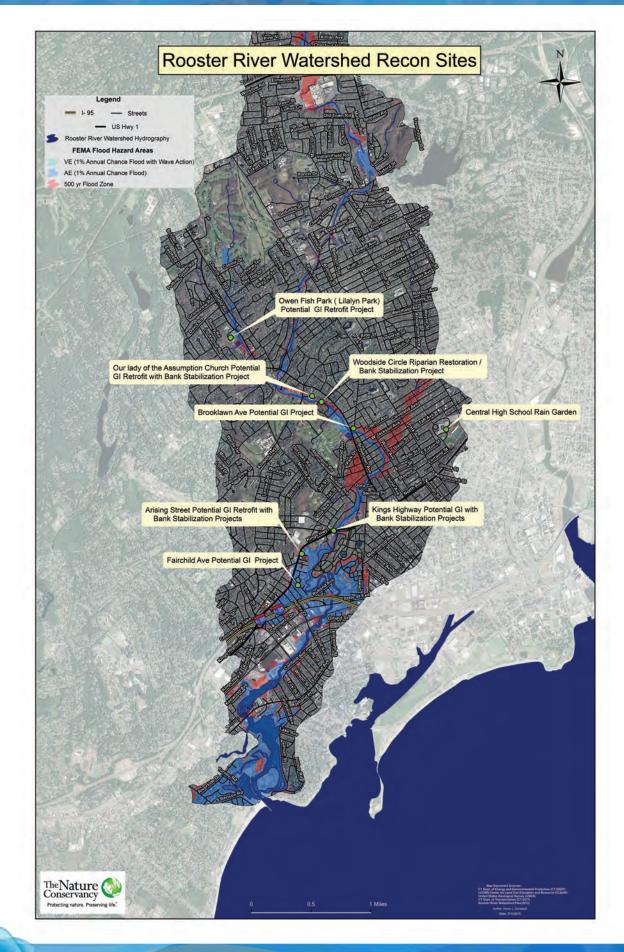


A74 APPENDIX C

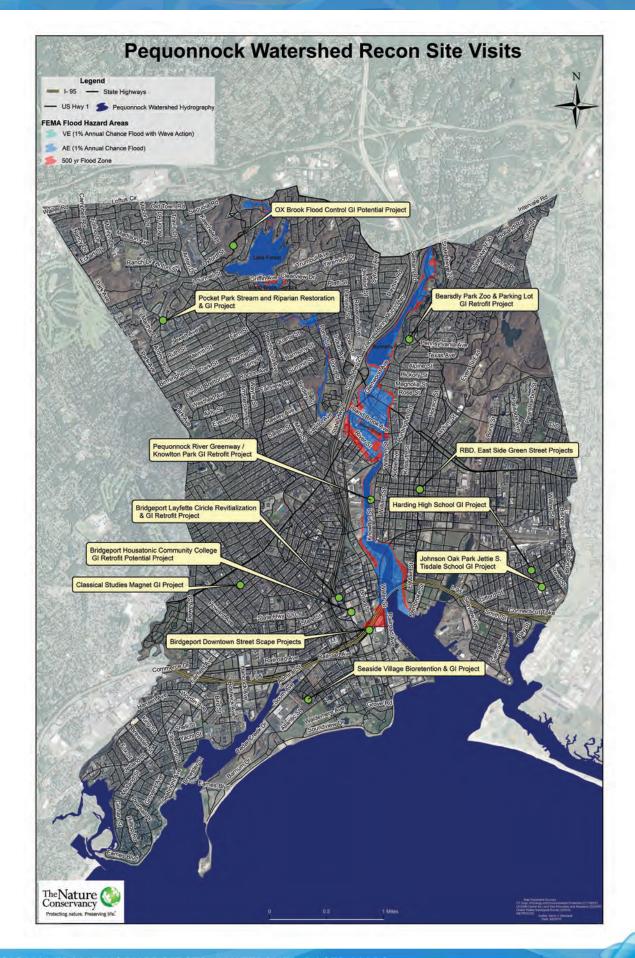


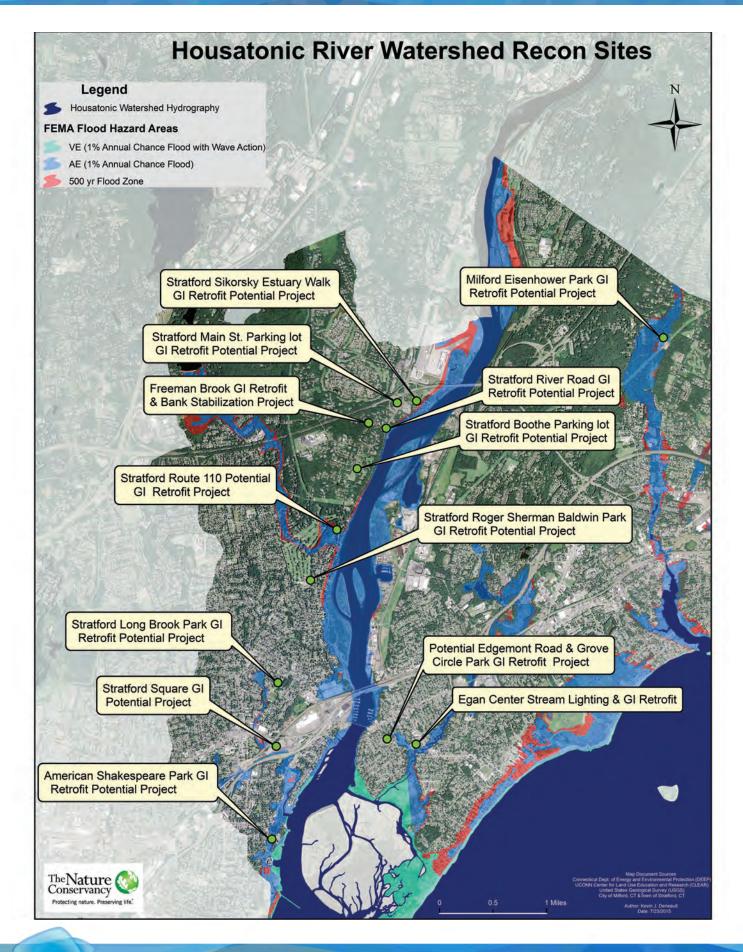




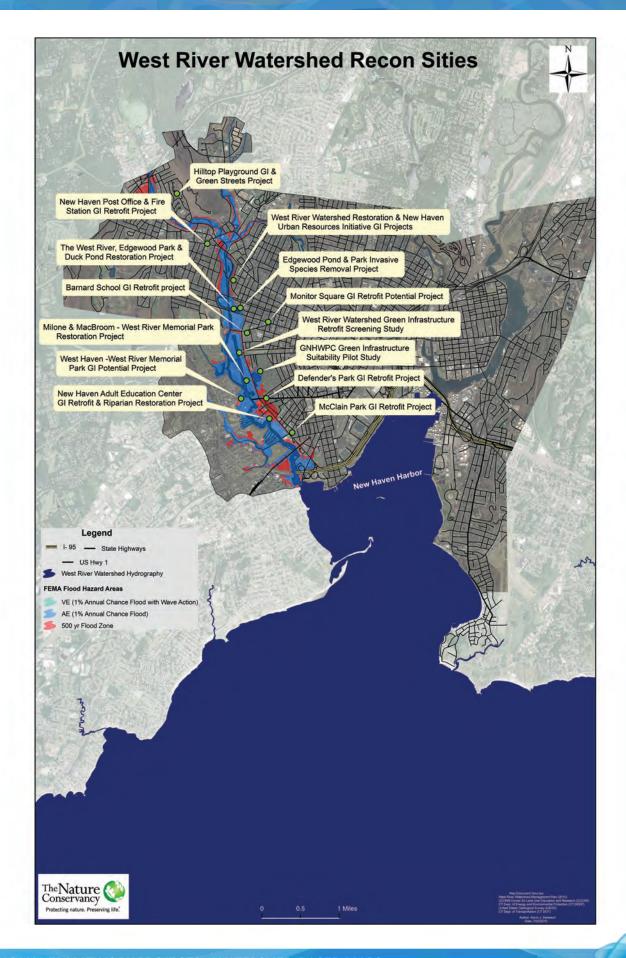


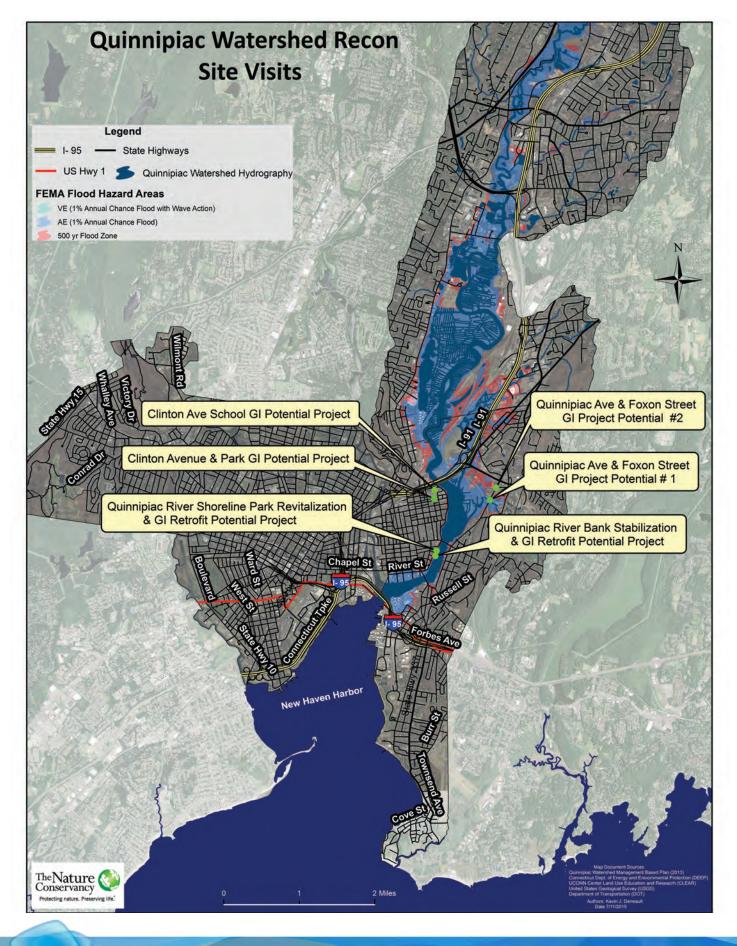
A78 APPENDIX D



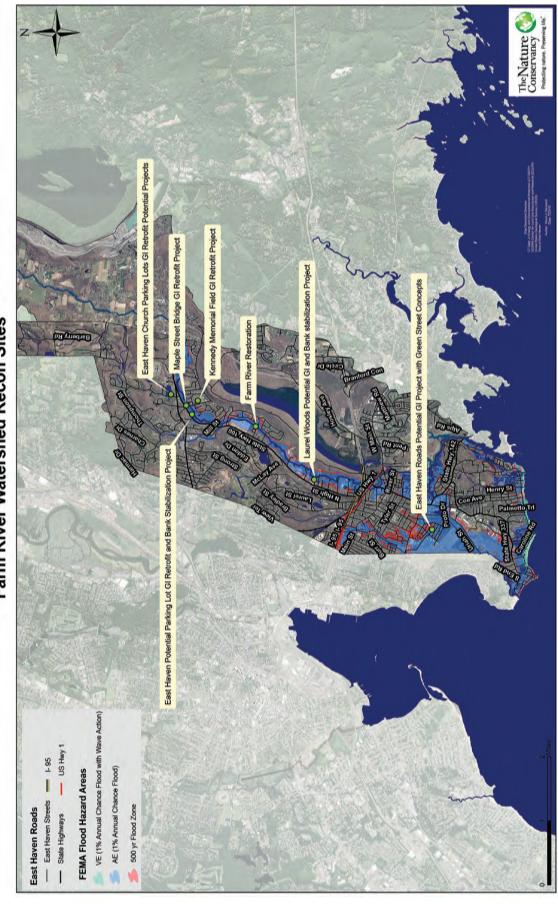


A80 APPENDIX D





A82 APPENDIX D



Farm River Watershed Recon Sites





FAIRFIELD: Penfield Beach to Shoal Point Dune Creation

Conceptual Design Basis: The Town of Fairfield experienced significant, widespread flooding during Tropical Storm Irene and Hurricane Sandy. Storm surge floodwaters easily crossed the section of Fairfield's beach between Shoal Point and Penfield Beach, where ground surface elevations are intermittently low between and among the 20-30 residential properties fronting the beach. Although there were other pathways for storm surge flooding to reach interior sections of coastal Fairfield, this particular gap has been viewed as potentially more challenging to address due to the numerous private properties and the geometry of the shoreline.

In the Flood Mitigation Plan developed by the Fairfield Flood and Erosion Control Board, two different measures were advanced to provide flood protection between Shoal Point and Penfield Beach – a dune ridge on the beach ("new dike" in the graphic to the right) and a flood wall on the rear side of the beachfront neighborhood the roadway. During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted a dune ridge project as a potential green infrastructure coastal resilience project in Fairfield.

The Connecticut Shoreline Change atlas classified this section of Fairfield as located in an area of tidal flats, glacial drift, and beaches; and the associated GIS analysis found that net shoreline movement had a mean of 6.37 meters seaward, but this average was dominated by a transect at Shoal Point. The mean without the Shoal Point data was 0.35 meters seaward, which generally demonstrates that long-term changes at this site have been minimal. Nevertheless, the beach width at high tide is very narrow. The site suitability model developed by UConn found the area suitable for beach enhancement and offshore breakwaters. The site suitability model does not directly address dune ridges.

Creation of a dune ridge needed to be protective of views and viewsheds. Furthermore, continuation of coastal access was critical, although this section of beach traditionally does not support public access except during low tide. The design needed to provide for access for all private properties along the beach. Dune crossings were laid out for pairs of properties (rather than one crossing per property).

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. Preservation of views was a critical design consideration. Elevations of back decks and patios likely range from 8 to 10 feet NAVD88. The top of the dune ridge was held to 12 feet to allow residents to see past (over) the top of the dune ridge. This elevation will be sufficient for some storm surge protection such as Hurricane Sandy (maximum WSE was approximately 9 to 10 feet). Note that the NACCS-calculated storm levels are approximately 10.5 to 11.5 feet in the 50 to 100-year RI range, implying that a dune at 12' may help reduce flooding from events within this range but not more severe. Full base flood protection is not anticipated nor is it desired from this project. A FEMA map revision is not proposed.

Relative to sea level rise, beach nourishment will be needed to keep up with loss of sand as sea level rises. Within one foot of sea level rise, the dune ridge will continue to provide protection from events like Hurricane Sandy. However, with a three foot rise in sea level, the 12' top of the dune ridge would provide protection that is not much better than the current conditions where the tops of some seawalls are at 9 feet. Future measures will need to be employed for protection in the long term, such as continued elevation of homes.

Project Highlights:

- This segment of the Fairfield shoreline is a pathway for storm surges to reach the coastal floodplain
- The Fairfield Flood and Erosion Control Board considers this is a priority area for mitigation
- · Private seawalls are at elevation 8 to 10 feet
- The FEMA base flood elevation is 13 (VE)
- The NACCS-calculated storm levels are 10.5 to 11.5 feet in the 50 to 100-year RI range
- Creation of a dune ridge at elevation 12 feet would provide increased protection
- The elevation 12 feet is sufficiently low to avoid obstructing views
- · A dune ridge would introduce vegetation to this beach
- The beach width must be increased to accommodate the dune ridge
- · With sea level rise of one foot, the dune ridge should still provide significant protection

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Name: Penfield Beach to Shoal Point Dune Creation

Town: Fairfield
Database ID: #104/105

Source/Parameter	Details					
CT Shoreline Change atlas	Exposed Tidal Flats, Glacial Drift & Beaches Combination accretion and erosion due to groins. Net shoreline movement: Mean 6.37 m seaward, but average dominated by shoal point transect; NSM without shoal point: Mean 0.35 m seaward					
Site suitability (Zylberman) model	Found parts of the area suitable for beach enhancement and offshore breakwaters. Found not suitable for marsh enhancement or marsh with structures.					
Existing structures understood	Private walls belie	eved to be at ele	evations 8 to 10 f	eet NAVD88		
Coastal jurisdiction line elevation	5.2 feet					
MHW	3.20 feet (interpol	ated)				
MHHW	3.54 feet (interpolated)					
FEMA FIS coastal transect data (NAVD 88)	MHHW 3.54 feet (interpolated) FEMA FIS coastal transect data (NAVD 88) #43 Fairfield Beach north of Shoal Point Significant Wave Height: 12.85 feet Peak Wave Period: 5.92 seconds Setup Depth: 1.03 feet 1% Stillwater Elevation: 10.1 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 11.1 feet Base Flood Elevation: 13-17 feet in Zone VE Average BFE on FIRM: 13 feet 0.2% Stillwater Elevation: 11.5 feet Maximum Wave Crest: 17 feet V-Zone Mapping Method: Breaking Wave Height					
FEMA FIS coastal transect runup model						
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR	
	Surge	6.71'	8.75'	9.63'	12.62'	
	Surge+Tide	8.71'	10.48'	11.44'	14.49'	
Ice data (qualitative)	Likely minimal					
Tidal wetland delineation	None present					

Source/Parameter	Details
Inland wetland delineation (if applicable)	Not applicable
Natural diversity database	In NDDB Area
Critical Habitat	Beachshore (Salt)
Stormwatershed delineation	Not applicable
Design precipitation events	Not applicable
FEMA FIS stream transect data	Floodway: No
Hydrologic data	Not applicable
Hydraulic data	Not applicable
Scour data	Not applicable
Provision of public access	Yes. Public access may increase if the beach nourishment requires public funds.
Preservation of views	Yes. Given the constraint stated above, the 12' elevation of the top of the dune ridge will be sufficient for some storm surge protection such as Hurricane Sandy (maximum WSE was approximately 9 to 10 feet) but not protection from the 1% annual chance event. Note that the NACCS-calculated storm levels are approximately 10.5 to 11.5 feet in the 50 to 100-year RI range, implying that a dune at 12' may help reduce flooding from events within this range but not more severe.
Conceptual design meets current criteria?	Yes. Given the constraint stated above, the 12' elevation of the top of the dune ridge will be sufficient for some storm surge protection such as Hurricane Sandy (maximum WSE was approximately 9 to 10 feet) but not protection from the 1% annual chance event. Note that the NACCS-calculated storm levels are approximately 10.5 to 11.5 feet in the 50 to 100-year RI range, implying that a dune at 12' may help reduce flooding from events within this range but not more severe.
Conceptual design meets future criteria?	Yes. Continued beach nourishment will be needed to keep up with loss of sand as sea level rises. Within one foot of sea level rise, the dune ridge will continue to provide protection from events like Hurricane Sandy. However, with a three foot rise in sea level, the 12' top of the dune ridge would provide protection that is not much better than the current conditions where the tops of some seawalls are at 9 feet. Future measures will need to be employed for protection in the long term, such as continued elevation of homes.

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Regional Framework for Coastal Resilience In Southern Connecticut Town #1 - Fairfield, CT 9/7/2016 MMI# 2733-14 BY: JCM

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Concept 1 - Proj #: 0104 & 0105 Penfield To Shoal Point Beach Nourishment and Dune Creation

(Cost Opinion Based on Conceptual Design Plans Dated June 6, 2016)

Unit	Quantity	Unit Cost	Cost
-77		7.00	
L.S.	1:	\$75,000.00	\$75,000.00
L.S.	1	\$15,000.00	\$15,000.00
LS.	15	\$15,000.00	\$15,000.00
C.Y.	5,500	\$100.00	\$550,000.00
C.Y.	3,500	\$100.00	\$350,000.00
1S.	3	\$35,000.00	\$105,000.00
L.F.	2,000	\$5.00	\$10,000.00
L.S.	1	\$150,000.00	\$150,000.00
		Subtotal =	\$1,270,000.00
	1+2	20% Contingency	\$254,000.00
		Total	\$1,524,000.00
L.F.	2,000	\$400.00	\$800,000.00
		Subtotal =	\$800,000.00
	140	20% Contingency	\$160,000.00
		Total	\$960,000.00
	L.S. L.S. L.S. C.Y. C.Y. L.S. L.F.	L.S. 1 L.S. 1 L.S. 1 C.Y. 5,500 C.Y. 3,500 L.S. 3 L.F. 2,000 L.S. 1	L.S. \$75,000.00 L.S. \$15,000.00 L.S. \$15,000.00 C.Y. 5,500 \$100.00 C.Y. 3,500 \$100.00 L.S. 3 \$35,000.00 L.F. 2,000 \$5.00 Subtotal = +20% Contingency Total L.F. 2,000 \$400.00

BRIDGEPORT: West Branch Johnson Creek Living Shoreline

Conceptual Design Basis: The City of Bridgeport intends to create a greenway trail along the Western Branch of Johnson Creek providing public access to Long Island Sound. The City has acquired a land bank of parcels on the west side of the inlet and has or is working to obtain easements along the remainder of the parcels that extend around the industrial developments on Webster Avenue. The West Branch of Johnson's Creek is located in a low energy environment and is currently dominated by tidal wetlands and tidal flats. There is a high potential for successful implementation of a vegetative living shoreline providing habitat enhancement, flood management, water quality benefits and increasing public access to the shoreline.

The 2006 City of Bridgeport Harbor Management Plan recognized the western arm of Johnson's Creek as a natural resource for the City of Bridgeport, and indicated it will be preserved by the City of Bridgeport Harbor Management Commission by limiting future commercial or industrial development of the properties (Apex Environmental, Inc. 2006). The Harbor Management Plan also stated that "municipal improvements made in order to enhance the recreational value of this area (such as walkways or educational kiosks) are also supported." During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted this project as the one of the important potential green infrastructure coastal resilience projects in Bridgeport.

The Connecticut Shoreline Change atlas only provides historical shoreline data for the Western Branch of Johnson's Creek site, and does not provide an output for the associated GIS analysis analyzing net shoreline movement. The site suitability model developed by UConn did not include this site within the analysis.

The proposed conceptual living shoreline design for the Western Branch of Johnson's Creek involves the construction of a vegetated living shoreline; enhancing the condition of tidal wetlands currently on the site; reducing the angle of the bank slope; removing invasive plants and fill on city-own properties located up-gradient; providing upland stormwater treatment through the development of a raingarden and stormwater treatment wetlands; and providing community access to the shorefront through a raised boardwalk and pedestrian paths. The conceptual design enhances the existing tidal marsh, and the low energy system provides a unique opportunity to support a vegetated living shoreline. The proposed conceptual design also plans for the preservation and enhancement of coastal views and view sheds, and promotes coastal public access in a municipality where City-owned public access is lacking.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. The conceptual design depicts the vegetative planting zones required by intertidal and high marsh species, and reduces the angle of the bank slope to encourage full vegetative stabilization. Full base flood protection is not anticipated nor is it desired from this project. A FEMA map revision is not proposed.

Relative to sea level rise, the proposed conceptual design reduces the wetland slope to provide a future marsh migration corridor. If sea level rises one foot within the design life of the vegetative wetland edge, the wetland vegetation can move up the bank. If sea level rises by three feet by the end of the century, new measures for adapting all property within the vicinity of the project area would need to be employed.

Project Highlights:

- The City has identified the west arm of Johnsons Creek as an area of future coastal public access
- · A living shoreline project would add to existing vegetated zones and increase biodiversity
- · Water quality benefits are also possible
- The design reduces the grade of bank slopes to allow stabilization
- Tidal marsh advancement is supported by the design

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Name: West Johnson Creek Living Shoreline

Town: Bridgeport

Database ID: #218

Source/Parameter	Details					
CT Shoreline Change atlas	Historical shorelin	Historical shoreline polylines only				
Site suitability (Zylberman) model	Not analyzed					
Existing structures understood	Yes					
Coastal jurisdiction line elevation	5.0 feet					
MHW	3.15 feet (at Bridge	3.15 feet (at Bridgeport station)				
MHHW	3.48 feet (at Bridg	eport station)				
FEMA FIS coastal transect data (NAVD 88)	#47 in Bridgeport Harbor Significant Wave Height: 12.41 feet Peak Wave Period: 6.64 seconds Setup Depth: 1.94 feet 1% Stillwater Elevation: 9.8 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 12.2 feet Base Flood Elevation: 12-14 feet in Zone AE Average BFE on FIRM: 13 feet 0.2% Stillwater Elevation: 11.1 feet Maximum Wave Crest: 18 feet V-Zone Mapping Method: Wave Overtopping Splash Zone					
FEMA FIS coastal transect runup model						
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR	
	Surge	6.78'	8.88'	9.83'	12.88'	
	Surge+Tide	8.78'	10.65'	11.67'	14.88'	
Ice data (qualitative)	Likely present in v	vinter due to sta	agnant condition	IS		
Tidal wetland delineation	Not conducted; project area is mainly intertidal zone or below CJL.					
Inland wetland delineation (if applicable)	Not applicable					
Natural diversity database	NDDB Area nearby	y in West Branc	h Johnson Creek	C		
Critical Habitat	Not defined					
Stormwatershed delineation	Not applicable					

Source/Parameter	Details
Design precipitation events	Not applicable
FEMA FIS stream transect data	Floodway: No XS B: Bruce Brook upstream of I-95, BFE 10.2 feet
Hydrologic data	Not applicable
Hydraulic data	Not applicable
Scour data	Not applicable
Provision of public access	Yes. The design will involve work primarily below the CJL and will provide increased access to the waterfront.
Preservation of views	Yes. The design will provide increased views of the waterfront.
Conceptual design meets current criteria?	Yes. The design addresses the vegetative planting zones required by marsh species, and reduces the grade of bank slopes to allow vegetative stabilization.
Conceptual design meets future criteria?	Yes. The design reduces the grade of wetland edge slope to provide wetland migration potential. If sea level rises one foot within the design life of the vegetative wetland edge, the wetland vegetation can move up the bank into the bioswale areas. If sea level rises by three feet by the end of the century, new measures for adapting all property within the vicinity of the project area would need to be employed.

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Regional Framework for Coastal Resilience In Southern Connecticut Town #2 - Bridgeport, CT 9/8/2016 GEI# 1506360 By. AMH

455 Winding Brook Drive, Suite 201 Glastonbury, Connecticut 06033 (860)368-5300



99 Realty Drive Cheshire, Connecticut 06410 (203) 271-1773

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Proj #: 0218 <u>Team Design</u>

(Cost Opinion Based on Conceptual Design Plans Dated September 8, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance			200	
Mobilization	L.S.	1	\$25,000,00	\$25,000,00
Water Control	L.S.	1	\$25,000.00	\$25,000.00
Sediment and Erosion Control	L.S.	1	\$10,000.00	\$10,000.00
2. Grading				
Removal and Disposal of Soil	C.Y.	6,108	\$9,00	\$54,970,00
Removal and Disposal of Debris	L.S.	1	\$20,000.00	\$20,000.00
General Regrading	L.S.	1	\$20,000.00	\$20,000.00
3. Site Improvements				
Install Osprey Pole	Ea.	1	\$1,200,00	\$1,200,00
Raised Boardwalk	S.F.	15,756	\$24.00	\$378,144.00
Invasives Control	L.S.	1	\$20,000.00	\$20,000.00
4. Site Restoration				
Intertidal Marsh Plantings	1000 S.F.	21.5	\$3,000.00	\$64,524.00
High Marsh Plantings	1000 S.F.	35.1	\$4,000.00	\$140,520.00
Stormwater Treatment Wetland Plantings	1000 S.F.	6.8	\$2,500.00	\$17,077.50
Salt Shrub Zone Plantings	1000 S.F.	15.1	\$3,500.00	\$52,696.00
Road End Biofilters	1000 S.F.	4.0	\$2,000,00	\$8,076.00
Stone-Lined Channel	C.Y.	21	\$60.00	\$1,242.22
Native Species Plantings (Invasives Control Areas)	1000 S.F.	55.9	\$4,000.00	\$223,640.00
			Subtotal =	\$1,062,100.00
		+2	20% Contingency	\$212,400.00
			Total	\$1,274,500.00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary.
- 2) Conceptual level cost opinion, for planning level assessment only.
- 3) All costs assume 2016 construction
- 4) Soil removal and disposal costs do not include costs for disposal of contaminated soil.

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Regional Framework for Coastal Resilience In Southern Connecticut Town #2 - Bridgeport, CT 9/8/2016 GEI# 1506360 By. AMH

455 Winding Brook Drive, Suite 201 Glastonbury, Connecticut 06033 (860)368-5300



99 Realty Drive Cheshire, Connecticut 06410 (203) 271-1773

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Proj #: 0218 Team Design

Quantity Computations

No. Item	Unit	Quantity	Source
Removal and Disposal of Material for Tidal Marsh (Excavation)	C.Y.	5,855	
Length of Regrading	FT.	2,291	AutoCAD measurement
Section Area - Regrading for Tidal Marsh	S.F.	69	AutoCAD measurement
Removal and Disposal of Material for Stormwater Treatment Wetland	C.Y.	253	
Average Depth	FT.	1	Assumed
Plan View Area	S.F.	6,831	AutoCAD measurement
Raised Boardwalk	S.F.	15,756	
Linear Feet	L.F.	2,626	AutoCAD measurement
Width	FT.	6	
Intertidal Marsh Plantings	S.F.	21508	AutoCAD measurements - Approximate
High Marsh Plantings	S.F.	35130	AutoCAD measurements - Approximate
Salt Shrub Zone Plantings	S.F.	15056	AutoCAD measurements - Approximate
Stormwater Treatment Wetland Plantings	S.F.	6,831	AutoCAD measurement
Road End Biofilters	S.F.	4,038	AutoCAD measurement
Stone-Lined Channel	C.Y.	21	
Average Thickness	FT.	1	Assumed
Plan View Area	S.F.	559	AutoCAD measurement
Native Species Plantings (Invasives Control Areas)	S.F.	55,910	AutoCAD measurement

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STRATFORD: Russian Beach Bank Protection

Conceptual Design Basis: Along the eastern portion of Russian Beach in the Town of Stratford, an eroding bank extends to from the intersection of York Street and Park Blvd the east toward the Cove Place alignment. Severe erosion appears to have taken place, and the bank is comprised of unconsolidated sand and gravel with only a thin topsoil and turf grass layer at the top. A resident reported that storms Irene and Sandy heightened the erosion that was occurring. The town roadway will be at risk in the future – and with this, utilities and egress will be at risk – with continued erosion along the bank.

Stratford is covered under the 2014 Natural Hazard Mitigation Plan Update by the Greater Bridgeport Regional Council. The regional plan's review of Natural Systems Protection, noted that within the area of Russian Beach, assessment of the ongoing and longer-term impacts from hazards should move towards developing a sustainable course of action. The HMP documented that Stratford is interested in considering application of living shoreline approaches throughout the coastline. During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted this project as a potential green infrastructure coastal resilience project in Stratford.

The Connecticut Shoreline Change atlas classified the Russian Beach site as located in an area of glacial drift and beaches and the associated GIS analysis found that net shoreline movement had a mean of 13.13 meters (approximately 43 feet) landward. The site suitability model developed by UConn found the area suitable for offshore breakwaters but not suitable for beach enhancement, marsh enhancement, or marsh with structures. The site suitability model uses broad range classifications to provide planning level recommendations. Additional site-specific data and information can provide alternatives for application of hybrid living shoreline techniques.

The proposed conceptual living shoreline design for Russian Beach involves the construction of primarily hybrid living shoreline; reducing the slope of the eroding bank; providing upland stormwater treatment through the development of biofilters, raing-ardens and stormwater treatment wetlands; and creating tidal wetlands stabilized by a stone sill. The design is consistent with preservation of views and viewsheds, and continuation of the somewhat limited coastal public access available in this part of Russian Beach.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. The design addresses the vegetative planting zones require by marsh species, and reduces the grade of bank slopes to allow vegetative stabilization. Note that the NACCS-calculated 10 and 50-year storm levels are 8.48 and 10.19 feet, respectively, which bracket the range of elevations found at the toe of the slope. These storms may be causing the most severe erosion, and the design will help reduce this erosion. In addition, the sill proposed as a component of design is located at elevations 2.5' to 6', an average of 2 feet above MHW. Full base flood protection is not anticipated nor is it desired from this project. A FEMA map revision is not proposed.

Relative to sea level rise, the living shoreline design reduces the grade of the bank slope to provide wetland migration potential. If sea level rises one foot within the design life of the vegetative wetland edge, the wetland vegetation can move up the bank. The stone sill would still function within 1-2 ft above the new MHW level of approximately elevation 4. If sea level rises by three feet by the end of the century, the reduced grade of bank should support marsh migration, although new dynamic and developing conditions may require that new measures need to be employed to stabilize the entire bank.

Project Highlights:

- · Significant erosion of the coastal bank has occurred at the eastern end of Russian Beach
- The NACCS-calculated 10 and 50-year storm levels are 8.48 and 10.19 feet, respectively, which bracket the range of elevations found at the toe of the slope
- The 10 and 50-year storms may be causing the most severe erosion, along with runoff from above and some groundwater seepage
- The design reduces the grade of bank slopes to permit vegetative stabilization and encourages planting of vegetation zones including marsh species
- With sea level rising, this design may work well in the long term

Name: Russian Beach Bank Protection

Town: Stratford Database ID: #304

Source/Parameter	Details					
CT Shoreline Change atlas	Glacial drift & beaches Net erosion: Net shoreline movement is mean of 13.13 m inland					
Site suitability (Zylberman) model	Found the area suitable for offshore breakwaters. Found not suitable for beach enhancement, marsh enhancement, or marsh with structures.					
Existing structures understood	Yes; picked up by	Yes; picked up by survey				
Coastal jurisdiction line elevation	5.0 feet					
MHW	3.14 feet (at I-95 b	ridge over Hou	satonic River)			
MHHW	3.48 feet (at I-95 bridge over Housatonic River)					
FEMA FIS coastal transect data (NAVD 88)	#50 at Lordship Beach Significant Wave Height: 11.68 feet Peak Wave Period: 5.55 seconds Setup Depth: 2.55 feet 1% Stillwater Elevation: 9.7 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 12.2 feet Base Flood Elevation: 14-18 feet in Zone VE Average BFE on FIRM: 14 feet 0.2% Stillwater Elevation: 11.0 feet Maximum Wave Crest: 18 feet					
FEMA FIS coastal transect runup model						
NACCS data (NAVD 88)	Type 10-YR 50-YR 100-YR 500-YR					
	Surge	6.55'	8.58'	9.47'	12.29'	
	Surge+Tide	8.48'	10.19'	11.08'	14.06'	
Ice data (qualitative)	Likely minimal					
Tidal wetland delineation	None present					
Inland wetland delineation (if applicable)	Not applicable					
Natural diversity database	In NDDB area					

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Source/Parameter	Details
Critical Habitat	Beachshore (salt); Coastal Woodland / Shrubland at west end of project area
Stormwatershed delineation	Not conducted; may revisit this
Design precipitation events	Not conducted; may revisit this
FEMA FIS stream transect data	Floodway: No
Hydrologic data	Not applicable
Hydraulic data	Not applicable
Scour data	Not applicable
Provision of public access	Yes. The design will neither impair nor improve public access.
Preservation of views	Yes. Designs will not impede view points from the top of the manicured lawn located upgradient from the bank project area. The design proposes wetland and shrub vegetation below re-graded bank slope which will not change current views from homes.
Conceptual design meets current criteria?	Yes. The design addresses the vegetative planting zones require by marsh species, and reduces the grade of bank slopes to allow vegetative stabilization. The bank stabilization component of the design functions entirely above the MHHW where erosion is occurring at the present time. Note that the NACCS-calculated 10 and 50-year storm levels are 8.48 and 10.19 feet, respectively, which bracket the range of elevations found at the toe of the slope. These storms may be causing the most severe erosion, and the design will help reduce this erosion. In addition, the sill proposed as a component of design is located at elevations 2.5' to 6', an average of 2 feet above MHW.
Conceptual design meets future criteria?	Yes, The design reduces the grade of the bank slope to provide wetland migration potential. If sea level rises one foot within the design life of the vegetative wetland edge, the wetland vegetation can move up the bank. The stone sill would still function within 1-2 ft above the new MHW level of approximately elevation 4. If sea level rises by three feet by the end of the century, the reduced grade of bank should support marsh migration, although new dynamic and developing conditions may require that new measures need to be employed to stabilize the entire bank.



Regional Framework for Coastal Resilience In Southern Connecticut Town #3 - Stratford, CT 9/8/2016 GEI# 1506360 By. AMH

\$883,200.00

Total

455 Winding Brook Drive, Suite 201 Glastonbury, Connecticut 06033 (860)368-5300



99 Realty Drive Cheshire, Connecticut 06410 (203) 271-1773

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Proj #: 0304 <u>Russian Beach Concept</u> (Cost Opinion Based on Conceptual Design Plans Dated September 8, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance	100			- W
Mobilization	L.S.	1	\$25,000.00	\$25,000.00
Water Control	L.S.	1	\$75,000.00	\$75,000.00
Sediment and Erosion Control	L.S.	1	\$15,000.00	\$15,000,00
2. Site Improvements				
Remove and Dispose of Soil	C.Y.	5,709	\$9.00	\$51,383.00
Fill Soil	C.Y.	3,293	\$25.00	\$82,333.33
Install Stone Sills	C.Y.	2,618	\$62.52	\$163,672.73
3. Site Restoration				
Fascine Bundles	L.F.	1,170	\$15.00	\$17,550.00
Switchgrass Plantings	1000 S.F.	27.4	\$1,500.00	\$41,064.00
Tidal Wetland Vegetation	1000 S.F.	19.8	\$3,000.00	\$59,472.00
Bioswale Plantings	1000 S.F.	9.7	\$2,000.00	\$19,300.00
Shrub Masses	1000 S.F.	14.4	\$3,500.00	\$50,239.00
Beach Grass Plantings	S.F.	46,246	\$2.00	\$92,492.00
Erosion Control Mat	S.Y.	5,138	\$5.00	\$25,692.22
Stone Dust Path	S.Y.	678	\$12.00	\$8,138.67
Wooden Steps	Flight	1	\$5,000.00	\$5,000.00
Boulder Steps	C.Y.	15.6	\$300.00	\$4,666.67
			Subtotal =	\$736,000.00
		+2	20% Contingency	\$147,200,00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary.
- 2) Conceptual level cost opinion, for planning level assessment only.
- 3) All costs assume 2016 construction

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Regional Framework for Coastal Resilience In Southern Connecticut Town #3 - Stratford, CT 9/8/2016 GEI# 1506360 By. AMH

455 Winding Brook Drive, Suite 201 Glastonbury, Connecticut 06033 (860)368-5300



99 Realty Drive Cheshire, Connecticut 06410 (203) 271-1773

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Proj #: 0304 Russian Beach Concept

Quantity Computations

Item	Unit	Quantity	Source
Install Fascine Bundles	L.F.	1,170	AutoCAD measurement
Plan Area of Shrub Masses	S.F.	14.354	AutoCAD measurement
Bioswale Plantings	S.F.	9,650	AutoCAD measurement
Install Stone Sills	C,Y,	2,618	
Linear Feet of Stone Sills	FT.	862	AutoCAD measurement
Section Area - Stone Sills	S.F.	82	AutoCAD measurement
Cut and Resurface	C.Y.	5,709	
Linear Feet of Cut - 3H;1V Slope or Flatter	L.F.	1,217	AutoCAD measurement
Section Area Cut - 3H:1V Slope or Flatter	S.F.	101	AutoCAD measurement - Section View
Section Area of Cut - Bioswales	S.F.	61	AutoCAD measurement - Section View
Length of Bioswales	L.F.	512	AutoCAD measurement
Fill and Resurface	C,Y,	3293	
Linear Feet of Fill	L.F.	1,170	AutoCAD measurement
Section Area - Fill	S.F.	76	AutoCAD measurement - Section View
Switchgrass Plantings (Wet Meadow)	S.F.	27,376	
Length of Plantings	L.F.	944	AutoCAD measurement
Width of Plantings	L.F.	29	AutoCAD measurement - Section View
Tidal Wetland Plantings	S,F.	19,824	
Length of Plantings	L.F.	944	AutoCAD measurement
Width of Plantings	L.F.	21	AutoCAD measurement - Section View
Beach Grass and Erosion Control Mat	S.F.	46,246	
Length of Plantings/Mat	L.F.	1,217	AutoCAD measurement
Width of Plantings/Mat	L.F.	38	AutoCAD measurement - Section View
Stone Dust Path	S.F.	6,104	AutoCAD measurement
Wooden Steps	Flight	1	
Boulder Steps	C.Y.	15.6	
	S.F.	140	Approximate based on AutoCAD measurements
Area of Steps			

MILFORD: Egan Center Urban Stream Restoration and Green Infrastructure

Conceptual Design Basis: The City of Milford operates a community center at the City-owned Egan Center property. An unnamed stream runs through the property within a culvert near the edge of the parking lot. Shortly downstream of the property, the stream daylights into a tidal marsh associated with Beaver Brook, a tributary of the tidal Housatonic River. The City has noted for several years that the amount of pavement at the property is relatively large in relation to the size and use of the site, and would like to incorporate green infrastructure to reduce stormwater runoff.

During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff did not initially promote this project as a potential coastal resilience green infrastructure project because the focus was on the shoreline. However, over the course of several meetings, the City's Hazard Mitigation Committee recognized the opportunity to daylight the culverted part of the stream and provide green infrastructure in one single project that was, indeed, connected to tidal waters.

The proposed conceptual design envisions removal of the culvert and daylighting of the stream with construction of a naturalized channel; removal of undesirable vegetation and addition of new native vegetation to enhance the stream corridor; replacement of asphalt with pervious pavers; and development of a raingarden and stormwater treatment wetlands. The Egan Center property will remain accessible, and parking spaces will not be lost. The project will create a more aesthetically pleasing environment at the Egan Center. Therefore, the proposed conceptual design preserves public access and improves views.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. The stream is at elevation of approximately 5 feet on the downstream side of the property where it currently daylights. The stream is above the MHHW indicating that it is not tidal on a daily basis, but the CJL of 5.1 feet indicates that the stream is likely capable of tidal conditions. The historical topographic map (see image to the right) shows that the stream was a tidal creek, or a creek surrounded by high marsh, prior to its placement in a culvert. The upstream end of the daylighted section will be at elevation approximately 7 feet, providing for an appropriate stream profile. This design will need to be verified or modified after site topographic mapping is conducted.

The entire project area is below the FEMA BFE and just below the NACCS-calculated 10-year storm WSE of 8.8 feet. The stream daylighting will not change coastal flooding conditions that occur during storm surges such as Hurricane Sandy.

Under a one foot rise in sea level, the current MHW and MHHW of 3.1 and 3.43 feet, respectively, will rise to approximately 4.1 and 4.4 feet and still be lower than the elevations in the daylighted section, and the stream will remain mostly non-tidal. Under a three foot rise in sea level, daily tidal fluctuation will extend onto the project site and the daylighted section will become a tidal creek. The design will allow for marsh advancement into the stream corridor, which is an improvement over current conditions where this is not possible. This design, therefore, is meant to accommodate sea level rise. The conceptual design depicts vegetative species that are somewhat salt-tolerant.

Project Highlights:

- The Egan Center is an important community asset
- A small tidal creek was long ago placed in a culvert beneath the site
- Daylighting the stream would provide opportunities to restore tidal and non-tidal wetland vegetation
- · A rain garden may be incorporated into the project to filter stormwater from the Egan Center
- · With a rise in sea level, tidal conditions will migrate upstream from the adjacent marsh into the daylighted part of the stream
- · Tidal wetlands could advance into the streambank areas; this is not possible under current conditions

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Name: Egan Center Urban Stream/GI

Town: Milford Database ID: #429

Source/Parameter	Details					
CT Shoreline Change atlas	Historical shorelin	e polylines only	1			
Site suitability (Zylberman) model	Not applicable					
Existing structures understood	No. The buried str	No. The buried stream culvert is not well understood.				
Coastal jurisdiction line elevation	5.1 feet					
MHW	3.10 feet (interpola	ated)				
MHHW	3.43 feet (interpol	ated)				
FEMA FIS coastal transect data (NAVD 88)	Significant Wave H Peak Wave Period Erosion Method: A VZone_Ext: Breaki Setup Depth: 1.03 1% Stillwater Eleva 1% Total Water Leva feet Base Flood Elevati Average BFE on Fl	Base Flood Elevation: 11-13 feet in Zone AE Average BFE on FIRM: 10 / 11 feet 0.2% Stillwater Elevation: 10.8 feet				
FEMA FIS coastal transect runup model						
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR	
	Surge	6.86'	8.93'	9.82'	12.84'	
	Surge+Tide	8.80'	10.70'	11.79'	15.10'	
Ice data (qualitative)	Not applicable at present time but will be present in daylighted stream; could also affect rain garden function.					
Tidal wetland delineation	Assumed to be located near edge of property where stream daylights.					
Inland wetland delineation (if applicable)	Not conducted					
Natural diversity database	In NDDB Area					
Critical Habitat	Intertidal Marsh (S	Salt Marsh)				

Source/Parameter	Details
Stormwatershed delineation	Not conducted; rain garden size is based on available space.
Design precipitation events	Not conducted; rain garden size is based on available space.
FEMA FIS stream transect data	Floodway: No (upstream of Naugatuck Avenue) XS A upstream of Naugatuck Avenue, BFE 11.3 feet
Hydrologic data	None in FIS for this stream
Hydraulic data	None in FIS for this stream
Scour data	Not applicable
Provision of public access	Yes. The Egan Center property will remain accessible, and parking spaces will not be lost.
Preservation of views	Yes. Views will be improved. The project will create a more aesthetically pleasing environment at the Egan Center.
Conceptual design meets current criteria?	Yes. The stream is at elevation of approximately 5 feet on the downstream side of the property where it currently daylights. The stream is above the MHHW indicating that it is not tidal on a daily basis, but the CJL of 5.1 feet indicates that the stream is capable of tidal conditions. The historical topographic map for Milford shows that the stream was a tidal creek, or a creek surrounded by high marsh, prior to its placement in a culvert.
	The upstream end of the daylighted section will be at elevation approximately 7 feet, providing for an appropriate stream profile. This design will need to be verified or modified after site topographic mapping is conducted.
	The entire project area is below the FEMA BFE and just below the NACCS-calculated 10-year storm WSE of 8.8 feet. The stream daylighting will not change this.
Conceptual design meets future criteria?	Yes. Under a one foot rise in sea level, the MHW and MHHW of 3.1 and 3.43 feet, respectively, will still be lower than the elevations in the daylighted section, and the stream will remain mostly non-tidal. Under a three foot rise in sea level, daily tidal fluctuation will extend onto the project site and the daylighted section will become a typical tidal creek. The design will allow for marsh advancement into the stream corridor, which is an improvement over current conditions where this is not possible.

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Regional Framework for Coastal Resilience In Southern Connecticut Town #4 - Milford, CT 9/7/2016 MMI# 2733-14 BY: BAM

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Concept 1 - Proj #: 0429 Daylight 250 L.F. of Stream Channel and GI Retrofit

(Cost Opinion Based on Conceptual Design Plans Dated May 18, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance				
Mobilization	L.S.	L	\$40,000.00	\$40,000.00
Water Control	L.S.	1.	\$75,000.00	\$75,000.00
Sediment and Erosion Control	L.S.	1	\$20,000.00	\$20,000.00
2. Removals				
Remove Existing Culven	C.Y.	150	\$175.00	\$26,250.00
Sawcut Existing Pavement	L.F.	200	\$4,00	\$800.00
Remove Existing Bituminous Pavement	S.Y.	610	\$8,00	\$4,880.00
Excavate Stream Channel	C.Y.	300	\$15.00	\$4,500,00
3. Site Improvements				
Install Permeable Concrete/Pavers	S.F.	5,450	\$10.00	\$54,500.0
Install Wood Pedestrian Bridge	L.F.	25	\$1,000.00	\$25,000.0
Install Rain Garden	C.Y.	200	\$25,00	\$5,000.0
4. Site Restoration				
Dogwood Plantings	1,000 S.F.	1.25	\$100.00	\$125.0
Switchgrass Plantings	1,000 S.F.	2.75	\$400.00	\$1,100.0
Beach Plum Plantings	1,000 S.F.	1.35	\$400,00	\$540.0
Boulders along stream edge (approx. 30)	TON	35	\$40.00	\$1,400.0
Flowering Trees	EA.	4	\$250.00	\$1,000.0
Rain Garden Plantings	1,000 S.F.	2.3	\$400.00	\$920.0
Vegetate Upper Banks	1,000 S.F.	2.9	\$8.00	\$23.2
Educational Signage	L.S.	1.0	\$1,000.00	\$1,000.0
			Subtotal =	\$262,000.00
		-+2	20% Contingency	\$52,400.00
			Total	\$314,400.00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary
- 2) Conceptual level cost opinion, for planning level assessment only.
- 3) All costs assume 2016 construction

WEST HAVEN: West Haven Dune Creation

Conceptual Design Basis: The City of West Haven provides some of the most extensive public access to the shoreline in the State of Connecticut. The City's beach from Savin Rock to Beach Street goes by many names such as Savin Rock Beach and West Walk Beach. The beach is wide and sandy, punctuated by several groins and jetties, and backed by a highly-developed neighborhood of apartments, condominiums, and commercial properties. This neighborhood and the beach are located in a FEMA SFHA. The storm surge from Hurricane Sandy crossed the beach in some areas and nearly flooded residential and commercial properties south of Captain Thomas Boulevard. The ground surface elevation of the beach, including localized areas of small dunes and dune ridges, help avert widespread damage.

The City of West Haven is responsible for maintenance of the beach, but many years have passed since sand was added to the beach. The Connecticut Shoreline Change atlas reports that net shoreline movement in this area had a mean of 16.3 meters seaward, which is a figure likely influenced by the historical addition of sand to the beach. Nevertheless, some erosion has occurred, and the beach is growing more narrow in some locations. The site suitability model developed by UConn found the area suitable for offshore breakwaters but not suitable for beach enhancement, marsh enhancement, or marsh with structures. In contrast to this finding, beach nourishment has been successful here in the past. The site suitability model does not directly address dune ridges.

The City of West Haven participated in the SCRCOG multi-jurisdiction hazard mitigation plan (2014) and recommended "beach sand nourishment and dune restoration" for this beach. The City also applied for a Hurricane Sandy grant from NFWF to nourish the beach and construct a dune ridge for flood protection, among other goals listed in the grant materials. During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted this project as the most important potential green infrastructure coastal resilience project in West Haven. Furthermore, the project is being highlighted as a critical natural infrastructure project in the West Haven Coastal Resilience Plan (underway, with completion in 2017). There is also public consensus for a dune ridge on the beach if it will reduce flood risk.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. Preservation of views was a critical design consideration. Working closely with the City, the top of the dune ridge was held to 13 feet to allow residents to see past (over) the top of the dune ridge and to access the beach over the dune ridge. The 13' elevation of the top of the dune ridge will be sufficient for some storm surge protection such as Hurricane Sandy (maximum WSE was approximately 9 to 10 feet) and protection from the 1% annual chance event. Note that the NACCS-calculated storm levels are approximately 10.3 to 11.4 feet in the 50 to 100-year RI range, implying that a dune at 13' will help reduce flooding from events within this range. Full base flood protection is not anticipated from this project and a FEMA map revision is not proposed, although these are long-term goals for the City and the West Walk residents. The design would need to provide significant freeboard and width to meet the requirements for a map revision.

Relative to sea level rise, beach nourishment will be needed to keep up with loss of sand as sea level rises. Within one foot of sea level rise, the dune ridge will continue to provide protection from events like Hurricane Sandy. However, with a three foot rise in sea level, the 13' top of the dune ridge would be overtopped by a 1% annual chance storm. Future measures will need to be employed for protection in the long term.

Project Highlights:

- · This segment of the Connecticut shoreline is a shining example of coastal public access
- · · Low dunes and patches of vegetation are found among wide sandy expanses
- • The City of West Haven considers this is a priority area for flood protection
- • The FEMA base flood elevation is 12 (VE)
- • The NACCS-calculated storm levels are 10.3 to 11.4 feet in the 50 to 100-year RI range
- • Creation of a dune ridge at elevation 13 feet would provide increased protection
- • A dune ridge would increase the density and types of vegetation at this beach
- • The beach width must be increased in some places to accommodate the dune ridge
- · · With sea level rise of one foot, the dune ridge should still provide significant protection

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Name: West Haven Dune Creation

Town: West Haven

Database ID: #510

Source/Parameter	Details					
CT Shoreline Change atlas	Glacial drift & beaches Net accretion: Net shoreline movement is mean of 16.30 m seaward, although minor erosion occurring near groins					
Site suitability (Zylberman) model		Found the area suitable for offshore breakwaters. Found not suitable for beach enhancement, marsh enhancement, or marsh with structures.				
Existing structures understood	From LiDAR; surve	From LiDAR; survey will be needed				
Coastal jurisdiction line elevation	4.6 feet					
MHW	2.85 feet (interpo	lated)				
MHHW	3.18 feet (interpola	ated)				
FEMA FIS coastal transect data (NAVD 88)	#16 at West Haven Beach Significant Wave Height: 12.19 feet Peak Wave Period: 6.58 seconds Setup Depth: 1.46 feet 1% Stillwater Elevation: 8.9 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 10.3 feet Base Flood Elevation: 12-16 feet in Zone VE Average BFE on FIRM: 12 feet 0.2% Stillwater Elevation: 10.1 feet Maximum Wave Crest: 12 feet V-Zone Mapping Method: Overland Wave Propagation					
FEMA FIS coastal transect runup model						
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR	
	Surge	6.55'	8.72'	9.77'	12.88'	
	Surge+Tide	8.36'	10.32'	11.44'	14.75'	
Ice data (qualitative)	Likely minimal					
Tidal wetland delineation	None present					
Inland wetland delineation (if applicable)	Not applicable					
Natural diversity database	Eastern end of pro	Eastern end of project area in NDDB area				
Critical Habitat	None identified					

Source/Parameter	Details
Stormwatershed delineation	Not applicable
Design precipitation events	Not applicable
FEMA FIS stream transect data	Floodway: No
Hydrologic data	Not applicable
Hydraulic data	Not applicable
Scour data	Not applicable
Provision of public access	Yes. The beach along this stretch of West Haven provides some of the most important public access in the state. Beach nourishment and dune creation will maintain this access, although the project will need to incorporate methods of crossing over the dune ridge.
Preservation of views	Somewhat. Views from the ground surface along the walkway – and from the lower levels of the residential units – will change. Direct views of the water may be impaired. However, views from the upper levels of the residential units should remain unchanged or may be more pleasant.
Conceptual design meets current criteria?	Yes. The 13' elevation of the top of the dune ridge will be sufficient for some storm surge protection such as Hurricane Sandy (maximum WSE was approximately 9 to 10 feet) and protection from the 1% annual chance event. Note that the NACCS-calculated storm levels are approximately 10.3 to 11.4 feet in the 50 to 100-year RI range, implying that a dune at 13' will help reduce flooding from events within this range.
Conceptual design meets future criteria?	Yes. Continued beach nourishment will be needed to keep up with loss of sand as sea level rises. Within one foot of sea level rise, the dune ridge will continue to provide protection from events like Hurricane Sandy. However, with a three foot rise in sea level, the 13' top of the dune ridge would be overtopped by a 1% annual chance storm. Future measures will need to be employed for protection in the long term.

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Regional Framework for Coastal Resilience In Southern Connecticut Town #5 - West Haven, CT 9/7/2016 MMI# 2733-14 BY: JCM

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Concept 1 ~ Proj #: 0510 Main Beach Bank Nourishment / Dune Project

(Cost Opinion Based on Conceptual Design Plans Dated June 6, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance				
Mobilization	L.S.	V	\$100,000.00	\$100,000.00
Sediment and Erosion Control	L.S.	1	\$15,000.00	\$15,000.00
Pedestrian Safety	L.S.	T.	\$25,000.00	\$25,000.00
2. Beach and Dune Restoration				
Dune Construction: Import, and Place/Grade Beach Sand	C.Y.	30,000	\$60,00	\$1,800,000.00
Beach Nourishment: Import, and Place/Grade Beach Sanc	C.Y.	5.000	\$60,00	\$300,000.00
Reeconstruct Walkway Over Dune	L.S.	3	\$35,000.00	\$105,000.00
3. Site Restoration				
Native Beach Grasses	L.S.	1.	\$5,000.00	\$5,000.00
			Subtotal	\$2,350,000.00
		+2	20% Contingency	\$470,000.00
			Total	\$2,820,000.00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary.
- 2) Conceptual level cost opinion, for planning level assessment only,
- 3) All costs assume 2016 construction

NEW HAVEN: Long Wharf Erosion Mitigation and Living Shoreline

Conceptual Design Basis: The City of New Haven has noted that erosion is occurring in Long Wharf Park for many years, with mention in the City's Hazard Mitigation Plan (2005) and Municipal Coastal Program (2006) and both updates to the Hazard Mitigation Plan (2011 and 2016). Severe erosion occurred during storms Irene and Sandy, damaging a paved walkway and bringing the edge of the low coastal bank within 20 feet of the edge of Long Wharf Drive and the critical utilities located beneath the roadway. The City commissioned Langan Engineering to develop a rock revetment design (2014) that was utilized to obtain a FEMA hazard mitigation grant under the Hazard Mitigation Grant Program (HMGP). The HMGP grant was obligated in 2015 but the project was cancelled in 2016. Meanwhile, the City obtained a CDBG-DR grant for a planning study of the Long Wharf area, including consideration of both flood protection and erosion mitigation. This study commenced in 2015 and was completed in 2016. In summary, significant attention has been focused on Long Wharf in the last 11 years.

During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted Long Wharf as one of the two most important potential green infrastructure coastal resilience project sites in New Haven, with East Shore Park cited as the other.

The Connecticut Shoreline Change atlas classified Long Wharf as located in an area of glacial drift and rock (although the entire area was filled extensively decades ago) and the associated GIS analysis found that net shoreline movement had a mean of 770 meters seaward, representative of the creation of land in this area. The site suitability model developed by UConn did not address Long Wharf.

Although erosion is a natural process, the importance of open space and coastal public access at Long Wharf coupled with the critical infrastructure at risk (Long Wharf Drive and its utilities) justifies mitigation of erosion. Because mitigation of the erosion at the edge of the active part of the park (roughly coincident with the top of the low coastal bank) may be pursued separately as recommended by the CDBG-DR funded Long Wharf study, our design focused on methods of reducing erosive wave energy, allowing sediment accretion in the intertidal zone, and expanding marsh grasses.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. Our objective was to design a series of "sills" rather than true breakwaters, although the sills will have characteristics similar to low breakwaters because they will reduce wave energy. However, our design avoids placing a continuous tall and wide line of rock. Wave data was available from the CREST project to augment wave data available from other sources. The FEMA FIS wave data was used to estimate a rock diameter of 2 feet and the CREST wave data was used to estimate a rock diameter of 4 feet (in both cases, the 100-year storm).

To keep the sills as low-impact as possible, the rock should consist of 2, 3, and 4-ft diameter boulders that are stacked as needed but never higher than four or five feet off the surface of the intertidal flats. The design provides an option for oyster castles tucked into the rock, which is consistent with the Long Wharf Study recommendation that oyster castles be considered. The sills should be placed at elevations -1 and -2, which will keep them in the intertidal zone and allow them to be functional as sea level rises. Gaps between sills are provided for horseshoe crabs. The sills will be visible at low tide, and the tops of some rocks will be visible at high tide.

Construction access will be challenging at Long Wharf. We developed a plan that depicts construction from land during low tide, rather than construction from barge or boat. We have minimized the number of access points and placed them where the existing marsh grasses are most narrow, to minimize grass disturbance. We have laid out construction roads that are aligned with the sills. A contractor would drive out to the end of the road and start placing rock, backtracking along the road and turning it into the sill. This will minimize the temporary disturbance. There will be some temporary roads that are at right angles to the sills, and those will need to be restored (the matting could be pulled back out after construction).

Full base flood protection is not anticipated nor is it desired from this project. A FEMA map revision is not proposed. Flood protection may be pursued separately as recommended by the CDBG-DR funded Long Wharf study. It is important to note that expansion of marsh grass and construction of several sills of rocky material in the intertidal zone are consistent with the preservation of views and viewsheds, and continuation of coastal public access at Long Wharf Park. Relative to sea level rise, future measures will need to be employed for a greater level of protection in the long term. However, in the next few decades, the project should reduce erosion and help accrete sediment.

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Project Highlights:

- · Significant erosion of the park edge has occurred in the last few years, following many years of gradual shoreline change
- The City planned to construct a stone revetment along the eroding edge of the park, but the project did not happen; nevertheless, the City Plan Department's Long Wharf study may propose a different shoreline treatment
- An opportunity is available to pursue a project in the intertidal zone to retain sediment and increase the area of vegetation, without being tethered to a park shoreline project
- The rocky sills are set with their bases above the MLW (-3.3 feet) at elevations -1.0 to -2.0 feet
- Marsh grasses will be planted to expand existing areas of marsh grass
- With sea level rise of 1-2 feet, the sills should remain effective

Name:	Long Wharf Erosion Mitigation and Living Shoreline
Town:	New Haven
Database ID:	#605

Source/Parameter	Details
CT Shoreline Change atlas	Glacial drift & rock Net accretion: Net shoreline movement is up to 770 m seaward
Site suitability (Zylberman) model	Not analyzed
Existing structures understood	Yes. The Langan plan set for FEMA-funded mitigation project (rock revetment) was originally considered for our design, although the project was later cancelled. The proposed design leaves the eroding edge of the park for others to directly address.
Coastal jurisdiction line elevation	4.6 feet
MHW	2.85 feet (old Long Wharf station)
MHHW	3.18 feet (old Long Wharf station)
FEMA FIS coastal transect data (NAVD 88)	#20 at Long Wharf Significant Wave Height: 8.78 feet Peak Wave Period: 5.65 seconds Setup Depth: 2.02 feet 1% Stillwater Elevation: 8.9 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 10.9 feet Base Flood Elevation: 13-16 feet in Zone VE Average BFE on FIRM: 13 feet 0.2% Stillwater Elevation: 10.5 feet Maximum Wave Crest: 12 feet V-Zone Mapping Method: Overtopping
FEMA FIS coastal transect runup model	

Source/Parameter	Details					
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR	
	Surge	6.68'	9.00'	10.19'	13.60'	
	Surge+Tide	8.35'	10.48'	11.66'	15.14'	
Long Wharf hydrodynamic modeling data results from GZA	Not provided					
Wave data from CREST project	Significant wave h yr storm. The heig	_		r storm to 7.11	m for a 100-	
Ice data (qualitative)	Likely minimal to	moderate durin	g some winters			
Tidal wetland delineation	Delineated on Lan	gan plan set				
Inland wetland delineation (if applicable)	Not applicable					
Natural diversity database	In NDDB area					
Critical Habitat	None identified					
Stormwatershed delineation	Not applicable					
Design precipitation events	Not applicable					
FEMA FIS stream transect data	Floodway: No	Floodway: No				
Hydrologic data	Not applicable	Not applicable				
Hydraulic data	Not applicable					
Scour data	Not applicable					
Provision of public access	Yes. Design will involve work below the CJL and adequately separated from the park.				parated	
Preservation of views	Yes. Design will involve work below the CJL and adequately separated from the park. Rocky sills are located with their bases at elevations -1.0 or -2.0. MHW will typically submerge the tops of the rocks.					
Conceptual design meets current criteria?	Yes. Rocky sills are located with their bases at elevations -1.0 to -2.0. The MLW is -3.3 feet. Therefore, they will be in the intertidal zone.					
Conceptual design meets future criteria?	Yes. Rocky sills are located with their bases at elevations -1.0 to -2.0. If sea level rises one foot within the design life of the project, the bases of the rocks will still be at or higher than MLW which will allow them to remain in the intertidal zone. If sea level rises by three feet by the end of the century, new measures would need to be employed, or the rocks can remain in place in favor of new rocky sills located landward in the new intertidal zone.					

A110 APPENDIX E



Regional Framework for Constal Resilience In Southern Connecticut Town #6 - New Haven, CT 6/13/2017 MMI# 2733-14 BY: JCM

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Concept 1 ~ Proj #: 0605 Long Wharf Living Shoreline / Reef Ball Project

(Cost Opinion Based on Conceptual Design Plans Dated/Revised Through November 22, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance				
Mobilization	L.S.	V	\$150,000.00	\$150,000.00
Sediment and Erosion Control	L.S.	1	\$15,000.00	\$15,000.00
Pedestrian Safety	L.S.	1.	\$30,000.00	\$30,000.00
Water/Turbidity Control	L.S.	1	\$100,000.00	\$100,000.00
Construction Access and Restoration	L.S.	1	\$45,000.00	\$45,000.00
2. Rock Barrier Placement				
Rock	C.Y.	2,500	\$125.00	5312,500.00
3. Site Restoration				
Native Beach Grasses	L.S.	1	\$40,000.00	\$40,000.00
Site Restoration	L.S.	Y.	\$5,000.00	\$5,000.00
			Subtotal =	\$697,500.00
		+7	10% Contingency	\$139,500.00
			Total	\$837,000,00
A. Add-Alternate				
Oyster Castles	Ea.	250	\$1,500.00	\$375,000.00
X			Subtotal =	\$375,000.00
		+5	10% Contingency	\$75,000.00
		Ad	d-Alternate Total	\$450,000.00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary.
- 2) Conceptual level cost opinion, for planning level assessment only.
- 3) All costs assume 2016 construction

EAST HAVEN: Brazos and Fairview Road Abandonment/Elevation

Conceptual Design Basis: The Town of East Haven owns and maintains several roads that traverse marsh areas for access to beachfront homes. Brazos Road and Fairview Road are two examples. These roads are parallel and relatively close to one another, providing access to the same part of East Haven beach. The Town's hazard mitigation plan recommends elevating coastal roads while considering the retirement or abandonment of roads that may not be necessary because they are redundant. Fairview Road and Brazos Road were specifically mentioned in the hazard mitigation plan.

The proposed conceptual design envisions elevating Fairview Road and retiring Brazos Road, or elevating Brazos Road and retiring Fairview Road. The elevated road would become more resilient infrastructure and the retired roadway would revert to high marsh surrounded by low marsh, available for immediate ecological value as well as making space for marsh zone advancement. The East Haven shoreline will remain accessible via the roadway that remains, and the project will result in an increase in marsh area and an open channel tidal creek. Therefore, the proposed conceptual design preserves public access and improves views. The design elements vary slightly depending on which road is selected for elevation vs. retirement. For example, a water main is located beneath Brazos Road but not Fairview Road, whereas a sewer pumping station is located adjacent to Fairview Road.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. The road that is selected to remain will be reconstructed at elevation 8 feet. This is above the MHW, MHHW, and CJL. It will be higher than the less-severe frequent floods, and approximately equal to the NACCS-calculated 10-year flood. Although it will not be higher than the FEMA BFE, it should provide a longer duration of emergency access during developing severe flooding conditions. For the Hurricane Sandy conditions (WSE of 9 feet), the elevated road would have allowed emergency vehicles to traverse the marsh by crossing areas with flood depth of one foot.

Under a one-foot rise in sea level, the elevated road will be above the MHW, MHHW, and CJL and it will be higher than the less-severe frequent floods as it would be today. Under a three-foot rise in sea level, the MHW, MHHW, and CJL would be approximately 5.78, 6.11, and 7.5 feet, respectively. The road would remain higher than these elevations, and therefore still allowing daily access through the tidal marsh. Under frequent (less severe) storm conditions, the road would experience shallow flooding. Under severe storm conditions, the road would be impassable. In the very long term, additional elevation of the road may be considered.

Project Highlights:

- · A pair of roads extends to the East Haven beach through a tidal marsh
- · A long-term opportunity exists for the Town to focus resources on elevating one road and retiring the other
- Retiring a road would provide space for marsh advancement into the former roadway alignment and would reduce the number of creek crossings
- The elevated road will be at elevation 8 feet, higher than less-severe frequent floods, and approximately equal to the NA-CCS-calculated 10-year flood
- · The FEMA base flood elevation is 12 (AE)

A112 APPENDIX E

Name: Brazos and Fairview Road Abandonment/Elevation

Town: East Haven
Database ID: #706-709

Source/Parameter	Details				
CT Shoreline Change atlas	No data	No data			
Site suitability (Zylberman) model	Not applicable	Not applicable			
Existing structures understood	Not applicable				
Coastal jurisdiction line elevation	4.5 feet	4.5 feet			
MHW	2.78 feet (interpol	ated)			
MHHW	3.11 feet (interpola	ited)			
FEMA FIS coastal transect data (NAVD 88)	#27 at Cosey Beach Avenue Significant Wave Height: 13.21 feet Peak Wave Period: 6.23 seconds Setup Depth: 1.85 feet VZone_EXT: Wave Overtopping Splash Zone 1% Stillwater Elevation: 8.9 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 11.4 feet Base Flood Elevation: 12-13 feet in Zone AE Average BFE on FIRM: 12 feet 0.2% Stillwater Elevation: 10.9 feet Maximum Wave Crest: 14 feet V-Zone Mapping Method: Overtopping				
FEMA FIS coastal transect runup model					
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR
	Surge	6.34'	8.44'	9.43'	12.48'
	Surge+Tide	8.12'	9.95'	11.04'	14.22'
Ice data (qualitative)	Not applicable				
Tidal wetland delineation	Assumed to be along both roads				
Inland wetland delineation (if applicable)	Not applicable				
Natural diversity database	In NDDB area				
Critical Habitat	None identified				
Stormwatershed delineation	Not applicable				

Source/Parameter	Details
Design precipitation events	Not applicable
FEMA FIS stream transect data	Floodway: No
Hydrologic data	None in FIS
Hydraulic data	None in FIS
Scour data	Not applicable
Provision of public access	Yes. Access to the shoreline is still provided by the remaining road.
Preservation of views	Yes. New tidal marsh (under either design alternative) will enhance views.
Conceptual design meets current criteria?	Yes. The remaining road will be at elevation 8 feet. This is above the MHW, MHHW, and CJL. It will be higher than the less-severe frequent floods, and approximately equal to the NACCS-calculated 10-year flood. Although it will not be higher than the FEMA BFE, it should provide a longer duration of emergency access during developing severe flooding conditions. For the Hurricane Sandy conditions (WSE of 9 feet), the elevated road may have allowed emergency vehicles to traverse the marsh by crossing areas with flood depth of one foot.
Conceptual design meets future criteria?	Yes. Under a one-foot rise in sea level, the roads will be above the MHW, MHHW, and CJL and it will be higher than the less-severe frequent floods. Under a three-foot rise in sea level, the MHW, MHHW, and CJL would be approximately 5.78, 6.11, and 7.5 feet, respectively. The road would be higher than these elevations, allowing daily access through the tidal marsh. Under frequent (less severe) storm conditions, the road would experience shallow flooding. Under severe storm conditions, the road would be impassable.

A114 APPENDIX E



Regional Framework for Coastal Resilience In Southern Connecticut Town #7 - East Haven, CT 9/7/2016 MMI# 2733-14 BY: JCM

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Concept 1 - Proj #: 0706 & 0709 Remove Brazos Road & Elevate Farview Road

(Cost Opinion Based on Conceptual Design Plans Dated May 9, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance				
Mobilization	L.S.	V	\$50,000.00	\$50,000,00
Water Control	L.S.	1	\$100,000.00	\$100,000.00
Sediment and Erosion Control	L.S.	L.	\$20,000.00	\$20,000.00
2. Removals				
Remove Brazos Road (Pavement and Embankment)	L.F.	760	\$80.00	\$60,800.00
Remove Existing Culvert	Ea-	3	\$10,000.00	\$30,000.00
Remove and Cap Existing Watermain	L.S.	į.	\$5,000.00	\$5,000,00
3. Roadway and Causeway Construction				
Raise Causeway/Embankment	L.S.	1	\$190,000.00	\$190,000,00
Install New Bridge	Ea.	2	\$150,000.00	\$300,000.00
Install New Watermain	L.S.	1/	\$87,500.00	\$87,500.00
Install Cul-De-Sac at Brazos Rd	L.S.	1	\$75,000.00	\$75,000.00
Drainage Improvements	L.S.	1	\$50,000.00	\$50,000.00
4. Site Restoration				
Revegetate Roadway Removal Site	L.S.	1.	\$20,000.00	\$20,000.00
Vegetate Causeway Banks	L.S.	J)	\$20,000.00	\$20,000.00
			Subtotal =	\$1,008,300.00
		+5	20% Contingency	\$201,700.00
			Total	\$1,210,000.00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary.
- 2) Conceptual level cost opinion, for planning level assessment only.
- 3) All costs assume 2016 construction

BRANFORD: Trolley Bridge Scour Mitigation Project

Conceptual Design Basis: The Town of Branford owns a former trolley bridge over Stony Creek. The bridge currently supports part of a popular trail system, providing public access to and near the shoreline. The Town has noted for several years that erosion of substrate around and behind the bridge abutments is creating risk of damage to the bridge. Erosion appears to be due mainly to scour in the tidal channel of Stony Creek, although some stormwater erosion and gullying could also be occurring.

During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted this project as a potential coastal resilience green infrastructure project if the erosion could be addressed with non-traditional methods that include vegetation and soft or hybrid structures. The site suitability model developed by UConn found the area suitable for marsh enhancement.

The proposed conceptual design envisions filling of voids behind the abutments and the use of rock to help protect the abutments, along with a widening of the most active part of the channel to decrease velocities associated with the ebb and flood tides. The design includes planting of marsh species and placement of oyster castles in the intertidal zone (between the low-tide channel and the abutments) to foster natural hardening through shellfish growth. The proposed conceptual design preserves important public access. All of the project components are much lower than the bridge deck, and distant views will not change. Near-field views may be enhanced because fewer bare patches of the intertidal zone will be visible.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. The oyster castles and vegetation are appropriate for the intertidal zone located on the banks of the channel up to the bridge abutments. The velocity of 5 to 6 feet per second may be too high for some vegetation to succeed. To address this, the low tide channel width will be increased, which may relax velocities somewhat. Also, rocky material will be interspersed with the marsh glasses to provide some protection. (The high tide channel width will remain unchanged since it is bounded by the bottom of the abutments, which are at elevation 2.6 feet).

With one foot rise in sea level, most of the intertidal vegetation will remain at appropriate elevations relative to the water levels. The larger concern is that flushing through the bridge opening will increase over time as the area that "holds" water increases on the upstream side of the bridge, potentially leading to worsening scour. Another concern is that the current MHW, MHHW, and CJL of 2.5, 2.82, and 4.3 feet will increase under the three-foot rise scenario to approximately 5.5, 5.82, and 7.3 feet. With the bottom of the bridge abutments at elevation 2.6 feet, this means that they will be in contact with water throughout most of the day, which is a very different condition than the present dynamics. The condition of the bridge will need to be evaluated relative to future conditions as they develop.

Project Highlights:

- • The old trolley line pedestrian bridge is an important community asset
- · · Scour has exposed the bridge abutments
- • Protection of the bridge may be possible using living shoreline techniques combined with hard structures
- The design envisions a widening of the channel coupled with the uses of oyster castles, rocky material, and grasses in the intertidal zone to stabilize the banks
- · · Boulders would be placed against the abutments
- · · With sea level rise of 1-2 feet, the zonation of the intertidal zone beneath the bridge may shift upland

A116 APPENDIX E

Name: Trolley Bridge Scour Mitigation

Town: Branford Database ID: #810

Source/Parameter	Details						
CT Shoreline Change atlas	Glacial Drift & Rock Net accretion: Net shoreline movement mean of 25.57 m seaward						
Site suitability (Zylberman) model	Found the area su beach enhancement						
Existing structures understood	Yes – picked up by	y survey					
Coastal jurisdiction line elevation	4.3 feet						
MHW	2.50 feet (interpo	lated)					
MHHW	2.82 feet (interpo	2.82 feet (interpolated)					
FEMA FIS coastal transect data (NAVD 88)	#38 near Pleasant Significant Wave I Peak Wave Period Setup Depth: 1.26 VZone_EXT: Break 1% Stillwater Elevat 1% Total Water Lev feet Base Flood Elevat Average BFE on Fl 0.2% Stillwater Ele Maximum Wave C V-Zone Mapping I	Height: 10.19 feet is 6.05 seconds if feet is wave Height ation: 9.0 feet is wel (includes Stite) ion: 12-15 feet is IRM: 12 feet evation: 12.0 feet is rest: 12 feet	nt Ilwater and effect in Zone VE		up): 10.3		
FEMA FIS coastal transect runup model							
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR		
	Surge	6.46'	8.66'	9.74'	13.02'		
	Surge+Tide	8.00'	10.00'	11.12'	14.30'		
Ice data (qualitative)	Likely present in v	vinter due to br	ackish condition	S			
Tidal wetland delineation	Not conducted; pr	oject area is en	tirely intertidal z	one.			
Inland wetland delineation (if applicable)	Not applicable						
Natural diversity database	In NDDB area						

Source/Parameter	Details
Critical Habitat	Intertidal Marsh (Salt Marsh)
Stormwatershed delineation	Not applicable
Design precipitation events	Not applicable
FEMA FIS stream transect data	Floodway: No
Hydrologic data	None in FIS
Hydraulic data	None in FIS
Scour data	Estimated velocities may be 5 to 6 feet per second.
Provision of public access	Yes. Protection of the bridge is critical to maintaining the access provided by the bridge.
Preservation of views	Yes. All of the project components are much lower than the bridge deck, and distant views will not change. Near-field views may be enhanced because fewer bare patches of the intertidal zone will be visible.
Conceptual design meets current criteria?	Yes. The oyster castles and vegetation are appropriate for the intertidal zone located on the banks of the channel up to the bridge abutments. The velocity of 5 to 6 feet per second may be too high for some vegetation to succeed. To address this, the low tide channel width will be increased, which may relax velocities somewhat. Also, rocky material will be interspersed with the marsh glasses to provide some protection. (The high tide channel width will remain unchanged since it is bounded by the bottom of the abutments, which are at elevation 2.6 feet).
Conceptual design meets future criteria?	Somewhat. With one foot rise in sea level, most of the intertidal vegetation will remain at appropriate elevations relative to the water levels. The larger concern is that flushing through the bridge opening will increase over time as the area that "holds" water increases on the upstream side of the bridge, potentially leading to worsening scour. Another concern is that the current MHW, MHHW, and CJL of 2.5, 2.82, and 4.3 feet will increase under the three-foot rise scenario to approximately 5.5, 5.82, and 7.3 feet. With the bottom of the bridge abutments at elevation 2.6 feet, this means that they will be in contact with water throughout most of the day, which is a very different condition than the present dynamics. The condition of the bridge will need to be evaluated relative to future conditions as they develop.

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Regional Framework for Coastal Resilience In Southern Connecticut Town #8 - Branford, CT 9/7/2016 MMI# 2733-14 BY: JCM

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Concept 1 - Proj #: 0810 Bridge Abutment Stabilization

(Cost Opinion Based on Conceptual Design Plans Dated May 9, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance				
Mobilization	L.S.	1	\$25,000.00	\$25,000.00
Water Control	L.S.	1	\$50,000.00	\$50,000.00
Sediment and Erosion Control	L.S.	L	\$5,000.00	\$5,000.00
2. Abutment Stabilization				
Removal and Disposal of Material from Within Channel	C.Y.	200	\$60,00	\$12,000.00
Install "Oyster Castle"	Ea.	40	\$750.00	\$30,000.00
Install Large 24"-36" Boulders	Ea.	100	\$250.00	\$25,000.00
Install Smaller, Rounded Stone	C.Y.	100	\$150.00	\$15,000.00
Replace Eroded Material from Bridge Abutment Voids	L.S.	1.	\$10,000.00	\$10,000.00
Geotextile Sooil Stabilization	L.S.	1.	\$2,000,00	\$2,000,00
3. Site Restoration				
Plant Spartina Alterniflora	L.S.	1	\$15,000.00	\$15,000.00
Plant Iva Frutescens	L.S.	1	\$15,000.00	\$15,000.00
Cobble Restoration	L,S,	Γ	\$2,000.00	\$2,000.00
			Subtotal =	\$206,000.00
		-6	20% Contingency	\$41,200.00
		~	Total	\$247,200.00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary
- 2) Conceptual level cost opinion, for planning level assessment only.
- 3) All costs assume 2016 construction

GUILFORD: Chittenden Beach and West River Living Shoreline

Conceptual Design Basis: The Town of Guilford has identified erosion of the shoreline tidal marshes and beach areas as a significant coastal concern. The coastline of Chittenden Park has experienced significant active marsh front erosion. The loss of marsh in this area has contributed to easterly currents or circulation that heads directly west into the vicinity of Brown's Boat Yard, where marsh erosion has been occurring on the south side of the property.

The Town of Guilford Municipal Coastal Program (2008), Natural Hazard Mitigation Plan (2012), and Community Coastal Resilience Plan (2014) identify existing vulnerabilities within the Town. Section 4 of the HMP deals specifically with Coastal Flooding and Shoreline Change, and references Section 7.1 of the Town of Guilford Harbor Management Plan for its combination of hard and soft methods for mitigation of tidal marsh erosion at Jacobs Beach, Chaffinch Island, and specifically Chittenden Beach. During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted this project as the one of the most important potential green infrastructure coastal resilience projects in Guilford. Furthermore, the project was included as a major component of a comprehensive Tidal Wetland Restoration proposal for a NFWF Hurricane Sandy Coastal Resiliency Competitive Grants Program Application submitted in 2014.

The Connecticut Shoreline Change atlas classified the Guilford Chittenden Park site as located in an area of glacial drift and beaches and the associated GIS analysis found that net shoreline movement had a mean of 114.7 meters (approximately 377 feet) landward. The site suitability model developed by UConn found the area suitable for marsh enhancement and marsh with structures, while not suitable for beach enhancement and offshore breakwaters.

The proposed conceptual living shoreline design for Chittenden Park involves the construction of a hybrid living shoreline focused on tidal wetland restoration and dune maintenance, stabilized through the incorporation of low gradient sills and nearshore breakwaters. The design emphasizes existing conditions within the current marsh system, enhancing stable tombolo features thereby reducing the volume of fill required for wetland restoration and enhancing a mosaic of coastal habitat. The proposed living shoreline conceptual design is consistent with preservation of views and viewsheds, and continuation of coastal public access.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. Stone sills are located with their bases at elevations 0 to -2.0. Sills are proposed at the toe of restored wetland areas in the intertidal zone, at the head of natural tombolo features. Breakwater bases are proposed at elevations from -10 to -8, with the surface approximately 1-2 ft. above MHW (elevation 2.32). These design criteria are sufficient for some storm surge protection such as the NACCS-calculated 50-year storm. Full base flood protection is not anticipated nor is it desired from this project. A FEMA map revision is not proposed.

Relative to sea level rise, the current design places low gradient stone sill base at elevations -0 to -2. Within one foot of sea level rise, the bases of the sills will remain in the intertidal zone, and top of sills should be close to MHW and will continue to provide protection from events like Hurricane Sandy and potentially from the NACCS-calculated 50-year storm. However, with a three foot rise in sea level, new measures would need to be employed to assist marsh stability here.

Project Highlights:

- Significant erosion of the Chittenden Beach shoreline has occurred over the last century
- · The hazard mitigation plan and community coastal resilience plan highlight this area for constructing a living shoreline
- Stone sills are located with their bases at elevations 0 to -2.0 feet
- Breakwater bases are proposed at elevations from -10 to -8 feet, with the surface approximately 1-2 feet above the MHW of 2.32)
- With sea level rise of 1-2 feet, the structural parts of the living shoreline should remain effective and marsh grasses should advance landward

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Name: Chittenden Beach & West River Living Shoreline

Town: Guilford Database ID: #901

Source/Parameter	Details						
CT Shoreline Change atlas	Glacial Drift & Beaches Net erosion: Net shoreline movement mean of 114.70 m inland						
Site suitability (Zylberman) model	Found parts of the area suitable for marsh enhancement and marsh with structures. Found not suitable for beach enhancement and offshore breakwaters.						
Existing structures understood	None present; old	jetty is visible a	nt low tide				
Coastal jurisdiction line elevation	4.0 feet						
MHW	2.32 feet (interpol	ated)					
MHHW	2.64 feet (interpol	2.64 feet (interpolated)					
FEMA FIS coastal transect data (NAVD 88)	#50 at Guilford Point Significant Wave Height: 12.85 feet Peak Wave Period: 6.11 seconds Setup Depth: 2.50 feet VZone_EXT: Wave Overtopping Splash Zone 1% Stillwater Elevation: 9.1 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 11.6 feet Base Flood Elevation: 14-17 feet in Zone VE Average BFE on FIRM: 14 feet 0.2% Stillwater Elevation: 13.0 feet Maximum Wave Crest: 14 feet						
FEMA FIS coastal transect runup model							
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR		
	Surge	6.33'	8.46'	9.44'	12.46'		
	Surge+Tide	7.77'	9.71'	10.85'	13.94'		
Ice data (qualitative)	May be present or	casionally in w	inter				
Tidal wetland delineation	Not conducted; pr	oject area is as	sumed to be mo	stly within any	delineation		
Inland wetland delineation (if applicable)	Not applicable						
Natural diversity database	In NDDB area						

Source/Parameter	Details
Critical Habitat	Intertidal Marsh (Salt Marsh) along West River
Stormwatershed delineation	Not applicable
Design precipitation events	Not applicable
FEMA FIS stream transect data	Floodway: No
Hydrologic data	Not applicable
Hydraulic data	Not applicable
Scour data	Not applicable
Provision of public access	Yes. The design will neither impair nor improve public access.
Preservation of views	Yes. The design is proposed below the CJL and will not inhibit views. The top of stone sills and breakwater are proposed at elevations from 0 to -2. MHHW should submerge the top of stone sills and cover the majority of breakwater structures.
Conceptual design meets current criteria?	Yes. Stone sills are located with their bases at elevations 0 to -2.0. Sills are proposed at the toe of restored wetland areas in the intertidal zone, at the head of natural tombolo features. Breakwater bases are proposed at elevations from -10 to -8, with the surface approximately 1-2 ft. above MHW (elevation 2.32).
Conceptual design meets future criteria?	Yes. Stone sill bases are located at elevations -0 to -2.0. If sea level rises one foot within the design life of the stone sill, the bases of the sills will remain in the intertidal zone, and top of sills should be close to MHW. If sea level rises by three feet by the end of the century, new measures would need to be employed to assist marsh stability here.

A122 APPENDIX E



455 Winding Brook Drive, Suite 201 Glastonbury, Connecticut 06033 (860)368-5300 Regional Framework for Coastal Resilience In Southern Connecticut Town #9 - Guilford, CT 9/8/2016 GEI# 1506360 By. AMH



99 Realty Drive Cheshire, Connecticut 06410 (203) 271-1773

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Proj #: 0901 <u>Team Design</u> (Cost Opinion Based on Conceptual Design Plans Dated June 2, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance				
Mobilization	L.S.	1	\$50,000.00	\$50,000,00
Water Control	L.S.	1	\$100,000.00	\$100,000,00
Sediment and Erosion Control	L.S.	1	\$20,000.00	\$20,000.00
2. Site Improvements				
Initial Sand Fill 4	C.Y.	32,208	\$25.00	\$805,200.00
Install Stone Sills	C.Y.	1,932	\$62.52	\$120,760.85
Install Breakwaters	C.Y.	2,967	\$127.12	\$377,117.96
Install Jetty	C.Y.	1,439	\$127.12	\$182,864,47
3. Site Restoration				
Shrub Plantings	1000 S.F.	15.0	\$3,500.00	\$52,458.00
Wetland Vegetation	1000 S.F.	15.0	\$3,000.00	\$44,964.00

	Subtotal =	\$1,753,400.00
7	+20% Contingency	\$350,700.00
	Total	\$2,104,100.00

Notes:

- 1) All quantities are based upon rough field measurements without detailed topographic survey, and are subject to vary.
- 2) Conceptual level cost opinion, for planning level assessment only.
- 3) All costs assume 2016 construction
- 4) Sand fill cost highly variable depending on source availability. Using dredged fill from the marina may is a possible alternative if the material is acceptable and available. Assuming the material is acceptable for use, and that the dredging is performed and paid for by the marina, the cost of the sand fill is estimated at \$15 per C.Y. (\$483,120 total), or a project cost reduction of approximately \$322,080.

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455 Winding Brook Drive, Suite 201 Glastonbury, Connecticut 06033 (860)368-5300 Regional Framework for Coastal Resilience In Southern Connecticut Town #9 - Guilford, CT 9/8/2016 GEI# 1506360 By. AMH



99 Realty Drive Cheshire, Connecticut 06410 (203) 271-1773

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Proj #: 0901 Team Design

Quantity Computations

Item	Unit	Quantity	Source
Install Sand Fill	C.Y.	32,208	
Plan View Area	S.F.	26,840	AutoCAD measurement
Average Depth	FT.	1	AutoCAD measurement
Install Stone Sill	C.Y.	1,932	
Linear Feet of Stone Sill	FT.	492	AutoCAD measurement
Section Area - Stone Sill	S.F.	106	AutoCAD measurement
Install Breakwater	C.Y.	2,967	
Linear Feet of Breakwater	FT.	463	AutoCAD measurement
Section Area - Breakwater	S.F.	173	AutoCAD measurement
Install Jetty	C.Y.	1,439	
Area of Jetty	S.F.	4,855	AutoCAD measurement
Depth of Jetty	FT.	8	Assumed
Maritime Shrub and Wetland Planting - Plan Area	S.F.	14988	AutoCAD measurement

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MADISON: Madison Surf Club Dune Restoration

Conceptual Design Basis: The Town of Madison public beach known as Madison Surf Club sustained damage during Tropical Storm Irene and Hurricane Sandy. In particular, a dune ridge located east of the pavilion experienced overwash. Waves crossing this stretch of beach contribute to elevated water levels on the north (landward) side, flooding a small partly-channelized tidal creek and contributing to flooding of private properties. The dune ridge breach has not recovered in the years since Hurricane Sandy.

In its annex to the South Central Region Hazard Mitigation Plan (2014), the Town of Madison included a mitigation action to restore the dune ridge. During the planning process for the Regional Framework for Coastal Resilience in 2015, municipal staff promoted this project as the most important potential green infrastructure coastal resilience project in Madison. Furthermore, the project was highlighted as the most important natural infrastructure project in the Town of Madison Coastal Resilience Plan (2016).

The Connecticut Shoreline Change atlas classified the Madison Surf Club site as located in an area of glacial drift and beaches and the associated GIS analysis found that net shoreline movement had a mean of 8.58 meters (approximately 25 feet) landward. The site suitability model developed by UConn found the area suitable for offshore breakwaters but not suitable for beach enhancement, marsh enhancement, or marsh with structures. The site suitability model does not directly address dune ridges.

Although dune overwash is a natural process, the long history of the dune at this location supports its restoration. Restoration of a dune ridge is consistent with preservation of views and viewsheds, and continuation of coastal public access in a municipality where Town-owned public access is relatively lacking.

The CJL, MHW, MHHW, FEMA, and NACCS data pertinent to this site is listed on the attached sheet. The proposed 11' elevation of the top of the dune was selected to meet the existing dune located closer to the pavilion, as well as the seawall located at the pavilion. This elevation will be sufficient for some storm surge protection such as Hurricane Sandy (maximum WSE was approximately 9 to 10 feet) or the NACCS-calculated 50-year storm. Full base flood protection is not anticipated nor is it desired from this project. A FEMA map revision is not proposed.

Relative to sea level rise, beach nourishment will be needed to keep up with loss of sand as sea level rises. Within one foot of sea level rise, the dune ridge will continue to provide protection from events like Hurricane Sandy and potentially from the NA-CCS-calculated 50-year storm. However, with a three foot rise in sea level, the 11' top of the dune ridge would provide protection that is not much better than the current conditions with the dune washed out. With reference to the NACCS-calculated events, the dune may provide protection from the equivalent of a current 10-year storm occurring under future conditions with a three foot rise in sea level. Future measures will need to be employed for a greater level of protection in the long term.

Project Highlights:

- · Madison Surf Club is Madison's public beach
- · Overwash processes have removed a section of the dune that was present
- Dunes and patches of vegetation are still present, but not continuous
- The Town of Madison considers this is a priority area for flood protection
- The FEMA base flood elevation is 14 (VE)
- The NACCS-calculated storm levels are 9.4 to 10.5 feet in the 50 to 100-year RI range
- Restoration of a dune ridge at elevation 11 feet would provide increased protection
- · Restoration of a dune ridge will allow for increased density and types of vegetation
- · The beach width likely does not need to be increased to accommodate the restoration

Name: Madison Surf Club Dune Restoration

Town: Madison
Database ID: #1003

Source/Parameter	Details							
CT Shoreline Change atlas	Glacial Drift & Beaches Net erosion: Net shoreline movement mean of 8.58 m inland							
Site suitability (Zylberman) model	Found the area su beach enhancement							
Existing structures understood	Seawall at pavilion by survey.	n at elevation 1	I NAVD88. Priva	te seawall was	s picked up			
Coastal jurisdiction line elevation	3.7 feet							
MHW	2.19 feet (interpola	ated)						
MHHW	2.50 feet (interpolated)							
FEMA FIS coastal transect data (NAVD 88)	#53 east of West Wharf Road Significant Wave Height: 13.57 feet Peak Wave Period: 6.34 seconds Setup Depth: 2.56 feet VZone_EXT: Wave Overtopping Splash Zone 1% Stillwater Elevation: 9.1 feet 1% Total Water Level (includes Stillwater and effects of wave setup): 12.0 feet Base Flood Elevation: 14-18 feet in Zone VE Average BFE on FIRM: 14 feet 0.2% Stillwater Elevation: 13.5 feet Maximum Wave Crest: 14 feet V-Zone Mapping Method: Overtopping							
FEMA FIS coastal transect runup model								
NACCS data (NAVD 88)	Туре	10-YR	50-YR	100-YR	500-YR			
	Surge	6.22'	8.32'	9.30'	12.32'			
	Surge+Tide	7.53'	9.40'	10.45'	13.44'			
Ice data (qualitative)	Likely minimal							
Tidal wetland delineation	None present at b	each; inferred a	it rear in overwa	sh area				
Inland wetland delineation (if applicable)	Not applicable							
Natural diversity database	Not in or near NDI	OB area		Not in or near NDDB area				

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Source/Parameter	Details
Critical Habitat	None identified
Stormwatershed delineation	Not applicable
Design precipitation events	Not applicable
FEMA FIS stream transect data	Floodway: No
Hydrologic data	Not applicable
Hydraulic data	Not applicable
Scour data	Not applicable
Provision of public access	Yes. The area is a public beach and will remain a public beach.
Preservation of views	Yes. The restored dune will not block any existing viewsheds. The sound cannot be viewed from Surf Club Road.
Conceptual design meets current criteria?	Yes. The 11' elevation of the top of the dune was selected to meet the existing dune located closer to the pavilion, as well as the seawall located at the pavilion. This elevation will be sufficient for some storm surge protection such as Hurricane Sandy (maximum WSE was approximately 9 to 10 feet) or the NACCS-calculated 50-year storm.
Conceptual design meets future criteria?	Yes. Beach nourishment will be needed to keep up with loss of sand as sea level rises. Within one foot of sea level rise, the dune ridge will continue to provide protection from events like Hurricane Sandy and potentially from the NACCS-calculated 50-year storm. However, with a three foot rise in sea level, the 11' top of the dune ridge would provide protection that is not much better than the current conditions. With reference to the NACCS-calculated events, the dune may provide protection from the equivalent of a current 10-year storm occurring with a three foot rise in sea level. Future measures will need to be employed for a greater level of protection in the long term.



Regional Framework for Coastal Resilience In Southern Connecticut Town #10 - Madison, CT 9/7/2016 MMI# 2733-14 BY: JCM

PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COSTS

Concept 1 - Proj #: 1003 Constructed Sand Dune

(Cost Opinion Based on Conceptual Design Plans Dated May 9, 2016)

No. Item	Unit	Quantity	Unit Cost	Cost
1. Construction Site Preparation and Maintenance				
Mobilization	L.S.	V	\$25,000.00	\$25,000.00
Sediment and Erosion Control	L.S.	T.	\$5,000.00	\$5,000.00
2. Dune Construction				
Import, and Place/Grade Beach Sand	C.Y.	2,000	\$100.00	\$200,000.00
Reeconstruct Walkway Over Dune	L.S.	1	\$25,000,00	\$25,000.00
3. Site Restoration				
Native Beach Grasses	L.S.	L	\$20,000.00	\$20,000.00
			Subtotal =	\$275,000.00
		+2	20% Contingency	\$55,000.00
Tall House			Total	\$330,000.00
4. Add-Alternate Optional: Concrete Core Wall Inside Dune	LF.	500	\$400.00	\$200,000.00
			Subtotal	\$200,000.00
		+2	20% Contingency	\$40,000.00
			Total	\$240,000.00

Notes:

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- 3) All costs assume 2016 construction

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PROJECT COMPONENT #2: COMMUNITY ENGAGEMENT

Overall Objectives

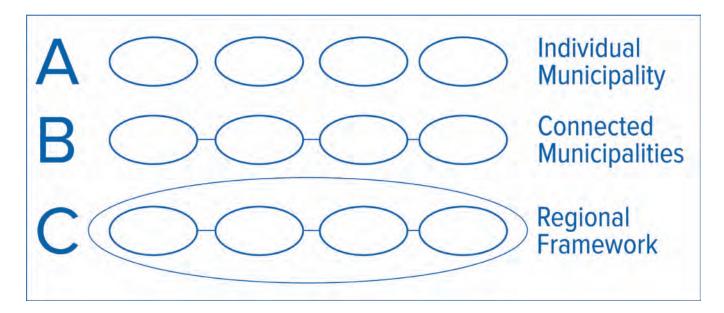
To create an opportunity to explore and define risk and resilience opportunities at a municipal and an interconnected regional scale. To strengthen support for the regional framework for resilience in South Central Connecticut. To reach consensus on top tier green/natural infrastructure projects to advance in Project Component #3/#4.

Key Process Outcomes:

- · Strengthen relationships and build trust within and across municipalities, Council of Governments, and supporting partners;
- Municipalities secure a clearer understanding of local risks and resilience opportunities;
- Municipalities identify and recognize shared risks across region;
- Support for Regional Framework for Resilience in South Central Connecticut.

Key Decision Outcomes:

- · Consensus on high risk zones across municipalities and at the regional scale;
- · Additional details on specific projects;
- Identification of top tier projects at the municipal scale and within/across the Regional Framework for Resilience in South Central Connecticut.



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CONCEPTUAL ENGAGEMENT STEPS: Developing a Regional Framework for Resilience.

Process Steps

Step #1: Initial Stakeholder Engagement

Objectives/Intended Outcomes: To begin a collaborative process that will increase awareness of risk and resilience opportunities at the municipal and regional scale. To increase level of detail for green/natural infrastructure projects across the region. Surface top tier projects to be carried forward in subsequent steps of Project Component #2.

TIMEFRAME: November - December

Step #2: Top Tier Project Site Visits

Objectives/Intended Outcomes: To strengthen cross-municipal relationships through site visits of top tier projects across region. To share specifics on individual projects and have robust exchange opportunities and/or concerns amongst municipal-based practitioners. Create an opportunity for greater awareness of projects and challenges across municipalities within regional framework.

TIMEFRAME: December - January

Step #3: Design Studio Workshop(s)

Objectives/Intended Outcomes: To reinforce consensus on top tier projects and to generate conceptual designs for select number of projects. To strengthen relationships across municipalities within a regional framework for resilience via top tier project focus.

TIMEFRAME: January - February; March - April

Step #4: Summarize Project Materials

Objectives/Intended Outcomes: Coalesce project specific materials generated via Step #1 - #3 in preparation for integration into final Regional Resilience Framework Final Report.

Timeframe: March - August

Step #1: Regional Risk and Project Opportunity Workshop

NOVEMBER 2015 (9:00am - 12:00pm)

Workshop OBJECTIVES:

- · Share perspectives on regional risk and resilience opportunities.
- · Surface and share additional information about municipal-based projects of importance.
- Surface and share additional information about specific projects of regional importance.
- Identify list of top tier projects within regional framework for resilience.

AGENDA and Facilitation Details

9:00 - WELCOME, Review of Agenda/Flow and Introductions

- · Welcome to the workshop (Core Team Representative)
- · Introductory remarks (VIP)
- · Introduce agenda and flow (Core Team Rep)
- · Round-the-room introductions. (Core Team Rep)

9:15 - EXERCISE #1: Greatest Risk Regionally

Strategy: Initiate discussion/consideration at regional scale.

Guiding Questions:

- Where are the areas within the "Regional Framework for Resilience" (10-town project area) with the greatest amount of risk? (Circle or mark in SeaSketch)
 - · Today?
 - In the Future (2030)?
- Why did you select these areas within the "Regional Framework"? (Add notes in SeaSketch)
 - What is at risk? (bridges, houses, beaches, wetlands, marinas, etc).
 - What categories of risk (economic, social, environmental)?
 - Degree of risk (1 to 10) for given scenario (Cat-3, SLR, both)?

Intended Outcomes:

- A number of polygons or points for areas of risk for each participant across the "Regional Framework" populated with details as to risk categories (economic, social, environmental) and degree of risk (1 to 10) today and in the future (2030 timeframe). (via SeaSketch)
- Aggregated map of areas of regional risk for all participants that show areas of highest and lowest unison (i.e., heat map of co-occurrence) or "consensus". (via SeaSketch)

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10:00 - EXERCISE #2: Regional Opportunity and Gaps

Strategy: Initiate consideration of projects at individual municipal scale and then multi-municipal scale to get to list of potential top tier projects.

Guiding Questions: (Independent/Individual Municipal Review)

- Where are the projects located? Do these project help to reduce risk? If so, how?
 - · Add detailed notes to specific projects identified
- Which projects will have the biggest impact reduce the most amount of risk? Why?
 - · Add detailed notes to specific projects identified

Guiding Questions: (Paired Multi-Municipal Reviews)

Madison-Fairfield; Guilford-Milford; Bridgeport-New Haven; Branford-WH; EH-Stratford

- Describe projects with biggest impact share detailed notes for top 2-3 projects for each municipality. Commonalities across projects in two municipalities? Differences? Degree of risk reduction?
- Come to agreement of top 2-3 projects across both towns? Why?
- · Prepared report out for larger group

Report out by all five, paired-municipal groups in succession

- Define report out format and points to hit to encourage comparative and collective dialogue after report outs. Need, urgency, risk, benefits, etc...
- As report outs are ongoing highlight projects on map in front of participants.

Group discussion and review of 15-20 projects identified

- · Commonalities, differences, risk reduction?
- · Consensus building facilitation

11:15 - EXERCISE #3: Reinforce Regional Framework

Strategy: Review regional areas of risk in context of potential list of top tier projects to reinforce selections and confirm working agreement on list of projects to advance to site visits.

Reinforce Regional Framework:

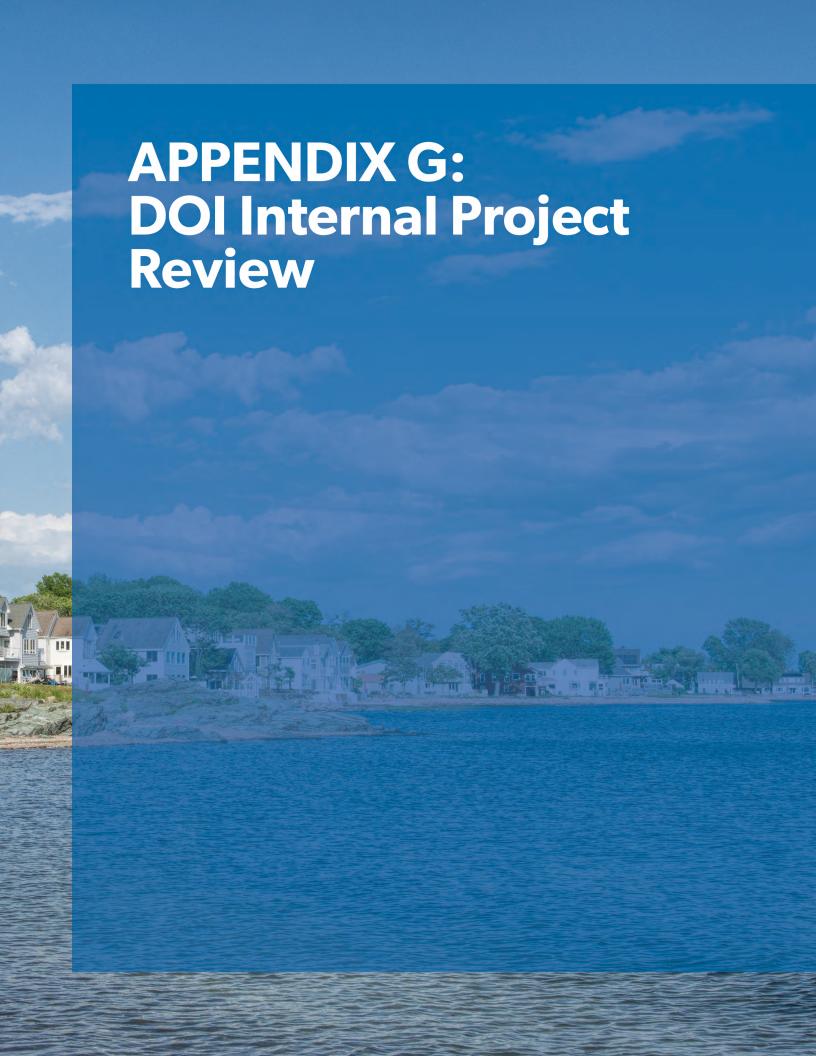
- Display all project with "regional areas of risk" generated in Exercise #1.
- Display just top 15-20 projects with "regional areas of risk".
- Dialogue on 15-20 projects
- · Which ones are most important for reducing risk a regional scale?
- · Capture discussion and pair down list of top tier projects as determined by participants
- · "Are these the projects that will provide the highest opportunities for risk reduction at the regional scale?"

11:50 - NEXT STEPS and FOLLOW-UP

- · Review and discuss immediate next steps
- · Additional detail input for individual projects
- · Independent state and expert input on regional areas of risk and specific projects
- · Site visit to top tier projects
- · Closeout and Thanks

12:00 - ADJOURN





APPENDIX G:

U.S. Department of Interior Internal Project Review

As part of the Disaster Relief Appropriations Act of 2013, the Department of Interior (DOI) received funds to address the impacts of Superstorm Sandy. DOI distribute project funds both internally and externally. All DOI projects were to address the impacts from Superstorm Sandy by reducing risk and increasing resilience throughout coastal communities along the Eastern Seaboard. A total of forty-five internal DOI projects were designated and assigned to regions that were affected by Sandy to enhance data sharing, improve communication, and provide an overall resilience assessment for the impacted coastline.

The Southern Connecticut Regional Framework for Coastal Resilience Core Team, composed of the South Central Regional Council of Governments, the Metropolitan Council of Governments, and the Nature Conservancy, thoroughly reviewed all forty-five DOI internal projects. The team recognized that there was valuable data, decision-support tools and approaches, as well as modeling from these internal DOI projects that had a critical importance and close connection to the Regional Resilience Framework in Southern Connecticut. A total of nine internal DOI projects were selected out of the suite of forty-five for greatest relevance including: GS2-5D USGS – Forecasting Biological Vulnerabilities; GS2-3B USGS – Storm Surge Science; GS2-5A USGS – Evaluating Ecosystem Resilience; FWS - #24 Decision-Support – Tidal Wetlands; FWS - #67 Decision-Support – Beach Habitat; FWS - #63 Culverts and Road Crossings Standards; FWS - #51 Pond Lily Dam Removal; FWS - #32 Tidal Marsh Bird Community Resilience; FWS - #30 A Stronger Coast.

All project coordinators and design teams were contacted to identify information and available resources for each of the nine internal DOI projects selected. These projects reviewed to identify each projects purpose and its future goals to reduce risk and increased resilience along Connecticut's shoreline. After an thorough investigation, only four out of the nine projects were identified as potentially relevant. Each one is described below and how they fit within the context of the Southern Connecticut Regional Framework for Coastal Resilience.

The four internal DOI projects are prearranged by their associated government organization. The first, "Regional, Cross-State & State Level Projects", are represented by the United States Geological Survey (USGS). Their purpose was to provide "science based needs," as a plan "to support all restoration and recovery in the wake of Superstorm Sandy." The first project, GS2-5A (USGS) focuses on "Evaluating Ecosystems Resilience". This project produces wetland impact assessments to obtain understanding on how coastal wetland resources have changed their overall ecological value, function, and structure due to impacts from Sandy. This project then proposed to use that data to identify and prioritize conservation efforts. In connection with Regional Resilience Framework, a couple on-the-ground projects have been identified with a central focus on wetland restoration due to their overall condition and ecological changes. One project that has been identified in the town of Guilford is the Long Cove Marsh Hydrological Restoration Project (#90) which consists of restoring wetlands and natural habitat throughout Long Cove with the removal of obstructions to allow the proper drainage of fresh water into the estuary. The project would be beneficial for the USGS's - "Evaluating Ecosystem Resilience" project due to the sites constant changing condition, as well as future flood risks it possess towards the surrounding neighborhoods and critical evacuation routes. This project would essentially add value for USGS due to the challenges and the many site assessments that have already been completed to provide ecological resilience for the Long Cove Estuary. The Eisenhower Park Restoration Project (#440) is another site that focuses on restoring the overall ecological function of the Park's wetlands and natural habitat. Ideally, implementing wet meadow depressions or other forms of green and natural infrastructure would control flood waters, mitigate erosion, and preserve natural habitat along the Wepawaug River. The Park is a vital public amenity to the city of Milford and would certainly be of value for USGS's regional project due to previous studies and site assessments focused on restoring Eisenhower Park and the surrounding natural habitat.

A second organization that is part of the DOI Sandy Recovery and Response Projects is the U.S. Fish and Wildlife Service. Their focus with these funds/projects is to restore and protect natural coastal systems while providing flood protection for communities, improving waterways for fish passages, and protecting all ecological systems from future weather related events. The first project for the FWS focuses on "Decision Support - Tidal Wetlands". The project will integrate data, support tools and applications to develop impact assessments and decisions on where to conduct tidal marsh restoration, conservation, and management. The project goal is to provide services that will build up and restore ecosystems to provide resiliency for tidal marshes and marsh species in the face of storm impacts, sea level rise, and other hazards. As part of the Regional Resilience Framework, there are a few projects that would provide value for the FWS in regards to tidal marsh restoration. The Leetes Marsh Restoration Project (#904) focuses on a tidal marsh being restored back to its natural state while providing flood protection and

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increasing tidal flow through the marsh. This project in Branford would become a valuable resource for FWS efforts due several site assessments and the amount of data that has been collected in the hopes of restoring the Leets Marsh Estuary. A secondary project is the Jarvis Creek Estuary Restoration Project (#819) - also located in Branford. This project focuses on restoring the tidal marsh to allow for further advancement, attenuation of wave action, and protection of major evacuation routes from future floods. This priority project would be of interest for FWS due to the site's impact from Sandy and its proximity to Route 146; a major access route in and out of the town of Branford. The Pine Creek Estuary Marsh Restoration Project (#823) is another priority site within the town of Branford that was affected by Sandy and would greatly contribute to FWS's project on tidal marsh restoration because of constant ecological changes and the flood risk reduction to critical infrastructure and major access routes. Furthermore, many studies and assessments have been completed for Pine Creek which shown significant changes before and after Sandy. This project focuses on tidal marsh restoration by improving methods of marsh advancement and providing other resilience opportunities for Pine Creek in the town of Branford.

The second FWS (#67) project focuses on "Decision Support - Beach Habitat and Restoration". This collaborative project through the North Atlantic Landscape Conservation Cooperative is a coordinated effort to integrate existing data and tools to help develop and improve impact assessments that will assess and guide decisions about where to conduct beach restoration, conservation, and management in regions affected by Sandy. Some of the Regional Resilience Framework projects are certainly closely aligned with FWS on restoring beaches and natural habitat. One project that focuses on beach and habitat restoration is the Chittenden Beach Living Shoreline Project (#901). The project is in the town of Guilford and focuses on stabilizing a halfmoon shaped section of beach using living shoreline techniques such as sills to nourish, restore, and stabilize both the beach and adjacent tidal marshes along the mouth of the West River. The project would provide critical value to the FWS's beach and habitat restoration regional project because it has been identified as a high priority site where significant changes are occurring, as well as the number of studies, assessments, and conceptual designs that have been completed for this particular living shoreline project. A second on-the ground priority project within the Regional Resilience Framework that would benefit FWS's project is the Grass Island Living Shoreline Project (#913) - also located in Guilford. The project focuses on marsh/beach and habitat restoration as part of a long-term effort to protect the harbor and marina along the mouth of the East River. Ideally, living shoreline techniques would help reduce long term risks to the harbor and adjacent critical infrastructure. This recommended project would be beneficial for FWS's regional project because it provides detailed information on where to prioritize efforts for future opportunities of resilience for beach habitat and restoration. This project would also provide opportunities for further data collection and impact assessments along Guilford's harbor and Grass Island.

Lastly, the FWS (#30) - "A Stronger Coast" project would be of utmost importance to the Southern Connecticut Regional Framework for Coastal Resilience. The FWS regional project focuses on marsh and shoreline restoration to increasing resilience from future storm surge and sea level rise. This project identifies the most at-risk areas and recommends restoration and management decisions for on-the-ground decision-makers. The highest design priority project that would benefit "A Stronger Coast" is the Long Wharf Park Erosion and Shoreline Enhancement Project (#605) - located along the City of New Haven's coastline. This project focuses on a comprehensive solution to mitigate erosion and flood risk of critical infrastructure using either green infrastructure or hybrid solutions to protect this vital shoreline and city park amenity. This project would be of importance to "A Stronger Coast" because it's one of the highest priority projects recommended by City where comprehensive solutions are needed. A second high priority project that would have considerable value for the FWS "A Stronger Coast" is the City of West Haven's Dune Creation and Beach Enhancement Project (#504). This project focuses on providing a combination of both beach nourishment and dune creation. A continuous high dune would be implemented to reduce storm surge risks to adjacent critical infrastructure along this section West Haven's shoreline. This on-the-ground project would be valuable for the FWS regional project because has been recommended by the City and provides an opportunity for future resilience solutions to protect a critical gap. Another project that is of highest priority is the Russian Beach Bank Stabilization Project (#304) in Stratford. The Russian Beach site is currently undergoing significant erosion without any protections in place. A green infrastructure or hybrid bank protection/ stabilization system could be implemented to protect adjacent homes and major evacuation routes along this critical section of Stratford's shoreline. The project would be of great value for "A Strong Coast" because it is currently a high priority for the municipality and provides a critical need for bank and beach stabilization along this section of Stratford's shoreline. Rowland Road Alley Dune Creation Project (#104) is another high priority site that focuses on an alleyway in Fairfield. The site consists of a narrow alley way with low-lying conduit for storm surge to pass directly between homes and into the Pine Creek estuary; just to the west of the Fairfield Beach Road. The development of a high dune structure in this area would eliminate the conduit and protect critical infrastructure from future storm surge and flooding. This project would be of high value for the FWS regional project due to importance to protect major access routes and nearby residential neighborhoods. Lastly, Madison Surf Club Dune Restoration Project (#1003) needs immediate protection at critical gap due to impacts from Sandy. This project has been identified by local officials and several site assessments that been completed. Ideally, both beach and dune restoration is

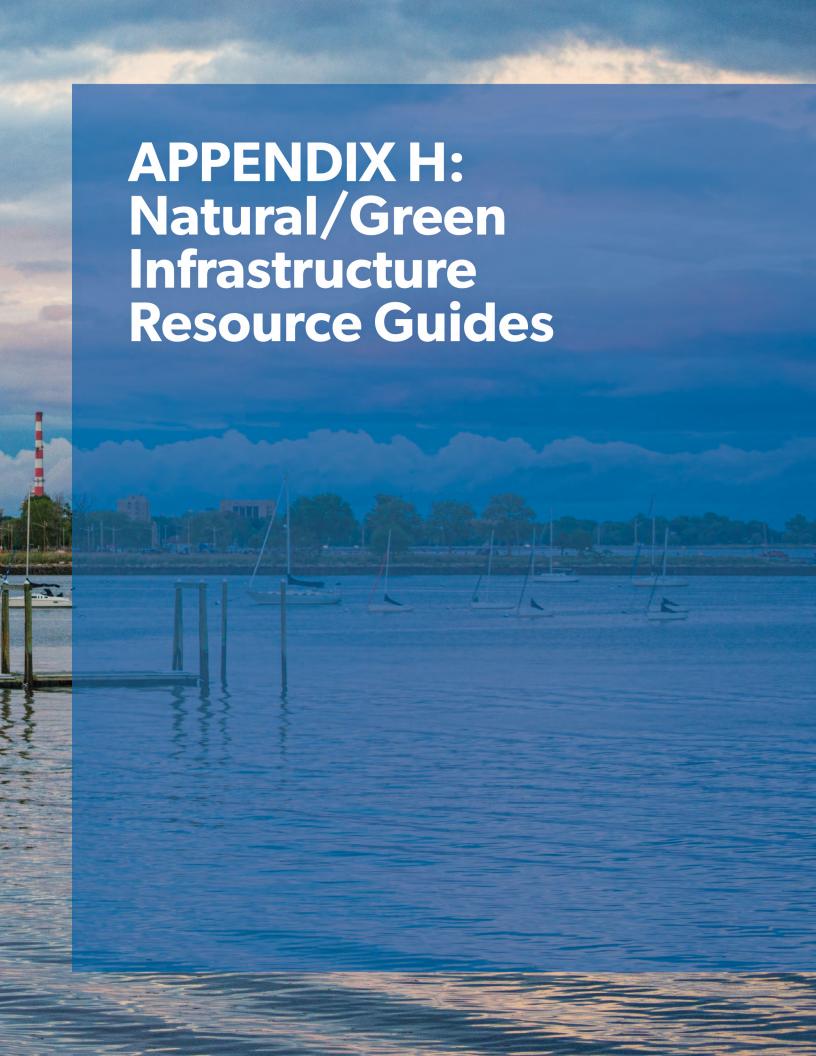
2017 SOUTHERN CONNECTICUT REGIONAL FRAMEWORK FOR COASTAL RESILIENCE

needed at Madison's Surf Club. Without a dune system, future storm surges will continue to cross the beach and contribute to flooding of residential areas, town facilities, and major evacuation routes. This project would be of importance for "A Stronger Coast" because it identifies an "at most-risk area" where protection is needed at a critical gap along this section of Madison's shoreline.

Each of the four DOI internal projects that have been identified and described above, all have significant importance and a close relationship within the context of the Southern Connecticut Regional Framework for Coastal Resilience. Ideally, many of these on-the-ground projects will enhance data sharing, improve communication, and inform ongoing restoration and recovery efforts across the Eastern Seaboard. Most importantly, these internal DOI projects could help elevate these priority, on-the-ground projects by "building community resilience for municipalities" and identifying "most-at risk areas" through prioritization projects focused on green and natural infrastructure to reduce risk and increase resilience across Connecticut's shoreline.

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APPENDIX H: Natural/Green Infrastructure Resource Guides

Review of Available Resources About Promoting Resilience through Green Infrastructure, Nature-Based Solutions, and Living Shorelines

The number of resources available for promoting nature-based solutions to risk reduction, green infrastructure, and living edges/shorelines (in the broad sense of the term) for advancing coastal resiliency has been growing at a hastening pace since about 2011. Several publications were released in 2015 and 2016 during the Southern Connecticut Regional Framework for Coastal Resilience timeline. A selection of resources is discussed below chronologically in hopes of enhancing awareness amongst the region served by this project in Southern Connecticut and beyond.

Future of our coasts: The Potential for Natural and Hybrid Infrastructure to Enhance the Resilience of our Coastal Communities, Economies and Ecosystems

The article Future of our coasts: The Potential for Natural and Hybrid Infrastructure to Enhance the Resilience of our Coastal Communities, Economies and Ecosystems (Ariana E. Sutton-Grier, Kateryna Wowk, and Holly Bamford) was published in spring 2015 coincident with the planning phase of the Southern Connecticut Regional Framework for Coastal Resilience. As such, it provided some useful early information and graphics for meetings with the ten municipalities. The article briefly described U.S. policy for coastal resilience, provides examples of natural and built infrastructure, summarizes knowledge about coastal protection benefits associated with natural and built infrastructure, and outlines the limitation and research needs. This article is one of the early narratives that concisely describe "hybrid" solutions to coastal protection.

Living Shorelines – From Barriers to Opportunities

The report Living Shorelines – From Barriers to Opportunities was released by Restore America's Estuaries in June 2015. The report's focus is to identify and assess barriers that prevent broad use of living shorelines in the U.S. A definition of living shoreline presented in the report is:

"Any shoreline management system that is designed to protect or restore natural shoreline ecosystems through the use of natural elements and, if appropriate, manmade elements. Any elements used must not interrupt the natural water/land continuum to the detriment of natural shoreline ecosystems."

This definition differs slightly from the DEEP definition, but is consistent with many of the examples discussed below in this report. The report also notes that a "management system that breaks the water/land continuum is not considered a living shore-line.... This choice is based on the belief that any manmade break in the water/land continuum will eventually become a de facto hardened structure functioning essentially like a bulkhead or revetment."

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Natural and Structural Measures for Shoreline Stabilization

NOAA and the USACE collaborated through their "Systems Approach to Geomorphic Engineering" ("SAGE") practice to publish materials in 2015 including *Natural and Structural Measures for Shoreline Stabilization*. This reference guide and manual promotes coastal risk reduction through use of living shorelines. The three goals of living shorelines are cited as:

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

One of the highlights of the SAGE publications is the graphical display of the range of green and soft techniques to gray and hard techniques, with the following depicted in clear graphics:

- · Vegetation only
- Edging
- · Sills
- · Beach nourishment
- · Beach nourishment and vegetation on dune
- Breakwater
- Groin
- Revetment
- Bulkhead
- Seawall

The SAGE resources also described anticipated benefits of living shorelines, challenges, and costs. The SAGE resources were helpful during the planning and design phases of the *Regional Framework for Coastal Resilience* timeline.

Urban Coastal Resilience: Valuing Nature's Role - Case Study: Howard Beach, Queens, New York

TNC published *Urban Coastal Resilience: Valuing Nature's Role – Case Study: Howard Beach, Queens, New York* in July 2015. The report considers the use of natural infrastructure to address flood and other climate change–induced risks in an urban area (specifically, New York City). The report had three stated objectives: to evaluate the relative merits of various approaches to climate change resilience using a case study; to propose an innovative approach to quantifying ecosystem functions and services; and to establish replicable methods for making decisions about using natural infrastructure in this context.

The report discusses how a cost-benefit analysis can account for environmental benefits that are often difficult to quantify, and discusses the application of a Habitat Equivalency Analysis to consider the benefits of natural infrastructure such as wetlands, beaches, berms, and shellfish reefs. Five alternative sets of protective infrastructure were considered for both their flood protection efficacy and their ecosystem services co-benefits, which when combined contribute to resilience. The five sets of alternatives included (in varying measures) restored marshes, hard toes of mussel shells, berms, breakwaters, groins, floodwalls, and flood gates.

The study found that when ecosystem functions and services are included in a cost-benefit analysis, hybrid infrastructure (combining nature and nature-based infrastructure with gray infrastructure) can provide the most cost-effective protection from sea-level rise, storm surges, and coastal flooding. The study had the means to evaluate different resilience methods in greater detail than the Southern Connecticut Regional Framework for Coastal Resilience, but the conclusions are consistent with the goals of the Regional Framework for Coastal Resilience.

Community Resilience Planning Guide for Buildings and Infrastructure Systems

The guidebook *Community Resilience Planning Guide for Buildings and Infrastructure Systems* (NIST Special Publication 1190, 2015) was developed to help communities address resilience through a practical approach that takes into account community social goals and their dependencies on the built environment (buildings and infrastructure systems). The guide defines Community resilience as the ability of a community to (1) Prepare for anticipated hazards, (2) Adapt to changing conditions, and (3) Withstand and recover rapidly from disruptions. Although the guide does not directly address the nature-based risk reduction methods and use of green and hybrid infrastructure highlighted by the Southern Connecticut Regional Framework for Coastal Resilience, it represents one of the more comprehensive reports that describe how to build resilience at the community level.

Performance of Natural Infrastructure and Nature-based Measures as Coastal Risk Reduction Features

The Environmental Defense Fund published *Performance of Natural Infrastructure and Nature-based Measures as Coastal Risk Reduction Features* in September 2015. The report is a narrative review of nature-based risk reduction methods based on workshops and literature reviews prepared by the authors. The various techniques addressed in the report include beach nourishment, vegetated dunes, edging and sills (living shorelines), oyster reefs, and coastal wetlands. For each method of risk reduction, the report outlines the strengths, weaknesses, uncertainties, suitable conditions, limitations, etc. Understanding strengths, weaknesses, uncertainties, suitable conditions, limitations of various nature-based risk reduction methods was useful for the planning and design phases of the Southern Connecticut Regional Framework for Coastal Resilience.

Natural Defenses in Action – Harnessing Nature to Protect Our Communities

The National Wildlife Federation, Allied World, and ASFPM collaborated on the report *Natural Defenses in Action – Harnessing Nature to Protect Our Communities* (2016). The report is essentially a handful of case study examples for nature-based solutions to risk reduction. The report notes that "Constructing engineered features designed to mimic natural features and functions can be an effective approach for reducing risks. Nature-based features can include such things as engineered dune complexes to buffer coastal communities, and living shorelines that use mostly native materials (biological and physical) to stabilize shorelines. Engineered reefs, built from or serving as substrate for oysters or corals, are another focus of active experimentation with potential wave attenuation and shoreline protection benefits." The report also noted that "Because many traditional ecological restoration efforts require engineering, design, and construction, restoration of purely natural systems and construction of nature-based features are probably best viewed as occurring on a continuum, and any given project may have elements of both." This is an important point that rings true for the Southern Connecticut Regional Framework for Coastal Resilience.

Furthermore, the report states that "Increasingly, practitioners are identifying opportunities to blend green and gray approaches to risk reduction. In some places the protective functions of a structural feature can be augmented with those provided by a natural or nature-based feature—such as dunes, marsh, or natural floodplain—creating multiple lines of defense. Creating such green—gray hybrids, where ecologically appropriate, can soften the impacts of the structural feature and provide other environmental benefits typically associated with natural infrastructure. Integrating natural, nature-based, non-structural, and structural approaches recognizes that risk reduction needs and opportunities are highly site specific and depend very much on the geophysical and ecological setting as well as the type and sensitivity of the assets to be protected. Given the traditional reliance on structural measures in most heavily populated areas, opportunities to promote and expand the use of natural and nature-based features will often involve incorporating them into such integrated, hybrid risk reduction systems." These are also important points that are consistent with the goals of the Southern Connecticut Regional Framework for Coastal Resilience.

Because the case studies in the report vary widely in geography, some are not directly applicable to Connecticut. However, the example from Cape May highlights the benefits of wide beaches and robust dune systems, stating that "After Hurricane Sandy, Cape May communities that had participated in U.S. Army Corps of Engineers dune and beach nourishment projects, starting in 1989 with Cape May City, had relatively little storm and flooding damages in places where wider beaches and deeper dune systems provided adequate buffers."

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Coastal Wetlands and Flood Damage Reduction

TNC, Wildlife Conservation Society, U.C. Santa Cruz, and Lloyd's Tercentenary Research Foundation collaborated on the report *Coastal Wetlands and Flood Damage Reduction* (October 2016). This report presents one of the most recent concise yet compelling arguments for protecting or restoring tidal wetlands (marshes) for storm surge and flood risk reduction. In the past, most reports speak of tidal wetlands "absorbing" storm surges or attenuating wave energy without presenting direct evidence. For this paper, modeling was conducted by the authors to demonstrate that the roughness associated with tidal wetlands will, in some cases, reduce the elevation of floodwaters caused by storm surges. However, the modeling also demonstrated that in some locations (especially at the leading edge of expansive marsh systems), the roughness of marshes may increase flood levels. The report calls this is a "piling up" of water."

Overall, flood damage reduction (in dollars) was found to be negligible for Connecticut's shoreline when compared to the other states in the study (Massachusetts to Virginia). This is a function of the setting and tidal wetland characteristics along the Connecticut shoreline rather than a direct measure of the importance of tidal wetlands in Connecticut.

The report notes that the study underestimates wave reduction capacities of wetlands and does not account for other risk reduction benefits such as long-term stabilization of shorelines. These are important risk reduction benefits that are considered in the Southern Connecticut Regional Framework for Coastal Resilience. For a site such as Chittenden Beach in Guilford, the benefits associated with shoreline stabilization and habitat enhancement are likely much greater than any potential drawback associated with a negligible increase in storm surge height at the marsh front. Furthermore, the elevation of flood waters would not be increased further inland; if anything, flood elevations would be the same or lower than current conditions if the living shoreline project were implemented.

Living Shorelines: Sound Science, Innovative Approaches, Connected Community

Toward the end of the planning phase for the Regional Framework for Coastal Resilience, Connecticut hosted its first living shoreline conference. The event, "Living Shorelines: Sound Science, Innovative Approaches, Connected Community" was sponsored by Restore America's Estuaries held on December 1 and 2, 2015. The conference included discussions pertaining to policy, regulations, and the science of living shorelines; and focused on four broad types of living shorelines from a national perspective: salt marshes, dunes/beaches, bioengineered coastal banks, and shellfish reefs. The ten designs of the Southern Connecticut Regional Framework for Coastal Resilience span the broad categories discussed during the "Living Shorelines: Sound Science, Innovative Approaches, Connected Community" conference: salt marshes, dunes/beaches, bioengineered coastal banks, and shellfish reefs.

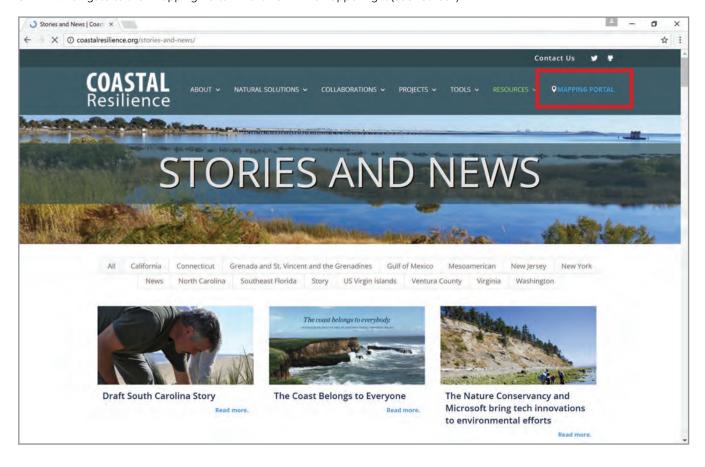




APPENDIX I: Regional Resilience Framework Project Application Guidance

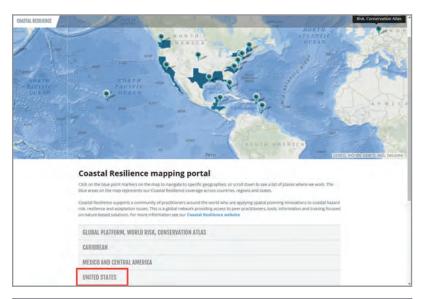
STEP 1: Navigate to the Coastal Resilience website - www.CoastalResilience.org

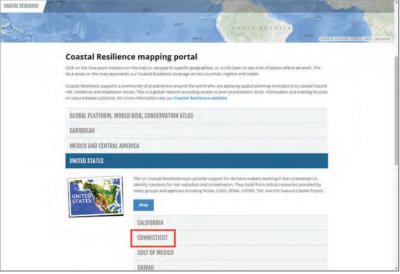
STEP 2: Navigate to the "Mapping Portal" – click on link on upper right (see red box).

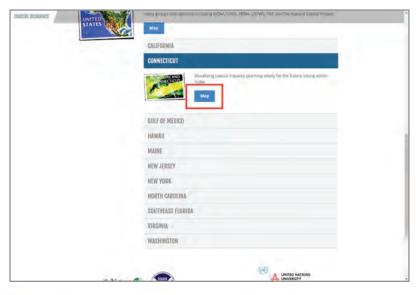


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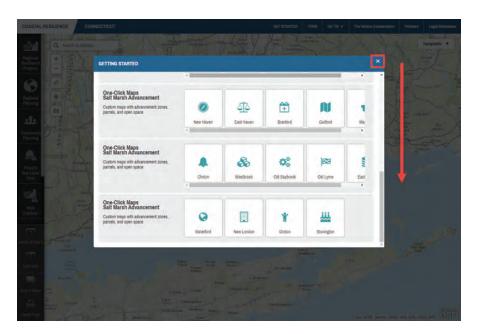
STEP 3: Scroll down page and click on United States and then Connecticut "MAP". Connecticut Mapping Portal link - http://maps.coastalresilience.org/connecticut/



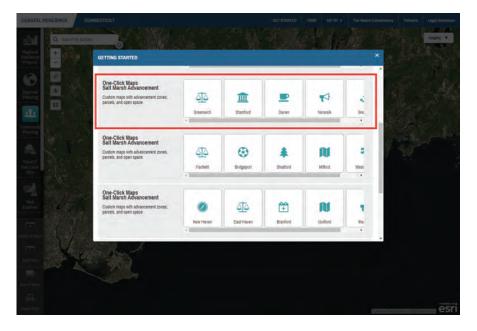




STEP 4: Explore landing pad information to get down-scaled sea level rise projections with or without Cat-2, Cat-3, and Sandy flood maps, social vulnerability, salt marsh advancement maps down to the parcel scale for all 24 coastal municipality, and much more. To close landing pad click on "x" upper right and enter the Connecticut Mapping Portal.

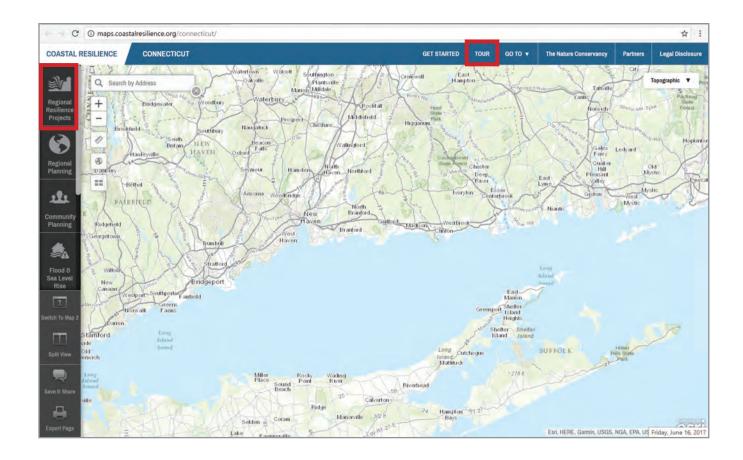


For Salt Marsh Advancement Zone Assessments: Municipalities arrayed in order from west to east along coast in rows. Scroll down and click.

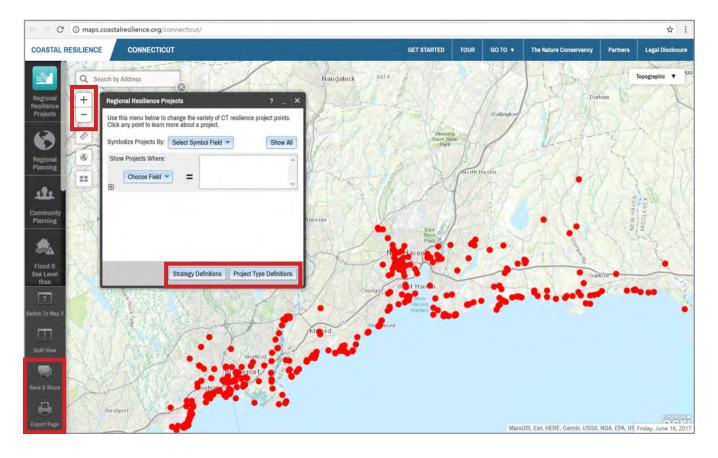


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STEP 5: Click on "Regional Resilience Projects" Application – top of left vertical tool bar (see red box). Consider taking a "Tour" to explore all possibility within Mapping Portal.

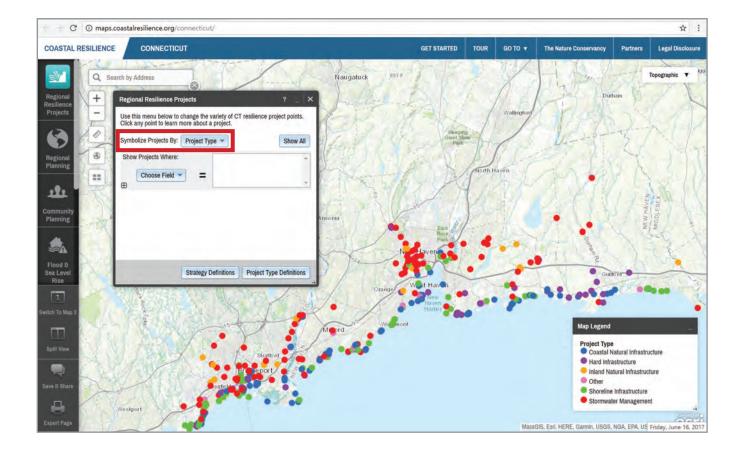


STEP 6: Review Regional Resilience Projects across the 10 municipalities. Zoom "In" and "Out" and move around the site (click, drag, release). Click on Strategy and Project Type Definitions for a refresher. Create then "Export" maps for meetings and report...

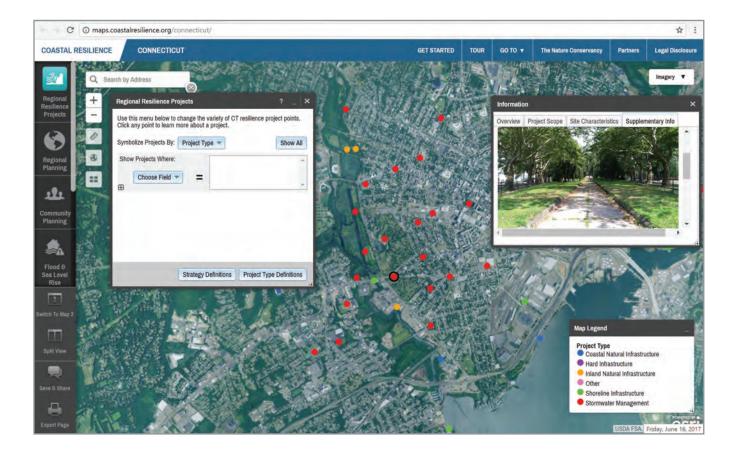


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STEP 7: Begin sorting projects by selecting "Project Type" in drop down menu (see red box).

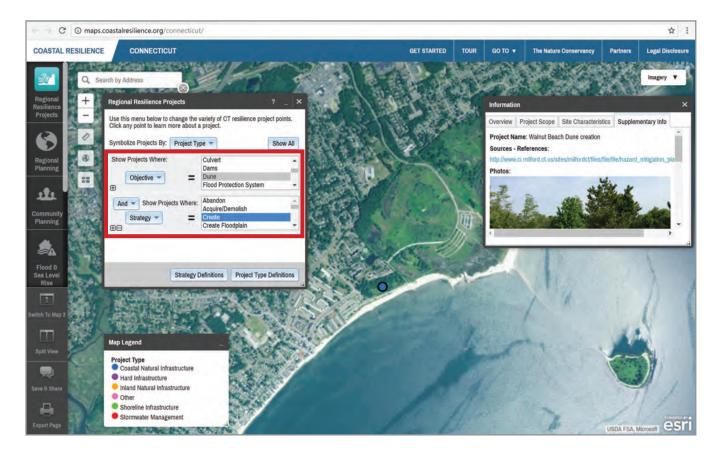


STEP 8: Zoom into area of interest to see project locations by "Project Type", "Objective", "Strategy", and "Town". Click on individual project dots to bring up "Overview', "Project Scope", "Site Characteristics", and "Supplementary Info" (including photos).

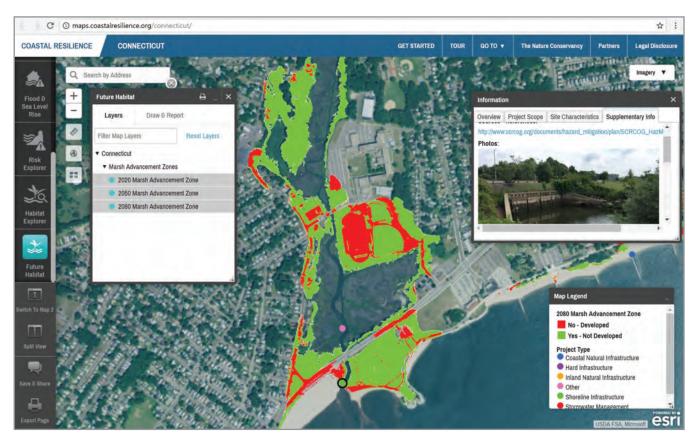


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STEP 9: Continue your resilience project investigation by using the cascading search box (see red box). As seen below for example: "Objective – Dune" and "Strategy – Create" – zoomed to and clicked open - Milford's Walnut Beach Dune Creation Project.



STEP 10: Bring up additional layers to assess risks from downscaled sea level rise projections with or without Cat-2, Cat-3 (1938 Hurricane), or Sandy as well as opportunities for Salt Marsh Advancement at the project scale or across networks of projects sites.



Cove River Tide Gate Replacement Project: Salt Marsh Advancement shown in red (inundation of existing built structures) and green (inundation of currently undeveloped parcels – potential future salt marsh if not developed).

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Cove River Projects – Cat-3 (1938 Hurricane) with downscaled sea level rise for Connecticut coastline (52"). Note: Highest Confidence (99%), Medium (66%), Lowest (33%).

