ATTACHMENT F

BENEFIT-COST ANALYSIS

AttFBCA
AttFBCA.pdf

U.S Department of Housing & Urban Development's

NATIONAL DISASTER RESILIENCE COMPETITION

APPLICANT: **THE STATE OF CONNECTICUT**
PHASE II APPLICATION

October 27, 2015

Attachment F Benefit-Cost Analysis

Executive Summary

A benefit-cost analysis (BCA) was conducted for the National Disaster Resilience Competition (NDRC) New Haven, Connecticut, Project for submission to the U.S. Department of Housing and Urban Development (HUD) as a requirement of a discretionary grant application for the National Disaster Resilience Competition (NDRC) program. The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S.HUD in the OMB Circular, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Federal Register (79 FR 11854) and conducted for a 100-year analysis period starting in 2015.

The analysis shows a benefit-cost ratio that exceeds 1.0, meaning the project returns economic benefits that exceed project costs over the life of the investment.

Hurricane Sandy clearly showed the ongoing vulnerability of Connecticut's villages, cities and extensive network of coastal infrastructure to storm activity, sea level rise and the forces of climate change. Connecticut must gravitate to an economy that is resilient to climate change. To do so, it must address the risks to its 618 miles of coastal and riverine communities, which contain 60% of the state's population. Connecticut has $542 billion at risk to coastal storms and flooding, the second highest exposure of vulnerable coastal assets on the eastern seaboard. It is that same vulnerable coastline that boasts significant development, density, economic vibrancy and critical infrastructure corridors, in large part because of the proximity to water. In response to Sandy (the qualifying storm for this application), the State has taken sweeping action to restructure its policies, programs and plans to prepare for, protect against and live with the impacts of climate change.

In perhaps its boldest statement of change, the State has established, through executive order, State Agencies Fostering Resilience (SAFR), ten State agencies and a coalition of strategic partners, to set a mission to respond to climate change, organize agency decision-making to respond to climate change and support local innovative plans to live with climate change. SAFR's mission is to craft policies that equitably promote

resilience across its impacted region and the entire State. SAFR has established two key principles that form the foundation of its resilience mission: Resilient TOD and Resilient Corridors.

SAFR will test these principles by implementing two immediate pilot projects in its two most impacted communities – the Union Station neighborhood in New Haven and the East South End of Bridgeport. Residents in these communities suffer from repetitive loss from flooding, loss of power during and after storm events, a lower income profile, downward spiraling economies and significant risk from future storm events. While proximate to their urban centers, these communities are isolated from nearby amenities and their downtowns and are cut-off from help during and after storm events. Without fundamental change, these coastal communities will continue to decline, leaving large gaps in the urban fabric and extending blight within these cities. SAFR has a plan to protect these communities and their supporting infrastructure, not by cutting them off from their connection to the water, but by establishing new paradigms through resilient TOD and resilient corridor approaches for living and flourishing with sea level rise in these dense, culturally significant and affordable communities that the State cannot afford to abandon. These two NDRC pilot projects will launch a statewide program for resilience that will be advanced through the implementation of resilience plans in thirteen additional coastal communities in Fairfield and New Haven Counties (Counties having high unmet need) with similar issues and challenges. The pilots and plans will be supported by a coordinated agency approach to establishing resilience policy and a commitment to funding projects that increase the resilience of these communities in keeping with the mission of SAFR.

Each pilot project was subjected to a benefit cost analysis to show individualized results. each were conducted in accordance with the benefit-cost methodology as recommended by the U.S.HUD in the OMB Circular, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Federal Register (79 FR 11854) using a benefit cost analysis spreadsheet that uses a methodology consistent with the guidelines in OMB Circular A-94. The analysis was conducted for a 100-year analysis period starting in 2015 using both the required 7% discount rate and a 5% discount rate for comparison purposes. Further project specific details

can be found in the individual project benefit cost analyses sections.

Summary of Results

Table 1: Benefit Cost Analysis for CT NDRC Pilot Projects and Total Program

Discounted Analysis @7%	Bridgeport Pilot	New Haven Pilot	Total Program
Total Benefits	$45,591,443	$77,283,887	$122,875,330
Total Costs	$37,387,387	$50,858,764	$88,246,151
B/C	**1.22**	**1.52**	**1.39**
NPV	$8,204,056	$26,425,123	$34,629,180

As shown in table 1, the Bridgeport pilot generates $45.6 million in benefits at a cost of $37 million, resulting in a benefit to cost ratio of 1.22. The New Haven Pilot generates $77 million in benefits at a cost of $51 million, which results in a benefit to cost ratio of 1.52. When evaluated as a whole, the total program benefit to cost ratio is 1.39.

A sensitivity analysis was undertaken to determine the impact of including the planning and administrative costs for SAFR and CIRCA applying the efforts encapsulated here within the pilot projects to other coastal communities in Connecticut. Although benefits could be construed as being accrued at other coastal communities at a similar rate as shown here for Bridgeport and New Haven, the unknown nature of the projects at those communities called for a more conservative sensitivity analysis in which we only considered what the additional costs implied to the total program benefit to cost ratio.

Table 2: Sensitivity Analysis of Additional Program Cost

Sensitivity Analysis Discounted @7%	Total Program with additional Planning and Admin Cost
Total Benefits	$122,875,330
Total Costs	$101,078,657
B/C	**1.22**
NPV	$21,796,673

As shown in Table 2, the benefit to cost ration decreases slightly to 1.22.

A Further sensitivity analysis was performed to determine the elasticity of the ratio, with respect to increased benefits, increased costs, decreased benefits, or decreased costs.

Table 3:

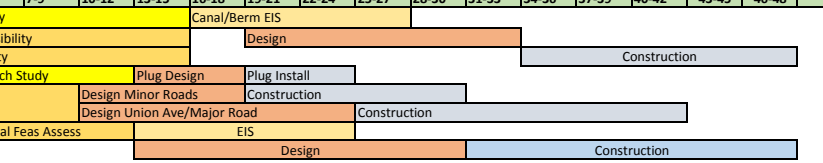
Sensitivity Analysis Discounted @7%	Bridgeport Pilot	New Haven Pilot	Total Program
B/C if Benefits increase by 15%	**1.40**	**1.75**	**1.60**
B/C if Benefits decrease by 15%	**1.04**	**1.29**	**1.18**
B/C if Costs increase by 15%	**1.06**	**1.32**	**1.21**
B/C if Costs decrease by 15%	**1.43**	**1.79**	**1.64**

As shown in table 3, decreasing costs has the largest positive impact, while decreasing benefits has the largest negative impact. That said, even in the worst case, the resultant benefit to cost ratios return a value greater than 1, indicating a return of benefits higher than the costs expended.

Further project specific details can be found in the individual project benefit cost analyses sections.

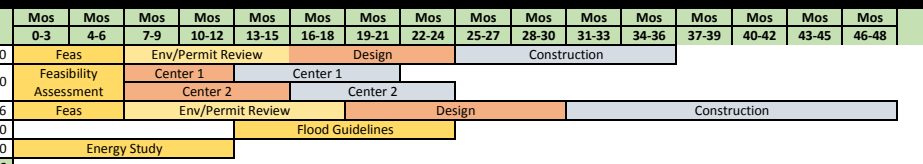
New Haven NDRC project components

#	Project Description	Total project cost	OUT MONTHS
1A	Stormwater System Long Wharf Canal and Railyard Protection Berm	$ 36,828,916	
1B	I-95 Plug		
2	Street and neighborhood storm water improvements	$ 3,501,200	
3	Coastal Protection Strategy, living shoreline with stone revetment edge	$ 18,228,600	
	Estimated Total	**$ 58,558,716**	



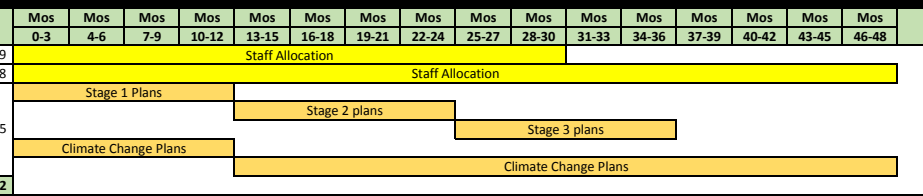
Bridgeport NDRC project components

#	Project Description	Total project cost	OUT MONTHS
1	University Avenue, elevated street with integral multi-functional wall	$ 5,264,000	
2	Community Center Restoration	$ 1,000,000	
3	Earthen berm, viaduct reinforcement and CSO Treatment park	$ 35,630,036	
4	Flood Design Guideline recommendations	$ 330,000	
5	District energy feasibility study	$ 350,000	
	Estimated Total	**$ 42,574,036**	



Regional Program and Administrative Costs

#	Project Description	Total project cost	OUT MONTHS
1	State Agencies Fostering Resilience (SAFR) staff mgmt	$ 5,585,609	
2	CIRCA Staffing toManage and Implement Planning Projects	$ 1,663,408	
3	Connecticut Connections Coastal Resilience Plan	$ 6,539,915	
		$ 13,788,932	
Total budget		**$ 114,921,684**	



Annual HUD Financial Drawdown Calculator

New Haven NDRC project components

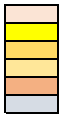
#	Project Description	Total project cost	Year 1	Year 2	Year 3	Year 4	TOTAL
1	Stormwater System Long Wharf Canal and Railyard Protection Berm and I-95 Plug	$ 36,828,916	$ 1,200,000	$ 5,241,446	$ 9,207,229	$ 21,180,241	$ 36,828,916
2	Street and neighborhood storm water improvements	$ 3,501,200	$ 350,000	$ 875,300	$ 1,925,780	$ 350,120	$ 3,501,200
3	Coastal Protection Strategy, living shoreline with stone revetment edge	$ 18,228,600	$ 1,000,000	$ 3,281,148	$ 5,833,152	$ 8,114,300	$ 18,228,600
	Estimated Total	**$ 58,558,716**	**$ 2,550,000**	**$ 9,397,894**	**$ 16,966,161**	**$ 29,644,661**	**$ 58,558,716**

Bridgeport NDRC project components

#	Project Description	Total project cost	Year 1	Year 2	Year 3	Year 4	TOTAL
1	University Avenue, elevated street with integral multi-functional wall	$ 5,264,000	$ 700,000	$ 726,400	$ 3,837,600	$ -	$ 5,264,000
2	Community Center Restoration	$ 1,000,000	$ 250,000.00	$ 750,000	$ -	$ -	$ 1,000,000
3	Earthen berm extending to Ferry Landing, onshore CSO treatment park and viaduct reinforcement	$ 35,630,036	$ 1,220,000	$ 1,692,601	$ 17,815,018	$ 14,902,417	$ 35,630,036
4	Flood Design Guideline recommendations	$ 330,000	$ -	$ 330,000	$ -	$ -	$ 330,000
5	District energy feasibility study	$ 350,000	$ 350,000	$ -	$ -	$ -	$ 350,000
	Estimated Total	**$ 42,574,036**	**$ 2,520,000**	**$ 3,499,001**	**$ 21,652,618**	**$ 14,902,417**	**$ 42,574,036**

Regional Program and Administrative Costs

#	Project Description	Total project cost	Year 1	Year 2	Year 3	Year 4	TOTAL
1	State Agencies Fostering Resilience (SAFR) staff mgmt	$ 5,585,609.00	$ 2,234,243.60	$ 2,234,243.60	$ 1,117,121.80	$ -	$ 5,585,609.00
2	CIRCA Staffing toManage and Implement Planning Projects	$ 1,663,408.00	$ 415,852.00	$ 415,852.00	$ 415,852.00	$ 415,852.00	$ 1,663,408.00



Admin/Staffing
Study/Action by others
Feasibility Study/Prelim Inv/Concept Design
Environmental Assessment/Impact Statement
Design
Construction

New Haven NDRC project components

	Component	Quantity	Unit	Cost per unit | preparation and construction			Total cost | construction and preparation	operation and maintenance cost	Total project cost	Total leverage cost	Cost Source	Issues
				low	average	high						
1	Management of coastal and inland storm water convergence in Long Wharf neighborhood						36,828,916.70	3,682,891.67	39,600,298.37			
a	Archimedes screw installation at J3 bypass	4,000,000	ump, screw, 15' lift	3,000,000	4,000,000	4,500,000	4,000,000.00	400,000.00	4,400,000.00		Rich Pattinelli	
a	entry park and landscape design around Archimedes screw public art entry feature	0.25	acre	700,000	1,000,000	1,500,000	250,000.00	25,000.00	275,000.00		Alex Felson	
	art bridge walk	NA	NA	NA	1,500,000.00	NA		0.00	0.00	1,500,000.00	Alex Felson	
a	storm water detention basins	365,000	square feet	NA	26.79	NA	9,778,350.00	977,835.00	10,756,185.00		V:\data\ny_rising2\1_SEBW\Project Development\coastal_Protection_&_shoreline\Costs&Quantities\Southeast Brooklyn Waterfront.xlsx	
a	dry canal	3278	linear feet	NA	327.65	NA	1,074,036.70	107,403.67	1,181,440.37		V:\data\ny_rising2\1_SEBW\Project Development\coastal_Protection_&_shoreline\Costs&Quantities\Southeast Brooklyn Waterfront.xlsx	
a	plug I-95 underpass at Long Wharf drive	108,192	cubic feet	NA	1,500,000	NA	1,500,000		1,500,000.00			
a	construct 4' flood wall along I-95 highway between Sargent and Canal do	700	linear feet	NA	5138	NA	3596600		3,596,600.00		VJ, CTNDRC_NewHaven_Projects_DesignSpecs_0915115	
b	expansion of retention basins into Long Wharf south of Church Street	150,000	square feet	NA	26.79	NA	4,018,500.00		4,018,500.00		V:\data\ny_rising2\1_SEBW\Project Development\coastal_Protection_&	
b	secondary protection berm-wall	3,510	linear feet	NA	3593	NA	12,611,430.00	1,261,143.00	13,872,573.00		VJ, CTNDRC_NewHaven_Projects_DesignSpecs_0915115	6' berm
2	Street and neighborhood storm water improvements			650	800	950	3,501,200.00		3,816,320.00		http://www.mass.gov/hed/docs/dhcd/cd/mdi/2013easthampton.pdf	
	South Orange Street	1237	linear feet	650	800	950	989,600.00	98,960.00	1,088,560.00		http://www.mass.gov/hed/docs/dhcd/cd/mdi/2013easthampton.pdf	
	Union Avenue	1986	linear feet	650	800	950	1,588,800.00	158,880.00	1,747,680.00		http://www.mass.gov/hed/docs/dhcd/cd/mdi/2013easthampton.pdf	
	Meadow street	350	linear feet	650	800	950	280,000.00	28,000.00	308,000.00		http://www.mass.gov/hed/docs/dhcd/cd/mdi/2013easthampton.pdf	
	Malcom Court	366	linear feet	650	800	950	292,800.00	29,280.00	322,080.00		http://www.mass.gov/hed/docs/dhcd/cd/mdi/2013easthampton.pdf	
	organize design competition and/or concept design for new affordable housing with transit oriented development	NA	NA	200,000	350000	500,000	350,000.00	NA	350,000.00		HUD	HUD Innovation in Affordable Housing competition
3	Coastal Protection Strategy, living shoreline with stone revetment edge	5700	linear feet		3198		18,228,600.00	1,822,860.00	20,051,460.00		Broad Channel project (O drive) Sunset Cove	
	Estimated Total						**98,888,833.40**	**8,592,253.34**	**63,468,078.37**	**1,500,000.00**		

Bridgeport NDRC project components

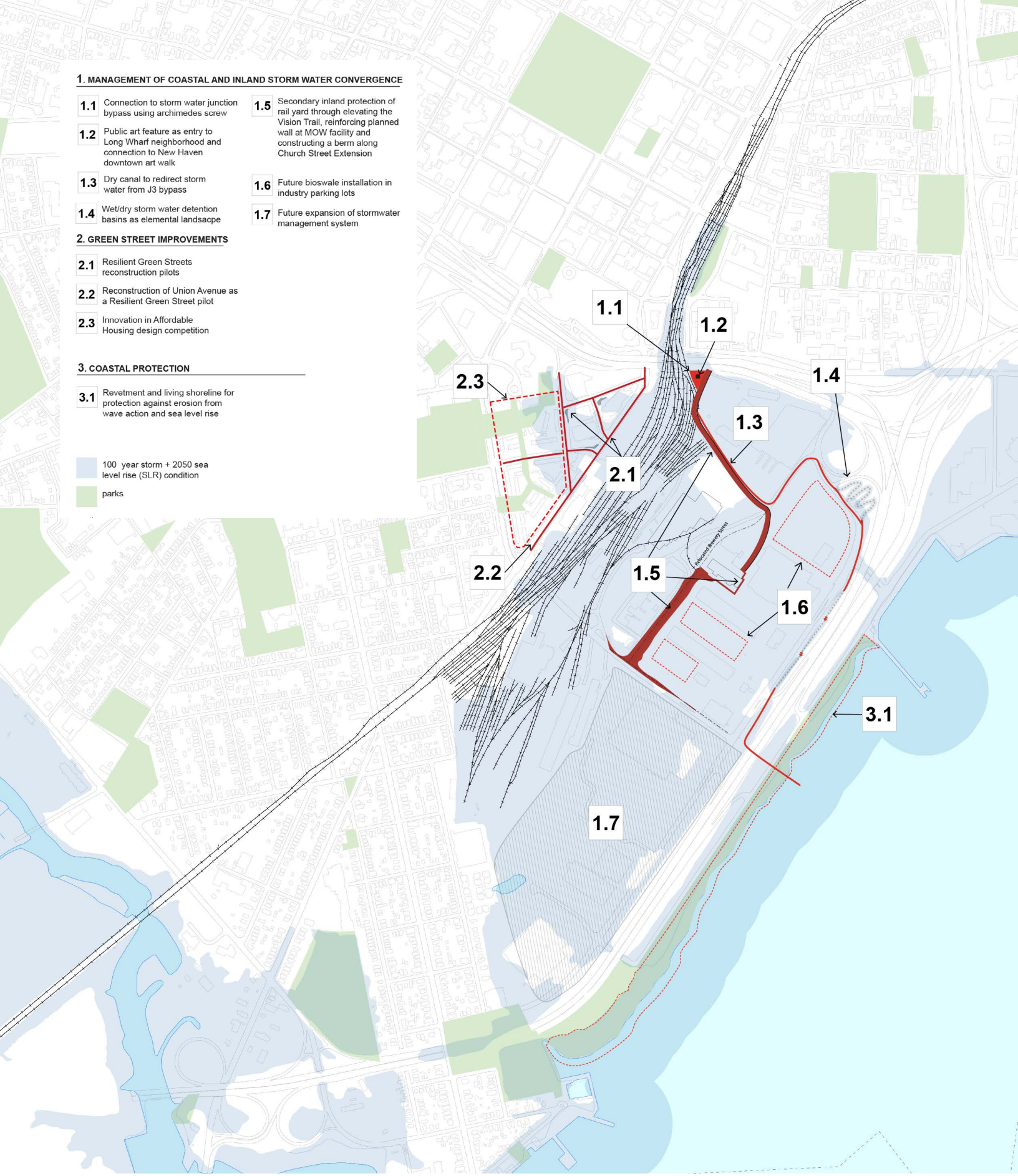
	Component	Quantity	Unit	Cost per unit			Total (average)	operation and maintenance cost	Total project cost	Total leverage cost	Cost Source	Issues
				low	average	high						
1	University Avenue, elevated street with integral multi-functional wall	1600	linear feet	NA	3,290.00	NA	5,264,000.00	526,400.00	5,790,400.00	0.00	Arcadis, City of Bridgeport, Elevated Singer Street with Integrated Multi-fu	
2	Community Center Restoration	NA	NA	NA	NA	NA	1,000,000.00	0.00	1,000,000.00		public outreach meeting	
3	Earthen berm extending to Ferry Landing	2850	linear feet	NA	9,396.00	NA	26,778,600.00	2,677,860.00	29,456,460.00	0.00	Arcadis, City of Bridgeport, Construction of Multi-Functional South End Be	
	Onshore CSO treatment park	90,000	square feet	NA	26.02	NA	2,341,800.00	234,180.00	2,575,980.00	0.00	V:\data\ny_rising2\1_SEBW\Project Development\coastal_Protection_&_shoreline\Costs&Quantities\Southeast Brooklyn Waterfront.xlsx	estimated using the co
t of train viaduct wall between State Street and John Street along Water Street		722	linear feet	NA	5,138.00	NA	3,709,636.00	370,963.60	4,080,599.60	0.00		
	Storm water management along Henry, Atlantic, and Main street	3,500	linear feet	NA	800.00	NA	2,800,000.00					
4	Flood Design Guideline recommendations	NA	NA	NA	300,000.00	NA	300,000.00	30,000.00	330,000.00	0.00	estimate	staff time for policy de
5	District energy feasibility study	NA	NA	NA	350,000.00	NA	300,000.00	0.00	0.00	300,000.00	estimate	
	Estimated Total						**42,494,036.00**	**3,839,403.60**	**43,233,439.60**	**300,000.00**		

State level programs

	Component	Quantity	Unit	Cost per unit			Total (average)	operation and maintenan	Total project cost		Cost Source	Issues
				low	average	high						
1	State Agencies Fostering Resilience (SAFR) operation								385,000			
2	Connecticut Connections Coastal Resilience Plan							NA	4,500,000.00			
							0.00	**0.00**	**4,885,000.00**			

Total budget **111,586,517.97**

Project Costs


1. MANAGEMENT OF COASTAL AND INLAND STORM WATER CONVERGENCE
1.1 Connection to storm water junction bypass using archimedes screw
1.2 Public art feature as entry to Long Wharf neighborhood and connection to New Haven downtown art walk
1.3 Dry canal to redirect storm water from J3 bypass
1.4 Wet/dry storm water detention basins as elemental landsacpe
1.5 Secondary inland protection of rail yard through elevating the Vision Trail, reinforcing planned wall at MOW facility and constructing a berm along Church Street Extension
1.6 Future bioswale installation in industry parking lots
1.7 Future expansion of stormwater management system
2. GREEN STREET IMPROVEMENTS
2.1 Resilient Green Streets reconstruction pilots
2.2 Reconstruction of Union Avenue as a Resilient Green Street pilot
2.3 Innovation in Affordable Housing design competition
3. COASTAL PROTECTION
3.1 Revetment and living shoreline for protection against erosion from wave action and sea level rise
100 year storm + 2050 sea level rise (SLR) condition
parks
1.1
1.2
1.3
1.4
2.1
2.2
2.3
1.5
1.6
1.7
3.1
Relocated Brewery Street

Costs and Benefits by Category	Page # in BCA Narrative	Qualitative Description of Effect and Rationale for including in the BCA	Quantitative Assessment (basis/methodology for calc monetized effect)	Monetized Effect	Uncertainty	Notes
Life Cycle Costs						
Rail yard Berm Construction	3,6			$ (17,708,030.00)		Undiscounted Construction Cost
Pumping Station Construction	3,6			$ (4,250,000.00)		Undiscounted Construction Cost
Retention System Construction	4,6			$ (14,870,886.70)		Undiscounted Construction Cost
Complete Streets Construction	4,6			$ (3,151,200.00)		Undiscounted Construction Cost
Coastal Revetment Construction	4,6			$ (18,228,600.00)		Undiscounted Construction Cost
O&M Costs	4			$ (4,246,669.27)		Total lifetime cost, undiscounted
Affordable Housing Design	4,6			$ (350,000.00)		Undiscounted Construction Cost
Resiliency Value						
Reduction in property damage	6	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and property damages will be avoided.	Using FEMA provided data of affected buildings with the floodplain, the replacement cost of those buildings, a value for costs avoided can be derived	$ 1,195,707	2	Annual Undiscounted Value
reduction in accidents and casualtie	7	With the construction of the various elements, people will be better protected and accidents/casualties will be avoided.	Using FEMA provided data of affected persons within the floodplain, DOH study on how many persons seek treatment post severe storms, the Willingness to Pay Table provided by FEMA, a value for costs avoided can be derived	$593,560	2	Annual Undiscounted Value
reduction in displacements	7	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and community displacements will be avoided.	Using FEMA provided data of affected residential buildings with the floodplain, the average household size for the community, and the FEMA permissable relocation cost per person, a value for costs avoided can be derived	0	2	Annual Undiscounted Value
reduction in rail fleet replacements	6	With the construction of the various elements, the New Haven Line railfleet will no longer be directly affected by coastal flooding, and railcar losses due to storms will be avoided.	Number of railcars stored in yard times car cost	$3,341,495	2	Annual Undiscounted Value
reduction in rail operations down tir	6	With the construction of the berm and coastal protection, the New Haven Railyard will no longer be directly affected by coastal flooding, and rail operations losses will be reduced.	Daily operating revenue of railroad, divided by the number of railcars serviced in the yard per day times the number of days yard is out of service results in a loss that would be avoided assuming the improvements are in place.	$7,028	2	Annual Undiscounted Value
Long Wharf Park breakwater protecti	7	With the constructon of the breakwaters, Long wharf park would be protected from continued erosion forces, and increase the recreational space of the community.	Number of acres saved times the land value	$272,923.21	2	Annual Undiscounted Value
Environmental Value						
improvement in riparian landscape				+	1	
improvement in neighborhood water	7	Wetland restoration has been shown to reduce pollutants and improve water quality, which reduces plant treatment needs	Number of acres of wetlands created times pollutant control value	++	4	
Protection of species breeding ground - blue crab, fish habitat along the coast of Long Wharf	7	New Haven bay represents 82% of CT's $62 million annual aquaculture industry and protecting species breeding grounds is important ecologically and economically		++	4	
storm water retention pond system c	7			+	3	
Community Development Value						
benefits to low/moderate income ho	8	With the construction of the various elements, homes will no longer be directly affected by coastal flooding, and home values will increase	Calculated as a simple percentage increase in parcel value	$6,853,942	2	One Time Increase at first year after contsruction
improved living environment	8	New AFH will be introduced, improving the living arrangements for these households	Number of new units, new households, and value of new workers	$417,240	2	Annual Undiscounted Value
ay, complete streets, biking, walking	8	With the construction of the berm and complete streets, more recreational mobility will occur improving peoples lifestyles	miles of additional pathways times the number of potential users times VTI benefit	$21,259	2	Annual Undiscounted Value
preservation of cultural amenities	8	Creating solid affordable communities has been shown to have positive benefit to a municipality		+	4	
on due to improved visual aesthetic	8			+	4	
redesign of church street village hou	8			+	4	
tion and extension of the vision trail	8			+	4	
social cohesion	8			+	4	

Economic Revitalization						
regional economic impact	8	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and workler productivity will be maintained	Using statistics of project area worker population, the earnings potential, and days of lost productivity avoided, a value can be derived.	$382,405	2	Annual Undiscounted Value
reduced insurance cost	8	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and insurance costs will be reduced	Using FEMA provided data of affected buildings with the floodplain, the insurance cost of the buildings before the improvements, a value for costs avoided can be derived	$22,625	2	Annual Undiscounted Value
construction jobs / maintenance jobs	8	Each improvement will create temporary construction jobs that will spend a portion of their income on the local economy. Additionally, any AFH created brings in permanent jobs, that also spend money within the local economy.	Number of temporary jobs times income times the percentage of income spent within the local economy; number of afh times the number of permanent jobs derived, times the income generated times the percentage of income spent on the local economy.	$2,905,080		One Time benefit during contsruction
potential redevelopment along chur	8			++	3	

Summary

New Haven and Fairfield Counties, designated by HUD as most impacted and distressed, incurred concentrated damages to housing, economic centers, key infrastructure, and social cohesion from Hurricane Sandy. In New Haven, Union Station and the Rail Yard are critical local, regional and national infrastructure assets that must be protected to ensure the continued operations of the Northeast rail corridor. The neighborhood surrounding Union Station experiences chronic flooding from rain events, and when coupled with high tide conditions, this creates a convergence of water, damaging homes, key regional infrastructure, and industrial properties that provide many jobs to New Haven's working class families. These conditions will only be exacerbated with expected sea level rise. The project approach to New Haven Station will be to solve for the upland and coastal flooding conditions simultaneously, protecting the Long Wharf neighborhood and train station, and in doing so, the project will enable future economic development opportunities in this downtown area. The specific needs of New Haven are described in more detail in the main application in Exhibit D.a, Unmet Recovery Need and Target Geography.

Results in Brief

All benefits and costs were estimated in constant 2015 dollars over an evaluation period extending 100 years. The base year for discounting is 2015. Results were computed at two discount rates, the primary BCA was discounted at a 7.0 percent discount rate, with an alternative discount rate of 5.0 percent.

Table 1 provides the evaluation results for the two cases. The proposed infrastructure investments yield a net present value of $26 million, and a benefit-cost ratio of 1.52 at the 7% discount rate. At a 5% discount rate, the proposed infrastructure investments yield a net present value of $57 million, and a benefit-cost ratio of 2.08.

Over the 100-year analysis period (2016-2115), there are $77 million in benefits at a 7% discount rate, in 2015 dollars and $111 million in benefits at a 5% discount rate.

Table 1. Benefit Cost Analysis Summary Results

	Net Present	
Case A (7 percent discount rate)	$26 million	1.52
Case B (5 percent discount rate)	$57 million	2.08

Source: WSP | Parsons Brinckerhoff, NDRC_BCA_NewHaven_v8.xlsx, 2015

A Further sensitivity analysis was performed to determine the elasticity of the ratio, with respect to increased benefits, increased costs, decreased benefits, or decreased costs.

Table 2: Benefit to Cost Ratio Sensitivity

Sensitivity Analysis Discounted @7%	New Haven Pilot
B/C if Benefits increase by 15%	**1.75**
B/C if Benefits decrease by 15%	**1.29**
B/C if Costs increase by 15%	**1.32**
B/C if Costs decrease by 15%	**1.79**

As shown in table 3, decreasing costs has the largest positive impact, while decreasing benefits has the largest negative impact. That said, even in the worst case, the resultant benefit to cost ratios return a value greater than 1, indicating a return of benefits higher than the costs expended.

Process for Preparing the Benefit-Cost Analysis

Preparer. The BCA was prepared by WSP | Parsons Brinckerhoff, a consultant to the State of Connecticut, in close consultation with the applicant staff. The Connecticut government project team provided information or were consulted about the full proposal cost; a description of the current situation and the problems to be solved; a description of the proposed project and the geographic service area; risks to Connecticut communities if the project is not implemented; the benefits and costs of the proposed elements of the project; a list of benefits and costs, with rationale; risks to ongoing benefits from proposal; and challenges to implementation.

Cost-Benefit Analysis Methodology

The benefit-cost analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S.HUD in the OMB Circular, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Federal Register (79 FR 11854).

This benefit cost analysis was done using a benefit cost analysis spreadsheet that uses a methodology consistent with the guidelines in OMB Circular A-94. The analysis was conducted for a 100-year analysis period starting in 2015.

Analytical Assumptions

Discount Rates

For project investments, dollar figures in this analysis are expressed in constant 2015 dollars. In instances where certain cost estimates or benefit valuations were expressed in dollar values in other (historical) years, the U.S. Bureau of Labor Statistics' Consumer Price Index for Urban Consumers (CPI-U) was used to adjust them.[1]

The real discount rate used for this analysis was 7.0 percent, consistent with the base-case discount rate in OMB Circular A-94[2].

Evaluation Period

For the NDRC New Haven Project, the evaluation period includes the relevant (post-design) construction period during which capital expenditures are undertaken, through 100 years of operations within which to accrue benefits. This period is the same as the return period of the 100-year storm.

For the purposes of this study, it has been assumed that capital investments will begin in the year 2016. The analysis period begins with the project's first expenditures in 2016 and continues through 100 years of analysis, or through 2115.

All benefits and costs are assumed to occur at the end of each year, and benefits begin in the calendar year immediately following the completion of construction.

(Note that in the benefit cost model, 2015 is the first year of the analysis (year zero) and all values are discounted to that year. Present value is calculated with respect to 2015. Unit costs and benefit factors are in 2015 dollars.)

[1] U.S. Bureau of Labor Statistics. Consumer Price Index, All Urban Consumers, U.S. City Average, Series CUSR0000SA0. 1982-1984=100

[2] White House Office of Management and Budget, Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (October 29, 1992). (http://www.whitehouse.gov/omb/circulars_a094).

Project Benefits by Category

Benefits have been estimated in the five categories listed below:

- Lifecycle costs
- Resilience value
- Environmental value
- Social value or Community development value
- Economic revitalization

The estimated values have been entered into a cost-benefit spreadsheet model. The model is used to estimate benefit and cost streams over a 100-year analysis period, and for discounting to present value to arrive at the benefit-cost ratio.

This benefit cost analysis takes into account pumping station construction, railyard berm protection construction, bioswale construction, economic benefits, and risk reduction benefits ONLY. The quantitative analysis does not include additional ecological or social benefits or costs, as ecological and social benefits were not monetized as part of this analysis, and thus could not be compared to the costs using this framework.

Project Metrics by Category

In order to measure longer-term project resiliency for the proposed pilot projects, many metrics and project outcomes will be used and measured periodically, examples of which are listed below. As a result, each coastal municipality will have a tool to assess the vulnerability to flooding risk and future climate change conditions. Many of these metrics are reflected in the quantification of benefits for this Benefit-Cost Analysis, using data for previous storms from FEMA and other

sources to derive the expected value of costs to be avoided due to the projects. The same metrics can track vulnerable populations as a subgroup.

Metrics for Resiliency value

- Reduction in property damage. (Assess current assets. Use FEMA data on damaged buildings in floodplain, and replacement cost of buildings. For Union Station, derive value of rail vehicles stored in yard. For Long Wharf Park, use acres of park saved from direct impact due to wave erosion.)
- Reduction in casualties, death, injuries, exposure to health risk. (Use FEMA data on affected persons in floodplain and FEMA Willingness to Pay Table.)
- Reduction in displacements. (Use FEMA data on affected residential buildings within the floodplain, the average household size, and the FEMA permissible relocation cost.)
- Reduction in outages of critical facilities and utilities, such as power, water, wastewater, rail operations. (e.g. daily operating revenue of railroad, number of railcars serviced in the yard per day, times days yard is out of service.)

Metrics for environmental value

- Improvement in water quality, increase in green infrastructure. (Reduction in stormwater runoff. Acres of wetlands created times pollutant control value.)
- Ecosystem and bio diversity effects, such as protection of species breeding ground. (New Haven bay represents 82% of CT's $62 million annual aquaculture industry.)
- Reduced energy use and pollution. (Include reduction in emissions and greenhouse gases.)
- Improved living environment. (Use number of new units, new households, and value of new workers.)
- Active lifestyle benefits. (Use miles of additional pathways, number of potential users, walk benefit from VTI.)

Metrics for social and community development value

- Improved living environment in target communities including property value increase, addition of pedestrian amenities, community spaces and recreational parkland.
- Savings in household income from reduction in home repairs due to storm damage and improvements in public transportation access to downtown economic corridors and train station.

Metrics for economic revitalization value

- Regional economic impact. (Use construction of the various elements, homes and businesses no longer directly affected by flooding. Worker productivity maintained.)
- Reduced insurance cost. (Use FEMA data on affected buildings within floodplain, the insurance cost of the buildings before the improvements, a value for costs avoided.)
- Construction and maintenance jobs. (Use number of temporary jobs x income x percentage of income spent within the local economy.)
- Permanent jobs. (Jobs times the income generated times % of income spent locally.)

Full Project Costs

Funding. The proposed New Haven NDRC project will be funded through a combination of Federal, Connecticut state, local, and private funding.

The capital costs in this project will include the following components:

- Railyard Berm
- Pumping Station
- Dry Canal Stormwater Management System
- Resilient Streets Reconstruction
- Naturalized Coastal Erosion Protection

For the benefit cost analysis, capital and program investments ($62.7 million) were assumed to begin in 2016, and the construction schedule has been assumed to last four (4) years. . These capital costs translate to $50.8 million when discounted at 7 percent and $53.2 million when discounted at 5 percent. A breakdown of capital cost components is provided in the Details section of the main body of this report.

Table 2. Project Capital Costs

	Cos	**Cost s**	**Cost s**
NDRC New Haven	$63	$51	$53 Million
Total	$63	$51 Million	$53 Million

Operations and maintenance costs. Due the varied nature of the project elements, the operations and maintenance required for the projects post construction was a percentage of the construction cost that was estimated based on an assessment of the scope/cost of operations/ maintenance activities, frequency of those activities, and the expected lifetime of the project elements. For each pilot project element, the maintenance scopes were rated low (limited operations oversight, simple testing/inspection and minor part replacement), medium (periodic operations oversight, system testing/inspections, secondary system cleanouts/replacements, repaving/regrading) or high (active operations oversight, system testing/inspections, requiring full system cleanouts/replacements, structural modifications including reshoring, or resloping beyond simple regrading or repaving). For each pilot project element, the operations/maintenance frequencies were rated low (annually or per major event), medium (quarterly) or high (monthly). For each pilot project element, the lifetimes were rated short (1 to 10 years), medium (10 - 25 years) or long (25 years plus). The ratings in each assessment category was then used to modify a base 10% operations and maintenance cost per item. For example, in the New Haven Pilot project, the railyard protection berm would be rated low for cost/scope of activities (some mowing of grasses, sounding of berms), low for frequency

(annual sounding inspection of berms, mowing only in spring/summer months), and would have a long lifetime. This would result in an operations and maintenance percentage of 2% of the element construction cost wherein deductions were made for each low rated event.

Current Situation and Problem to be Solved

(The current situation and problem is described in Exhibit D.a, **Unmet Recovery Need & Target Geography,** of the application document.) Connecticut's unique topography defined by north-south ridgelines shaped the development of the east-west rail and road transportation corridors that traverse the state's coastal communities. These systems connect diverse communities, provide linkages to critical infrastructure services, and connect to key assets, forming a network across the state that serves as the backbone of the local, state, and north-east regional economy. In October 2012, Hurricane Sandy hit the coastline of Connecticut, revealing the community, environmental, and economic impacts when this network is interrupted.

Future vulnerability

Connecticut has the second highest exposure of vulnerable coastal assets on the East Coast. (Only Florida has a greater exposure.) Following Sandy, roughly 7,270 property owners in the state applied for FEMA assistance, including 6,000 along the shoreline. With over 60% of the state's population living in coastal communities and over $542 billion in assets (64% of properties) at risk, the State of Connecticut remains vulnerable to future storm events, an exposure that will be exacerbated by climate change. In Connecticut, the historic rate of sea level rise is .10 inches per year (at the Bridgeport datum), which is slightly higher than the average rate of sea level rise due to post-glacial regional subsidence, however projections indicate an increasing rate of sea level rise. With over 32,000 homes in the 100-year floodplain, coastal and riverine communities remain vulnerable to a changing shoreline and increased flooding due to more frequent and intense storm events.

Union Station Neighborhood Target Area:

New Haven and Fairfield Counties, designated by HUD as most impacted and distressed, incurred concentrated damages to housing, economic centers, key infrastructure, and social cohesion from Hurricane Sandy. (A detailed description of the Target Area and its needs is provided in the application in Exhibit D.a., **Unmet Recovery Need & Target Geography.**)

The Union Station Neighborhood target area encompasses the Long Wharf and Hill to Downtown communities (census tracts 1401 (partial), 1402, 1403, 1404 (partial), 1422 (partial), 3614.01 (partial)). Long Wharf is a mixed use area, home to over 120 commercial buildings, key infrastructure including I-95 and the New Haven Union Station Rail yard, and state facilities including CT DOT maintenance facilities and the Regional Water Authority building.

During Hurricane Sandy, this community experienced extensive flooding from the Harbor with surge ranging from 1 to 7 feet high and as far inland as Church Street. The combination of a high storm surge coupled with a high-tide condition caused coastal waters to infiltrate a combined sewer overflow (CSO) that outfalls into New Haven Harbor during storm events. Collecting water from a 580-acre upland watershed, the backflow over capacitated the J3 junction box located at West Water and Union Streets. The resulting backup flooded the Hill-to-Downtown community and converged with surge to exacerbate flooding within Long Wharf.

A protected New Haven Union Station and Rail yard is vital to the future resilience of Long Wharf community. The busiest rail line in America, the New Haven Rail Line connects commuters along the Northeast Corridor stretching from Boston to Washington D.C. According to the Regional Plan Association's Report, Getting Back on Track, New Haven Union Station is Amtrak's tenth busiest station nationwide with over 746,000 ons and offs. With a direct trip between New Haven Union Station and Grand Central Terminal running approximately one hour and 45 minutes, Union Station is the second most common departure point into Grand Central, behind Stamford. While Union Station is part of the larger rail system, the station is vital to the continued recovery,

revitalization, and resilience of the target area communities. With both communities located directly adjacent to the rail yard, Union Station provides residents with commuting opportunities and increased mobility, as well as providing opportunities to bring visitors and economic opportunities to the target area. On a larger scale, the station and rail yard, as part of the larger line, is vital to the economic base for Connecticut as well as the larger North East Corridor, which is estimated to contribute more than $50 billion annually to the national economy. Over 200 buildings in the target area were inundated during Sandy, with an additional 100 buildings located within the FEMA designated 100-year floodplain.

Environmental conditions.

The stormwater management system in this area contributes to poor environmental conditions during major storm events that occur repeatedly. For example, during Hurricane Sandy, this community experienced extensive flooding from the Harbor with surge ranging from 1 to 7 feet high and as far inland as Church Street. The combination of a high storm surge coupled with a high-tide condition caused coastal waters to infiltrate a combined sewer overflow (CSO) that outfalls into New Haven Harbor during storm events. Collecting water from a 600-acre upland watershed, the backflow over capacitated the J3 bypass located at West Water and Union Streets. The resulting backup flooded the Hill to Downtown community and converged with surge to exacerbate flooding within Long Wharf. The storm water flooding in the Hill to Downtown area inundated local streets including Route 34, Union Avenue, Church Street and other local streets in the community.

Similarly the rail yards at Union Station were inundated with up to 7 feet of surge. Service was preemptively halted prior to the onset of Sandy and cars were safely stored upland, limiting the damages incurred. Inundation did lead to damages to the station's low-lying power infrastructure, partially addressed by a $8,978,750 FTA grant administered by the Connecticut DOT for New Haven Rail Yard Power Upgrades.

The community needs an integrated storm water management strategy that utilizes both hard and soft infrastructure to expand the system capacity while simultaneously reducing the amount of water entering the system. A system of green infrastructure or detention basins would reduce pressure on the system, while an increased storage capacity at the J3 bypass would reduce the risk of back-up. This system would reduce the risk of flooding and damages to the local housing, streets, and infrastructure and promote opportunities for new development. In particular, this would benefit the residents of the Hill to Downtown community, a low-moderate income neighborhood, as well as the Church Street Affordable Housing Complex, which face particular resiliency hardships.

Vulnerable populations.

As described in the application's Exhibit D.b.3. Vulnerable Populations, in New Haven, the Union Station / Long Wharf target area is home to roughly 16,700 residents. According to the HVRI Social Vulnerability Index, a majority of the Long Wharf target area is within the top fifth percentile of communities vulnerable to environmental hazards in the country. 7,990 residents or 65% of the population in the target area is considered low and moderate income (LMI), with 15.27% of the population unemployed. The average area median household income is $34,998, which is substantially lower than the statewide median household income of $69,461.

The post-Sandy recovery and repairs to homes and infrastructure in the area did not include resilient measures to protect these damages from future storm events. The affordable housing community directly adjacent to Union Station and the larger downtown area suffers from chronic flooding during simultaneous high tide and heavy rain conditions resulting in repetitive losses, stagnating economic growth in a community that is otherwise a strong candidate for economic investment. The community faces the continued threat of future storm events and sea level rise, as well as more chronic flooding from storm water backup, an eroding shoreline, disconnected neighborhoods, vulnerable populations and a lack of affordable housing that hinder the community's resiliency and ability to recover from future events. Looking forward, the target area has continued recovery

needs that if met, will enhance the resilience of community moving forward against current and future threats. A more detailed description of the problem and the unmet recovery need is in Exhibit D.a of the application.

Proposed Project Improvements

Objectives. In New Haven Connecticut, a series of project applications will strengthen and improve New Haven's strengthen and future shocks and stresses. These project applications recognize the critical position of the New Haven Union Station and associated rail yard in the regional economy and together they present a hybrid of passive, green infrastructure and mechanically engineered solutions in adapting the surrounding neighborhood to be more resilient to future natural disasters and long term change along the northeastern United States seaboard.

This proposal outlines a long-term vision for establishing resilient communities. The main tenets of the program include:

- *Focusing community development around transit (resilient TOD),*
- *Creating corridors resilient to climate change (resilient corridors),*
- *Creating opportunities for affordable housing, and preserving and enhancing the quality of life of existing affordable communities*
- *Developing energy, economic and social resilience,*
- *Increasing transit connectivity,*
- *Adapting structures and critical infrastructure in the flood zone to withstand occasional flooding, and*
- *Protecting communities through healthy buffering ecosystems, where critical services, infrastructure and transport hubs are located on safer, higher ground, and where strong connections exist between the two.*

Increasing investment in identified TOD *resilience zones* provides an opportunity to increase economic resilience by strongly tying back to the regional transportation network and regional economic opportunities.

Elements of the proposed project.

1. **Management of coastal and inland storm water convergence**. In New Haven, we have developed a natural storm water management solution that generates significant co-benefits: (1) building a rich natural storm water system in the downtown; (2) recreating historic wetlands without reducing development potential; (3) introducing water as a design element into Long Wharf; and (4) creating storm water detention that filters pollutants before distribution back into the Sound. Using an Archimedes screw to lift storm water out of two outflow culverts and into a natural flood canal and irrigation system, the initial Long Wharf storm water management system will revive portions of the historic wetland, relieving 30 percent of flooding in Hill-to-Downtown.
2. **Street and neighborhood improvements.** The plan envisions an extensive bioswale network using pervious pavement and other natural catchment techniques to retain storm water runoff from upland areas constructed along local streets. The State, led by DEEP and CTDOT, are looking into advancing design guidelines for resilient streets and would look to pilot street reconstructions in this district to increase storm water retention, enhance pedestrian connectivity and improve the quality of the public realm in keeping with the goals put forth in the Hill to Downtown study, building the foundation for a new urban fabric that would support a transit-oriented development and create a grand entry to Union Station.
3. **Protection of New Haven Rail Yard.** The third piece to the flood control challenge is the protection of the New Haven Rail Yard and the Long Wharf community from 50 and 100 year storms, such as Hurricane Sandy. Our plan takes protection out to the street, raising

Vision Trail and Brewery Road to connect directly to the planned raised infrastructure at the MOW facility and the Component Change Out Shop in the rail yard and then extending an earthen berm along Church Street Extension to Church Street to protect New Haven Rail Yard from flood waters that could enter Long Wharf through Long Wharf drive under I-95. This raised street/berm will double as the conveyance device (dry canal) for upland storm water (see above) and provide a new historic connection between Hill to Downtown and Long Wharf, bridging the gap between these two neighborhoods and beginning the path towards a shared economic future. This secondary berm will be coupled with an inflatable gate sealing the southern two lane I-95 underpass. In the long-term, as predicted sea level rise takes place, further protection to I-95 will be required and the berm constructed to protect the rail yard will continue to serve as protection against potential overtopping.

4. **Layered Coastal Protection utilizing Green Infrastructure and Living Shoreline Approaches.** The approach includes restoring and creating tidal wetland fringe along the length of Long Wharf Drive incorporated with the potential for on land and in-water structural features such as sills and narrow, linear created islands to provide protection for stable wetland development. More structural elements such as rip rap will be minimized, but are necessary at key locations to protect vulnerable and critical assets such as the sewer pump station.

Risks to Community if Improvements are not Implemented

If the improvements are not implemented, the Long Wharf and Hill to Downtown communities will continue to be at risk for damages due to inundation from flooding and all the related consequences from major storms and extreme weather. The low-lying communities in this portion of New Haven will continue to suffer damages from repetitive flooding and sea-level rise, especially if the flood mitigation elements of the project (berm, pumping station, retention system)

are not implemented.

Repeated Storm Events. Hurricane Sandy emphasized the need for drainage improvements in the Long Wharf area that would mitigate flooding during future coastal storm events as well as more regular lesser storm events. According to NOAA National Climactic Data Center, three flash floods and two severe storms were recorded in New Haven between 2005 and 2010. Following two storms in the Spring and Summer of 2010, over thirty properties in the city applied for FEMA Individual assistance. More recently, a March 2013 Nor'easter resulted in $8,249,992 FEMA public assistance funds granted to the city.

Risks to Vulnerable Populations. As described in Exhibit D.a (Unmet recovery need and target geography), the Long Wharf and Hill to Downtown communities are isolated from each other and from the surrounding neighborhoods by unappealing roadways and large scale infrastructure. This lack of community connectivity and social cohesion reduces the community's resilience to future flood events. The current isolation of the Hill to Downtown area limits residents' ability to mobilize or evacuate, or reach critical facilities, including nearby medical centers, during storm events. Additionally, as discussed in the City of New Haven's *Hill-to-Downtown Community Plan*, the existing conditions are limiting economic revitalization of the community. Much of the properties within Long Wharf and Hill to Downtown remain underused or neglected, and in the case of Long Wharf, at low-density. In addition to exacerbating the socio-economic conditions of the neighborhood, if the proposed improvements are not implemented (especially the complete streets and affordable housing elements), the lack of economic livelihood will continue to reduce the community's ability to quickly respond and recover following future events.

Economic Benefits and Costs Included

This section identifies and groups the benefits that are included in the BCA for the NDRC New Haven project.

The following broad categories and any quantifiable benefits have been included in this Benefit Cost Analysis:

- Lifecycle costs:
    - Resilient corridor construction
    - Pumping station
    - Rail yard berm
    - Bioswale and environmental modification
- Resiliency value
    - Reduction in property damage
    - Reduction in accidents and casualties
    - Reduction in displacements
    - Reduction in property damage (rail fleet and downtown buildings)
- Environmental value
    - Improvement in riparian landscape
    - Improvement in neighborhood water quality
    - Protection of species breeding ground
    - Stormwater retention pond system
- Social value or Community development value
    - Community benefits value
    - Benefits to low/moderate income households
    - Improved living environment
    - Redesign of Church Street village housing development
- Economic revitalization
    - Regional economic impact o
      Increased property value o
      Reduced insurance cost

- West River Outfall design modification
- Construction jobs/maintenance jobs
- Potential redevelopment along Church Street extension

Lifecycle Costs

This benefit cost analysis captures the life cycle costs of the capital, maintenance, and operating costs of the proposed components of the project. The Life Cycle costs include the components of resilient corridor construction, pumping station, rail yard berm, and bioswale and environmental modification. These are detailed within the costs data subsection.

Resiliency Value

In the BCA, the group of benefits under the heading of Resiliency Value captures the following components of the New Haven project:

- Reduction in property value. With the construction of the various resilience elements of the project, a significant set of homes and businesses will no longer be directly affected by coastal flooding. Property damages associated with major 100-year storms and extreme weather will be reduced or avoided.
- Reduction in property damage for the rail fleet and downtown buildings. With the construction of rail yard berm and storm water retention/dry canal, the New Haven Line rail fleet in the rail yard will suffer a much smaller direct threat of coastal flooding. Damage to or loss of use of railcars due to storms will be reduced or avoided. For the purposes of this BCA analysis, it was assumed that a portion of the rail fleet would be damaged in the event of a major storm event (100-year storm or higher).
- Reduction in rail operations down time. With the construction of the berm and coastal

protection, the New Haven Railyard will no longer be directly affected by coastal flooding, and rail operations losses will be reduced.

- Protection of Long Wharf Park breakwater from erosion

These are further summarized in the benefits data subsection.

Casualties and Accident Cost Savings

The cost savings that arise from a reduction in the number of casualties, injuries, and deaths include direct savings (e.g., reduced personal medical expenses, lost wages, and lower individual insurance premiums), as well as significant avoided costs to society (e.g., second party medical and litigation fees, emergency response costs, incident congestion costs, and litigation costs).

The value of all such benefits – both direct and societal – could also be approximated by emergency response costs to the region, medical costs, litigation costs, property damages, and economic productivity loss due to workers' inactivity.

Environmental Value

In the BCA, the group of benefits under the heading of Environmental Value captures the following components of the New Haven project:

- Improvement in riparian landscape
- Improvement in neighborhood water quality. Wetland restoration has been shown to reduce pollutants and improve water quality, which reduces plant treatment needs.
- Protection of species breeding ground. There is habitat for blue crab, fish, along the coast of Long Wharf. New Haven Bay represents 82% of CT's $62 million annual aquaculture industry, and protecting species breeding grounds is important ecologically

and economically.

- Stormwater retention pond system. The retention pond system has the potential to create new wildlife and ecosystem habitats.

None of these items here were included in a quantitatitve analysis, as although enviromental benefits are resoundingly positive, their monetization is limited to a trade-off value of usable land space, which can be exceedingly speculative.

Social/Community Development Value

In the BCA, the group of benefits under the heading of Community Development Value or Social Value captures the following components of the New Haven project:

- Benefits to low/moderate income households. With the construction of the various elements of the New Haven project, homes will have a reduced chance of being directly affected by coastal flooding. As a result of lowered risk, home values will increase.
- Improved living environment. New AFH will be introduced, improving the living arrangements for these households. There will be another benefit in terms of improved access to greenway, which provides a more active and healthy lifestyle.
- The redesign of housing development. Redesign of housing developments such as Church Street Village will provide cultural protection and expansion. Reactivation and extension of the vision trail.

These are further summarized in the benefits data subsection.

Economic Redevelopment

In the BCA, the group of benefits under the heading of Economic Redevelopment/Revitalization Value captures the following components of the New Haven project:

- Regional economic impact. With the construction of the various elements, homes and businesses will have a reduced likelihood of being directly affected by coastal flooding. There will be fewer days and weeks lost to full or partial closings. Worker productivity will be maintained.
- Increased property value.
- Reduced insurance cost. With the construction of the various elements, homes and businesses will have a reduced probability of being directly affected by coastal flooding. To the degree that their flood ratings change, their insurance premiums will be reduced.
- Construction jobs/maintenance jobs. Each improvement project will create temporary construction jobs where the workers will spend a portion of their income on the local economy. Additionally, any AFH created brings in permanent jobs, where the workers also spend money within the local economy.
- Potential redevelopment along Church Street extension between Church and Brewery.

For the purposes of the benefit cost analysis, it is assumed that properties that are in higher flood zones are more likely to suffer damage. It is assumed that the average reconstruction cost for affected properties (residential and commercial), facilities (parks, etc), and infrastructure (roads, rail, etc.) depends on the flood zone of the property. The highest cost per unit (square foot, mile, etc.) is assumed for properties in the Erosion zone, and the lowest cost is for properties in the A zone.

These are further summarized in the benefits subsection.

Economic Costs Included and Assumptions

In the benefit-cost analysis, the term "cost" refers to the additional resource costs or expenditures required to implement, and maintain the investments associated with the NDRC New Haven Project.

The BCA uses project costs that have been estimated for the project on an annual basis. Operations and maintenance costs and rehabilitation costs were initially expressed in real dollars while the capital costs were initially expressed in real 2015 dollars. All costs were converted to real 2015 dollars based on CPI-U adjustments.[4]

Initial Project Investment Costs

Initial project investment costs include engineering and design, construction, other capital investments, and contingency factors.

The capital expenditures for the project will be a total of $62 million in 2016.

Note that outlays spent for the acquisition of real estate or real assets (right of way) are generally excluded from total costs in BCAs. This is because when the government acquires a real asset, it is classified as an asset purchase and not a cost. The owning agency would be in possession of tangible assets that, generally, does not depreciate in value.

Key Benefit-Cost Evaluation Measures

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following two (2) common benefit-cost

evaluation measures are included in this BCA.

Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.

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[4] Bureau of Labor Statistics, Consumer Price Index, All Urban Consumers, U.S. City Average, All Items, Series CUSR0000SA0.

Benefit Cost (B/C) Ratio: The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of their associated costs.

Risks to Ongoing Benefits from the Proposed Project

There are risks associated with the proposed project, primarily related to the severity of extreme weather events. If the frequency of large storms and flooding events increases faster than expected, or if sea-level rise occurs at a faster pace than expected, then the proposed mitigation such as the stormwater management measures will lose their effectiveness sooner than expected. That would require the future "layered" mitigation steps to be needed for implementation for protection of I-95 and other facilities sooner than expected, possibly exceeding the future available budget.

If the risk of increased weather severity does occur, the proposed project has been designed to be flexible, and it can be adapted. The proposed project has been conceived in a layered fashion, so that protection is added in an incremental process as the level of climate change becomes more evident.

The State of Connecticut recognizes that actual rise in sea level will involve variable risk. Through the SAFR construct, CIRCA is charged with taking NOAA scenario guidance and equating it to CT specific factors to develop localized sea level rise projections. For the purpose of this application, the State of Connecticut used the FEMA 100-year storm event plus an estimated 2050 sea level rise (SLR) of 1 foot for design standards. The proposal, however, is designed with a vision towards the future, often incorporating a layered approach by employing measures that can be further extended or built upon in the future to protect against

potential increases in sea level rise.

If powerful storms hit the living revetment shoreline treatments, it is possible that elements of the revetment will be washed away or eroded. In that case, maintenance of the revetment shoreline will need to be increased, possibly exceeding the expected O&M budget.

Challenges Faced with Project Implementation

Political or stakeholder risks. There are many political and stakeholder risks that could affect the implementation schedule. If the political situation changes and the state coordinating group SAFR changes its organizational structure, mission, or other leadership role, it could become more difficult to implement the proposed changes. There are many stakeholders and partners who have a role in elements of the project. For example, for the elements of the project related to the New Haven Rail Yard, the operators Amtrak, Metro North, and CTDOT all have their needs, which can possibly be competing and overlapping. However, this overall resilience project will have a strong planning component, and close coordination with stakeholders will be built into the planning process, to help prevent implementation from becoming delayed.

Technical risks. Besides coordination among stakeholders, partners, and agencies, there are technical risks associated with the engineering and construction of the project elements, such as the berm, the stormwater retention system, and the living revetment. For example, CTDOT is in the process of reconstructing and raising critical infrastructure to protect against 100-year storm conditions. Our project's work to raise local streets must be properly coordinated with CTDOT's effort, while avoiding clashes and interferences. Our project's interaction with other infrastructure projects like Route 34 (removing the chronic upland flooding condition in adjacent communities) must be well coordinated, with designs and construction budgets available at the right times for collaboration.

Summary of Benefit Cost Analysis (New Haven Pilot)

This benefit cost analysis takes into account pumping station construction, railyard berm protection construction, bioswale construction, economic benefits, and risk reduction benefits ONLY. It does not include additional ecological or social benefits or costs as ecological and social benefits were not monetized as part of this anlysis, and thus could not be compared to the costs using this framework. For a summary of the additional ecological and social benefits, which are great, see the "expanded benefits" section.

BENEFITS

	Loss/damages Without Project	Loss/damages With Project	Benefits (difference)
Risk Reduction			
Residential			
Reconstruction	$20,792,985	$0	$20,792,985
Relocation	$0	$0	$0
Commercial			
Reconstruction	$98,777,698	$0	$98,777,698
Revenue	$1,000,000	$0	$1,000,000
Roads			
Reconstruction	$6,356,624	$0	$6,356,624
Parks & Beaches			
Reconstruction	$27,292,321	$0	$27,292,321
Safety			
Loss of Life	$0	$0	$0
Hospitalizations	$0	$0	$0
Treat and Release	$43,054,000	$0	$43,054,000
Self Treatment	$16,302,000	$0	$16,302,000
Railroad			
Reconstruction	$3,399,469	$0	$3,399,469
Railcar Replacement	$330,750,000	$0	$330,750,000
Loss of operation	$702,757	$0	$702,757
Property Values			
Value Lost	$1,151,566	$0	$1,151,566
Power Loss			
Cost to consumers	$4,043,475	$0	$4,043,475
Insurance			
Cost to consumers	$2,564,400	$301,944	$2,262,456
Storm Year Impacts	**$556,187,295**	**$301,944**	**$555,885,351**
Effective Annual Impact	**$5,561,873**	**$3,019**	**$5,558,854**
Additional Benefits			
Local Economy		$417,240	$417,240
Pedestrian Health		$21,259	$21,259
Effective Annual Benefit			**$5,997,352**
One Time Benefits (first year)			**$9,759,022**
Construction job local revenue			$2,905,080
land value increase			$6,853,942

Assumptions:

Effective Life of Project	100 years
Discount Rate	7%

for additional assumptions and sources, see detailed benefit-cost materials

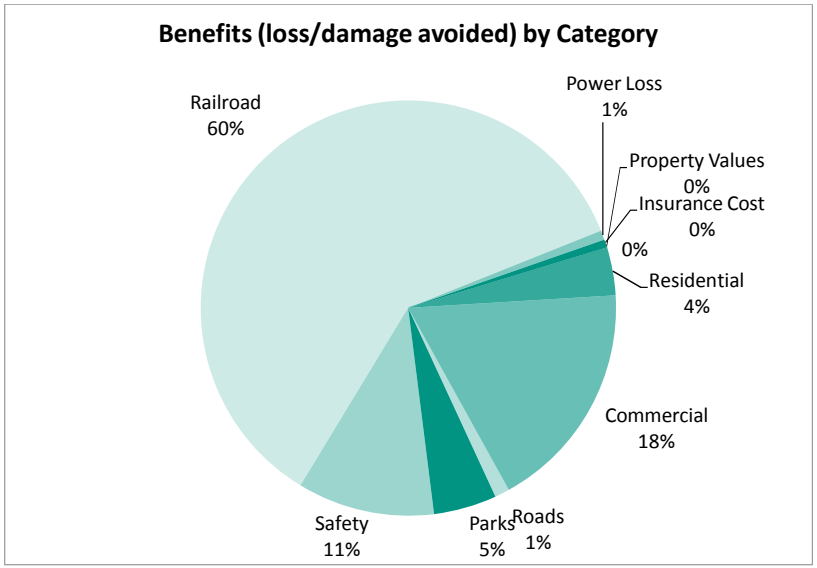
COSTS

Cost Assumptions (in 2015$)	
Capital Costs (end of construction)	$58,558,716
Ongoing monitoring expenditures (for 5 years)	$4,000
Repair & Rehab Costs (per year)	$42,467
Total Costs (year 1)	**$58,605,183**
Total Undiscounted Costs	$62,697,985
Total Discounted Costs (@ 7%)	**$50,858,764**

BENEFIT-COST ANALYSIS

Discounted Analysis (@ 7%)	
Total Benefits	$77,283,887
Total Costs	$50,858,764
BC Ratio	1.52
NPV	$26,425,123

Sensitivity Analysis (@ 7%)	
15% Increase in Benefits	
Benefits	$88,876,470
BC Ratio	**1.75**
NPV	$38,017,706
15% Decrease in Benefits	
Benefits	$65,691,304
BC Ratio	**1.29**
NPV	$14,832,540
15% Increase in Costs	
Costs	$58,487,579
BC Ratio	**1.32**
NPV	$18,796,309
15% Decrease in Costs	
Costs	$43,229,950
BC Ratio	**1.79**
NPV	$34,053,938



BENEFITS (Monitized)

IMPACTS: BASELINE SCENARIO

Scenario

Storm Type	100 year
Annual Probability	1%
Days without Power	5 days

Residential

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$20,792,985
.2% chance	$0
adjacency	$0

Relocation Impacts:

Total Relocated Households	0
Total Years of Relocation	1 year

Commercial

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$23,506,734
Coastal A	$0
A zone	$75,270,964
.2% chance	$0
adjacency	$0

Revenue Impacts

Total Years of Loss Revenue	1 year

Roads

Proportion of Full Reconstruction Cost by Zone:

Erosion Zone	100%
V Zone	50%
Coastal A	25%
A zone	25%
.2% chance	0%
adjacency	0%

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$1,816,178
Coastal A	$0
A zone	$4,540,446
.2% chance	$0
adjacency	$0

IMPACTS: WITH PROJECT

Residential

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

Relocation Impacts:

Total Relocated Households	0
Total Years of Relocation	0 year

Commercial

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

Revenue Impacts

Total Years of Loss Revenue	0 year

Roads

Proportion of Full Reconstruction Cost by Zone:

Erosion Zone	100%
V Zone	50%
Coastal A	25%
A zone	25%
.2% chance	0%
adjacency	0%

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

BENEFITS (Monitized)

IMPACTS: BASELINE SCENARIO		IMPACTS: WITH PROJECT		
Parks		**Parks**		
Proportion of Full Reconstruction Cost by Zone:		*Proportion of Full Reconstruction Cost by Zone:*		
Erosion Zone	100%	Erosion Zone	100%	
V Zone	50%	V Zone	50%	
Coastal A	25%	Coastal A	25%	
A zone	25%	A zone	25%	
.2% chance	0%	.2% chance	0%	
adjacency	0%	adjacency	0%	
Reconstruction Costs by Zone:		*Reconstruction Costs by Zone:*		
Erosion Zone	$0	Erosion Zone	$0	
V Zone	$24,602,574	V Zone	$0	
Coastal A	$0	Coastal A	$0	
A zone	$2,689,747	A zone	$0	
.2% chance	$0	.2% chance	$0	
adjacency	$0	adjacency	$0	
Railyard		**Railyard**		
Proportion of Full Reconstruction Cost by Zone:		*Proportion of Full Reconstruction Cost by Zone:*		
Erosion Zone	100%	Erosion Zone	100%	
V Zone	50%	V Zone	50%	
Coastal A	25%	Coastal A	25%	
A zone	25%	A zone	25%	
.2% chance	0%	.2% chance	0%	
adjacency	0%	adjacency	0%	
Reconstruction Costs by Zone:		*Reconstruction Costs by Zone:*		
Erosion Zone	$0	Erosion Zone	$0	
V Zone	$0	V Zone	$0	
Coastal A	$0	Coastal A	$0	
A zone	$3,399,469	A zone	$0	
.2% chance	$0	.2% chance	$0	
adjacency	$0	adjacency	$0	
Loss of Railroad Operation				
railcars replaced	$330,750,000		$0	assumes A Zone replacement of 25% of total cars
economic value of time lost	$702,757		$0	
Necessary Coastal Protection		**Baseline Necessary Capital or O&M Costs**		
Erosion Control	$0 every year	Erosion Control	$0	
Health and Safety		**Health and Safety**		
Monetized Total deaths	0	Monetized Total deaths	0	
Monetized Total hospitalizations	0	Monetized Total hospitalizations	0	
Monetized Total treat and release	$43,054,000	Monetized Total treat and release	0	
Monetized self treat	$16,302,000	Monetized self treat	0	Uses DOH study of NY post Sandy
Total monetized value	$59,356,000	Total monetized value	$0	
Total walkable distance		Total walkable distance	2.73	
total person trips	0	total person trips	34288	
Pedestrian Health benefit	$0	Pedestrian Health benefit	$21,259	

BENEFITS (Monitized)

IMPACTS: BASELINE SCENARIO		IMPACTS: WITH PROJECT	
Property Value Loss by Zone			
Residential:			
Erosion Zone	4%		
V Zone	3%		
Coastal A	2%		
A zone	1%		
.2% chance	0%		
adjacency	0%		
Total Property Values Lost	$41,834		
Commercial:			
Erosion Zone	4%		
V Zone	3%		
Coastal A	2%		
A zone	1%		
.2% chance	0%		
adjacency	0%		
Total Property Values Lost	$1,109,732		
Commercial Revenue Loss			
Anticipated Revenue Loss	5%		
Total Revenue Lost	$1,000,000		
Losses Due to Power Outage			
Residential Losses (spoilage, cleanlin	$14,000	Residential Losses (spoilage, cleanli	$0
Commercial Losses (productivity, goc	$4,029,475	Commercial Losses (productivity, gc	$0
Insurance Costs			
Residential:			
Erosion Zone			
V Zone	$0	V Zone	$0
Coastal A	$0	Coastal A	$0
A zone	$87,500	A zone	$0
.2% chance	$0	.2% chance	$17,500
Commercial:			
Erosion Zone			
V Zone	$1,406,240	V Zone	$0
Coastal A	$0	Coastal A	$0
A zone	$1,070,660	A zone	$0
.2% chance	$0	.2% chance	$284,444
Economic Growth			
one time construction jobs	0	one time construction jobs	344
Local Revenue generated by one time	$0	Local Revenue generated by one tir	$2,905,080
Local Jobs		Local Jobs	61
Local Revenue generated by local Jol	$0	Local Revenue generated by local J	$372,405
		CT payroll taxes (one time)	252840
CT payroll taxes (annual)	$0	CT payroll taxes annual	44835
		one time land value increase	6,853,942.47

BENEFITS (Monitized)

IMPACTS: BASELINE SCENARIO
IMPACTS: BASELINE SCENARIO

Storm Year Impacts	**$556,187,295**
Residential	$20,792,985
Residential Reconstruction	$20,792,985
Residential Relocation	$0
Commercial	$99,777,698
Commercial Reconstruction	$98,777,698
Commercial Revenue	$1,000,000
Roads	$6,356,624
Roads Reconstruction	$6,356,624
Parks	$27,292,321
Parks/Beach Reconstruction	$27,292,321
Safety	$59,356,000
Loss of Life	$0
hospitalizations	$0
treat and release	$43,054,000
self treat	$16,302,000
Railroad	$334,852,225
Reconstruction	$3,399,469
Railcar Replacement	$330,750,000
Loss of operation	$702,757
Power Loss	$4,043,475
Residential	$14,000
Commercial	$4,029,475
Insurance Cost	$2,564,400
Total Spent	$2,564,400
Property Values	$1,151,566
Value Lost	$1,151,566

Effective Annual Impact $5,561,873

IMPACTS: WITH PROJECT
IMPACTS: WITH PROJECT

Storm Year Impacts	**$301,944**
Residential	$0
Residential Reconstruction	$0
Residential Relocation	$0
Commercial	$0
Commercial Reconstruction	$0
Commercial Revenue	$0
Roads	$0
Roads Reconstruction	$0
Parks	$0
Parks/Beach Reconstruction	$0
Safety	$0
Loss of Life	$0
hospitalizations	$0
treat and release	$0
self treat	$0
Railroad	$0
Reconstruction	$0
Railcar Replacement	$0
Loss of operation	$0
Power Loss	$0
Residential	$0
Commercial	$0
Insurance Cost	$301,944
Total Spent	$301,944
Property Values	$0
Value Lost	$0

Effective Annual Impact $3,019

DIFFERENCE

Storm Year Impacts	**$555,885,351**
Residential	$20,792,985
Commercial	$99,777,698
Roads	$6,356,624
Parks	$27,292,321
Safety	$59,356,000
Railroad	$334,852,225
Power Loss	$4,043,475
Insurance Cost	$2,262,456
Property Values	$1,151,566

Additional Annual Benefits	
Pedestrian Health	$21,259
Local Job Revenue	$372,405
Local Job Payroll Taxes	44835

Annual Project Benefit **$5,997,352**

One Time (initial year benefits)	
Construction job local revenue	$2,905,080
land value increase	$6,853,942
	$9,759,022

COSTS

New Haven Pilot Estimate	O&M Percent	
Stormwater System Long Wharf Canal and Railyard Protection Berm		**$36,828,916**
Railyard Berm	2%	17,708,030.00
Pumping Station	10%	$4,250,000
Retention System	10%	$14,870,887
Street and neighborhood storm water improvements		**$3,501,200**
Complete Streets	5%	$3,151,200
Affordable Housing Design	0%	$350,000
Coastal Revetment	10%	**$18,228,600**
Subtotal Project Costs		**$58,558,716**
Escalation	8% included	
TOTAL PROJECT COSTS		**$58,558,716**
Maintenance		$ 4,246,669
Monitoring (5 yrs)		$ 20,000
TOTAL COST (undiscounted)		**$62,825,385**

COSTS

Cost Assumptions (in 2015 $)

Project Costs	$58,558,716	in Years 1 - 4
Ongoing capital expenditures	$4,000	per year for first 5 years post construction
Maintenance Costs	$42,467	per year
Total First Year Costs	$2,550,000	

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Total Undiscounted Costs	$62,697,985	$2,550,000	$9,397,894	$16,966,161	$29,644,661	$46,467	$46,467	$46,467	$46,467	$46,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
Total Discounted Costs (@ 5%)	$53,239,544	$2,550,000	$8,950,375	$15,388,808	$25,608,173	$38,228	$36,408	$34,674	$33,023	$31,450	$27,374	$26,071	$24,829	$23,647	$22,521	$21,449	$20,427	$19,454
Total Discounted Costs (@ 7%)	$50,858,764	$2,550,000	$8,783,078	$14,818,902	$24,198,874	$35,449	$33,130	$30,963	$28,937	$27,044	$23,099	$21,588	$20,176	$18,856	$17,622	$16,469	$15,392	$14,385

costs developed by Project Team

2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
$18,528	$17,646	$16,806	$16,005	$15,243	$14,517	$13,826	$13,168	$12,541	$11,943	$11,375	$10,833	$10,317	$9,826	$9,358	$8,912	$8,488	$8,084	$7,699	$7,332	$6,983	$6,651	$6,334	$6,032	$5,745	$5,471	$5,211	$4,963	$4,726
$13,444	$12,564	$11,742	$10,974	$10,256	$9,585	$8,958	$8,372	$7,824	$7,313	$6,834	$6,387	$5,969	$5,579	$5,214	$4,873	$4,554	$4,256	$3,978	$3,717	$3,474	$3,247	$3,034	$2,836	$2,650	$2,477	$2,315	$2,164	$2,022

2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090
$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
$4,501	$4,287	$4,083	$3,888	$3,703	$3,527	$3,359	$3,199	$3,047	$2,902	$2,763	$2,632	$2,507	$2,387	$2,273	$2,165	$2,062	$1,964	$1,870	$1,781	$1,697	$1,616	$1,539	$1,466	$1,396	$1,329	$1,266	$1,206	$1,148
$1,890	$1,766	$1,651	$1,543	$1,442	$1,347	$1,259	$1,177	$1,100	$1,028	$961	$898	$839	$784	$733	$685	$640	$598	$559	$523	$488	$456	$427	$399	$373	$348	$325	$304	$284

2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116
$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
$1,094	$1,042	$992	$945	$900	$857	$816	$777	$740	$705	$671	$639	$609	$580	$552	$526	$501	$477	$454	$433	$412	$393	$374	$356	$339	$323
$266	$248	$232	$217	$203	$189	$177	$165	$155	$144	$135	$126	$118	$110	$103	$96	$90	$84	$79	$73	$69	$64	$60	$56	$52	$49

New Haven Costs (cont...)

Analysis

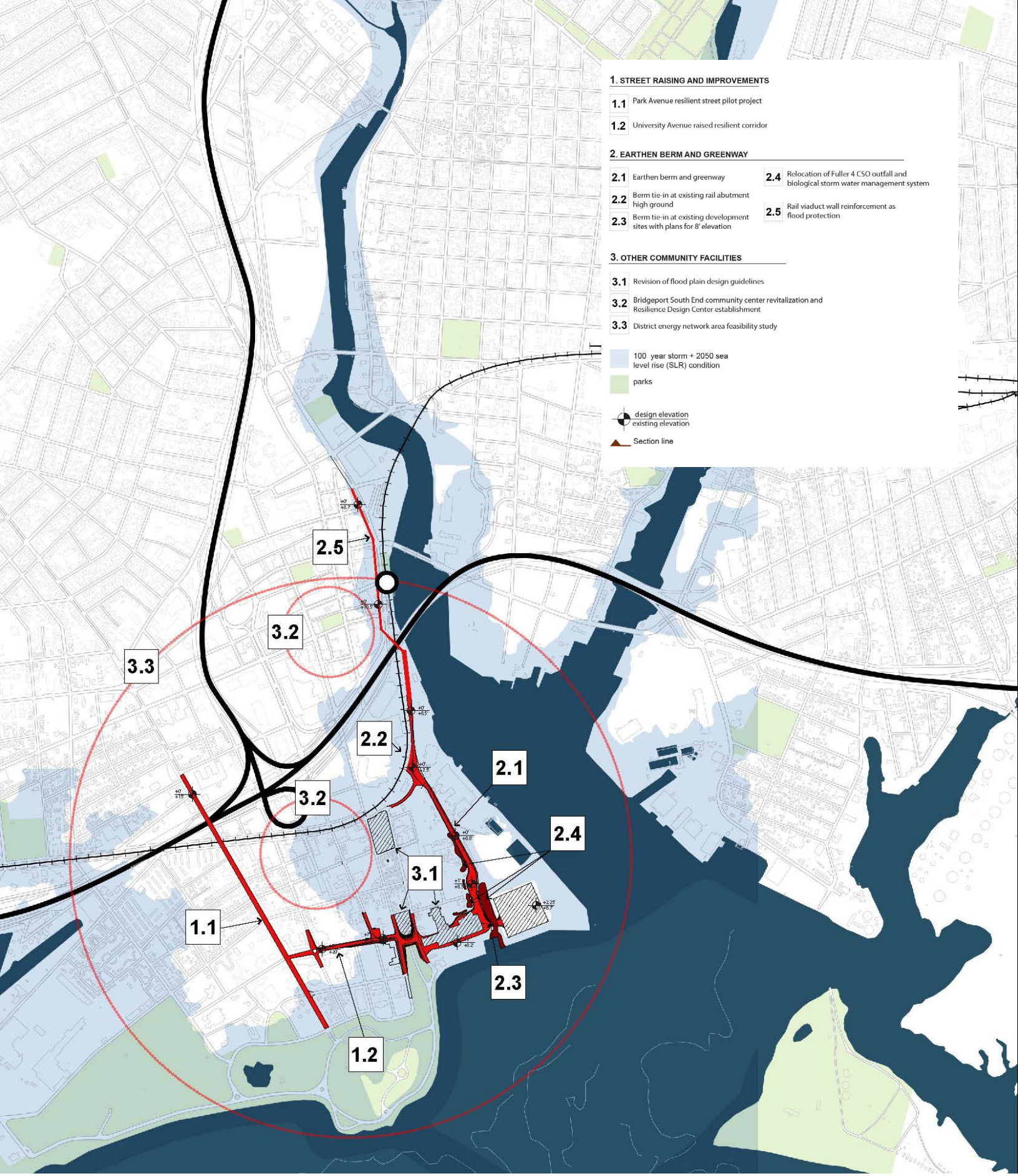
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Undiscounted Analysis																				
Total Undiscounted Benefits	$591,502,197					$15,756,375	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352
Total Undiscounted Costs	$62,697,985	$2,550,000	$9,397,894	$16,966,161	$29,644,661	$46,467	$46,467	$46,467	$46,467	$46,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
BC Ratio	9.43																			
Discounted Analysis (@ 5%)																				
Total Benefits	$110,731,404	$0	$0	$0	$0	$12,962,808.53	$4,699,082.47	$4,475,316.64	$4,262,206.32	$4,059,244.11	$3,865,946.78	$3,681,854.07	$3,506,527.69	$3,339,550.18	$3,180,523.98	$3,029,070.46	$2,884,829.01	##########	##########	##########
Total Costs	$53,239,544	$2,550,000	$8,950,375	$15,388,808	$25,608,173	$38,228	$36,408	$34,674	$33,023	$31,450	$27,374	$26,071	$24,829	$23,647	$22,521	$21,449	$20,427	$19,454	$18,528	$17,646
BC Ratio	2.08																			
NPV	$57,491,860																			
Discounted Analysis (@ 7%)																				
Total Benefits	$77,283,887	$0	$0	$0	$0	$12,020,463	$4,276,029	$3,996,289	$3,734,850	$3,490,514	$3,262,162	$3,048,750	$2,849,299	$2,662,896	$2,488,688	$2,325,877	$2,173,716	$2,031,511	$1,898,608	$1,774,400
Total Costs	$50,858,764	$2,550,000	$8,783,078	$14,818,902	$24,198,874	$35,449	$33,130	$30,963	$28,937	$27,044	$23,099	$21,588	$20,176	$18,856	$17,622	$16,469	$15,392	$14,385	$13,444	$12,564
BC Ratio	1.52																			
NPV	$26,425,123																			

2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352
$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	##########	$986,178.42	$939,217.55	$894,492.90	$851,898.00	$811,331.43	$772,696.60	$735,901.52	$700,858.59	$667,484.38	$635,699.41	$605,428.00
$16,806	$16,005	$15,243	$14,517	$13,826	$13,168	$12,541	$11,943	$11,375	$10,833	$10,317	$9,826	$9,358	$8,912	$8,488	$8,084	$7,699	$7,332	$6,983	$6,651	$6,334	$6,032	$5,745	$5,471	$5,211	$4,963	$4,726	$4,501	$4,287
$1,658,318	$1,549,830	$1,448,439	$1,353,681	$1,265,123	$1,182,358	$1,105,007	$1,032,717	$965,156	$902,015	$843,005	$787,855	$736,313	$688,143	$643,124	$601,051	$561,730	$524,981	$490,636	$458,539	$428,541	$400,505	$374,304	$349,817	$326,932	$305,544	$285,555	$266,874	$249,415
$11,742	$10,974	$10,256	$9,585	$8,958	$8,372	$7,824	$7,313	$6,834	$6,387	$5,969	$5,579	$5,214	$4,873	$4,554	$4,256	$3,978	$3,717	$3,474	$3,247	$3,034	$2,836	$2,650	$2,477	$2,315	$2,164	$2,022	$1,890	$1,766

2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352
$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
$576,598.10	$549,141.05	$522,991.47	$498,087.12	$474,368.68	$451,779.70	$430,266.38	$409,777.50	$390,264.29	$371,680.28	$353,981.22	$337,124.97	$321,071.40	$305,782.28	$291,221.22	$277,353.54	$264,146.23	$251,567.84	$239,588.42	$228,179.45	$217,313.76	$206,965.49	$197,109.99	$187,723.80	$178,784.57	$170,271.02	$162,162.87	$154,440.83	$147,086.51
$4,083	$3,888	$3,703	$3,527	$3,359	$3,199	$3,047	$2,902	$2,763	$2,632	$2,507	$2,387	$2,273	$2,165	$2,062	$1,964	$1,870	$1,781	$1,697	$1,616	$1,539	$1,466	$1,396	$1,329	$1,266	$1,206	$1,148	$1,094	$1,042
$233,098	$217,848	$203,597	$190,277	$177,829	$166,196	$155,323	$145,162	$135,665	$126,790	$118,495	$110,743	$103,498	$96,727	$90,399	$84,485	$78,958	$73,793	$68,965	$64,453	$60,237	$56,296	$52,613	$49,171	$45,954	$42,948	$40,138	$37,513	$35,058
$1,651	$1,543	$1,442	$1,347	$1,259	$1,177	$1,100	$1,028	$961	$898	$839	$784	$733	$685	$640	$598	$559	$523	$488	$456	$427	$399	$373	$348	$325	$304	$284	$266	$248

2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116
77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352	$5,997,352
$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467	$42,467
$140,082.39	$133,411.80	$127,058.85	$121,008.43	$115,246.13	$109,758.22	$104,531.63	$99,553.94	$94,813.27	$90,298.36	$85,998.43	$81,903.27	$78,003.11	$74,288.68	$70,751.12	$67,382.02	$64,173.36	$61,117.48	$58,207.13	$55,435.36	$52,795.58	$50,281.50	$47,887.15	$45,606.81
$992	$945	$900	$857	$816	$777	$740	$705	$671	$639	$609	$580	$552	$526	$501	$477	$454	$433	$412	$393	$374	$356	$339	$323

$32,765	$30,621	$28,618	$26,746	$24,996	$23,361	$21,833	$20,404	$19,069	$17,822	$16,656	$15,566	$14,548	$13,596	$12,707	$11,876	$11,099	$10,373	$9,694	$9,060	$8,467	$7,913	$7,395	$6,912
$232	$217	$203	$189	$177	$165	$155	$144	$135	$126	$118	$110	$103	$96	$90	$84	$79	$73	$69	$64	$60	$56	$52	$49


1. STREET RAISING AND IMPROVEMENTS
1.1 Park Avenue resilient street pilot project
1.2 University Avenue raised resilient corridor
2. EARTHEN BERM AND GREENWAY
2.1 Earthen berm and greenway
2.2 Berm tie-in at existing rail abutment high ground
2.3 Berm tie-in at existing development sites with plans for 8' elevation
2.4 Relocation of Fuller 4 CSO outfall and biological storm water management system
2.5 Rail viaduct wall reinforcement as flood protection
3. OTHER COMMUNITY FACILITIES
3.1 Revision of flood plain design guidelines
3.2 Bridgeport South End community center revitalization and Resilience Design Center establishment
3.3 District energy network area feasibility study
100 year storm + 2050 sea level rise (SLR) condition
parks
design elevation
existing elevation
Section line
2.5
3.2
3.3
2.2
2.1
3.2
2.4
3.1
1.1
2.3
1.2

Costs and Benefits by Category	Page # in BCA Narrative	Qualitative Description of Effect and Rationale for including in the BCA	Quantitative Assessment (basis/methodology for calc monetized effect)	Monetized Effect	Uncertainty	Notes
Life Cycle Costs						
Resilient Corridors	4,6			$ (5,264,000.00)	1	Undiscounted Construction Cost
Earthen Berm	4,6			$ (29,578,600.00)	1	Undiscounted Construction Cost
Community Center Restoration	4,6			$ (1,000,000.00)	1	Undiscounted Construction Cost
CSO treatment park	4,6			$ (2,341,800.00)	1	Undiscounted Construction Cost
Flood Design Guidelines and district energy Study	4,6			$ (330,000.00)	1	Undiscounted Construction Cost
O&M	4,6			$ (4,352,603.60)	2	Total lifetime cost, undiscounted
Resiliency Value						
Reduction in property damage	6	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and property damages will be avoided.	Using FEMA provided data of affected buildings with the floodplain, the replacement cost of those buildings, a value for costs avoided can be derived	$1,454,988.02	2	Annual Undiscounted Value
reduction in accidents and casualties	6	With the construction of the various elements, people will be better protected and accidents/casualties will be avoided.	Using FEMA provided data of affected persons within the floodplain, DOH study on how many persons seek treatment post severe storms, the Willingness to Pay Table provided by FEMA, a value for costs avoided can be derived	$156,200	2	Annual Undiscounted Value
reduction in displacements	6	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and community displacements will be avoided.	Using FEMA provided data of affected residential buildings with the floodplain, the average household size for the community, and the FEMA permissable relocation cost per person, a value for costs avoided can be derived		2	Annual Undiscounted Value
reduced vulnerability to large scale water and power outages	6	With the costruction of the various elements, local power plants will no longer be succeptible to prolonged shut downs, therefore reducing customer losses.	Using UI customer numbers affected during Superstorm Sandy, and cost factors from the Berkeley report, a value for the costs avoided can be derived.	$241,918	2	Annual Undiscounted Value
Environmental Value						
Enhanced greenway - increased permeable surface, air quality, more recreational open space	7	With the constructon of the berm a portion of Seaside park would be protected and increase the recreational space of the community.	Number of acres saved times the land value	$179	2	Annual Undiscounted Value
Improved water quality from wetland landscape at CSO outfall on south side of berm	7	Wetland restoration has been shown to reduce pollutants and improve water quality, which reduces plant treatment needs		++	4	
Flood design guidelines reduce environmental damage and pollutants at regional and global scale	7	Creating design guidelines for all subsequent area development will further reduce property, insurance and community function losses.		++	2	
Community Development Value						
benefits to low/moderate income households	7	With the construction of the various elements, homes will no longer be directly affected by coastal flooding, and home values will increase	Calculated as a simple percentage increase in parcel value	$27,324,265	2	One Time Increase at first year after contsruction
improved living environment	7	New AFH will be introduced, improving the living arrangements for these households	Number of new units, new households, and value of new workers	$104,505.14	2	Annual Undiscounted Value
active lifestyle - access to green way, complete streets, biking, walking	7	With the construction of the berm and complete streets, more recreational mobility will occur improving peoples lifestyles	miles of additional pathways times the number of potential users times VTI benefit	$8,996		Annual Undiscounted Value
preservation of cultural amenities	7	Creating solid affordable communities has been shown to have positive benefit to a municipality		+		
increased social cohesion due to improved visual aesthetic	7			+		
	7			+	2	
church and community center redevelopment - high cultural value	7			+		
social cohesion	7			+		
Economic Revitalization						
Broad street economic development - bringing in x number of businesses GFR and mixed use land	8			++	4	
regional economic impact	8	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and workler productivity will be maintained	Using statistics of project area worker population, the earnings potential, and days of lost productivity avoided, a value can be derived.	$98,275.42	3	Annual Undiscounted Value
employment from construction, maintenance, vacant land downtown that can be redeveloped	8	Each improvement will create temporary construction jobs that will spend a portion of their income on the local economy. Additionally, any AFH created brings in permanent jobs, that also spend money within the local economy.	Number of temporary jobs times income times the percentage of income spent within the local economy; number of afh times the number of permanent jobs derived, times the income generated times the percentage of income spent on the local economy.	$726,206		One Time benefit during contsruction
University of Bridgeport future growth using new flood design policy	8					
				+	4	
reduced insurance costs	8	With the construction of the various elements, homes and businesses will no longer be directly affected by coastal flooding, and insurance costs will be reduced	Using FEMA provided data of affected buildings with the floodplain, the insurance cost of the buildings before the improvements, a value for costs avoided can be derived	$21,528	3	Annual Undiscounted Value
One new x ft2 affordable housing development at Broad street and Gregory Street.	8	There is a current design @ the city of Bridgeport.		++	4	
one new market rate housing development at Henry and Main street	8					

Summary

New Haven and Fairfield Counties, designated by HUD as most impacted and distressed, incurred concentrated damages to housing, economic centers, key infrastructure, and social cohesion from Hurricane Sandy.

In Bridgeport, South End East encompasses the eastern portion of South End as well as Downtown Bridgeport, extending north to just above Bridgeport Station. With the South End located on a barrier peninsula, and the downtown facing the Pequonnock River, South End East remains one of the most vulnerable communities in Bridgeport. The specific needs of Bridgeport are described in more detail in the main application in Exhibit D.a, Unmet Recovery Need and Target Geography.

After Hurricane Sandy, there was a major effort to conduct repair of damaged facilities. This recovery, and repairs to homes and infrastructure in the area, however, did not include resilient measures, protecting these damages from future storm events. The community faces the continued threat of future storm events coupled with sea level rise, as well as economic and social challenges that hinder the growth of the community and ability to recover from future events. Looking forward, the target area has continued recovery needs that if met, will enhance the resilience of community towards current and future threats.

Hurricane Sandy emphasized the need for protective measures in Bridgeport South End East that will mitigate flooding during future coastal storm events. A system of integrated coastal protection measures would reduce the risk of flooding and damages to the local housing stock, including the historic houses that make up much of the residential community in South End East. Protection would also reduce flood risk to key infrastructure assets including the local street system and multiple power facilities that provide electricity locally and regionally.

The project approach is to create a network of resilient corridors, protecting the economically disadvantages South End East neighborhood, and ultimately downtown Bridgeport and the train station from damage due to storm surge flooding and expected sea level rise. These resilient corridors will set a new datum for development using a series of street elevations, construction of an earthen berm and greenway path and leverage of existing plans to elevate new development in the South End East neighborhood. These new raised rights-of-way will be supported with new community centers, an energy study to promote energy technologies and turn energy technologies into economic opportunity and new development guidelines for raised infrastructure to promote an holistic approach to resilience in East South End.

Results in Brief

All benefits and costs were estimated in constant 2015 dollars over an evaluation period extending 100 years. The base year for discounting is 2015. Results were computed at two discount rates, the primary BCA was discounted at a 7.0 percent discount rate, with an alternative discount rate of 5.0 percent.

Table 1 provides the evaluation results for both cases. The proposed infrastructure investments yield a net present value of $8.5 million at the 7% discount rate, with a benefit- cost ratio of 1.22. At a 5 percent discount rate, the proposed infrastructure investments yield a net present value of $19.5 million, and a benefit-cost ratio of 1.50. Over the 100-year analysis period (2016-2115), there are $46 million in benefits at a 7% discount rate, in 2015 dollars and $59 million in benefits at a 5% discount rate.

Table 1. Benefit Cost Analysis Summary Results

	Net Present Value	
Case A (7 percent discount rate)	$8.5	1.22
Case B (5 percent discount rate)	$19.5	1.50

Source: WSP | Parsons Brinckerhoff, 2015

Project Costs

For the benefit cost analysis, capital and program investments ($43 million) were assumed to begin in 2016 and take four years for construction, assuming the design and construction schedule for the project (see attached schedule). These capital and program costs translate to $35 million when discounted at 7% and $39 million when discounted at 5%. A breakdown of capital cost components is provided in the Details section of the main body of this report.

Table 2. Project Capital Costs

	Cos	**Cost s**	**Cost s**
NDRC Bridgeport Project	$43	$35	$39
Total	$43	$35	$39

A Further sensitivity analysis was performed to determine the elasticity of the ratio, with respect to increased benefits, increased costs, decreased benefits, or decreased costs.

Table 2: Benefit to Cost Ratio Sensitivity

Sensitivity Analysis Discounted @7%	Bridgeport Pilot
B/C if Benefits increase by 15%	**1.40**
B/C if Benefits decrease by 15%	**1.04**
B/C if Costs increase by 15%	**1.06**
B/C if Costs decrease by 15%	**1.43**

As shown in table 3, decreasing costs has the largest positive impact, while decreasing benefits has the largest negative impact. That said, even in the worst case, the resultant benefit to cost ratios return a value greater than 1, indicating a return of benefits higher than the costs expended.

Process for Preparing the Benefit-Cost Analysis

Preparer. The BCA was prepared by WSP | Parsons Brinckerhoff, a consultant to the State of Connecticut, in close consultation with the applicant staff. The Connecticut government project team provided information or were consulted about the full proposal cost; a description of the current situation and the problems to be solved; a description of the proposed project and the geographic service area; risks to Connecticut communities if the project is not implemented; the benefits and costs of the proposed elements of the project; a list of benefits and costs, with rationale; risks to ongoing benefits from proposal; and challenges to implementation.

Cost-Benefit Analysis Methodology

The benefit-cost analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S.HUD in the OMB Circular, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," Federal Register (79 FR 11854).

This benefit cost analysis was done using a benefit cost analysis spreadsheet that uses a methodology consistent with the guidelines in OMB Circular A-94. The analysis was conducted for a 100-year analysis period starting in 2015.

Analytical Assumptions

Discount Rates

For project investments, dollar figures in this analysis are expressed in constant 2015 dollars. In instances where certain cost estimates or benefit valuations were expressed in dollar values in other (historical) years, the U.S. Bureau of Labor Statistics' Consumer Price Index for Urban Consumers (CPI-U) was used to adjust them.[1] The real discount rate used for this analysis was 7.0 percent, consistent with the base- case discount rate in OMB Circular A-94[2].

Evaluation Period

For the NDRC Bridgeport Project, the evaluation period includes the relevant (post-design) construction period during which capital expenditures are undertaken, through 100 years of operations within which to accrue benefits. This period is the same as the return period of the 100-year storm.

For the purposes of this study, it has been assumed that capital investments will begin in the year 2016. The analysis period begins with the project's first expenditures in 2016 and continues through 100 years of analysis, or through 2115. All benefits and costs are assumed to occur at the end of each year, and benefits begin in the calendar year immediately following the completion of construction.[3]

(Note that 2015 is the first year of the analysis (year zero) and all values are discounted to that year. Present value is calculated with respect to 2015. Unit costs and benefit factors are in 2015 dollars.)

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[1] U.S. Bureau of Labor Statistics. Consumer Price Index, All Urban Consumers, U.S. City Average, Series CUSR0000SA0. 1982-1984=100

[2] White House Office of Management and Budget, Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (October 29, 1992). (http://www.whitehouse.gov/omb/circulars_a094).

Project Benefits by Category

Benefits have been estimated in the five categories listed below:

- Lifecycle costs
- Resilience value
- Environmental value
- Social value or Community development value
- Economic revitalization

The estimated values have been entered into a cost-benefit spreadsheet model used to estimate benefit and cost streams over a 100-year analysis period, and for discounting to present value to arrive at the benefit-cost ratio.

This benefit cost analysis takes into account resilient corridor construction costs, economic benefits, and risk reduction benefits ONLY. **The BCA does not include additional ecological or social benefits or costs as ecological and social benefits were not monetized as part of this analysis,** and thus could not be compared to the costs using this framework.

Project Metrics by Category

In order to measure longer-term project resiliency for the proposed pilot projects, many metrics and project outcomes will be used and measured periodically, examples of which are listed below. Each coastal municipality will have a tool to assess the vulnerability to flooding risk and future climate change conditions. Many of these metrics are reflected in the quantification of benefits for this Benefit-Cost Analysis, using data for previous storms from FEMA and other sources to derive the expected value of costs to be avoided due to the projects. The same metrics can track vulnerable populations as a subgroup.

Metrics for Resiliency value

- Reduction in property damage. (Assess current assets. Use FEMA data on damaged buildings in floodplain, and replacement cost of buildings.)
- Reduction in casualties, death, injuries, exposure to health risk. (Use FEMA data on affected persons in floodplain and FEMA Willingness to Pay Table.)
- Reduction in displacements. (Use FEMA data on affected residential buildings within the floodplain, the average household size, and the FEMA permissible relocation cost.)
- Reduction in outages of critical facilities and utilities, such as power, water, wastewater, rail operations.

Metrics for environmental value

- Improvement in water quality, increase in green infrastructure. (Reduction in stormwater runoff. Acres of wetlands created times pollutant control value.)
- Ecosystem and bio diversity effects, such as protection of species breeding ground.
- Reduced energy use and pollution. (Include reduction in emissions and greenhouse gases.)
- Improved living environment. (Use number of new units, new households, and value of new workers.)
- Active lifestyle benefits. (Use miles of additional pathways, number of potential users, and walk benefit from VTI.)

Metrics for social and community development value

- Improved living environment in target communities including property value increase, addition of pedestrian amenities, community spaces and recreational parkland.

- Savings in household income from reduction in home repairs due to storm damage and improvements in public transportation access to downtown economic corridors and train station.

Metrics for economic revitalization value

- Regional economic impact. (Use construction of the various elements, homes and businesses no longer directly affected by flooding. Worker productivity maintained.)
- Reduced insurance cost. (Use FEMA data on affected buildings within floodplain, the insurance cost of the buildings before the improvements, a value for costs avoided.)
- Construction and maintenance jobs. (Use number of temporary jobs x income x percentage of income spent within the local economy.)
- Permanent jobs. (Jobs times the income generated times % of income spent locally.)

Full Project Costs

Funding. The proposed Bridgeport NDRC project will be funded through a combination of Federal, State, local, and private funding.

The capital costs in this project will include the following components:

- Earthen berm
- Viaduct restoration
- CSO treatment park
- Resilient University Avenue Corridor
- Community Center restoration
- Flood design guideline recommendations
- District energy feasibility study

For the BCA, capital and program investments ($43 million) were assumed to begin in 2016, and the construction schedule has been assumed to last four (4) years. . These capital costs translate to $35 million when discounted at 7% and $39 million when discounted at 5%. A breakdown of capital cost components is provided in the Details section of the main body of this report.

Table 2. Project Capital Costs

	Costs (2015	**Costs 2015 (7% discount)**	**Costs (2015 $**
NDRC Bridgeport Project	$43 Million	$35 Million	$39 Million
Total	$43 Million	$35 Million	$39 Million

Operations and maintenance costs. Due the varied nature of the project elements, the operations and maintenance required for the projects post construction was estimated as a percentage of the construction cost. The estimate was based on an assessment of the scope/cost of operations/maintenance activities, frequency of those activities, and the expected lifetime of the project elements. For each pilot project element, the maintenance scopes were rated low (limited operations oversight, simple testing/inspection and minor part replacement), medium (periodic operations oversight, system testing/inspections, secondary system cleanouts/replacements, repaving/regrading) or high (active operations oversight, system testing/inspections, requiring full system cleanouts/replacements, structural modifications including reshoring, or re-sloping beyond simple regrading or repaving). For each pilot project element, the operations/maintenance frequencies were rated low (annually or per major event), medium (quarterly) or high (monthly). For each pilot project element, the lifetimes were rated short (1 to 10 years), medium (10 - 25 years) or long (25 years plus). The ratings in each assessment category was then used to modify a base 10% operations and maintenance cost per item. For details, see the BCA cost data.

Current Situation and Problem to be Solved

The current situation and problem is described in Exhibit D.a, **Unmet Recovery Need & Target Geography,** of the application document. Connecticut's unique topography defined by north-south ridgelines shaped the development of the east-west rail and road transportation corridors that traverse the state's coastal communities. These systems connect diverse communities, provide linkages to critical infrastructure services, and connect to key assets, forming a network across the state that serves as the backbone of the local, state, and north-east regional economy. In October 2012, Hurricane Sandy hit the coastline of Connecticut, revealing the community, environmental, and economic impacts when this network is interrupted.

Future vulnerability

Connecticut has the second highest exposure of vulnerable coastal assets on the East Coast. (Only Florida has a greater exposure.) Following Sandy, roughly 7,270 property owners in the state applied for FEMA assistance, including 6,000 along the shoreline. With over 60% of the state's population living in coastal communities and over $542 billion in assets (64% of properties) at risk, the State of Connecticut remains vulnerable to future storm events, an exposure that will be exacerbated by climate change. In Connecticut, the historic rate of sea level rise is .10 inches per year (at the Bridgeport datum), which is slightly higher than the average rate of sea level rise due to post-glacial regional subsidence, however projections indicate an increasing rate of sea level rise. With over 32,000 homes in the 100-year floodplain, coastal and riverine communities remain vulnerable to a changing shoreline and increased flooding due to more frequent and intense storm events.

South End East Target Area:

New Haven and Fairfield Counties, designated by HUD as most impacted and distressed, incurred concentrated damages to housing, economic centers, key infrastructure, and social

cohesion from Hurricane Sandy. (A more detailed description of the Target Area and its needs is provided in the application in Exhibit **D.a., Unmet Recovery Need & Target Geography.)**

South End East project area encompasses the eastern portion of South End as well as Downtown Bridgeport, extending north to just above Bridgeport Station (census tracts, 705, 706, and 704 (partial)). This waterfront community of historic residences and industrial uses sits very close to downtown Bridgeport, but is isolated by infrastructure and large footprint developments. With South End located on a barrier peninsula, and the downtown facing the Pequonnock River, South End East remains one of the most vulnerable communities in Bridgeport.

Bridgeport was hit hard during Sandy, pummeled with sustained 70 mph gale force winds and experiencing the highest storm surge in the state, nearly 9.8 feet above normal high tide, that resulted in damages to 570 single family homes city-wide. Within the target area, 31.2 acres containing 211 buildings were inundated resulting in over 100 FEMA Individual Assistance Household inspections completed in this area.

Downtown Bridgeport, located to the north of the rail line, contains mostly commercial and institutional buildings. Surge from the Pequonnock River ranged in height from 1 to 5 feet along the coastline, but only inundated the area as far inland as Water Street, sparing most properties in the Downtown from damage. Bridgeport Station and rail, located at an elevation of approximately 11' NAVD88, avoided damages. South of I-95, the community consists of single family homes, industry, and critical infrastructure including the PSE&G Plant, Bridgeport Power, and a fuel depot. Surge as high as 7 feet inundated this area, flooding streets and damaging residential properties.

Throughout the target area, residents relayed accounts of power outages that lasted from a few hours to over a week. The United Illuminated Company which serves the larger region reported that over 250,000 customers experienced outages. Of the roughly 57,835 Bridgeport customers, over 41% or 23,414 still experienced outages 4 days following the onset of Sandy.

Environmental conditions.

The stormwater management system in this area contributes to poor environmental conditions during major storm events that occur repeatedly. In South End East, as well as throughout the city, the sewer and stormwater system infrastructure is aging, including an existing outfall that runs along Singer Street in the target area and drains into Bridgeport Harbor during CSO events. Flooding can also occur on a more regular basis as stormwater flows south from a higher elevation at Downtown Bridgeport.

Vulnerable populations.

As described in the application's Exhibit D.b.3. Vulnerable Populations, in Bridgeport, the target area is home to roughly 4,400 residents. According to the HVRI Social Vulnerability Index, a majority of the South End East target area is within the top fifth percentile of communities vulnerable to environmental hazards in the country. 85% of the population in the target area is considered LMI, with the average area median household come at $21,102. 21.20% of the population is unemployed; 11% above 65 years old, and 30% have not graduated from high school.

The target areas' biggest obstacle to continued recovery and resilience is economic redevelopment. Already experiencing economic downturn, Sandy resulted in flooding in the area that shut down or relocated most remaining businesses and further exacerbated vacancies in the neighborhood. With over 24 properties vacant today, the vulnerability of the area to future storm events and sea level rise has limited the opportunities for redevelopment in the area. Looking forward, the target area has continued recovery needs that if met, will enhance the resilience of community moving forward against current and future threats. A more detailed description of the problem and the unmet recovery need is in Exhibit D.a of the application.

Proposed Project Improvements

Objectives. In Bridgeport Connecticut, a series of project applications will strengthen Bridgeport's resiliency towards future shocks and stresses from climate change, including sea level rise. In Bridgeport this includes redeveloping key streets in Bridgeport's South End East neighborhood to form a network of resilient corridors; construction of a multi-purpose earthen berm between Tongue Point and the rail viaduct on Ferry Access Road; a feasibility study for connecting existing, isolated, neighborhood energy initiatives; rehabilitation of existing community centers including creation of a Resilience Design Center in downtown Bridgeport; and a revision of existing flood plain development guidelines governing future growth in Bridgeport's South End.

This proposal outlines a long-term vision for establishing resilient communities. The main tenets of the program include:

- *Focusing community development around transit (resilient TOD),*
- *Creating corridors resilient to climate change (resilient corridors),*
- *Creating opportunities for affordable housing, and preserving and enhancing the quality of life of existing affordable communities*
- *Developing energy, economic and social resilience,*
- *Increasing transit connectivity,*
- *Adapting structures and critical infrastructure in the flood zone to withstand occasional flooding, and*
- *Protecting communities through healthy buffering ecosystems, where critical services, infrastructure and transport hubs are located on safer, higher ground, and where strong connections exist between the two.*

Elements of the proposed project. Each specific project application is described in detail as follows:

Street Raising and Street Improvements: Streets in the South End East neighborhood will be improved and raised in order to create a Resilient Corridor Network. The corridors are multi-purpose; serving as complete streets that provide multimodal transportation options for residents, while protecting against future flooding from tidal waters during 50-, 100- and 500- year storms. This network leverages the South End's existing ridge-line along Park Avenue, connecting this naturally elevated street to key lateral streets through strategically designed and landscaped street elevation. Raising sections of the east-west streets will ensure the local community has vehicular and public transit access to the Park Avenue corridor during major storm events and sets a new, higher, ground plain for future long term development. The initial pilot street raising is anticipated for University Avenue, but eventually other lateral street connections such as Linden, Gregory and Atlantic streets could also be raised out of the 100-year floodplain. As part of the state funded Green Streets program, public streets within this pilot resilient corridor network will be retrofit with green infrastructure improvements such as installing median rain gardens and bio-swales to retain and prevent damage from storm water flooding. More ambitious flood management strategies will be undertaken for University Avenue in coordination with the raising of University, to develop guidelines for resilient street raising that can be replicated in low-lying areas throughout the State.

Earthen Berm: The Bridgeport Resilient Corridor Network includes an earthen berm extending up to 9.4 feet in height constructed at the outer edge of the South End East neighborhood between Tongue Point and the rail viaduct at Ferry Access Road. The northern section of the berm would tie into the existing high ground at the rail abutment near the I-95 bridge and the southern section of the berm would tie into the two existing re-development sites; construction of an elevated natural gas fired power plant at the existing site of the Bridgeport Harbor Generating Station (1 Atlantic Street) and redevelopment of the former Remington Shaver facility brown field site (60 Main Street). Both of these redevelopment plans address climate resilience through raising new industrial and mixed-use residential spaces eight feet above FEMA Mean High Water (MHW)

levels. The earthen berm will connect these new elevated facilities using a raised public greenway, and create an opportunity for relocation and bioremediation of the existing Fuller 4 Combined Sewer Overflow (CSO) outfall, as a landscape feature of the greenway. Extending north, the berm will be integrated into the protection strategy for the UI owned power station adjacent to the berm, creating efficiencies in protection by integrating individual utility site protection into a larger protection strategy for the community. This component of the project capitalizes on existing private sector investment in order to protect all low and moderate income residents within the South End East neighborhood from flood damage, while providing elevated, scenic, pedestrian and bicycle access to downtown Bridgeport and to the TOD at the Bridgeport Train Station. In the long term, it is envisioned that the berm would extend north to the Downtown edge and transition to a sea wall outboard of the railroad platform, protecting downtown Bridgeport from future 500 year storm surge and estimated sea level rise by the year 2100.

Revision of existing flood plain design guidelines governing South End East neighborhood: Using the 1 Atlantic, 60 Main street and any new developments proposed along University Avenue as precedents, the project will be guided by DEEP, FEMA, the United States Army Corps of Engineers (USACE) and other relevant standards to build progressively upon existing flood plain design guidelines, incorporating cutting edge technologies and national innovation strategies as permissible strategies. Additional private building-level retrofits in the project area would be governed by the new flood design guidelines to ensure that future development is designed as an integral component of the resilient corridor network.

The berm serves both as protection and as a critical connection to downtown Bridgeport, the Amtrak station and the amenities centered in the CBD. Isolated from the downtown by recent developments, this community has suffered from losing the through traffic that once passed through the community from downtown to the waterfront. This project, by strengthening the Broad Street

corridor as the new Main Street of South End and building a new pedestrian waterfront connection directly into and through South End from downtown, will re-establish the economic connection to downtown that this community sorely needs and create the basis for reinvestment on a number of currently vacant sites that are ripe for redevelopment. The raising of University Avenue and the berm create a new paradigm for protection that promotes redevelopment and rebuilds community through a continued relationship with the water as opposed to just keeping out the water.

South End District Energy Infrastructure: Bridgeport's South End is home to three discrete energy distribution networks. The first network includes the Public Service Enterprise Group (PSE&G), a major land owner in the South End East neighborhood operating two coal fired power plants with plans to build one additional gas fired power plant at 12 Ferry Access Road, all within the project target area. Nearby, the University of Bridgeport Renewable Energy Research Laboratory is the recipient of a $2.2 million dollar Connecticut Department of Energy and Environmental Protection (DEEP) grant developing a micro-grid from fuel cell technology that provides power to six campus buildings including two residence halls. Downtown Bridgeport is a recipient of a ($2.95 Million) _DEEP grant to develop a micro-grid for its downtown office buildings. And recently the Green Bank of Connecticut has funded installation of a district heating loop that will capture low temperature heat from the Wheelabrator waste-to-energy plant and re-distribute it to buildings in the South End neighborhood. The project believes there is potential to network discrete systems, creating unique energy ecosystem that provides redundant power in event of emergency or during peak demand. The study would analyze how new and existing networked energy infrastructure can be housed within the newly constructed berm and raised streets, protecting this critical infrastructure from damage due to tree fall (when elevated above streets) and flooding (when buried underground) in this low lying exposed region of Bridgeport.

The Resilient Corridor Network in South End East Bridgeport not only enables community evacuation and reliable access to electricity during a major storm event, while

increasing the neighborhoods flood storage capacity, but it also ensures protection of existing developments and creates incentives for growth of future businesses and industries in this key area of downtown Bridgeport.

Risks to Community if Improvements are not Implemented

If the proposed improvements are not implemented, the South East End community will continue to be at risk for damages due to inundation from flooding and all the related consequences from major storms and extreme weather. The low-lying communities in this portion of Bridgeport will continue to suffer damages from repetitive flooding and sea-level rise, especially if the flood mitigation elements of the project (berm, CSO treatment park) are not implemented.

Repeated Storm Events. Hurricane Sandy emphasized the need for drainage and stormwater improvements in the South East End area that would mitigate flooding during future coastal storm events as well as more regular lesser storm events.

Risks to Vulnerable Populations. As described in Exhibit D.a (Unmet recovery need and target geography), the South East End waterfront community of residences and industrial uses sits very close to downtown Bridgeport, but is isolated by infrastructure and large footprint developments. With South End located on a barrier peninsula, and the downtown facing the Pequonnock River, South End East remains one of the most vulnerable communities in Bridgeport. Up through the 1930s, the South End was an industrial center due to its favorable location near both port and rail. By the 1980s, the shift away from manufacturing and subsequent job loss resulted in an economic decline. Today, many of these former industrial buildings (24) along Railroad and Myrtle Aves and Atlantic and Broad Sts. remain vacant or underutilized, but have an effective land value of over $750,000. Similarly, the housing stock have remained mostly unchanged, with only 34 units of housing constructed across the entire South End peninsula since 1990.

While the community has begun to recover with new businesses in the service industries and small light manufacturing shops, the full extent of development needed to revitalize the economy has been limited. With the future risk of storm events and flooding damages, the isolated street network and disconnection from downtown, the community has a difficult time attracting new development in the area. Over 66% of existing structures throughout the entire peninsula were built before 1940. In addition to exacerbating the socio-economic conditions of the neighborhood, if the proposed improvements are not implemented, the lack of economic livelihood will continue to reduce the community's ability to quickly respond and recover following future events.

Economic Benefits and Costs Included

This section identifies and groups the benefits that are included in the BCA for the NDRC Bridgeport project.

The following broad categories and quantifiable benefits have been included in this Benefit Cost Analysis:

- Lifecycle costs:
    - Resilient corridor construction
- Resiliency value
    - Reduction in property damage
    - Reduction in accidents and casualties
    - Reduction in displacements
    - Reduction in vulnerability to large scale water and power outages
- Environmental value
    - Enhanced greenway

- Improvement in water quality
- New flood design guidelines

- Social value or Community development value
    - Benefits to low/moderate income households
    - Improved living environment
    - Affordable housing
    - Church and community center redevelopment

Economic revitalization

- Broad Street economic development
- Regional economic impact
- University of Bridgeport future growth
- Increased property value
- Reduced insurance cost
- Construction jobs/maintenance jobs
- New affordable housing development
- New market rate housing development

Lifecycle Costs

This benefit cost analysis captures the life cycle costs of the capital, maintenance, and operating costs of the proposed components of the project. The Life Cycle cost for Bridgeport includes the construction of the resilient corridor. These are detailed within the costs data subsection.

Resiliency Value

In the BCA, the group of benefits under the heading of Resiliency Value captures the following components of the Bridgeport project:

- Reduction in property value. With the construction of the resilient corridor elements of the project, a significant set of homes and businesses will no longer be directly affected by coastal flooding. Property damages associated with major 100-year storms and extreme weather will be reduced or avoided.
- Reduction in vulnerability to large scale water and power outages. With the construction of the resilient corridor elements, homes and businesses will have reduced vulnerability to outages caused directly or indirectly by coastal flooding. The number of water and power outages will be reduced or avoided.

These are further summarized in the benefits data subsection.

Casualties and Accident Cost Savings

The cost savings that arise from a reduction in the number of casualties, injuries, and eaths include direct savings (e.g., reduced personal medical expenses, lost wages, and lower individual insurance premiums), as well as significant avoided costs to society (e.g., second party medical and litigation fees, emergency response costs, incident congestion costs, and litigation costs). The value of all such benefits – both direct and societal – could also be approximated by emergency response costs to the region, medical costs, litigation costs, property damages, and economic productivity loss due to workers' inactivity.

Environmental Value

In the BCA, the group of benefits under the heading of Environmental Value captures the following components of the Bridgeport project:

- Enhanced greenway. The greenway will provide increased permeable surface, air quality, more recreational open space.
- Improvement in water quality. The water quality will improve from wetland landscape at the CSO outfall on south side of berm. Wetland restoration has been shown to reduce pollutants and improve water quality, which reduces plant treatment needs.
- New flood design guidelines. The guidelines would reduce environmental damage and pollutants at regional and global scale.

None of these items here were included in a quantitative analysis, as although environmental benefits are resoundingly positive, their monetization is limited to a trade-off value of usable land space, which can be exceedingly speculative.

Social/Community Development Value

In the BCA, the group of benefits under the heading of Community Development Value or Social Value captures the following components of the Bridgeport project:

- Benefits to low/moderate income households. With the construction of the elements of the resilience corridor, homes will have a reduced chance of being directly affected by coastal flooding. As a result of lowered risk, home values will increase.
- Improved living environment. The project will result in the elimination of vacant land and the preservation of cultural amenities. There will be increased social cohesion due to the improved visual aesthetic. There will be another benefit in terms of improved access to greenway and complete streets, which provides convenient access to biking and walking

and a more active and healthy lifestyle.

- Affordable housing
- Church and community center redevelopment. This will provide high cultural value and social cohesion.

These are further summarized in the benefits data subsection.

Economic Redevelopment

In the BCA, the group of benefits under the heading of Economic Development/Revitalization Value captures the following components of the Bridgeport project:

- Broad Street economic development. This will foster the new businesses and mixed use land.
- Regional economic impact. With the construction of the elements of the resilient corridor, homes and businesses will have a reduced likelihood of being directly affected by coastal flooding. There will be fewer days and weeks lost to full or partial closings. Worker productivity will be maintained.
- Increased property value. As the community becomes safer (crime) and beautiful and more commercial development moves in, land values go up.
- Reduced insurance cost. With the construction of the various elements, homes and businesses will have a reduced probability of being directly affected by coastal flooding. To the degree that their flood ratings change, their insurance premiums will be reduced.
- Local tourism. Visitors who come to walk on the greenway will contribute to the local economy.
- Construction jobs/maintenance jobs. Each improvement project will create temporary construction jobs where the workers will spend a portion of their income on the local economy. Additionally, redevelopment of vacant land downtown brings in permanent

jobs, where the workers also spend money within the local economy.

- University of Bridgeport. There will be opportunities for future growth using new flood design policy.
- New affordable housing development at Broad Street and Gregory Street. There is a current design at the City of Bridgeport.
- New market rate housing development at Henry and Main Street.

For the purposes of the benefit cost analysis, it is assumed that properties that are in higher flood zones are more likely to suffer damage. It is assumed that the average reconstruction cost for affected properties (residential and commercial), facilities (parks, etc.), and infrastructure (roads, rail, etc.) depends on the flood zone of the property. The highest cost per unit (square foot, mile, etc.) is assumed for properties in the Erosion zone, and the lowest cost is for properties in the A zone.

Economic Costs Included and Assumptions

In the benefit-cost analysis, the term "cost" refers to the additional resource costs or expenditures required to implement, and maintain the investments associated with the NDRC Bridgeport.

The BCA uses project costs that have been estimated for the project on an annual basis. Operations and maintenance costs and rehabilitation costs were initially expressed in real dollars while the capital costs were initially expressed in real 2015 dollars. All costs were converted to real 2015 dollars based on CPI-U adjustments.[4]

Initial Project Investment Costs

Initial project investment costs include engineering and design, construction, other capital investments, and contingency factors.

The capital expenditures for the project will be a total of $43 million starting in 2016. Note that outlays spent for the acquisition of real estate or real assets (right of way) are generally excluded from total costs in BCAs. This is because when the government acquires a real asset, it is classified as an asset purchase and not a cost. The owning agency would be in possession of tangible assets that, generally, does not depreciate in value.

Key Benefit-Cost Evaluation Measures

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following two (2) common benefit-cost evaluation measures are included in this BCA.

Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.

Benefit Cost (B/C) Ratio: The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of their associated costs.

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[4] Bureau of Labor Statistics, Consumer Price Index, All Urban Consumers, U.S. City Average, All Items, Series CUSR0000SA0.

Risks to Ongoing Benefits from the Proposed Project

There are risks associated with the proposed project, primarily related to the severity of extreme weather events. If the frequency of large storms and flooding events increases faster than expected, or if sea-level rise occurs at a faster pace than expected, then the proposed mitigation such as the stormwater management measures will lose their effectiveness sooner than expected. That would require the future "layered" mitigation steps to be needed sooner than expected, possibly exceeding the future available budget.

If the risk of increased weather severity does occur, the proposed project has been designed to be flexible, and it can be adapted. The proposed project has been conceived in a layered fashion, so that protection is added in an incremental process as the level of climate change becomes more evident.

The State of Connecticut recognizes that actual rise in sea level will involve variable risk. Through the SAFR construct/organization, CIRCA is charged with taking NOAA scenario guidance and equating it to CT specific factors to develop localized sea level rise projections. For the purpose of this application, the State of Connecticut used the FEMA 100-year storm event plus an estimated 2050 sea level rise (SLR) of 1 foot for design standards. The proposal, however, is designed with a vision towards the future, often incorporating a layered approach by employing measures that can be further extended or built upon in the future to protect against potential increases in sea level rise.

If powerful storms hit the living revetment shoreline treatments, it is possible that elements of the revetment will be washed away or eroded. In that case, maintenance of the revetment shoreline will need to be increased, possibly exceeding the expected O&M budget.

Challenges Faced with Project Implementation

Political or stakeholder risks. There are many political and stakeholder risks that could affect the implementation schedule. If the political situation changes and the state coordinating group SAFR changes its organizational structure, mission, or other leadership role, it could become more difficult to implement the proposed changes. There are many stakeholders and partners who have a role in elements of the project. However, this overall resilience project will have a strong planning component, and close coordination with stakeholders will be built into the planning process, to help prevent implementation from becoming delayed.

Technical risks. Besides coordination among stakeholders, partners, and agencies, there are technical risks associated with the engineering and construction of the project elements, such as the berm, the viaduct reinforcement, and the CSO treatment park.

Procedural/legal risks. With any large multi-faceted project, there are possibly components that may be challenged by agencies with jurisdiction or by members of the affected communities. Our project is working hard to avoid those risks through a long and thorough public outreach process. One of the strengths of the NDRC process is the requirement for a large element of coordination and outreach, so that the resiliency objects can be met with community support.

Community Support. As shown in the applications Exhibit A, Partner Documentation, and Exhibit D, Consultation Summary, the project team and partnership that has developed the project plan and this proposal has performed extensive outreach to many other agencies and members of the community. Strong state leadership and an extensive outreach effort should minimize the political and stakeholder risks. Low income and minority groups have been consulted during the project planning process, to help set the goals and mission of the project.

Summary of Benefit Cost Analysis (Bridgeport Pilot)

This benefit cost analysis takes into account resilient corridor construction costs, economic benefits, and risk reduction benefits ONLY. It does not include additional ecological or social benefits or costs as ecological and social benefits were not monetized as part of this anlysis, and thus could not be compared to the costs using this framework. For a summary of the additional ecological and social benefits, which are great, see the "expanded benefits" section.

BENEFITS

	Loss/damages Without Project	Loss/damages With Project	Benefits (difference)
Risk Reduction			
Residential			
Reconstruction	$45,719,800	$0	$45,719,800
Relocation	$0	$0	$0
Commercial			
Reconstruction	$99,279,002	$0	$99,279,002
Revenue	$500,000	$0	$500,000
Roads			
Reconstruction	$1,816,178	$0	$1,816,178
Parks & Beaches			
Reconstruction	$17,864	$0	$17,864
Safety			
Loss of Life	$0	$0	$0
Hospitalizations	$0	$0	$0
Treat and Release	$11,330,000	$0	$11,330,000
Self Treatment	$4,290,000	$0	$4,290,000
Property Values			
Value Lost	$7,098,266	$0	$7,098,266
Power Loss			
Cost to consumers	$24,191,833	$0	$24,191,833
Insurance			
Cost to consumers	$2,679,020	$526,216	$2,152,804
Storm Year Impacts	**$196,921,963**	**$526,216**	**$196,395,747**
Effective Annual Impact	**$1,969,220**	**$5,262**	**$1,963,957**
Additional Benefits			
Local Economy		$104,505	$104,505
Pedestrian Health		$8,996	$8,996
Effective Annual Benefit			**$2,077,459**
One Time Benefits (first year)			**$28,050,471**
Construction job local revenue			$726,206
land value increase			$ 27,324,265

Assumptions:

Effective Life of Project	100 years
Discount Rate	7%

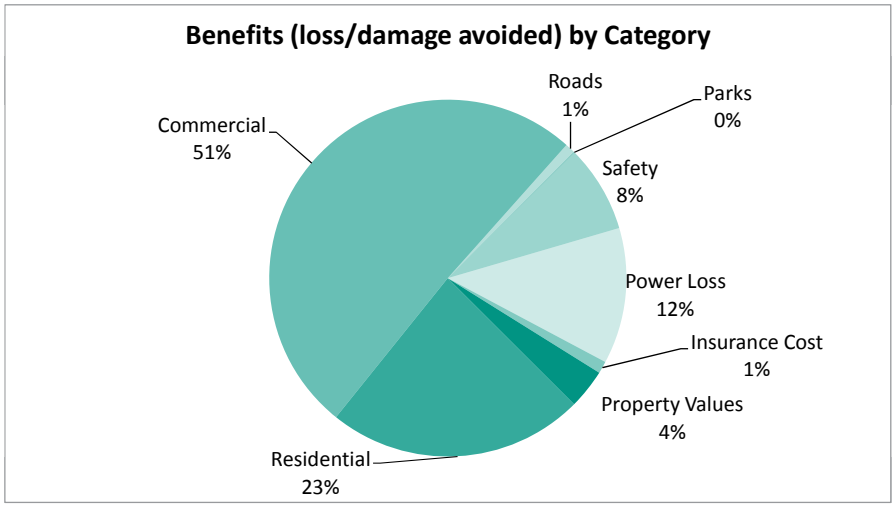
for additional assumptions and sources, see detailed benefit-cost materials

COSTS

Cost Assumptions (in 2015$)	
Capital Costs (year 0)	$42,574,036
Ongoing monitoring expenditures (for 5 years)	$4,000
Repair & Rehab Costs (per year)	$43,526
Total Costs (year 1)	**$42,621,562**
Total Undiscounted Costs	$46,816,061
Total Discounted Costs (@ 7%)	**$37,387,387**

BENEFIT-COST ANALYSIS

Discounted Analysis (@ 7%)	
Total Benefits	$45,591,443
Total Costs	$37,387,387
BC Ratio	1.22
NPV	$8,204,056
Sensitivity Analysis (@ 7%)	
15% Increase in Benefits	
Benefits	$52,430,160
BC Ratio	**1.40**
NPV	$15,042,773
15% Decrease in Benefits	
Benefits	$38,752,727
BC Ratio	**1.04**
NPV	$1,365,340
15% Increase in Costs	
Costs	$42,995,495
BC Ratio	**1.06**
NPV	$2,595,948
15% Decrease in Costs	
Costs	$31,779,279
BC Ratio	**1.43**
NPV	$13,812,164



Benefits (Monitized)

IMPACTS: BASELINE SCENARIO

Scenario

Storm Type	100 year
Annual Probability	1%
Days without Power	3 days

Residential

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$45,719,800
.2% chance	$0
adjacency	$0

Relocation Impacts:

Total Relocated Households	0
Total Years of Relocation	1 year

Commercial

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$19,074,177
Coastal A	$0
A zone	$80,204,825
.2% chance	$0
adjacency	$0

Revenue Impacts

Total Years of Loss Revenue	1 year

Roads

Proportion of Full Reconstruction Cost by Zone:

Erosion Zone	100%
V Zone	50%
Coastal A	25%
A zone	25%
.2% chance	0%
adjacency	0%

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$1,816,178
.2% chance	$0
adjacency	$0

IMPACTS: WITH PROJECT

Residential

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

Relocation Impacts:

Total Relocated Households	0
Total Years of Relocation	0 year

Commercial

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

Revenue Impacts

Total Years of Loss Revenue	0 year

Roads

Proportion of Full Reconstruction Cost by Zone:

Erosion Zone	100%
V Zone	50%
Coastal A	25%
A zone	25%
.2% chance	0%
adjacency	0%

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

Benefits (Monitized)

IMPACTS: BASELINE SCENARIO

Parks

Proportion of Full Reconstruction Cost by Zone:

Erosion Zone	100%
V Zone	50%
Coastal A	25%
A zone	25%
.2% chance	0%
adjacency	0%

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$17,864
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

Necessary Coastal Protection

Erosion Control	$0	every year

Health and Safety

Monetized Total deaths	$0
Monetized Total hospitalizations	$0
Monetized Total treat and release	$11,330,000
Monetized self treat	$4,290,000
Total monetized value	$15,620,000
Total walkable distance	
total person trips	0
Pedestrian Health benefit	$0

IMPACTS: WITH PROJECT

Parks

Proportion of Full Reconstruction Cost by Zone:

Erosion Zone	100%
V Zone	50%
Coastal A	25%
A zone	25%
.2% chance	0%
adjacency	0%

Reconstruction Costs by Zone:

Erosion Zone	$0
V Zone	$0
Coastal A	$0
A zone	$0
.2% chance	$0
adjacency	$0

Baseline Necessary Capital or O&M Costs

Erosion Control	$0	every 10 years

Health and Safety

Monetized Total deaths	0	Uses DOH study of NY post Sandy
Monetized Total hospitalizations	0	
Monetized Total treat and release	0	
Monetized self treat	0	
Total monetized value	$0	
Total walkable distance	4	
total person trips	14510	
Pedestrian Health benefit	$8,996	

NDRC

Updated 10/22/2015

Benefits (Monitized)

IMPACTS: BASELINE SCENARIO		IMPACTS: WITH PROJECT	
Property Value Loss by Zone			
Residential:			
Erosion Zone	4%		
V Zone	3%		
Coastal A	2%		
A zone	1%		
.2% chance	0%		
adjacency	0%		
Total Property Values Lost	$392,450		
Commercial:			
Erosion Zone	4%		
V Zone	3%		
Coastal A	2%		
A zone	1%		
.2% chance	0%		
adjacency	0%		
Total Property Values Lost	$6,705,816		
Commercial Revenue Loss			
Anticipated Revenue Loss	5%		
Total Revenue Lost	$500,000		
Losses Due to Power Outage			
Residential Losses (spoilage, cleanlir	$8,185,891	Residential Losses (spoilage, cleanl	$0
Commercial Losses (productivity, goc	$16,005,941	Commercial Losses (productivity, gc	$0
Insurance Costs			
Residential:			
Erosion Zone			
V Zone	$0	V Zone	$0
Coastal A	$0	Coastal A	$0
A zone	$697,500	A zone	$0
.2% chance	$0	.2% chance	$139,500
Commercial:			
Erosion Zone			
V Zone	$63,920	V Zone	$0
Coastal A	$0	Coastal A	$0
A zone	$1,917,600	A zone	$0
.2% chance	$0	.2% chance	$386,716
Economic Growth			
one time construction jobs	0	one time construction jobs	86
Local Revenue generated by one tim	$0	Local Revenue generated by one tir	$726,206
Local Jobs		Local Jobs	15
Local Revenue generated by local Jo	$0	Local Revenue generated by local J	$93,275
		CT payroll taxes (one time)	$63,204
CT payroll taxes (annual)	$0	CT payroll taxes annual	$11,230
		one time land value increase	$ 27,324,265

NDRC

Updated 10/22/2015

Benefits (Monitized)

IMPACTS: BASELINE SCENARIO
IMPACTS: BASELINE SCENARIO

Storm Year Impacts	**$196,921,963**
Residential	$45,719,800
Residential Reconstruction	$45,719,800
Residential Relocation	$0
Commercial	$99,779,002
Commercial Reconstruction	$99,279,002
Commercial Revenue	$500,000
Roads	$1,816,178
Roads Reconstruction	$1,816,178
Parks	$17,864
Parks/Beach Reconstruction	$17,864
Safety	$15,620,000
Loss of Life	$0
hospitalizations	$0
treat and release	$11,330,000
self treat	$4,290,000
Power Loss	$24,191,833
Residential	$8,185,891
Commercial	$16,005,941
Insurance Cost	$2,679,020
Total Spent	$2,679,020
Property Values	$7,098,266
Value Lost	$7,098,266

Effective Annual Impact	$1,969,220

IMPACTS: WITH PROJECT
IMPACTS: WITH PROJECT

Storm Year Impacts	**$526,216**
Residential	$0
Residential Reconstruction	$0
Residential Relocation	$0
Commercial	$0
Commercial Reconstruction	$0
Commercial Revenue	$0
Roads	$0
Roads Reconstruction	$0
Parks	$0
Parks/Beach Reconstruction	$0
Safety	$0
Loss of Life	$0
hospitalizations	$0
treat and release	$0
self treat	$0
Power Loss	$0
Residential	$0
Commercial	$0
Insurance Cost	$526,216
Total Spent	$526,216
Property Values	$0
Value Lost	$0

Effective Annual Impact	$5,262

DIFFERENCE

Storm Year Impacts	**$196,395,747**
Residential	$45,719,800
Commercial	$99,779,002
Roads	$1,816,178
Parks	$17,864
Safety	$15,620,000
Power Loss	$24,191,833
Insurance Cost	$2,152,804
Property Values	$7,098,266
Additional Annual Benefits	
Pedestrian Health	$8,996
Local Job Revenue	$93,275
Local Job Payroll Taxes	$ 11,229.72

Annual Project Benefit	**$2,077,459**

One Time (initial year benefits)	
Construction job local revenue	$726,206
land value increase	$27,324,265
	$28,050,471

PARSONS BRINCKERHOFF

COSTS

Bridgeport Pilot Estimate

	O&M Percent	
University Avenue "RESILIENT CORRIDOR"	15%	**$5,264,000**
Community Center Restoration	0%	**$1,000,000**
Earthen berm, viaduct reinforcement and CSO Treatment park	10%	**$35,630,036**
Earthen Berm		$29,578,600
CSO treatment park		$2,341,800
Viaduct Reinnforcement		$3,709,636
Flood Design Guideline recommendations	0%	**$330,000**
District energy feasibility study	0%	**$350,000**
Subtotal Project Costs		**$42,574,036**
Escalation	8% included	
TOTAL COSTS		**$42,574,036**
Maintenance		$ 4,352,604
Monitoring (5 yrs)		$ 20,000
TOTAL COST (undiscounted)		**$46,946,640**

COSTS

Cost Assumptions (in 2015 $)

Project Costs	$42,574,036	in Years 1 - 4
Ongoing expenditures	$4,000	per year for first 5 years post construction
Maintenance Costs	$43,526	per year
Total First Year Costs	$42,574,036	

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Total Undiscounted Costs	$46,816,061	$2,520,000	$3,499,001	$21,652,618	$14,902,417	$47,526	$47,526	$47,526	$47,526	$47,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
Total Discounted Costs (@ 5%)	$39,125,541	$2,520,000	$3,332,382	$19,639,563	$12,873,268	$39,100	$37,238	$35,465	$33,776	$32,167	$28,057	$26,721	$25,449	$24,237	$23,083	$21,984	$20,937	$19,940
Total Discounted Costs (@ 7%)	$37,387,387	$2,520,000	$3,270,094	$18,912,235	$12,164,812	$36,257	$33,885	$31,669	$29,597	$27,661	$23,675	$22,126	$20,679	$19,326	$18,062	$16,880	$15,776	$14,744

costs developed by Project Team

	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061
	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
	$18,990	$18,086	$17,225	$16,405	$15,623	$14,879	$14,171	$13,496	$12,853	$12,241	$11,658	$11,103	$10,574	$10,071	$9,591	$9,135	$8,700	$8,285	$7,891	$7,515	$7,157	$6,816	$6,492	$6,183	$5,888	$5,608	$5,341	$5,087	$4,844
	$13,779	$12,878	$12,035	$11,248	$10,512	$9,824	$9,182	$8,581	$8,020	$7,495	$7,005	$6,546	$6,118	$5,718	$5,344	$4,994	$4,668	$4,362	$4,077	$3,810	$3,561	$3,328	$3,110	$2,907	$2,717	$2,539	$2,373	$2,217	$2,072

	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090
	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
	$4,614	$4,394	$4,185	$3,985	$3,796	$3,615	$3,443	$3,279	$3,123	$2,974	$2,832	$2,697	$2,569	$2,447	$2,330	$2,219	$2,114	$2,013	$1,917	$1,826	$1,739	$1,656	$1,577	$1,502	$1,431	$1,362	$1,298	$1,236	$1,177
	$1,937	$1,810	$1,692	$1,581	$1,478	$1,381	$1,291	$1,206	$1,127	$1,054	$985	$920	$860	$804	$751	$702	$656	$613	$573	$536	$501	$468	$437	$409	$382	$357	$334	$312	$291

	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116
	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
	$1,121	$1,067	$1,017	$968	$922	$878	$836	$797	$759	$723	$688	$655	$624	$594	$566	$539	$513	$489	$466	$444	$422	$402	$383	$365	$348	$331
	$272	$254	$238	$222	$208	$194	$181	$170	$158	$148	$138	$129	$121	$113	$106	$99	$92	$86	$81	$75	$70	$66	$61	$57	$54	$50

Bridgeport Costs (cont...)

Analysis

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Undiscounted Analysis																						
Total Undiscounted Benefits	$229,563,981					$30,127,930	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459
Total Undiscounted Costs	$46,816,061	$2,520,000	$3,499,001	$21,652,618	$14,902,417	$47,526	$47,526	$47,526	$47,526	$47,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
BC Ratio	4.90																					
Discounted Analysis (@ 5%)																						
Total Benefits	$58,652,973	$0	$0	$0	$0	$24,786,323	$1,627,743	$1,550,232	$1,476,411	$1,406,106	$1,339,149	$1,275,380	$1,214,647	$1,156,807	$1,101,721	$1,049,258	$999,293	$951,708	$906,388	$863,227	$822,121	$782,972
Total Costs	$39,125,541	$2,520,000	$3,332,382	$19,639,563	$12,873,268	$39,100	$37,238	$35,465	$33,776	$32,167	$28,057	$26,721	$25,449	$24,237	$23,083	$21,984	$20,937	$19,940	$18,990	$18,086	$17,225	$16,405
BC Ratio	1.50																					
NPV	$19,527,432																					
Discounted Analysis (@ 7%)																						
Total Benefits	$45,591,443	$0	$0	$0	$0	$22,984,454	$1,481,199	$1,384,299	$1,293,737	$1,209,100	$1,130,000	$1,056,075	$986,986	$922,417	$862,072	$805,674	$752,967	$703,707	$657,670	$614,645	$574,435	$536,855
Total Costs	$37,387,387	$2,520,000	$3,270,094	$18,912,235	$12,164,812	$36,257	$33,885	$31,669	$29,597	$27,661	$23,675	$22,126	$20,679	$19,326	$18,062	$16,880	$15,776	$14,744	$13,779	$12,878	$12,035	$11,248
BC Ratio	1.22																					
NPV	$8,204,056																					

2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459
$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
$745,688	$710,179	$676,361	$644,153	$613,479	$584,266	$556,444	$529,947	$504,711	$480,677	$457,788	$435,988	$415,227	$395,454	$376,623	$358,689	$341,608	$325,341	$309,849	$295,094	$281,042	$267,659	$254,913	$242,775	$231,214	$220,204	$209,718	$199,731
$15,623	$14,879	$14,171	$13,496	$12,853	$12,241	$11,658	$11,103	$10,574	$10,071	$9,591	$9,135	$8,700	$8,285	$7,891	$7,515	$7,157	$6,816	$6,492	$6,183	$5,888	$5,608	$5,341	$5,087	$4,844	$4,614	$4,394	$4,185
$501,734	$468,910	$438,233	$409,564	$382,770	$357,729	$334,326	$312,454	$292,013	$272,910	$255,056	$238,370	$222,776	$208,202	$194,581	$181,851	$169,954	$158,836	$148,445	$138,733	$129,657	$121,175	$113,248	$105,839	$98,915	$92,444	$86,396	$80,744
$10,512	$9,824	$9,182	$8,581	$8,020	$7,495	$7,005	$6,546	$6,118	$5,718	$5,344	$4,994	$4,668	$4,362	$4,077	$3,810	$3,561	$3,328	$3,110	$2,907	$2,717	$2,539	$2,373	$2,217	$2,072	$1,937	$1,810	$1,692

2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459
$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
$190,220	$181,162	$172,535	$164,319	$156,495	$149,043	$141,945	$135,186	$128,749	$122,618	$116,779	$111,218	$105,922	$100,878	$96,074	$91,499	$87,142	$82,992	$79,040	$75,277	$71,692	$68,278	$65,027	$61,930	$58,981	$56,173	$53,498	$50,950
$3,985	$3,796	$3,615	$3,443	$3,279	$3,123	$2,974	$2,832	$2,697	$2,569	$2,447	$2,330	$2,219	$2,114	$2,013	$1,917	$1,826	$1,739	$1,656	$1,577	$1,502	$1,431	$1,362	$1,298	$1,236	$1,177	$1,121	$1,067
$75,462	$70,525	$65,911	$61,599	$57,569	$53,803	$50,283	$46,994	$43,919	$41,046	$38,361	$35,851	$33,506	$31,314	$29,265	$27,351	$25,562	$23,889	$22,326	$20,866	$19,501	$18,225	$17,033	$15,918	$14,877	$13,904	$12,994	$12,144
$1,581	$1,478	$1,381	$1,291	$1,206	$1,127	$1,054	$985	$920	$860	$804	$751	$702	$656	$613	$573	$536	$501	$468	$437	$409	$382	$357	$334	$312	$291	$272	$254

2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116
77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459	$2,077,459
$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526	$43,526
$48,524	$46,213	$44,013	$41,917	$39,921	$38,020	$36,209	$34,485	$32,843	$31,279	$29,790	$28,371	$27,020	$25,733	$24,508	$23,341	$22,229	$21,171	$20,163	$19,203	$18,288	$17,417	$16,588	$15,798
$1,017	$968	$922	$878	$836	$797	$759	$723	$688	$655	$624	$594	$566	$539	$513	$489	$466	$444	$422	$402	$383	$365	$348	$331
$11,350	$10,607	$9,913	$9,265	$8,659	$8,092	$7,563	$7,068	$6,606	$6,173	$5,770	$5,392	$5,039	$4,710	$4,402	$4,114	$3,845	$3,593	$3,358	$3,138	$2,933	$2,741	$2,562	$2,394
$238	$222	$208	$194	$181	$170	$158	$148	$138	$129	$121	$113	$106	$99	$92	$86	$81	$75	$70	$66	$61	$57	$54	$50