RARITAN BAY AND SANDY HOOK BAY, NEW JERSEY

HURRICANE SANDY LIMITED REEVALUATION REPORT

FOR

COASTAL STORM RISK MANAGEMENT

UNION BEACH, NEW JERSEY

U.S. Army Corps of Engineers, New York District

ECONOMICS APPENDIX

June 2017

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1 Introduction

1.1 Purpose

This appendix provides an update to the benefits and associated analysis procedures used in the determination of the economic viability for Federal participation in shore protection and storm damage reduction in the Borough of Union Beach, New Jersey. Project benefits were originally provided within Appendix B of the Raritan Bay and Sandy Hook Bay, New Jersey Feasibility Report for Hurricane and Storm Damage Reduction Union Beach, New Jersey dated September 2003. The project was authorized for construction in the Water Resources Development Act of 2007 (2007 Authorized Plan)

This document, which is an appendix to the Hurricane Sandy Limited Reevaluation Report (HSLRR), updates the economic analysis of the 2007 Authorized Plan, reaffirms the economic justification of the plan, and documents compliance with P.L. 113-2.

As stated in the 2003 Feasibility Report, benefits to be derived from the selected plan of improvement included:

- Reduced inundation damage to structures
- Reduced public emergency costs
- Reduced maintenance of the existing beach and structures
- Reduced Federal Insurance Administrative costs

1.1.1 Conditions

Estimates of current damages are based on August 2016 price levels and a 50-year period of economic analysis, and reflect the current economic condition of Union Beach. Damages have been annualized over the 50-year period of economic analysis using the fiscal year 2016 discount rate of $3^{1/8}$ percent. The base year for the period of analysis is 2022 (projected project completion year), and the 50-year period of analysis is 2022 to 2072.

1.1.2 Exclusions

Benefits due to reduced transportation costs, as well as those associated with reduced flood proofing costs, were not anticipated to be significant and were therefore not included in the analyses.

1.2 Description of the Study Area

The area of study described in the 2003 Feasibility Report, and in this report is contained within the Borough of Union Beach, a Bayshore borough located in northern Monmouth County, New Jersey. The northern border of the study area is defined by Raritan Bay while the southern border is designated by New Jersey State Route 36. The western border is denoted by Chingarora Creek and the eastern by the Keansburg flood control improvements east of East Creek (See Figure 1). Past flood records and existing topography indicate that many structures in the study area are subject to significant flooding.

Figure 1
Study Area Overview

Union Beach is characterized by low flat terrain bordered by a bay shoreline with various compositions. Shorelines in the eastern portion near East and Thorn Creeks, and the western portion near Chingarora Creek consist of low-lying marsh. The central, developed section of the borough is protected by assorted public and private bulkheads, seawalls, and revetments. These structures are generally fronted by either beach or rock toe protection. A locally constructed 1,850-foot long public bulkhead with walkway parallels Front Street along the northern side of the study area.

1.2.1 Accessibility

The study area is convenient to major population centers through a network of modern highways. The Garden State Parkway and Route 9 run northward to New York State and southward to Cape May, New Jersey. Route 287 extends westward beyond Middlesex County and the New Jersey Turnpike provides additional north-south access. Direct access from these major corridors to the Bayshore is provided by Route 35 and Route 36. Primary routes from the Borough of Union Beach to Route 36 include Union, Poole, and Florence Avenues. The bayshore communities are also serviced by the shoreline of New Jersey Transit, which provides passenger rail access to Newark and New York City, and by ferry service to downtown Manhattan.

1.2.2 Population

Population in Monmouth County increased by 296,000 persons between 1950 and 2000, which represents a 50-year increase of 89 percent. Population growth exploded by 37 percent between 1960 and 1970, stabilized at approximately 10 percent per decade from 1970 through 2000, and then slowed to two percent between 2000 and 2010. The population in Monmouth County is projected to grow by 4 percent in each of the next two decades (2010-2020 and 2020-2030). Population data for New Jersey, Monmouth County and adjacent counties is shown in Table 1.

Table 1
Population in Monmouth and Neighboring Counties

						Projected	
	1970	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
Monmouth CO	459,400	503,200	553,100	615,300	630,400	654,000	680,400
Middlesex CO	583,800	595,900	671,800	750,200	809,900	863,900	909,400
Ocean CO	208,500	346,000	433,200	510,900	576,600	630,600	677,100
New Jersey	7,168,200	7,364,800	7,730,200	8,414,400	8,791,900	9,241,900	9,648,100

Source: www.census.gov and http://lwd.dol.state.nj.us/labor/lpa/dmograph/lfproj/lfproj_index.html

A summary of population data for Bayshore municipalities is provided in Table 2. Population for Union Beach has fluctuated within 10 percentage points up or down over the last fifty years, and has shown a relatively small net growth of 7 percent from 1960-2010. Union Beach has one of the smallest populations among the Bayshore communities, with only 6,245 persons on 1.8 square miles.

Table 2
Population in Union Beach and Other Bayshore Communities

	1970	**1980**	**1990**	**2000**	**2010**	**Land Area (sq mi)**	**Population Density, 2010**
Middletown	54,623	62,574	68,183	66,327	66,522	41.1	1,619
Sayreville	32,508	29,969	34,986	40,377	42,704	15.8	2,696
Hazlet	22,239	23,013	21,976	21,378	20,334	5.6	3,612
Aberdeen	17,680	17,235	17,038	17,454	18,210	5.6	3,275
Keansburg	9,720	10,613	11,069	10,732	10,105	1.1	9,444
South Amboy	9,338	8,322	7,863	7,913	8,631	1.6	5,568
Keyport	7,205	7,413	7,586	7,568	7,240	1.4	5,171
Union Beach	6,472	6,354	6,156	6,649	6,245	1.8	3,469
Highlands	3,916	5,187	4,849	5,097	5,005	0.8	6,500
Atlantic Highlands	5,102	4,950	4,629	4,705	4,385	1.2	3,536

Source: www.census.gov

Union Beach is a homogeneous, family-oriented community in comparison to Monmouth County and the State, as shown in Table 3. The Union Beach population is 93 percent Caucasian, versus 84 percent for Monmouth County and 71 percent for the State. In 2010, the percentage of family households was 76 percent for Union Beach, versus 70 percent for Monmouth County and 69 percent for the State.

Table 3
Demographic Characteristics

	Union Beach	Monmouth County	New Jersey
White	93%	84%	71%
Black or African-American	2%	8%	15%
American Indian and Alaska Native	1%	1%	1%
Asian	3%	6%	9%
Some Other Race	4%	3%	8%
Family Households	76%	70%	69%
Average Household Size	2.91	2.66	2.68
Average Family Size	3.32	3.22	3.22

Source: factfinder2.census.gov

1.2.3 Economy

Table 4 shows income levels for the study area. Union Beach incomes are low to moderate in comparison to Monmouth County and the State. Borough median household income is $66,419 and per capita income is $26,625, both of which are lower than for the County and State. However, the percent of persons below the poverty line is 4.1 percent in Union Beach, versus 6.6 percent in the County and 9.9 percent in the State.

Table 4
Income Levels in the Study Area

	Union Beach	Monmouth County	New Jersey
Median Household Income	$66,419	$84,746	$71,637
Per Capita Income, last 12 months	$26,625	$42,678	$35,928
Persons below poverty level	4.1%	6.6%	9.9%

Source: factfinder2.census.gov
2008-2012 American Community Survey 5-Year Estimates

Figure 2 shows the historic unemployment rates for Monmouth County, neighboring counties and New Jersey. The rate in Monmouth County increased dramatically in 2008-2009 as a result of the recession; however, it has remained consistently lower than the rates for New Jersey and Ocean County, and on par with the rates for Middlesex County. The 2012 unemployment rates were 8.5 percent in Union Beach, 8.9 percent in Monmouth County and 9.5 percent in New Jersey.

Figure 2
Unemployment Rates in the Study Area

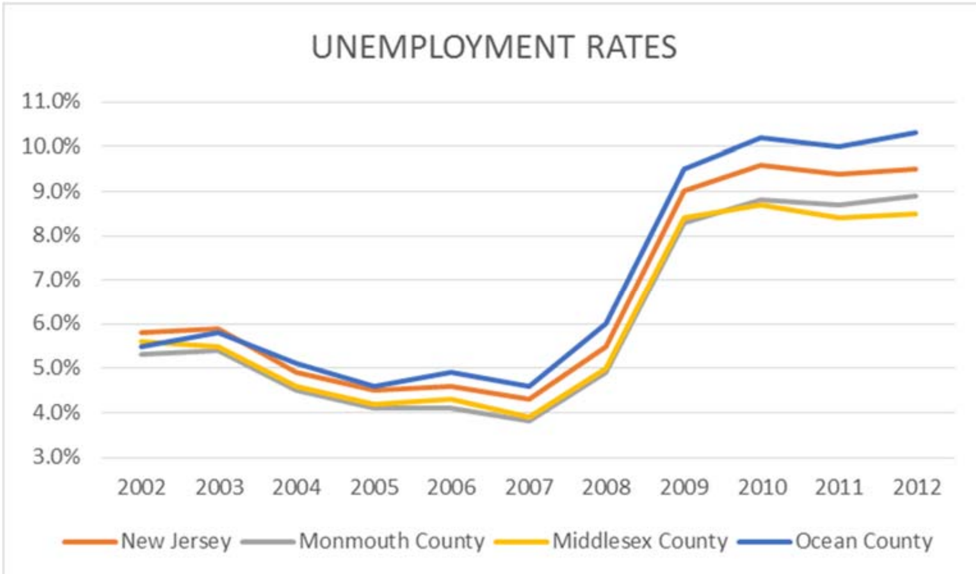


Table 5 shows the breakdown of civilian employment by industry in Union Beach and Monmouth County. The largest employment industry for both is Educational Services, Health Care and Social Assistance, which employs 22 percent of persons in Union Beach and 25 percent of persons in Monmouth County. The next largest employment industries in Union Beach are Retail Trade (15 percent) and Construction (14 percent).

Table 5
Civilian Employment by Industry

	Union Beach		Monmouth CO	
	Persons	Pct	Persons	Pct
Agriculture, forestry, fishing and hunting, and mining			1,622	1
Construction	385	14	20,827	7
Manufacturing	265	10	19,320	7
Wholesale trade	66	2	10,477	4
Retail trade	407	15	35,560	13
Transportation and warehousing, and utilities	191	7	15,412	5
Information	99	4	10,736	4
Finance and insurance, and real estate and rental and leasing	134	5	32,944	12
Professional, scientific, and management, and administrative and waste management services	375	14	39,232	14
Educational services, and health care and social assistance	607	22	69,796	25
Arts, entertainment, and recreation, and accommodation and food services	232	8	25,912	9
Other services, except public administration	123	4	12,269	4
Public administration	122	4	14,010	5

Source: factfinder2.census.gov
2008-2012 American Community Survey 5-Year Estimates

1.2.4 Land Use

The majority of land in the immediate study area contains residential development with commercial development concentrated along Route 36. The majority of land development within Union Beach is more than 25 years old. Most structures were constructed prior to the implementation of the Flood Insurance Program and adoption of the associated Floodplain Management Regulations.

Table 6 shows land use in Union Beach. Residential is the most common land use, at 32.7 percent. Commercial and retail uses are clustered along Union Avenue and Route 36. Major industrial uses include the Bayshore Regional Sewerage Authority in the northwestern portion of the borough along the Raritan Bay waterfront and the International Flavor and Fragrance Company (IFF) office, laboratory, and manufacturing facilities in the eastern portion along Route 36. Land owned by IFF, including parcels classified as industrial and vacant, accounts for approximately 20 percent of the total land area in the Borough.

Table 6
Land Use in Union Beach

Residential	32.7%
Commercial	1.8%
Industrial	17.8%
School	0.6%
Church & Charitable Property	0.5%
Public Property	16.5%
Vacant Land	9.4%
Other*	20.6%

Source: Bayshore Region Strategic Plan, adopted by the Monmouth County Planning Board on 9/18/06
*Includes Conaskonk Point, which is a natural area owned by Jersey Central Power & Light Company

The International Flavors and Fragrance facility located on the easternmost side of Union Beach is no longer in production operation. The shutdown of this plant represented a significant loss of tax revenue and local employment for the community. There are currently no specific plans to re-open this facility.

Natco Lake is a large public open space in the Borough. Conaskonk Point covers approximately 185 acres of undeveloped land along the Borough's western waterfront adjacent to the Sewerage Authority. There is a public beach along a large portion of Front Street. Approximately 9 percent of the land in Union Beach is vacant, including wetland areas near Conaskonk Point and Natco Lake.

Waterfront uses along Union Beach are mainly industrial, residential, and open space. The eastern portion of Union Beach, extending from the mouth of Waackaack Creek to Flat Creek, is not accessible to the public. Much of this waterfront area is privately-held wetlands owned by the International Flavor and Fragrances Corporation. Just west of Flat Creek, and paralleling Front Street, a waterfront promenade and public beach extends from Firefighter's Park to the eastern edge of Conaskonk Point. There are a few beachfront eating establishments along the promenade. At the northwestern corner of Union Beach, Conaskonk Point is one of the largest natural areas in the Bayshore Region, second only to Sandy Hook. This 40-acre area includes tidal marshes, sandy beach, wooded fringes, as well as coastal floodplain wildlife habitat. It is privately owned by Jersey Central Power & Light Company (JCP&L), and is not publicly accessible. Adjacent to Conaskonk Point is the Bayshore Regional Sewerage Authority and the Aeromarine Site located in Keyport Borough.

Historically, the Bayshore played a role as a market and distribution center for the agricultural goods produced on the fertile soils of the County's interior. Later the Bayshore's local commercial resources were developed. These included shellfish, clay (used in brick and tile manufacturing) and the waterfront as a tourist attraction.

The economy of Monmouth County has undergone extensive growth in recent years with much of the development concentrated along the major transportation routes. The majority of non-residential development has been for office and research facilities, probably due to the availability of comparatively inexpensive land with access to the Northern New Jersey - New York City markets.

2 Description of the Problem

Extratropical storms, northeasters, and hurricanes historically impact the Raritan and Sandy Hook Bayshore areas, greatly altering the shoreline composition over time and causing extensive flooding and erosion to the study area. Storm induced erosion had removed much of the beachfront and expedited deterioration of the existing coastal protection and drainage structures prior to reconstruction of the public beach and the seawall. In addition to physical alterations, tidal surges often block existing storm drainage systems, resulting in prolonged and extensive flooding.

A Federal beach erosion control and hurricane protection project for Raritan Bay and Sandy Hook Bay, New Jersey was authorized by the Flood Control Act of 1962. The project included adoption of improvements for the prevention of beach erosion and hurricane damages along a 21-mile portion of the Raritan Bay and Sandy Hook Bay shoreline for Keansburg and Union Beach. While the Keansburg portion was completed in 1973, the Union Beach portion was not constructed and was deauthorized in January 1990. After the 1992 storm the State of New Jersey funded reconstruction of the publicly-owned bulkhead along the shore front.

Storms impacting the area include:

- September 14, 1944 hurricane;
- Extratropical storm of November 25,1950 and November 6-7, 1953;
- Hurricane Donna (1960);
- March 6-8, 1962, Northeaster;
- March 12, 1984, Northeaster;
- December 11, 1992, Northeaster; and most recently
- October 29, 2012 Hurricane Sandy

These storms resulted in transportation problems such as loss of rail service and damaged roads and bridges; damage or destruction of shoreline structures such as dunes, jetties, bulkheads, groins; damage to utility lines and sewers; damage and destruction of homes and commercial properties; and the deposit of storm debris throughout Union Beach and surrounding Bayshore areas. Overall, these storms have resulted in extensive damage to shorefront and upland properties, numerous evacuations, and a significant constraint to commerce and regional economic development.

Historically, the largest damages within the Union Beach area have resulted from tidal inundation within the low-lying areas adjacent to Chingarora Creek, Flat Creek, and East Creek. Tidal floodwaters enter the creeks and quickly spread over the low-lying flood plain from both the east and the west. Extensive damage to hundreds of structures has been recorded in Union Beach during such storms. In addition, near shore structures are subject to damage when waves overwash the beach and bulkheads. It is estimated that 8 percent of building damages are due to waves or erosion, with the remaining 92 percent due to inundation alone.

When Hurricane Sandy struck the coast of New Jersey on October 29, 2012, it brought extensive damage to Union Beach Borough. Approximately 90 percent of the Borough's land was flooded, ranging from 2 to 10 feet in depth. Union Beach reported that 60 properties were destroyed by Hurricane Sandy and 629 properties faced substantial damage. Approximately 24,500 tons of storm damage debris littered the Borough. Trees and power lines throughout the Borough fell. The Borough also faced total power outages for over two weeks.

A summary list of Hurricane Sandy's impacts[1] to Union Beach include (but are not limited to) the following:

- Major inundation of approximately 90 percent of the Borough's land ranging from 2 to 10 feet in depth;
- Approximately 24,500 tons of storm damage debris littering the entire Borough;
- Loss of fuel across the Borough;
- Loss of power and cell phone service across the Borough for a little over two weeks;
- Destruction of the Borough's emergency warning system;
- Inoperability due to damages of most municipal buildings (excluding Borough Hall), fire houses, and emergency medical service buildings for months after the storm hit;
- Extensive damage to the bulkhead, walkway, open space areas, and businesses along the bayfront and throughout town;
- Extensive damages to the Scholer Park area;
- Damage to asphalt roads and their sub-grade on four (4) roads in the Borough;
- Prevention of the circulation of emergency vehicles;
- Destruction of Borough-owned vehicles (declared a total loss by the insurance company and not in use during Superstorm Sandy), including one EMS chief vehicle, one EMS first responder unit, one OEM vehicle, two new ambulances, 12 police vehicles and their equipment/contents, and 16 Public Works vehicles;
- Destruction of Borough vehicles-owned vehicles (declared a total loss by the insurance company and in use during Superstorm Sandy), including one OEM vehicle, one Public Works vehicle, and one police vehicle;
- Damage to one Fire Department Chief vehicle and three EMS vehicles (not declared a total loss by the insurance company and in use during Superstorm Sandy);
- Forced evacuation of hundreds of Borough residents from their homes.
- Destroyed approximately 60 homes. Approximately 145 homes were severely damaged and served as hazards to public health and safety until they were demolished. Sandy's record storm surge inundated about 2,043 housing units by flood waters ranging from 2 to 10 feet in depth.
- 629 properties (approximately 22% of the Borough's housing stock) were "substantially damaged." This is defined as damage of any origin sustained by a structure whereby the

[1] Taken from *"Union Beach Strategic Recovery Planning Report"*, 17 April 2014. T&M Associates.

total costs of restoring the structure to its before-damaged condition would equal or exceed 50% of the structure's pre-storm market value.

Prior to Hurricane Sandy there were 35 properties with repetitive loss claims in Union Beach, but now the Borough has over 500 homes listed on the Severe Repetitive Loss and Repetitive Loss lists. A repetitive loss property is defined as one in which a National Flood Insurance Plan (NFIP) claim of $1,000 has been reported at least twice in the last ten years.

2.1 Without-project Future Conditions

The without-project future conditions at Union Beach are identified as: (1) continued flooding and wave impacts from future storm episodes, (2) continued erosion of unprotected Bayfront shorelines, and (3) continued maintenance and reconstruction of shore protection facilities.

Currently there is a plan and budget for the maintenance of the existing state bulkhead along Front Street and the groin and the rock revetment to the east. It is assumed that these structures will continue to offer protection in the future. The without-project economic analysis herein is based on the assumption that such facilities will not need to be repaired over the life of the project due to the existing toe and splash protection.

It is also assumed that, over the long term, the beach profile and layout shape will be maintained, and that beach alignment variations between renourishment activities will not significantly alter current conditions.

While no long-term plan exists to maintain the private bulkheads, historic patterns indicate that they will be rebuilt after storm-related failure. Since the amount of beach in front of the private bulkheads is limited, any continued erosion will not significantly alter the future stability of these structures, which are assessed to fail in approximately 25 years. Future without-project renourishment requirements, however, will be based on the historic data.

Tidal inundation is expected to increase gradually over time, in direct relation to the anticipated rise in relative sea level. Based upon long-term trends measured at the Sandy Hook Gage, a 0.014 foot per year increase is anticipated, resulting in a 0.7 foot increase over the 50-year period of economic analysis. In future years this will result in more frequent and higher stages of flooding.

3 Reevaluation of Damage Reduction Benefits

The 2007 Authorized Plan described in the 2003 Feasibility Report includes a dune/berm system along the bayshore and a levee/floodwall system for inland areas. The 2007 Authorized Plan alignment includes tidal gates and pump stations spanning the creeks to control flooding from tidal as well as fluvial flows. The levees/floodwalls tie into the shoreside dune/berm system.

3.1 Inundation Damage Calculations

Flood damage calculations were performed using Version 1.2.5 of the Hydrologic Engineering Center's Flood Damage Analysis computer program (HEC-FDA, October 2010). This program applies Monte Carlo Simulation to calculate expected damage values while explicitly accounting for uncertainty in the input data. HEC-FDA models were prepared for existing without-project conditions, and for the 2007 Authorized Plan. Additional models were prepared to evaluate alternatives to provide drainage through the levee and floodwall system.

The following basic steps were utilized in the analysis of inundation damage:

- Assign economic evaluation reaches,
- Inventory floodplain development,
- Estimate depreciated replacement cost,
- Assign generalized damage functions,
- Calculate aggregated stage vs. damage relationships.

3.1.1 Economic Reaches

In order to conduct economic benefit analyses for the without-project and with-project selected plan, and to simplify the stage vs. damage and interior drainage analyses, the study area was separated into 24 economic reaches. Economic reach selection documented in the 2003 Feasibility Report and maintained in the current analysis was determined by the criteria outlined below.

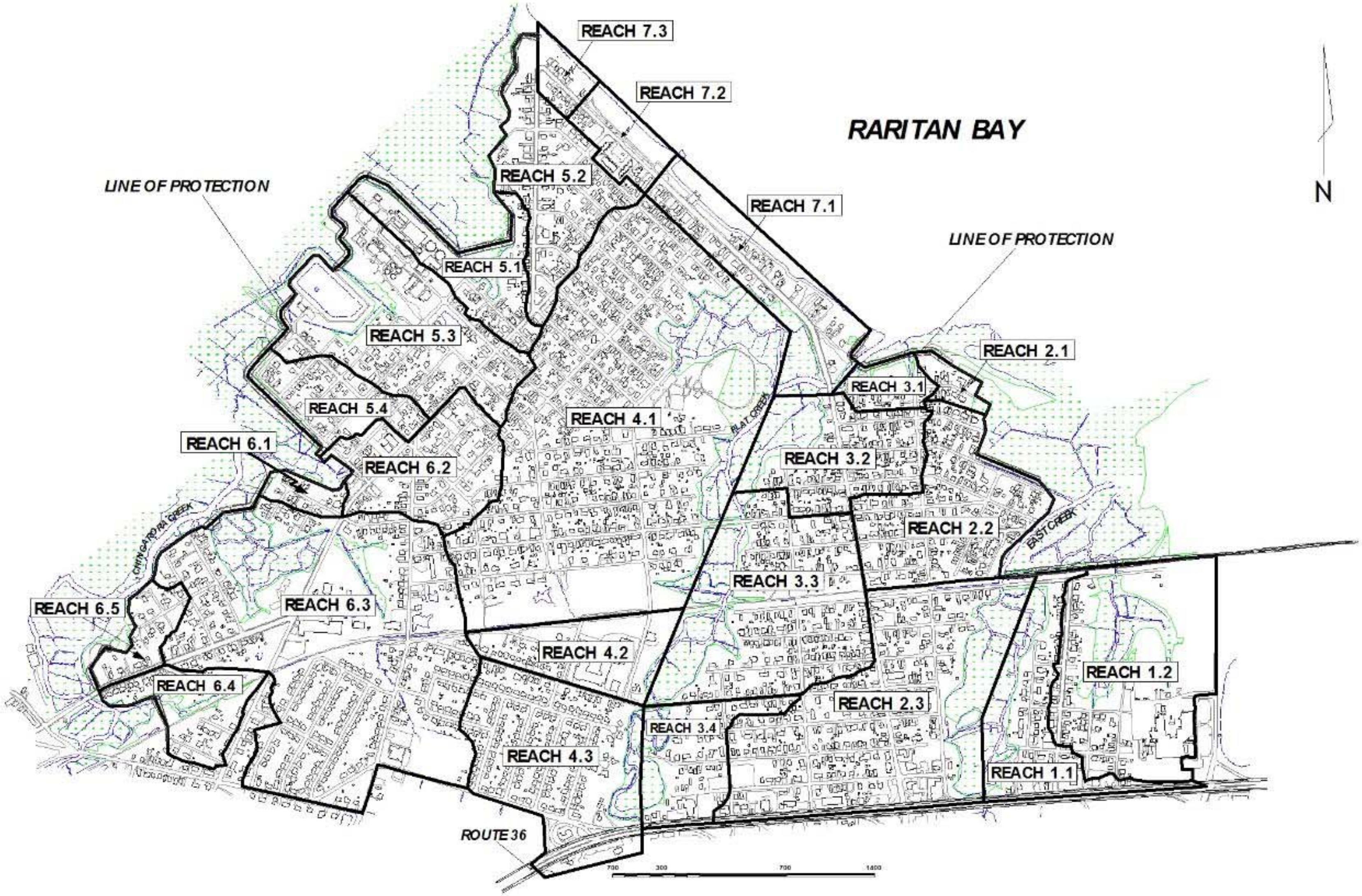
- Interior drainage areas. High ground between creek drainage areas was identified and the structures within the areas were assigned to reaches corresponding to left and right creek drainage areas. This delineation simplified the HEC-FDA stage vs. damage modeling and allowed alignment of the reaches with the interior drainage modeling.
- Damage mechanisms. Due to the proximity to the current Bayshore protection features, some structures are susceptible to wave attack damage in addition to flood damage during major storms. These structures were assigned to separate reaches for analysis of wave damage.

Reach descriptions and structure counts for 24 economic reaches (21 inland and 3 along the bayshore) are provided in Table 7; plan delineation of the economic reaches is provided on Figure 3.

Table 7
Economic Reach Descriptions and Structure Counts

Reach	Description	Res	Nonres	Total
1.1	Right Bank of East Creek	39	3	42
1.2	Right & Left Banks of East Creek Tributary	41	3	44
2.1	Left Bank of East Creek, Bayfront	10	0	10
2.2	Left Bank of East Creek	141	3	144
2.3	Left Bank of East Creek	186	19	205
3.1	Right Bank of Flat Creek, Bayfront	15	0	15
3.2	Right Bank of Flat Creek	111	4	115
3.3	Right Bank of Flat Creek	157	9	166
3.4	Right Bank of Flat Creek	43	2	45
4.1	Left Bank of Flat Creek	475	6	481
4.2	Left Bank of Flat Creek	20	5	25
4.3	Left Bank of Flat Creek	145	0	145
5.1	Right Bank of Chingarora Creek	33	1	34
5.2	Right Bank of Chingarora Creek	99	2	101
5.3	Right Bank of Chingarora Creek	93	1	94
5.4	Right Bank of Chingarora Creek	50	1	51
6.1	Right Bank of Chingarora Creek	12	1	13
6.2	Right Bank of Chingarora Creek	71	6	77
6.3	Right Bank of Chingarora, Both Banks of Chingarora Trib	259	11	270
6.4	Right Bank of Chingarora Creek	54	0	54
6.5	Right Bank of Chingarora Creek	17	0	17
7.1	Bayfront (Bulkhead, No Beach)	34	6	40
7.2	Bayfront (Bulkhead, With Beach)	24	2	26
7.3	Bayfront (Private Bulkhead)	15	0	15

Figure 3
Union Beach Borough Economic Reaches



3.2 Inventory Methodology used in 2003 and 2016 HSLRR Adjustments

The analysis documented in the 2003 Feasibility Report was conducted using a full scale structure database that was developed as part of the overall effort that spanned the period 2001 through 2003. The structure database was generated through a survey of the structures adjacent to the project area, and was obtained through a windshield survey of the area using topographic mapping with a 2-foot contour interval. Table 8 below shows the type of physical characteristics obtained for the building inventory as part of the 2001-2003 analysis.

Table 8
Physical Characteristics of Union Beach Structure Inventory

Structure ID	Setback from Shoreline
Map Number	Midpoint from Shoreline
Type	Owner
Usage	Quality of Construction
Size	Condition
Story	Ground Elevation (NGVD29)
Basement Type	Main Floor Opening
Number of Garage Openings	Low Opening
Exterior Construction	Reach

The data collected for the 2003 analysis was used to categorize the structure population into groups having common physical features. Data pertaining to structure usage, condition, size and number of stories assisted in the structure value analysis. For each building, data was also gathered pertaining to its damage potential including ground and main floor elevations, lowest opening, construction material, basement, and proximity to the shorefront.

The structure inventory and the analysis of benefits is in full compliance with 33 USC 2318, which states that benefits shall not be counted for structures constructed in the 100-year floodplain after 1991. The first floor of all structures in the inventory constructed after 1991 are above elevation 12.5 NGVD29, which was the 100-year base flood elevation in effect at Union Beach Borough up through 2013 following Hurricane Sandy. Further, Union Beach Borough has been a participant in the National Flood Insurance Program since 1981, and has been a member of the National Flood Insurance Program Community Rating System since 2003.

3.2.1 Structure Values

The 2003 analysis assigned depreciated replacement values (DRVs) based on a calculations using standard building cost estimating procedures from R.S. Means and Marshall & Swift. This type of analysis combines the physical characteristics obtained in the inventory with standard unit prices per square foot. Depreciation was then calculated based on the observed type and condition of each structure. Values were updated to January 2001 price levels.

Changes to Depreciated Replacement Values – 2016 HSLRR

The current analysis began with the values as stated in the 2003 Feasibility Report. Eighty-four structures in the study area were constructed after 2001. For those structures, the depreciated replacement value was taken from the Monmouth County assessor database (values stated as 2012 valuation year). For the remaining structures, adjustments were made to the 2001 database values to reflect not only higher construction costs, but also an additional 15 years of depreciation.

The ENR Building Cost Index shows that the cost of building construction specific to northern New Jersey increased by a factor of 1.649 in the years since the 2003 Feasibility Report was completed. The first step in updating the structure values was to multiply the original structure values by 1.649 to arrive at the new structure value. For those structures where sufficient data were available in the existing structure inventory (2001 values), an estimate was made of the amount by which each structure had been depreciated on an annual basis. An extra 15 years of depreciation was added to the 2001 depreciation factor, and the resulting (larger) depreciation factor was applied to the new structure value, to arrive at the new depreciated structure value.

For example, a structure in the original inventory has a replacement value of $200,000, a depreciated replacement value of $170,000, was constructed in 1984, and reflects 17 years of depreciation at a 15 percent depreciation rate ($200,000 depreciated by 15 percent equals $170,000). The allocation of 15 percent depreciation over 17 years is approximately 0.9 percent per year. Over an additional 15 years, the structure will incur an additional 13 percent of depreciation, which yields a total depreciation rate of 28 percent. The updated depreciated replacement cost for this structure would be:

New Structure Replacement Cost:	$ 329,800 = ($ 200,000 x 1.649)
New Depreciation:	$ 85,960 = ($ 329,800 x 0.28)
Revised Depreciated Replacement Value:	$ 221,040 = ($ 329,800 - $ 85,960)

In cases where sufficient data were not available in the 2001 database to estimate depreciation per year, the 2001 depreciation percentages were adjusted by a factor equal to the average ratio of (depreciated value as of 2016 / depreciated value as of 2001), which was calculated based on data from structures for which the estimate was available.

Changes to Structure Elevations – HSLRR Analysis

Appendix B of the 2003 Feasibility Report states that ground elevations used in development of the structure inventory were derived from topographic mapping with two-foot contour intervals. For the current analysis, ground elevations were taken directly from LiDAR mapping conducted by the USACE Joint Airborne LiDAR Bathymetry Technical Center of Expertise (Topobathy LiDAR) specifically to map ground and water elevations following Hurricane Sandy. The original reference datum developed for the dataset was NAVD88, but all elevations were converted to NGVD29 prior to use in the current analysis.

Points representing each structure in the GIS shapefile were assigned a new ground elevation using the current LiDAR data. Of the 2,229 structure points in the inventory:

- new ground elevation was higher for 264 structures (average change of 1.17 feet);
- new ground elevation was lower for 1,356 structures (average change of 1.39 feet); and
- ground elevation was unchanged for 609 structures.

3.2.2 Structures Demolished or to be Demolished – Replaced within Inventory

Hurricane Sandy caused substantial damage to hundreds of residential structures in the study area. As a result, many homes were demolished and rebuilt. Still more will be rebuilt in the coming years. When the new homes are constructed, they will be elevated with their first floor elevated to a point at which the structures and contents are safe from frequent flooding – to the base flood elevation (BFE) plus one foot. Many other existing structures that were not demolished after the storm have been - or will be - raised the BFE plus one foot, safe from high frequency flood events.

These structures remain in the structure database, though damages to the structures and the associated contents are not damaged under without project conditions by flood events that do not exceed +14 feet NGVD29. However, values that represent property stored at ground level associated with a re-built structure (e.g., landscaping, out-buildings, garages, outdoor equipment, automobiles, etc.) remain in the inventory at ground level.

Using data provided by Union Beach, 310 structures were identified as having been demolished (either directly during Hurricane Sandy or later by the Borough), raised-in-place, or constructed after Hurricane Sandy. Another 70 structures were identified by the Borough as being unsafe and vacant[2]. It was assumed that each of the 70 structures would be replaced by a structure at the base flood elevation (BFE) plus one foot (14 feet NGVD29). This conservative assumption was made because of the extremely robust construction activity prevalent throughout Union Beach. It is not possible to select which vacant and unsafe structures would be slated for demolition and rebuilding. Because substantial damage precludes repair without raising the structure to the base flood elevation + one foot, and because property owners have several years in which to act, it was prudent to assume that all of the structures would be replaced by a structure with the first floor located at the BFE plus one foot.

Figure 4 shows the distribution of the 380 structures throughout the study area, each of which is indicated by a red dot.

3.2.3 Inundation Damage Functions

Based on the type, usage and size of each structure inventoried, damage was calculated relative to the main floor elevation of the structure. Using structure and ground elevation data these depth vs. damage relationships were converted to corresponding stage (NGVD29) vs. damage relationships. Damages for individual structures at various stages were aggregated according to structure type (residential, apartment, commercial, etc.) and location (reach).

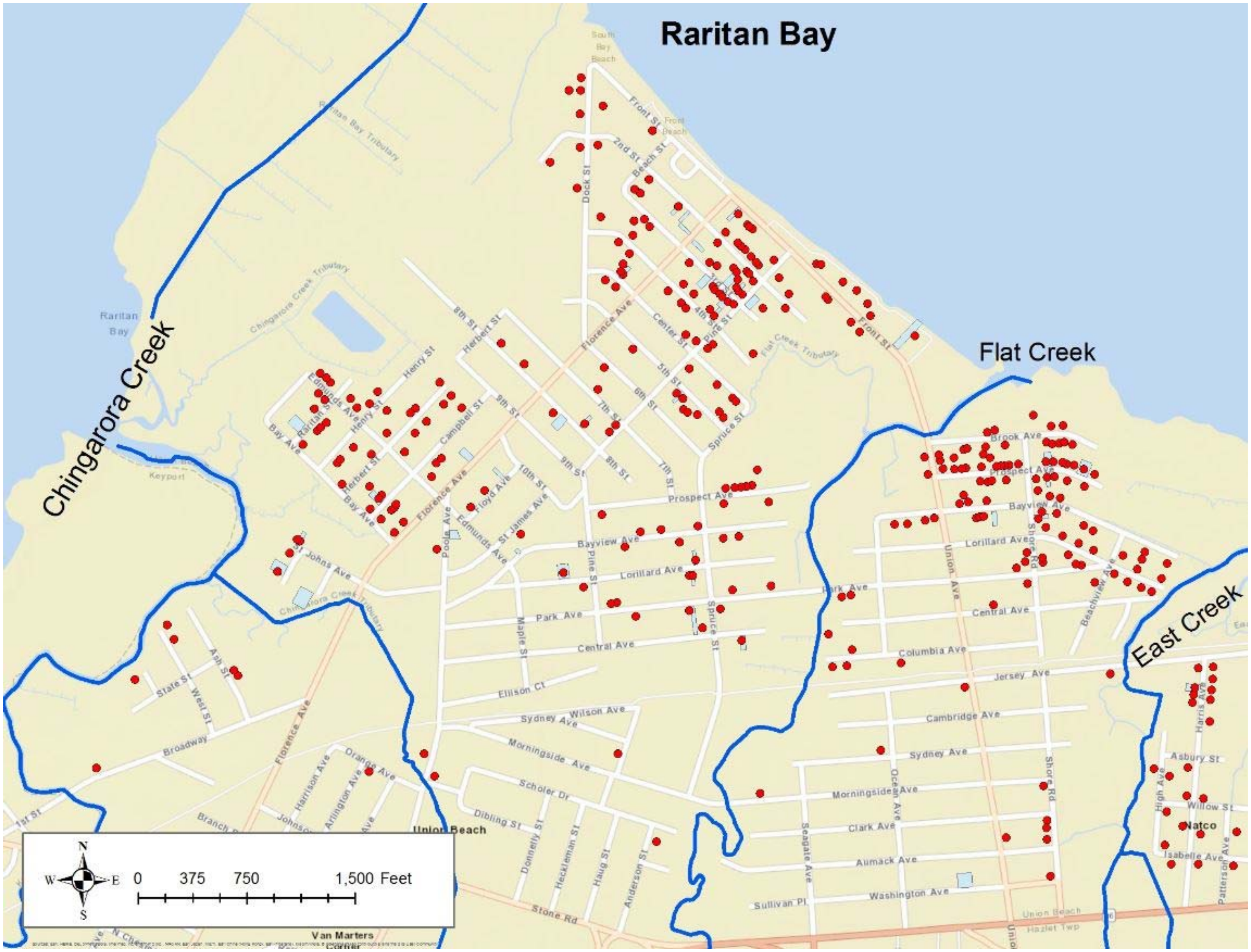
3.2.4 Generalized Functions

Generalized depth-percent damage functions for structure, structure content and other items were applied to the vast majority of structures for calculation of inundation damage.

For the 2003 analysis, all of the generalized damage functions used were developed from on-site surveys conducted for the Passaic River Basin flood control project. It was argued that since most of the development in Union Beach is similar to the development in the nearby Passaic River Basin, these functions would relate the percentage of damage at various flood depths to the

[2] The list of unsafe vacant structures includes a total of 83 structures. Of the 83 structures, 13 were already accounted for within the list of 310 structures previously identified as being "demolished" or "to be demolished".

Figure 4
Demolished Structures / Structures to be Demolished



DRV of the structure and its contents. Non-residential damage categories include commercial, industrial, municipal, utility and emergency structures. The analyses assume that residential content values average 43.5% of the structure value (consistent with guidance set forth in EM 1110-2-1619). The functions also calculate other damage (including damage to landscaping, vehicles, storage sheds, garages, etc.) as a percentage of structure value.

This approach was used for the current analysis, with the following exception for residential structures without basements. After Hurricane Katrina, the New Orleans District, USACE conducted a study (*Depth-Damage Relationships For Structures, Contents, and Vehicles and Content-To-Structure Value Ratios in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study – March, 2006*) that investigated depth-damage relationships for structures, contents, and content-to-structure value ratios for residential and commercial structures in eight parishes in Louisiana. These relationships and ratios will be used by the New Orleans District as a basis for damage calculations in ongoing and future flood control and hurricane protection studies.

The relationships and ratios were developed using estimates from experts in the fields of construction, repair and restoration, and insurance claims adjustment. Homeowner interviews and inspections were used to assist the experts with their estimates. This study produced content-to-structure value ratios, as well as expected, minimum and maximum depth-damage curves for a number of structure types, in freshwater or saltwater conditions, in short- or long-duration flood events.

In the Union Beach study, the Passaic River depth-damage curves were replaced with the saltwater, short-duration New Orleans curves for one- and two-story residential structures without basements. The flooding experienced in the study area during Hurricane Sandy was coastal, not riverine. The New Orleans curves are better able to capture the effects of rapid inundation and saltwater intrusion. The New Orleans curves also provide maximum and minimum expected values, which paint a more accurate picture of the true potential for damage in an extreme event than the Passaic River curves or IWR curves[3], which only provide a standard deviation around the mean.

3.2.5 Individualized Functions

Individualized depth-percent damage functions were generated for two utility structures, which are not accurately represented by generalized Passaic River non-residential depth-damage functions:

- Bayshore Regional Sewage Authority wastewater treatment plant (BRSA). The plant is a 16 MGD, secondary activated sludge treatment plant that currently serves approximately 100,000 people in eight townships (Hazlet, Holmdel, Union Beach, Keyport, Keansburg, Matawan, Aberdeen, and a portion of Marlboro). The plant was constructed in 1974, and was later expanded in 1993. Floodwaters from Sandy inundated the facility's 24 acres in three to five feet of salt water. The flooding damaged every process in the plant, with the greatest damage incurred at the plant's incineration system. Inundation and significant

[3] Corps of Engineers' Economic Guidance Memoranda EGM 01-03 and EGM 04-01 provide generic depth-damage curves for use in Corps of Engineers flood damage reduction studies. EGM 01-03 provides generic depth-damage relationships for residential structures with basements, and EGM 04-01 provides generic depth-damage relationships for residential structures without basements.

damage begins for the plant at elevation 11 feet NGVD29, at a damage cost of $15 million for damage to the plant's incinerator system. When Hurricane Sandy destroyed the BRSA incinerator system, it was necessary to transport and dispose of liquid sludge. Dewatering equipment was then deployed for several months while the incinerators were repaired and brought back on-line. The annual cost for managing sludge was $1.5 million.

- Damages to the Jersey Central Power and Light electricity substation were estimated by using a damage curve represented in Table 7.9 of the HAZUS MR4 technical manual. The damage curve assumes electrical switch gear is located 3-feet above grade. Percent damage by depth of flooding feet ranges from 2 percent for one foot of inundation to 15 percent for 10 feet of inundation.

3.2.6 Wave Damage Analysis

Buildings located in the three reaches along the bayshore (Reaches 7.1, 7.2, and 7.3) were evaluated for their potential susceptibility to wave attack. The 2003 analysis determined that structures located in the three reaches along the bayshore were deemed susceptible to wave attack (wave damage) under existing without-project conditions. Ground elevations in Reach 7.3 are such that most structures located within this reach are not susceptible to wave damage until the 500-year frequency storm. Site visits conducted as part of the 2003 analysis identified buildings for modified damage modeling, incorporating wave damage in addition to inundation damage. Any demolished structures within reaches 7.1, 7.2, and 7.3 were assumed to be rebuilt at the BFE + 1 foot for the current analysis.

The Bayfront area of Union Beach is susceptible to attack by ocean waves as well as wind-driven waves from the Raritan Bay and Lower New York Harbor. In order to simplify the stage vs. damage analysis while accounting for waves from the bay, wave heights at the structures in Reaches 7.1 through 7.3 were assumed to be depth-limited. Since offshore wave heights are consistently greater than wave heights typically associated with building failures, this assumption of depth-limited waves is consistent with local conditions. The wave damage algorithm for masonry structures provides that a 3.3-foot deep still water level (SWL) at a structure will support the formation of a breaking wave of sufficient height to cause failure of typical structures. The corresponding SWL depth for a wood structure was determined to be 3.0 feet.

Damage Limits

In order to create such damaging wave conditions at the structures, an incident breaking wave of sizeable height must exist. Incident design storm wave heights can be expected to exceed 6 feet. Using FEMA's "Ways of Estimating Wave Heights in Coastal Hazard Areas" (April 1981), wave height transmission beyond a shoreline structure (such as seawall or dune) will be limited by the water depth leeward of the structure. Analysis results indicate that an incident non-breaking wave height of approximately 3 feet would be required to transmit structure-damaging waves.

Wave Damage Functions

Depth-percent damage functions for each building in the first row of structures along Front Street were individually modified to account for wave damage. Function values were revised to show 100% damage at and above depths where exterior flood stages could support a 100% damage-inducing wave. Such depths are specific to each structure's first floor elevation and were determined individually. Prior to damage function modification, the elevation and location of each structure was reviewed to determine if the establishment of a controlling shoreward elevation was required to properly model wave heights. The depth-percent damage functions were modified to include 100% damage at water surface depths of 3.0 feet above ground elevation for wood frame structures, and at 3.3 feet above ground elevation for masonry structures, unless a controlling elevation (higher than the ground elevation at the structure) existed. Controlling elevations were used to calculate the resultant water surface at which wave damage would occur. Once the depth-percent damage functions were revised for each of the affected structures, the model was rerun to calculate structure damages attributable to both inundation and wave action. Since structure failure due to wave action would occur above the FEMA Base Flood Elevation, no adjustments were made to the depth-percent damage functions for future with-project conditions.

3.2.7 Sea Level Rise

Sea level rise is a significant factor contributing to future impacts of tidal inundation and wave action. Based upon NOAA tide gauge readings at Sandy Hook, sea level has been increasing at an average rate of 0.014 feet per year. This is equivalent to a 0.7 foot increase in tidal stage over the 50-year period of economic analysis. In future years, more frequent and higher-stage flooding is likely. The calculated existing base year (2022) without-project condition expected annual damage for residential structures is $6,850 per structure. Economic analysis results indicate that the average annual expected without-project damage to residential structures would increase to $9,890 per structure by the end of the 50-year period of economic analysis in the year 2072.

3.3 Inundation Damages Calculations

The stage vs. damage data were combined with stage vs. frequency data using the HEC-FDA program. The HEC-FDA program quantifies uncertainty in discharge-frequency, stage-discharge, and stage-damage functions and incorporates it into economic and performance analyses of alternatives. The process applies a procedure (Monte Carlo simulation) that computes the expected value of damage while accounting for uncertainty in the basic value.

The HEC-FDA program presents results for expected annual damages and equivalent annual damages. The impacts of sea level rise were incorporated by increasing the end of project stages (Year 2072) in the stage vs. frequency curve by the projected rate of sea level rise, 0.7 feet.

3.3.1 Uncertainty

Under current Corps guidance, risk and uncertainty must be incorporated in flood risk management studies. The following areas of uncertainty were incorporated into the HEC-FDA program:

- stage frequency (for exterior bay stages)
- discharge frequency (for interior runoff)
- stage discharge (for interior drainage)
- first floor elevation
- structure value
- content-to-structure value
- other-to-structure value

A first floor standard deviation of 0.6 feet was selected based on recommendations in the USACE Engineering Manual, EM 1110-2-1619 Table 6-5, and the ground elevations provided in the project 2013 LiDAR mapping. The coefficient of variation in structure value was estimated at 10 percent. EM 1110-2-1619 suggests that in lieu of better site-specific information, content-to-structure value ratios based on large samples of Flood Insurance Administration (FIA) claims records can be used (Table 6-4 presented in EM 1110-2-1619). An approximate average standard deviation of 25 percent was utilized for structure value uncertainty. Since the damage functions present other damage as a percent of structure value, the other-to-structure value ratio was estimated to have a standard deviation of 10 percent.

3.3.2 Public Emergency Costs

The 2003 analysis calculated the cost of providing additional public services and repairing damage to public infrastructure during storms based on data provided by the Borough of Union Beach Director of Emergency Management. For the storm of December 1992 (10 feet NGVD29), the data indicated that public emergency costs within the Borough totaled $3,856,490 (1992 dollars), or 11.56% of all damages incurred, excluding damage to the bulkhead and 50% of the debris removal costs (it was assumed that 50% of debris was associated with wind).

Damage functions for public emergency costs were developed for each economic reach in the 2003 analysis. These costs consist of:

- Police and fire department actions to warn and evacuate residents, and maintain order before and during an event;
- Flood fighting efforts and materials;
- Debris removal;
- Emergency road repair;
- Emergency shelter, longer-term temporary housing and the provision of necessities such as money, food, and clothing to flood victims; and
- Administrative costs incurred in the delivery of emergency services.

Costs of each of these items were sustained during Hurricane Sandy and in its aftermath. In addition, extended costs for power restoration, telecommunications outages, and an extended duration of wastewater treatment plant disruptions were incurred as a result of Hurricane Sandy.

Debris removal costs alone amounted to over $6 million following Hurricane Sandy, and FMEA assistance totaled $9 million. Considering that Public Emergency costs continue to be comprised of the same elements as modeled in the September 2003 Feasibility Report, the public emergency cost functions were updated to current values using a factor of 1.372, which represents an inflation of costs from 2001 through 2016 as reflected in the Consumer Price Index for all Northeast Urban Consumers[4]. The update factor differs from update factors used for construction projects (e.g., the Engineering News Record Building Cost Index or Construction Cost Index) in that the update factor used for public emergency costs are not weighted heavily by the costs of construction.

Public emergency costs are incorporated into the analysis through the HEC-FDA model as individual items on a reach-by-reach basis.

[4] The U.S. Bureau of Labor Statistics data are available at: http://data.bls.gov/pdq/SurveyOutputServlet using the series identification numbers CUUR0100SA0, and CUUS0100SA0.

Public emergency cost functions used in the 2003 Feasibility Report and updated cost functions used in the HSLRR are both shown on Table 9.

Table 9
Emergency Services Cost Functions ($ thousands) – 2003 Feasibility Report and 2016 HSLRR Update

Emergency Services Costs from 2003 Analysis:

	Economic Reach																							
Stage	**1.1**	**1.2**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**	**3.3**	**3.4**	**4.1**	**4.2**	**4.3**	**5.1**	**5.2**	**5.3**	**5.4**	**6.1**	**6.2**	**6.3**	**6.4**	**6.5**	**7.1**	**7.2**	**7.3**
8	14	49	4	51	78	4	37	56	17	160	22	58	70	49	110	17	4	34	110	13	7	7	13	2
9	34	122	10	126	182	10	92	139	41	396	53	143	173	122	272	41	10	85	272	32	17	17	32	5
10	65	232	19	241	366	19	176	164	79	756	102	274	329	232	520	79	19	162	520	60	32	32	60	9
11	107	351	30	396	601	30	289	434	129	1,241	167	449	540	381	853	129	30	266	853	99	52	53	99	15
12	168	600	48	624	948	48	456	684	204	1,955	264	708	852	600	1,344	204	48	420	1,344	156	84	84	156	24
13	241	859	69	894	1,358	69	653	980	292	2,802	378	1,014	1,220	859	1,925	292	69	602	1,925	223	120	120	223	34
14	320	1,142	91	1,187	1,804	91	868	1,302	388	3,722	502	1,347	1,621	1,142	2,557	388	91	799	2,557	297	160	160	297	46
15	391	1,397	112	1,453	2,207	112	1,062	1,592	475	4,554	615	1,648	1,983	1,397	3,129	475	112	978	3,129	363	196	196	363	56
16	451	1,609	129	1,674	2,543	129	1,223	1,835	547	5,246	708	1,899	2,285	1,609	3,605	547	129	1,126	3,605	418	225	225	418	64
17	506	1,805	144	1,878	2,852	144	1,382	2,058	614	5,886	794	2,130	2,564	1,805	4,044	614	144	1,264	4,044	469	253	253	469	72
18	556	1,985	159	2,065	3,137	159	1,509	2,263	675	6,472	874	2,342	2,819	1,985	4,447	675	159	1,390	4,447	516	278	278	516	79
19	600	2,144	172	2,230	3,387	172	1,629	2,444	729	6,989	943	2,529	3,044	2,144	4,802	729	172	1,501	4,802	557	300	300	557	86
20	638	2,280	182	2,371	3,602	182	1,732	2,599	775	7,431	1,003	2,690	3,237	2,280	5,106	775	182	1,596	5,106	593	319	319	593	91

Emergency Services Costs Updated to 2016:

	Economic Reach																							
Stage	**1.1**	**1.2**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**	**3.3**	**3.4**	**4.1**	**4.2**	**4.3**	**5.1**	**5.2**	**5.3**	**5.4**	**6.1**	**6.2**	**6.3**	**6.4**	**6.5**	**7.1**	**7.2**	**7.3**
8	19	67	5	70	106	5	51	77	23	220	30	79	96	67	151	23	5	47	151	18	9	9	18	3
9	47	167	13	173	250	13	127	190	57	544	73	197	237	167	374	57	13	117	374	43	23	23	43	7
10	89	318	25	331	503	25	242	226	108	1,038	140	376	452	318	713	108	25	223	713	83	45	45	83	13
11	146	482	42	543	825	42	397	595	178	1,702	230	616	742	522	1,170	178	42	366	1,170	136	72	73	136	21
12	230	823	66	856	1,300	66	626	938	280	2,683	362	971	1,169	823	1,844	280	66	576	1,844	214	115	115	214	33
13	330	1,179	94	1,226	1,863	94	896	1,344	401	3,845	519	1,391	1,675	1,179	2,642	401	94	826	2,642	307	165	165	307	47
14	439	1,567	125	1,629	2,475	125	1,191	1,786	533	5,107	689	1,848	2,225	1,567	3,509	533	125	1,097	3,509	407	219	219	407	63
15	537	1,917	153	1,993	3,028	153	1,457	2,185	652	6,248	843	2,261	2,722	1,917	4,293	652	153	1,342	4,293	498	268	268	498	77
16	618	2,208	177	2,296	3,489	177	1,678	2,517	751	7,199	972	2,605	3,136	2,208	4,946	751	177	1,546	4,946	574	309	309	574	88
17	694	2,477	198	2,576	3,914	198	1,896	2,824	842	8,076	1,090	2,923	3,518	2,477	5,549	842	198	1,734	5,549	644	347	347	644	99
18	763	2,724	218	2,833	4,304	218	2,070	3,105	926	8,880	1,199	3,214	3,868	2,724	6,102	926	218	1,907	6,102	708	381	381	708	109
19	824	2,942	235	3,059	4,648	235	2,236	3,353	1,000	9,590	1,294	3,471	4,177	2,942	6,589	1,000	235	2,059	6,589	765	412	412	765	118
20	876	3,128	250	3,253	4,942	250	2,377	3,566	1,063	10,197	1,376	3,690	4,442	3,128	7,006	1,063	250	2,190	7,006	813	438	438	813	125

3.3.3 Without-Project Expected Annual Damages

For this analysis, estimated storm damages include structure, content and other damages for buildings, and costs of damage to public infrastructure and emergency response. Expected annual damages for the without-project / base year condition (2022), and for the without-project/future year (2072) conditions are provided in Tables 10 and 11, respectively. Equivalent annual damages, annualized over the 50-year period of economic analysis using a $3^{1/8}$ percent discount rate, have been summarized in Table 12.

Damage values for economic reaches 1.1 to 6.5 include damages due to flood inundation alone, while those for shoreline reaches 7.1 to 7.3 include damages due to both inundation and wave action. Without-project equivalent annual damage for all reaches equals $21,764,000 (base year annual damage for all reaches equals $18,763,000 while future year annual damage for all reaches equals $26,948,000). This value includes damages due to both inundation and wave action.

Table 10
Summary of Without-Project Condition / Base Year 2022 Annual Damage By Damage Categories and Damage Reaches ($ 1,000)

Damage Reach	Apartment	Commercial	Industrial	Municipal	Residential	Utilities	Public Emergency	Total
1.1		91			541		24	656
1.2		63	124	0	522		85	793
2.1					145		7	152
2.2		3		0	761		88	852
2.3		172		1	550		133	855
3.1					109		7	116
3.2		72			648		64	784
3.3		3			563		92	658
3.4		6			68		29	102
4.1		63		42	4,376		275	4,755
4.2				122	68		38	228
4.3		144			721		100	966
5.1					311	986	119	1,416
5.2	1	16			1,315		85	1,416
5.3		6			938		189	1,133
5.4		11			541		29	581
6.1		36			187		7	230
6.2		73		34	492		59	658
6.3		4	62	80	941	26	189	1,302
6.4					131		22	153
6.5					76		12	88
7.1		81		41	563		12	698
7.2	5	29			52		22	108
7.3					59		3	63
TOTAL	5	873	185	321	14,676	1,011	1,692	18,763

Table 11
Summary of Without-Project Condition / Future Year 2072 Annual Damage By Damage Categories and Damage Reaches ($ 1,000)

Damage Reach	Apartment	Commercial	Industrial	Municipal	Residential	Utilities	Public Emergency	Total
1.1		135			808		33	976
1.2		92	170	0	767		119	1,147
2.1					220		9	229
2.2		5		0	1,093		123	1,221
2.3		248		1	772		187	1,208
3.1					165		10	175
3.2		107			925		90	1,122
3.3		4			789		129	922
3.4		8			92		41	141
4.1		91		60	6,361		388	6,901
4.2				169	94		53	316
4.3		220			994		140	1,354
5.1					453	1,357	168	1,978
5.2	1	22			1,939		118	2,080
5.3		8			1,372		267	1,646
5.4		15			810		40	866
6.1		56			279		10	345
6.2		105		49	701		83	939
6.3		6	88	110	1,315	36	266	1,821
6.4					183		31	214
6.5					106		17	123
7.1		112		56	807		17	992
7.2	6	39			72		31	148
7.3					81		5	85
TOTAL	7	1,272	258	447	21,196	1,393	2,375	26,948

Table 12
Summary of Without-Project Condition / Equivalent Annual Damage By Damage Categories and Damage Reaches ($ 1,000 50-Year Period of Analysis, $3^{1/8}$ % Discount Rate)

Damage Reach	Apartment	Commercial	Industrial	Municipal	Residential	Utilities	Public Emergency	Total
1.1		107			639		27	773
1.2		74	141	0	612		97	923
2.1					172		8	180
2.2		4		0	882		101	987
2.3		200		1	631		153	985
3.1					129		8	137
3.2		85			750		74	908
3.3		4			646		106	755
3.4		7			76		33	116
4.1		73		49	5,104		317	5,542
4.2				140	77		43	260
4.3		172			821		115	1,108
5.1					363	1,122	137	1,622
5.2	1	18			1,544		97	1,660
5.3		6			1,097		218	1,321
5.4		13			640		33	685
6.1		44			221		8	272
6.2		85		40	569		68	761
6.3		5	71	91	1,078	29	218	1,492
6.4					150		25	176
6.5					87		14	101
7.1		93		47	653		14	806
7.2	5	33			59		25	122
7.3					67		4	71
TOTAL	6	1,019	212	367	17,066	1,151	1,942	21,764

3.3.4 With-Project Levee / Floodwall Overtopping & Failure Analysis

The 2003 Feasibility Report states (page 161) that the Union Beach levee/floodwall system would provide "protection against the 100 year (1 % annual chance) storm with 92 % reliability...", and economic analyses of the 2007 Authorized Plan accrued benefits up to the levee/floodwall elevation of 15 feet NGVD29. This HSLRR incorporates lessons learned from Katrina regarding the susceptibility of levees and floodwalls when still water elevations allow waves to interact with the levee/floodwall system. As such, economic benefits calculations have been revised to incorporate levee/floodwall failure analyses for storms resulting in water surface elevations lower than the 2007 Authorized Plan protective features elevation of 15 feet NGVD29.

Union Beach levees and floodwalls are subject to wave action during more severe events on the northeast and west-facing alignments. When the still-water elevation is significantly lower than the top of the levee/floodwall system at 15 feet NGVD29, small waves may break on the levee/floodwall system, but the freeboard (defined as the vertical distance between the top of the levee/floodwall system and flood waters) prevents waves from overtopping the system. When the still-water elevation approaches 15 feet NGVD29 – yet still below this elevation – less freeboard exists, and waves impacting the levee/floodwall system are more likely to result in overtopping.

As part of this HSLRR, five overtopping models were used to develop the mean overtopping flowrates for the different return intervals, and overtopping calculations were performed for stage elevations both with and without 0.7 feet of sea level rise over the period of analysis. Using post-Katrina levee studies, and assuming soil cement reinforcing on the landward slopes of the levees, the non-failure point of the Union Beach levee/floodwall system would be 13.1 feet NGVD29 and the failure point of the system would be 13.6 feet NGVD29.

At the beginning of the period of analysis in 2022, the non-failure-point elevation of 13.1 feet NGVD29 corresponds to an event with a 94-year exceedance interval, and the failure-point elevation of 13.6 feet NVGD29 corresponds to an event with a 123-year exceedance interval. At the period of analysis in 2072, when 0.7 feet of sea level rise is assumed to occur, the non-failure-point elevation of 13.1 feet NGVD29 corresponds to an event with a 67-year exceedance interval, and the failure-point elevation of 13.6 feet NVGD29 corresponds to an event with an 87-year exceedance interval.

Variables that factor into the interior stage elevation after failure are numerous – direction of the storm, wind direction, duration of the storm, etc. – and this HSLRR did not address these factors. For this HSLRR, it was assumed that water accumulations behind the levee/floodwall system up to the failure point are negligible, and that the interior water elevations at the failure event are assumed to equal the bay stage elevations. It was likewise assumed that the interior water levels rise linearly between the non-failure point of 13.1 feet NGVD29 and the failure point of 13.6 feet NGVD29.

3.3.5 With-Project Expected Annual Damages

Storm damages were modeled for the 2007 Authorized Plan, and include all of the damage categories evaluated under without-project conditions. As discussed above, this HSLRR incorporates post-Katrina overtopping and failure analysis into the calculation of with-project expected annual damages, which is a major difference from the economic analysis documented in the 2003 Feasibility Report.

Expected annual damages with the 2007 Authorized Plan in place were calculated for the base year (2022), and for the end of the 50-year period of economic analysis (2072) are provided in Tables 13 and 14, respectively. Equivalent annual damages, annualized over the 50-year period of economic analysis using a $3^{1/8}$ percent discount rate, have been summarized in Table 15.

Table 13
Summary of With-Project Condition / Base Year 2022 Annual Damage By Damage Categories and Damage Reaches ($ 1,000)

Damage Reach	Apartment	Commercial	Industrial	Municipal	Residential	Utilities	Public Emergency	Total
1.1		16			111		8	135
1.2		9	110	0	108		30	258
2.1					26		2	28
2.2		3		0	280		31	314
2.3		35		1	270		47	353
3.1					33		2	35
3.2		9			246		23	278
3.3		3			238		34	275
3.4		3			49		10	62
4.1		10		8	1,266		98	1,381
4.2				42	37		13	91
4.3		16			346		35	397
5.1					88	258	43	389
5.2	1	7			314		30	352
5.3		2			261		67	330
5.4		4			129		10	143
6.1		3			32		2	37
6.2		16		7	183		21	226
6.3		2	14	27	422	8	67	541
6.4					64		8	71
6.5					36		4	40
7.1		49		21	162		4	237
7.2	4	24			32		8	69
7.3					49		1	50
TOTAL	5	210	124	106	4,780	266	599	6,092

Table 14
Summary of With-Project Condition / Future Year 2072 Annual Damage By Damage Categories and Damage Reaches ($ 1,000)

Damage Reach	Apartment	Commercial	Industrial	Municipal	Residential	Utilities	Public Emergency	Total
1.1		22			150		11	183
1.2		12	149	0	147		41	349
2.1					35		3	38
2.2		4		0	379		42	425
2.3		48		1	365		64	478
3.1					44		3	48
3.2		12			334		31	377
3.3		4			323		46	373
3.4		4			66		14	84
4.1		14		11	1,718		132	1,874
4.2				57	50		18	124
4.3		22			471		48	541
5.1					119	352	58	529
5.2	1	9			427		41	477
5.3		3			354		91	447
5.4		5			175		14	194
6.1		4			43		3	50
6.2		22		9	249		29	308
6.3		3	19	37	572	11	91	734
6.4					86		11	96
6.5					48		6	54
7.1		66		29	220		6	321
7.2	6	33			44		11	93
7.3					66		2	68
TOTAL	7	286	168	145	6,484	363	814	8,267

Table 15
Summary of Without-Project Condition / Equivalent Annual Damage By Damage Categories and Damage Reaches
($ 1,000 50-Year Period of Analysis, $3^{1/8}$ % Discount Rate)

Damage Reach	Apartment	Commercial	Industrial	Municipal	Residential	Utilities	Public Emergency	Total
1.1		18			125		10	153
1.2		10	125	0	122		34	291
2.1					29		3	32
2.2		3		0	316		35	355
2.3		40		1	305		53	399
3.1					37		3	40
3.2		10			278		26	314
3.3		3			269		38	311
3.4		3			55		11	70
4.1		11		9	1,431		110	1,562
4.2				47	41		15	103
4.3		18			392		40	450
5.1					99	292	49	440
5.2	1	8			356		34	398
5.3		2			295		76	373
5.4		4			146		11	162
6.1		3			36		3	42
6.2		18		8	207		24	256
6.3		2	16	31	477	9	76	611
6.4					72		9	81
6.5					40		5	45
7.1		55		24	184		5	268
7.2	5	27			36		9	78
7.3					55		1	57
TOTAL	6	238	141	120	5,405	302	678	6,889

3.3.6 Interior Drainage Residual Damages

The interior drainage analysis provided in the 2003 Feasibility Report subdivided the protected area into three main watershed areas: Chingarora Creek, Flat Creek, and East Creek. The subdivision of the interior area was maintained for the current analysis. Within the three watersheds, a total of ten interior areas were identified and evaluated. A brief summary of the interior drainage facilities selected for each interior area is provided below, and shown in Figure 5.

Interior Facilities for Chingarora Creek

The Chingarora Creek watershed lies in the westernmost portion of the study area, and comprises an area of approximately 265 acres, which was divided into a series of smaller individual areas (a total of seven); all of these areas are located along the right bank of Chingarora Creek.

Chingarora Creek Area CI-l consists of approximately 13 acres, and is located in the southwestern portion of the Chingarora Creek watershed. The 2003 analysis optimized interior drainage features as minimum facilities. Minimum facility conditions for Interior Area CI -1 consist of a 36-inch reinforced concrete pipe (RCP) primary outlet, a 24-inch RCP secondary outlet, and 90 linear feet of channel excavation.

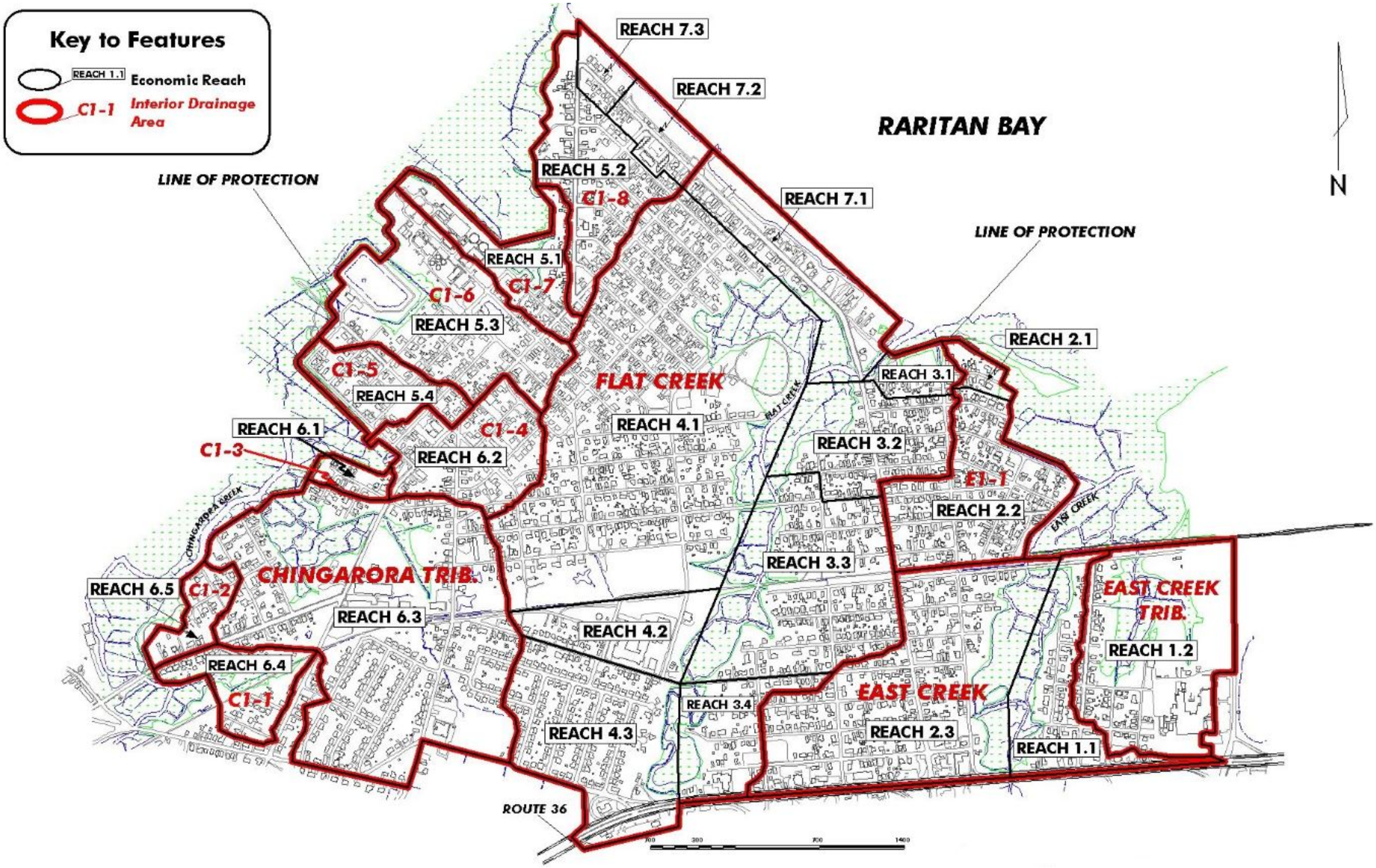
Chingarora Creek Area CI-2 is also located in the southwestern portion of the Chingarora Creek watershed, lying just west of area CI-l. Interior area CI-2 accounts for roughly 7 acres of the Chingarora Creek watershed. The 2003 analysis optimized interior drainage features as minimum facilities. Minimum facility conditions for Interior Area CI-2 consist of one 24-inch RCP primary outlet, two 18-inch RCP secondary outlets, and 380 linear feet of channel excavation.

Chingarora Creek Tributary Area is approximately 125 acres in area, and is located northeast of Interior Areas CI-l and CI-2 in the southern portion of the Chingarora Creek watershed. The 2003 analysis optimized interior drainage features as minimum facilities. Minimum facility conditions for the Chingarora Creek Tributary Interior Area incorporate the following: one twin 48-inch RCP primary outlet through the line of protection at the flood gate for the main channel, two 24-inch RCP secondary outlets, and three 6'x6' sluice gates to maintain the tidal interchange of the wetlands behind the line of protection.

Combined Chingarora Creek Areas CI-3, CI-4, and CI-5 is a combination of three small unir areas: CI-3, CI-4, and CI-5. Together, the combined Interior Area CI3-5 is approximately 40 acres in area, located north of the Chingarora Creek Tributary Interior Area. The 2003 analysis optimized interior drainage features as minimum facilities plus a 40 cfs pump station. In addition to the pump station, the facilities included consist of extending an existing 18-inch outlet with a 36-inch RCP primary outlet; one 36-inch RCP secondary outlet, one twin 24-inch RCP secondary outlet; five 24-inch RCP secondary outlets, one 36-inch RCP secondary outlet extension on an existing 24-inch outlet, and 725 linear feet of channel excavation.

Chingarora Creek Area CI-6 is located near the Monmouth County Outfall Authority settling pond and consists of approximately 36.0 acres. The 2003 analysis determined optimized interior drainage facilities as minimum facilities plus a ponding area. Minimum facility conditions in this interior area consist of a twin 48-inch RCP primary outlet, and a 48-inch RCP secondary outlet.

Figure 5
Interior Drainage Economic Reaches



Chingarora Creek Area CI-7 is located just north of Interior Area CI-6, and comprises an area of approximately 16 acres of the Chingarora Creek watershed. The 2003 analysis optimized interior drainage features as minimum facilities, which were defined as one 4-ft x 4-ft box culvert primary outlet, four 24-inch RCP secondary outlets, and 540 linear feet of channel excavation.

Chingarora Creek Area CI-8 comprises an area of approximately 29 acres, and is located on the Raritan Bay just north of Interior Area CI -7. Construction of a ponding area was identified as the most cost-effective interior facility for Interior Area CI -8 as part of the 2003 analysis. Also included in the interior drainage plan for Area CI-8 are one twin 24-inch RCP primary outlet, one twin 24-inch RCP secondary outlet, two 24-inch RCP secondary outlets, and approximately 230 linear feet of channel excavation.

Flat Creek consists of approximately 1,734 acres of tributary drainage area. The Flat Creek watershed originates upstream of Union Beach in Holmdel Township. The entire Flat Creek watershed tributary to the line of protection is included within this interior area. Minimum facilities for Flat Creek consist of six 60-inch RCP primary outlets through the line of protection at the floodgate for the main channel, and an existing 24-inch secondary outlet. A 35-ft floodgate will be used to maintain the tidal interchange of the wetlands behind the line of protection, which will be closed during storm events. The 2003 analysis determined that the most cost-effective interior facility for the Flat Creek Interior Area was identified as the installation of a 250-cfs pump station accompanied by minimum facilities.

East Creek Area EI-1 is located at the northern limits of the East Creek watershed and consists of approximately 34 acres. In this area, minimum facility consists of a twin 36-inch RCP primary outlet, four 24-inch RCP secondary outlets, and 275 linear feet of channel excavation. Analyses conducted in 2003 determined that construction of a ponding area would be the most cost-effective interior facility for Interior Area EI-l.

East Creek / East Creek Tributary consists of approximately 1,601 acres tributary to the East Creek at the line of protection along Jersey Avenue. Minimum facilities for this area consist of a twin 60-inch RCP primary outlet through the line of protection at the floodgate for the main channel, a 60-inch RCP outlet through the line of protection at the East Creek Tributary main channel, and three 60-inch RCP secondary outlets. A 35 ft flood gate will be used to maintain the tidal interchange of the wetlands behind the line of protection at East Creek, and three 6 ft x 6 ft sluice gates will be used to maintain the tidal interchange of the wetlands behind the line of protection at the East Creek Tributary. These gates will be closed during storm events. Both the primary and secondary outlets are being provided with a flap gate, sluice gate, and trash rack. An equalization ditch will be provided along the levee to connect the East Creek and East Creek Tributary interior areas during low intensity, high frequency storm events. Drainage ditches will direct runoff along the protected side of the levee to a nearby outfall. Analyses conducted in 2003 determined that a 100 cfs pump alternative with a levee at 8 feet NGVD29 was selected for the combined East Creek/East Creek Tributary Interior Area.

Interior Drainage Residual Damages Update

Updated HEC-HMS models were developed in order to assess the changes to the ponding elevations at the line of protection due to: revisions in methodology for determining hypothetical rainfall data, the occurrence of additional storm events that changed the tailwater tide marigrams, and recalculation of ponding storage. Peak pond elevations were calculated for each of the 10 interior areas, and evaluated within HEC-FDA to determine residual interior drainage damages with the 2007 Authorized Plan interior drainage facilities in place. The results of the HEC-FDA analysis for interior drainage damages with the 2007 Authorized Plan interior drainage features in place are provided in Table 16, and amount to $562,000.

Table 16
Interior Drainage Residual Damages With Selected Features In Place

Damage Category	Residual Interior Drainage Damages
Apartment	$ 0
Commercial	$ 38,000
Industrial	$ 0
Municipal	$ 2,000
Residential	$ 499,000
Utilities	$ 0
Public Emergency Costs	$ 22,000
Total	**$ 562,000**

3.3.7 Damage Reduction Benefits

Damage reduction benefits are the difference between without-project conditions damages and with-project conditions damages annualized over the 50-year period of analysis. A summary of expected annual damages provided in the detailed tables above are summarized below.

Table 17
Summary of With and Without Project Condition / Equivalent Annual Damage
(50-Year Period of Analysis, $3^{1/8}$ % Discount Rate)

Damage Category	Without-Project Damages	With-Project Damages
Apartment	$ 6,000	$ 6,000
Commercial	$ 1,019,000	$ 238,000
Industrial	$ 212,000	$ 141,000
Municipal	$ 367,000	$ 120,000
Residential	$ 17,066,000	$ 5,405,000
Utilities	$ 1,151,000	$ 302,000
Damages to Structures & Contents	**$ 19,821,000**	**$ 6,212,000**
Public Emergency Costs	$ 1,942,000	$ 678,000
Total	**$ 21,763,000**	**$ 6,890,000**

Preliminary damage reduction benefits of $14,873,000 ($21,763,000 – $6,890,000) are calculated without consideration of residual interior drainage damages with the 2007 Authorized Plan in place. Residual interior drainage damages of $562,000 are then subtracted from the preliminary damage reduction benefits to arrive at total damage reduction benefits of $14,311,000 ($14,873,000 – $562,000).

4 Reevaluation of FIA Administrative Cost Reduction Benefits

The Borough of Union Beach participates in the National Flood Insurance Program (NFIP). Information received from the Federal Emergency Management Agency indicates that there are currently 1,195 structures within the Borough[5] whose owners are currently maintaining flood insurance policies. As a result of the implementation of any project that is certified by FEMA as meeting the requirements of the NFIP, policyholders within the protected area will no longer be required to maintain flood insurance. Avoided administrative costs for these policies are considered a benefit associated with that particular project.

Annual project benefits of $127,000 were attributed to reduced flood insurance administrative costs in the 2003 Feasibility Report. However, guidance issued since 2003 precludes the inclusion of benefits for projects that include a sacrificial feature, such as a protective dune. For this reason, reduced flood insurance administrative costs will not be claimed in this HSLRR evaluation.

5 Reevaluation of Recreation Benefits

The 2003 Feasibility Report provided an evaluation of the recreation benefits that could be realized from implementation of the project, and determined that the recreation benefits would amount to an annual value of $8,500. This document provides an update to recreation benefits of the project, but only to the extent that it uses information provided in Economic Guidance Memorandum, 16-03, Unit Day Values for Recreation for Fiscal Year 2016 to convert points to a unit day value dollar amount. The discussion of recreation benefits from the 2003 analysis is summarized below.

The two main recreational attractions to the area are beach attendance and fishing from shore. The main fishing areas are west of the town beach, to the mouth of Chingarora Creek, and from the terminal groin adjacent to the beach. In addition to fishing and bathing, the waterfront bulkhead receives heavy use by bicyclists, joggers and walkers throughout the year. A small boat-launching ramp, used during high tide, is located off Front Street at the mouth of Flat Creek.

5.1 Usage

In the 2003 analysis, data from nearby areas was used to aid in estimating beach attendance at Union Beach. Using information obtained during site inspections, in conjunction with data from previous surveys performed between Sandy Hook and Manasquan Inlet, an estimated attendance was developed as a function of the approximate number of area residents/visitors and their estimated frequency of attendance. Since the most popular fishing areas are in the vicinity of both the beach area and the available parking spaces, it was assumed that beach attendance would also include fishermen. It was also assumed that beach attendance would include walkers, joggers, and bicyclists.

[5] Number of policies stated as of 31 May 2014, see http://bsa.nfipstat.fema.gov/reports/1011.htm#NJT

A field survey determined that there are approximately 300 homes within reasonable walking distance to the beach (estimated to be a 1,000-foot distance), with an estimated three residents per household. Review of Contingent Valuation Method (CVM) surveys conducted at nearby beaches indicated that the typical local visitor uses the beach sixteen to twenty-six times per summer season. It was assumed that the immediate Union Beach populace would frequent the beach twenty times per summer season. Therefore, on average, local residents within walking distance were estimated to have 18,000 beach visits during the summer season (300 homes x 3 people/home x 20 visits/person). In addition to summer usage, these same nearby residents were assumed to use the shorefront throughout the year for many activities. It was assumed that the same base of 900 local residents use the facilities one time per week for each of 40 off-season weeks, which results in 36,000 off-season visits.

In addition to providing local residents with recreation space, the beach area provides a public recreation resource within reasonable travel distance of thousands of potential users. Attendance by day visitors was estimated as a function of the number of parking spaces available, the turnover rate of the spaces, and the length of the recreational season. In the analysis, parking space was limited to 88 spaces in shorefront parking lots and 40 street-side spaces. Based on the previous studies referenced for the 2003 analysis, it was estimated that each parking space would be occupied two times per day with two people per car during peak days (weekends and holidays). Off-peak days were estimated at fifty percent of peak days. Thus, usage by the visiting public was estimated as follows:

30 peak days x 2 car/space/day x 2 people/car x 128 spaces	= 15,360
60 off-peak days x 2 car/space/day x 2 people/car x 128 spaces x 50%	= 5,360
Summer Visitor Total	= 30,720

Therefore, there are an estimated 30,720 visits to the beach for bathing and fishing from non-local residents. Combining visits by area residents (18,000 + 36,000) with those by the visiting public (30,720) resulted in an estimated without-project annual use of the town beach and waterfront area of 84,720 user days.

5.2 Unit Day Value

The Unit Day Value (UDV) method was used to estimate the annual value of recreation benefits for the without-project condition, and for the with-project condition. With the use of guidelines established in ER 1105-2-100 (Apri1 2000), points were assigned to various criteria under existing without-project conditions and future with-project conditions. These points were then converted to dollar values, which were applied to the attendance data described above.

5.2.1 Unit Day Value – Without-Project Conditions

The 2003 UDV analysis of the waterfront area for the existing without-project condition is shown in Table 18, which indicates that the point total for this scenario is 33. This point total was then converted to a dollar value in accordance with the standard tables of general recreational values found in Economic Guidance Memorandum, 01-01, Unit Day Values for Recreation for Fiscal Year 2002. The current analysis converts the 33 points to a dollar value using the standard tables of general recreational values found in Economic Guidance Memorandum, 16-03, Unit Day Values for Recreation for Fiscal Year 2016.

The 33-point conversion to dollar value for the without-project condition for the 2003 analysis, and the current analysis are:

- 2003 Analysis: 33 points = $ 4.55 per user day; and
- 2016 Analysis: 33 points = $ 6.30 per user day.

This dollar value was then applied to the attendance data to establish the estimated recreation value of the beach. The annual recreation value for the 84,720 visits are:

- 2003 Analysis: $ 4.55 per user day x 84,720 visits = $ 385,500 per year; and
- 2016 Analysis: $ 6.30 per user day x 84,720 visits = $ 533,700 per year.

Table 18
Without-Project Condition Unit Day Value Analysis

Criterion	Factors Affecting Point Values	Points Assigned
Recreation Experience Max Points: 30	The town beach was constructed in 1997. New parking areas were also added adjacent to the beach. The jetty and beach area west of the beach are popular local fishing areas. The waterfront bulkhead east of the beach provides an attractive walkway for joggers, bicyclists and walkers. In addition to the bathing and fishing areas, there is a waterfront bar and restaurant which offers outside dining on a deck over the water and scenic views of Raritan Bay and the New York City skyline. The Henry Hudson Trail, a former rail line converted to a walking/bicyc1e path, also passes through the town.	8
Availability of Opportunity Max Points: 18	With many local waterfront parks or beaches along the bayshore and numerous nearby ocean beaches, availability of opportunity is moderately high. Although this site offers recreational swimming, there are no town lifeguards. The community notes the popularity of its shoreside fishing.	3
Carrying Capacity Max Points: 14	The new public beach and jetty provide moderate space for the general public as well as an opportunity for water-oriented activities such as swimming and fishing. The small boat ramp, although limited to use at high tide, provides boating access to the shoreside fishing areas.	6
Accessibility Max Points: 18	Access via Route 36, the only road that connects all of the Bayshore communities, is often impeded by traffic congestion resulting from the high volume of visitors to Sandy Hook. The roads within the site are in good condition and there is ample parking at the beach/bulkhead. There are limited parking facilities in the area providing access to the Henry Hudson Trail. A portion of the use is estimated to be from the local residents who enjoy excellent access to walk, jog or ride bikes to or at the site.	8
Environmental Max Points: 20	Due to the general esthetic qualities of waterfront parks and beaches, the esthetics quality of the Bayfront area is reasonably good. Although periodic moderate erosion of the beach may limit the esthetics value, renourishment plans should ensure that the beach condition is maintained. Several scenic resources are also available including spacious wetlands, various wildlife, open areas, and a view of the Manhattan Skyline. Although perception of the water quality tends to be negative due to the proximity of NYC and Raritan River drainage, bay waters generally exceed the standards required for swimming.	8
Total Points		33

5.2.2 Unit Day Value – With-Project Conditions

The 2003 analysis also used the Unit Day Value method to estimate the annual value of recreation use for with-project conditions. The with-project condition UDV analysis shown in Table 19 reflects the minimal change the proposed project will have on recreation experience.

The point total for proposed with-project conditions was determined to be 34 – an increase in one point from without-project conditions. This point total was converted to a dollar value in accordance with the standard tables of general recreation values, as outlined above. The 34-point conversion to dollar value for the with-project condition for the 2003 analysis, and the current analysis are:

- 2003 Analysis: 34 points = $ 4.65 per user day; and
- 2016 Analysis: 34 points = $ 6.44 per user day.

This dollar value was then applied to the attendance data to establish the estimated recreation value of the beach. The with-project annual recreation value for the 84,720 visits are:

- 2003 Analysis: $ 4.65 per user day x 84,720 visits = $ 394,000 per year; and
- 2016 Analysis: $ 6.44 per user day x 84,720 visits = $ 545,600 per year.

5.3 Net Recreation Benefits

Net recreation benefits for with-project conditions are calculated by subtracting the without-project condition recreation values from the with-project condition recreation values. Net recreation benefit values for the 2003 analysis and the current update are:

- 2003 Analysis: $ 8,500 = $ 394,000 – $ 385,500
- 2016 Analysis: $ 11,900 = $ 545,600 – $ 533,700

Table 19
With-Project Condition Unit Day Value Analysis

Criterion	Factors Affecting Point Values	Points Assigned
Recreation Experience Max Points: 30	No significant change.	8
Availability of Opportunity Max Points: 18	No significant change.	3
Carrying Capacity Max Points: 14	Increasing the size of the beach will increase the available beach space. The construction of terminal groins will provide additional fishing potential. The storm closure gate on Flat Creek should not significantly limit the use of the boat ramp.	9 (increase from 6)
Accessibility Max Points: 18	No significant change.	8
Environmental Max Points: 20	The project would have several impacts upon aesthetic resources. The dune would create a barrier between the beach and promenade, creating a more natural isolated beach environment. The view of the beach from the promenade and from Front Street will be somewhat obstructed, however, reducing some aesthetic qualities. When combined with the impact of the gates, pump stations, and floodwalls, a slight decrease in the overall environmental conditions could be realized.	6 (reduction from 8)
Total Points		34 (increase of 1)

6 Reevaluation of Reduced Maintenance Benefits

In the absence of a Federal project, it is anticipated that the Borough of Union Beach will continue to conduct annual beach nourishment operations in the Front Street area. Based upon information provided by the Borough for the 2003 Feasibility Report, an amount of $25,000 was budgeted annually to cover expenses associated with this activity.

The 2007 Authorized Plan incorporates future periodic nourishment as a design feature. Costs associated with this activity are included in the plan's annual cost. As such, periodic nourishment expenditures, which would have occurred in the without-project future condition, may be included as a reduced maintenance benefit. In this case that amount equals $25,000 per year and is applicable to the with-project condition.

7 Project Costs Comparison

In the case of explaining Union Beach's maintained economic justification with a near tripling of costs, it is useful to first examine the change in project costs and annualized costs. Project costs represented in the September 2003 Feasibility Report (page 306), and project costs for the HSLRR are shown below in Table 20 below.

Table 20
Project Cost and Annualized Cost Comparison – 2003 and 2016

	2003 Feasibility Estimate	2016 HSLRR Estimate
Initial Project Cost	96,669,300	273,005,000
Interest During Construction	7,237,700	20,402,000
Total Investment Cost	103,907,000	293,407,000
Annualized Investment Cost	6,478,000	11,675,500
Annual LOP System O&M Costs	231,000	685,200
Annual Interior Drainage O&M Costs	155,000	650,900
Annual Project Cost (50 years)	6,864,000	13,011,600

As shown in the table, total investment costs as reported in the September 2003 Feasibility Report have increased by $189.5 million (a 182% increase) in this 2016 HSLRR, though the annualized investment costs have increased by only $5.20 million (a 80% increase), and total annual costs have increased by $6.1 million (a 90 % increase).

The increase in annualized and total annual costs is not as dramatic as the increase in total investment costs because the annualized investment costs in the September 2003 Feasibility Report were calculated using a discount rate of $5^{7/8}$ percent, and the discount rate used in the 2016 HSLRR is $3^{1/8}$ percent. The annual cost impact of the discount rate change is significant, and helps to explain why economic justification is maintained when the project cost has more than doubled – economic justification is based on a comparison of annual benefits to annual costs.

7.1 Interest During Construction

Interest during construction (IDC) was calculated to account for the cost of capital during the construction period prior to the realization of project benefits. Upon completion of an initial cost estimate for this reevaluation study, it was decided that the project could be broken into 5 construction phases to properly account for escalation, multiple mob/demob, etc., and move forward as quickly as possible. All drainage structures, pump stations, road raisings and pump stations would be constructed in their respective phases. Phase 1 construction would start in January 2018, and all phases would be completed by early 2022. The phasing plan is provided below.

7.1.1 Phase 1 – Shoreline Protection

Construction Initiation: January 2018, Construction Duration: 12 months

The entire beachfront line of protection would be constructed under one contract. Since this feature would be outflanked by a large storm event, consideration will be given to including the portion of levee parallel to Flat Creek to minimize wave damage to the condominium complex before Phases 3 or 4 are completed.

7.1.2 Phase 2: Flat Creek to East Creek Levee and Floodwall and Interior Levee

Construction Initiation: July 2019, Construction Duration: 30 months

This contract begins at the eastern terminal groin at the beachfront and extends along Flat Creek to Front Street before extending Oceanside of Brook Avenue toward East creek . The levee/floodwall then parallels East Creek before turning east along the Henry Hudson Bike Trail and tying into the levee constructed under Phase 3.

7.1.3 Phase 3 - East Creek Levee East of East Creek only

Construction Initiation: January 2019, Construction Duration: 12 months

This contract represents the initial levee construction by beginning just east of East Creek and extending to the eastern tie-out with the existing Keansburg levee. The existing bikeway will be rebuilt on top of the new levee embankment. Drainage facilities include three 6’x6’ tide gates with sluice gates and four 60” culverts with sluice gates and flap gates

7.1.4 Phase 4: Chingarora Levee and Floodwall

Construction Initiation: July 2019, Construction Duration: 33 months

Under this major contract, the entire western reach of the levee and floodwall line of protection would be constructed from the beginning near Bank Street across the Henry Hudson Bike Trail to the Broadway Closure Gate. Levee and floodwall continue along the rear of properties past Ash Street, along Bay Avenue and Chingarora Street, around the Regional Treatment facility, then parallel to Dock Street before tying into the western terminal groin and dune. Construction of drainage facilities will need to be closely coordinated with the levee and floodwall construction. This phase would complete the coastal storm risk management components for the Union Beach project.

7.1.5 Phase 5: Environmental Mitigation

Construction Initiation: June 2018, Construction Duration: 12 months

The Selected Mitigation Plan would convert 12.0 acres of wetland Phragmites in the Flat Creek area to 10.0 acres of salt marsh and 2 acres of wetland scrub-shrub habitat. Also in the Flat Creek area, 2.5 acres of upland Phragmites would be converted to wetland herbaceous/scrubshrub habitat. The Selected Mitigation Plan for the East Creek area would convert 3.0 acres of wetland Phragmites to wetland scrub-shrub habitat. The 2016 HSLRR Proposed Plan will impact 22.0 acres of wetlands, though development of the HSLRR mitigation plan has been deferred to PED. It is expected that mitigation for the additional 4.5 acres of wetland impacts will be addressed in a manner similar to the mitigation plan developed for the overall 2007 Authorized Plan.

7.1.6 Interest During Construction Calculation

Construction costs were separated into three categories for the IDC analysis: initial costs, phasing costs, and construction costs. Initial costs include the costs of real estate acquisition, which were assumed to be incurred at the inception of the project in January 2018. Phasing costs include PED and Utility Relocation, which were assumed to be incurred at the beginning of each construction phase. Construction costs, which include all construction features and construction management, were assumed to be distributed evenly across each construction period of each phase. Project costs were amortized over the expected period of project construction (52 months) at an interest rate of $3^{1/8}$ percent, and all interest charges were accrued at mid-month. Table 21 shows the IDC calculations for the HSLRR Recommended Plan.

Table 21
Interest During Construction ($1,000)

Month	Year	Real Estate	Reloc	Structures	PED	Cons Mgt	Spent in Period	Months to Completion	Interest
Jan	2018	16,699	1,793	3,860	5,568	253	28,172	50.5	3,895
Feb	2018			3,860		253	4,112	49.5	557
Mar	2018			3,860		253	4,112	48.5	545
Apr	2018			3,860		253	4,112	47.5	533
May	2018			3,860		253	4,112	46.5	521
Jun	2018			4,974	1,488	323	6,785	45.5	840
Jul	2018			4,974		323	5,297	44.5	640
Aug	2018			4,974		323	5,297	43.5	625
Sep	2018			4,974		323	5,297	42.5	610
Oct	2018			4,974		323	5,297	41.5	595
Nov	2018			4,974		323	5,297	40.5	580
Dec	2018			4,974		323	5,297	39.5	565
Jan	2019		342	1,621	933	104	3,001	38.5	311
Feb	2019			1,621		104	1,726	37.5	174
Mar	2019			1,621		104	1,726	36.5	169
Apr	2019			1,621		104	1,726	35.5	164
May	2019			1,621		104	1,726	34.5	160
Jun	2019			507		35	541	33.5	49
Jul	2019		52	5,183	17,077	329	22,642	32.5	1,968
Aug	2019			5,183		329	5,513	31.5	464
Sep	2019			5,183		329	5,513	30.5	448
Oct	2019			5,183		329	5,513	29.5	433
Nov	2019			5,183		329	5,513	28.5	418
Dec	2019			5,183		329	5,513	27.5	403
Jan	2020			4,677		295	4,972	26.5	350
Feb	2020			4,677		295	4,972	25.5	336
Mar	2020			4,677		295	4,972	24.5	322
Apr	2020			4,677		295	4,972	23.5	309
May	2020			4,677		295	4,972	22.5	295
Jun	2020			4,677		295	4,972	21.5	282
Jul	2020			4,677		295	4,972	20.5	268
Aug	2020			4,677		295	4,972	19.5	255
Sep	2020			4,677		295	4,972	18.5	242
Oct	2020			4,677		295	4,972	17.5	228
Nov	2020			4,677		295	4,972	16.5	215
Dec	2020			4,677		295	4,972	15.5	202
Jan	2021			4,677		295	4,972	14.5	188
Feb	2021			4,677		295	4,972	13.5	175
Mar	2021			4,677		295	4,972	12.5	162
Apr	2021			4,677		295	4,972	11.5	149
May	2021			4,677		295	4,972	10.5	136
Jun	2021			4,677		295	4,972	9.5	123
Jul	2021			4,677		295	4,972	8.5	110
Aug	2021			4,677		295	4,972	7.5	97
Sep	2021			4,677		295	4,972	6.5	84
Oct	2021			4,677		295	4,972	5.5	71
Nov	2021			4,677		295	4,972	4.5	58
Dec	2021			4,677		295	4,972	3.5	45
Jan	2022			3,089		194	3,284	2.5	21
Feb	2022			3,089		194	3,284	1.5	13
Mar	2022			3,089		194	3,284	0.5	4
TOTAL		16,699	2,187	213,345	25,066	13,708	273,005		20,402

8 Project Benefits and Economic Performance Comparison

Project benefits represented in the September 2003 Feasibility Report (Appendix B), and project benefits calculated under the current analysis are shown below in Table 22. As shown in the table, the economic performance metrics of the project, as represented by the Benefit-to-Cost ratio and Net Excess Benefits, indicate that the project remains economically justified.

Table 22
Annual Project Benefits and Economic Performance Comparison

	2003 Feasibility	2016 HSLRR
Without-Project Expected Annual Damages	11,047,000	19,821,000
Without-Project Expected Annual Emerg Svc Costs	1,554,000	1,942,000
With-Project Expected Annual Damages	1,069,000	6,212,000
With-Project Expected Annual Emerg Svc Costs	186,000	678,000
Benefits: Reduced Damage to Structures	9,978,000	13,609,000
Benefits: Reduced Public Emergency Costs	1,368,000	1,264,000
Benefits: Reduced FIA Administration Costs	127,000	0
Total Annual Flood Damage Reduction Benefits	11,174,000	14,873,000
Less: Residual Interior Drainage Damages with Selected Features in Place	474,000	562,000
Net Flood Damage Reduction Benefits	10,999,000	14,311,000
Ancillary Benefits: Reduced Maintenance	25,000	38,000
Ancillary Benefits: Recreation[6]	8,500	12,500
TOTAL ANNUAL PROJECT BENEFITS	**11,159,500**	**14,361,500**
TOTAL ANNUAL PROJECT COSTS	**6,864,000**	**13,011,600**
BENEFIT TO COST RATIO	**1.6**	**1.1**
NET EXCESS ANNUAL BENEFITS	**4,295,500**	**1,349,900**

[6] It is important to note that the project remains justified without the inclusion of annual recreation benefits of $12,500 and reduced maintenance benefits of $38,000 in the benefit-to-cost ratio.