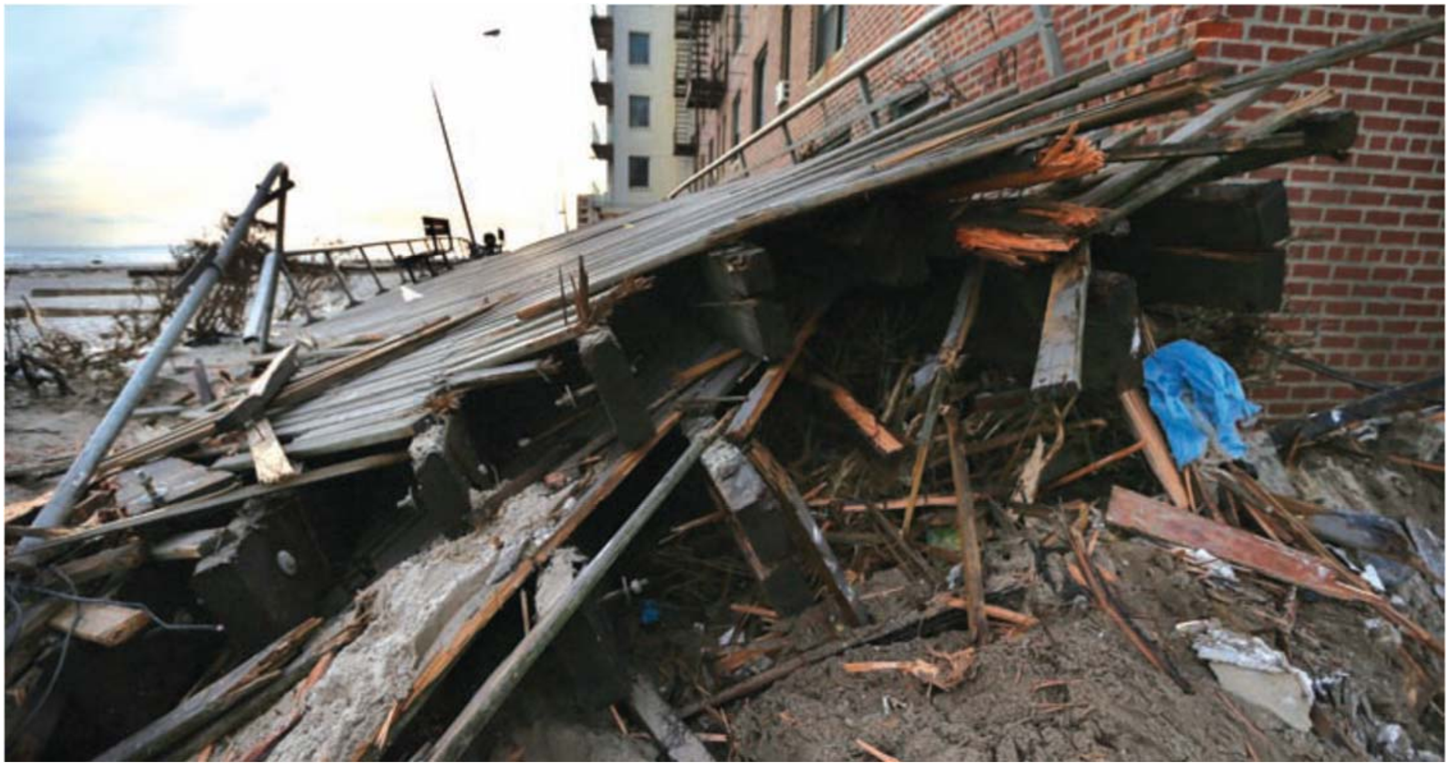
US Army Corps
of Engineers
New York District

Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet and Jamaica Bay



Draft Integrated Hurricane Sandy General Reevaluation Report and Environmental Impact Statement

Benefits Appendix Overview

August 2016

Economics Appendix:
Atlantic Coast of New York
East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

Draft Hurricane Sandy General Reevaluation Report
and Environmental Impact Statement

This Economics Appendix consists of multiple Sub appendices as described below.

- Appendix D-1 Atlantic Shoreline Planning Reach Benefits

  This appendix presents the benefits and associated analysis procedures used in the determination of the economic viability for Federal participation in in coastal storm risk management for the Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet and Jamaica Bay project. Since each of the two planning reaches in the larger study area are subject to distinct risk mechanisms, the evaluation of with and without project damages requires a different model. Specific information in this appendix, relates only to the Atlantic Shoreline Planning Reach which is at risk from erosion, wave attack and inundation. This document, which is an appendix to the Hurricane Sandy General Reevaluation Report (HSGRR), evaluates existing and future without-project conditions, of the alternative scales of the Atlantic Shoreline components of the Tentatively Selected Plan (TSP). The Atlantic Shoreline benefit analysis was prepared initially as a legacy study and has been incorporated into a SMART planning study within the Main HSGRR.

  This Appendix includes:

  Sub-Appendix A = Value of Development by Subreaches
  Sub-Appendix B = Damage Functions
  Sub-Appendix C = Recreation Benefits Report

Estimates of current damages are based on January 2015 price levels and a 50-year period of economic analysis. Damages have been annualized over the 50-year period of economic analysis using the fiscal year 2016 discount rate of $3^{1/8}$ percent.

- Appendix D-2 Jamaica Bay Planning Reach Benefits

This appendix provides the benefits and associated analysis procedures used in the determination of the economic viability for Federal participation in coastal storm risk management for the Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet and Jamaica Bay project. Since each of the two planning reaches in the larger study area are subject to distinct risk mechanisms, the evaluation of with and without project damages requires a different model. Specific information in this appendix, relates only to the Jamaica Bay Planning Reach which is most impacted by inundation. This document, which is an appendix to the Hurricane Sandy General Reevaluation Report (HSGRR), evaluates existing and future without-project conditions, as well as alternative plans and the Tentatively Selected Plan (TSP). The Jamaica Bay planning reach benefits analysis was completed as a SMART planning study and has been consolidated with the Atlantic Shoreline planning reach benefits in the Main HSGRR.

Estimates of current damages are based on January 2016 price levels and a 50-year period of economic analysis, and reflect the economic condition of the study area as of December 2016. 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 2020 (projected project completion year), and the 50-year period of analysis is 2020 to 2070.

ATLANTIC COAST OF NEW YORK,
EAST ROCKAWAY ROCKAWAY TO INLET AND JAMAICA BAY

HURRICANE SANDY INTEGRATED GENERAL REEVALUATION STUDY AND ENVIRONMENTAL IMPACT STATEMENT

APPENDIX D-1 Atlantic Shoreline Benefits

US Army Corps of Engineers
New York District

July 2016

DISCLAIMER

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INTRODUCTION

Purpose and Scope

1. This interim report documents the procedures and results of the economic storm damage analysis for the Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet and Jamaica Bay, Hurricane Sandy General Reevaluation Study. This document presents the findings of the different benefit and cost assessments in a format that will facilitate plan selection decisions. The alternatives discussed in the document are limited to plans constructed along the Atlantic Shoreline planning reach and do not include alternatives to manage risk associated with flooding from Jamaica Bay.

2. The data compilation and analysis is initially presented based on the Low Sea Level Rise scenario, which assumes a continuation of historic sea level changes. The scenario analysis considers two additional accelerated sea level change scenarios.

3. Economic analyses include development of stage versus damage relationships and annual damages over a 50-year analysis period. Damage assessments include damages due to tidal flood inundation along the shoreline and damages caused by cross-shore/backbay flooding.

4. Benefits that were evaluated for the alternatives are:
    - Reduced inundation damage to structures
    - Costs avoided (Emergency Nourishment)
    - Cross shore flood damages reduced
    - Recreation

5. Estimates of damages are based on January 2015 price levels and a 50-year period of analysis. Damages have been annualized over the 50-year analysis period using the fiscal year 2015 discount rate of 3.375 percent.

6. This Benefits Appendix:
    - provides an overview of the problems and opportunities,
    - describes the without-project future conditions,
    - summarizes the analysis methodologies, and
    - evaluates storm damage reduction benefits.

Prior Studies

History of Federal Participation

7. In an application dated January 6, 1959, a cooperative beach erosion control study was initiated by the State of New York acting through the Long Island State Park Commission. The application requested a study of the Atlantic Coast of Nassau County, New York, between Jones Inlet and East Rockaway Inlet; Atlantic Coast of New York City, between East Rockaway Inlet and Norton Point; and Staten Island, New York, between Fort Wadsworth and Arthur Kill. The Chief of Engineers approved the application on March 23, 1959, in accordance with Section 2 of Public Law 520 (River and Harbor Act of 1930).

8. In response to severe damage to coastal and tidal areas of the eastern and southeastern United States from the hurricanes of August 31, 1954 and September 11, 1954 in New England, New York and New Jersey and the damages caused by other hurricanes in the past, a hurricane study was authorized by Public Law 71, 84th Congress, 1st Session on June 15, 1955. A combined report covering the cooperative beach erosion control study and the hurricane survey was approved by the Chief of Engineers on December 7, 1960.

Prior Projects

9. The shorefront of the Rockaway Peninsula has had a long history of beach nourishment and erosion control structures. The shoreline has been stabilized since the 1880s with beach fill, groins, bulkheads, and a stone jetty at Rockaway Inlet. An overview of key activities is presented here. Additional details are provided in the main text.

10. <u>1910 to 1962</u>. From 1910 to 1962, over 200 timber and stone groins were constructed along Rockaway's beaches. Over this same time period, approximately 12 million cubic yards of sediment were placed along the beach. Beachfill operations were a mixture of either inlet maintenance dredging of East Rockaway and Rockaway Inlets or larger beach restoration projects with sediment dredged from offshore borrow areas.

11. <u>WRDA 1974 Beach Erosion Control Project (1978 to 1988)</u>. The multiple purpose beach erosion control and hurricane protection project was authorized by the Flood Control Act of 26 October 1965. It was then modified by Section 72 of the Water Resources Development Act of 6 March 1974, which authorized the separate construction of the beach erosion control portion.

12. The project provided for the restoration of a protective beach along 6.2 miles of Rockaway Beach, between Beach 19th Street and Beach 149th Street. The project authorization also

provided for Federal participation in the cost of periodic beach nourishment to stabilize the restored beach for a period not to exceed ten years after the completion of the initial beach fill. A post-authorization change allowed the construction of 380-foot long quarry stone groin at the western limit of the project in the vicinity of Beach 149th Street in 1982.

13. The initial nourishment was completed from 1975 to 1977. The authorized construction profile varied along Rockaway Beach with berm widths of between 100 and 200 feet. The storm damage reduction features of the authorized project consisted only of a 100-foot berm width. The top of the berm elevation was constructed to +9 feet NAVD88. A total of 6,634,000 cubic yards of fill were placed during initial construction.

14. Five renourishment operations and one emergency renourishment operation were performed over the 10 years following initial construction. Renourishment operations entailed constructing feeder beaches in the two most highly erosive areas in the project area. The expectation was that the material would be eroded from those areas and would supply, or feed, sand to the rest of the project area, thereby offsetting long-term erosion. However, monitoring of the shoreline positions between renourishment cycles showed the authorized beach dimensions were not maintained along the project area. A total of 6,364,000 cubic yards of fill were placed during these activities between 1978 and 1988.

15. <u>Section 934 Beach Erosion Control Project (1996 to 2004)</u>. Additional erosion after the WRDA 1974 authorization expired led to a second major construction effort authorized through Section 934 of the Water Resources Development Act of 1986, which allowed continued Federal participation in periodic beach fill nourishment. A total of 2,685,000 million cubic yards of fill were placed as part of this project. Initial construction was completed in 1996 and two renourishment operations occurred in 2000 and 2004. The construction profile dimensions were the same as the WRDA 1974 Project except that all berm widths were 100 feet. Advance fill was placed during initial construction.

16. The Section 934 Project placed renourishment along the entire project area during each renourishment operation. Inlet maintenance dredging operations also occurred four times over the project period (in 1998, 2000, and 2002; and again between 2004 and 2005). During each renourishment, the beach was restored to its authorized dimension plus advance fill. Including inlet maintenance dredging operations, approximately 354,000 cubic yards per year were placed in the project area in the eight years after initial construction between 1996 and 2004.

17. Flood Control and Coastal Emergencies (FCCE) Act (2013 to 2014). After Hurricane Sandy, the Corps of Engineers was authorized to repair the previously constructed project and return the project area to pre-storm conditions. Roughly 3.5 million cubic yards of sand were placed on the beaches building a wide berm and dune with a crest elevation of +16 feet NAVD88.

Description of the Study Area

Location

18. The Atlantic Shoreline planning reach of the study area extends the full length of the Rockaway Peninsula, from Rockaway Inlet on the west, to Beach 19th Street on the east (Figure 1). The Rockaway Peninsula is a narrow strip of land in the Atlantic Coastal Plain, stretching along the western end of the South Shore of Long Island. Located in in Queens County, New York, it is approximately 11 miles in length, averages less than 0.75 miles in width, and is about 7 square miles total[i]. Jamaica Bay forms the northern border of the peninsula. Across the bay are Kings County (Brooklyn) and the remainder of Queens County. At the west end of the peninsula, Rockaway Inlet connects Jamaica Bay to the Atlantic Ocean. On the south, the peninsula is bounded by the Atlantic Ocean. East of the peninsula, close to where it connects to the mainland, is Nassau County, including the barrier islands of Long Beach and Jones Beach. The Rockaway Peninsula encompasses multiple communities, including Breezy Point, Roxbury, Neponsit, Belle Harbor, Rockaway Park, Seaside, Hammel, Averne, Edgemere, and Far Rockaway[ii].

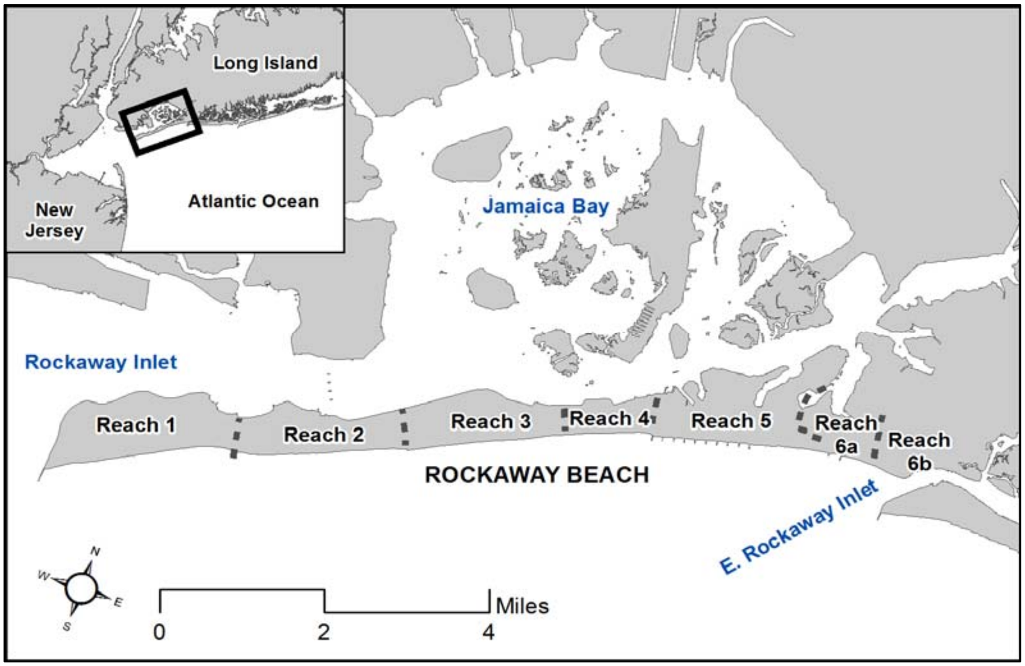


Figure 1: Overview of Rockaway Beach Including Coastal Reaches

Physical Setting

19. The project area terrain is virtually flat across the peninsula. Development generally extends from the Atlantic Ocean beachfront north to Jamaica Bay, from Breezy Point on the far west end of the peninsula to Far Rockaway in the east, with the exception of Jacob Riis Park and Fort Tilden.

20. Historical records and existing topography indicate that most structures within the study area neighborhoods are susceptible to significant flooding. Nearly 7,200 buildings were identified as being susceptible to storm damage in the area of the peninsula covered by this analysis, with virtually all structures located in the one percent annual chance of exceeding (ACE) floodplain.

Accessibility

21. The study area is secluded from the rest of the surrounding metropolitan area by the expanse of water that surrounds it. The peninsula connects to the mainland on the east, where the Rockaway Freeway and Beach Channel Drive provide access to the study area via Rockaway Boulevard and Seagirt Boulevard. From the north, two bridges connect Rockaway Peninsula to the mainland; one runs out of Kings County, the other from Queens County. From Kings County, the Gil Hodges Memorial Bridge connects Flatbush Avenue with Beach Channel Drive and Rockaway Boulevard in the study area. In addition to providing direct access from numerous local streets in Brooklyn, Flatbush Avenue runs northwest to Manhattan via the Manhattan Bridge. It also connects with the Brooklyn-Queens Expressway. From Queens, the Cross Bay Bridge connects Woodhaven Boulevard/Crossbay Boulevard with Beach Channel Drive in the study area. On the mainland, Woodhaven Boulevard runs north to connect to the east-west corridors of the Long Island Expressway, the Jackie Robinson Parkway, and the Belt Parkway. From an evacuation, and disaster response and recovery perspective, the water surrounding the Rockaway Peninsula and the area’s limited vehicular access routes have the effect of hampering storm evacuation and recovery, a condition that is expected to worsen in the future as more and more of the peninsula is built-out.

22. The Rockaway Peninsula is served by various rail and bus transportation alternatives for those lacking vehicle access or preferring to use public transit. These include:
    - MTA/ New York City Subway - A Train (IND Rockaway Line and Rockaway Shuttle)
    - LIRR – Far Rockaway Branch
    - Q35 – Rockaway Park - Brooklyn College

- Q52 – Elmhurst - Arverne Limited
- Q53 – Woodside - Rockaway Park Limited
- Q113 – Guy Brewer Boulevard - Rockaway Turnpike
- QM16 – Neponsit - Midtown
- QM17 – Far Rockaway – Midtown
- N31 – Far Rockaway – Lynbrook/Hempstead
- N32 – Far Rockaway – Lynbrook/Hempstead
- N33 – Long Beach – Far Rockaway
- NYC Beach Bus From Downtown Brooklyn or Williamsburg

23. After the A Train tracks through Jamaica Bay were washed out by Hurricane Sandy, the Rockaway Line was shut down for a period of seven months before it was restored in late May 2013. In response, New York City subsidized a temporary ferry service from Beach 108th Street to Wall Street, with stops at the Brooklyn Army Terminal and a free transfer to 34th Street. The ferry operated year round, Monday through Friday, to compensate for the damaged subway lines. Funding for the ferry was discontinued in October 2014. A summer ferry service does exist. The lack of regular ferry service at this time provides one less transit option for those who may need to evacuate the peninsula in future disaster scenarios. It is possible that the daily ferry service will be reinstated. As part of the Federal Transit Administration (FTA) Emergency Relief Program & Disaster Relief Appropriations following Hurricane Sandy, New York City and the Metropolitan Transportation Authority (MTA) have requested and received significant funding to improve the resiliency of the A-line and other evacuation routes in the study area.

24. Large scale mandatory evacuations in a disaster scenario in areas where a high proportion of residents lack access to a vehicle can be particularly problematic as public transit systems become overloaded with a sudden influx of riders. System capacity is often a constraint during evacuation, as sudden surges in ridership cannot be accommodated by the system in time to transport all riders out of harm's way before the event occurs. This is a particular vulnerability on the Rockaway Peninsula because it is surrounded by water and emergency evacuation on foot is not possible.

25. While not evaluated in economic terms, the project is expected to provide some level of protection to the evacuation routes.

Demographics

26. The Rockaway Peninsula comprises Queens Borough Community District 14. Total population of District 14 was 114,978 in 2010. Approximately 55 percent of the population of District 14 (63,664) reside within the limits of the study area. A very small proportion of

the population of Queens County resides on the Rockaway Peninsula (approximately 5 percent in 2010). The population on the Peninsula has been increasing rapidly since the 1990s (**Table 1**).

Table 1: Historical Populations, Rockaway Peninsula, Queens County, New York City[iii]

Region	1980	1990	2000	2010	2014
Rockaway Peninsula	100,590	100,596	106,686	114,978	Not Available
Rockaway Peninsula, net change from prior decade	Not available	6	6,090	8,292	Not Available
Queens	1,891,325	1,951,598	2,229,379	2,230,722	2,321,580
New York City	7,071,639	7,322,564	8,008,278	8,174,959	8,491,079

27. Sixty-five percent of the population on the Rockaway Peninsula is of minority status. Minority populations tend to have higher rates of vulnerability at all stages of disaster. Real estate discrimination is sometimes observed among minority populations, as is employment discrimination. For the subset of the minority population with limited English proficiency, disaster communications can be difficult or impossible, particularly for non-English and non-Spanish speakers for whom translators and accurate translations of advisories and directives may be scarce. **Table 3** provides Census 2010 ethnicity statistics for the Rockaway Peninsula as compared to Queens County and New York City.

Table 3: Ethnicity Statistics, Rockaway Peninsula

Race	Rockaway Peninsula[iv]		Queens County[v]		New York City[vi]	
	Population	%	Population	%	Population	%
White	40,446	35%	886,053	40%	3,597,341	44%
Black/African American	44,663	39%	426,683	19%	2,088,510	26%
Asian	2,555	2%	511,787	23%	1,038,388	13%
Other	1,249	1%	305,286	14%	1,124,993	14%
Two or More Races	1,950	2%	100,913	5%	325,901	4%
Hispanic Origin (of any race)	24,098	21%	613,750	28%	2,336,076	29%
Total	**114,961**	**100%**	**2,230,722**	**100%**	**8,175,133**	**100%**

28. As shown in **Table 4**, it is estimated that 21 percent of the population on the Rockaway Peninsula is either under the age of 5 (8 percent) or over the age of 64 (13 percent). This is

slightly higher than the percentage observed in Queens County (19 percent) and New York City (18 percent). These two particular subsets of the peninsula's population, the very young and the elderly, tend to require unique types of assistance in terms of preparation for, response to, and recovery from natural disasters.

Table 4: Population Statistics, Rockaway Peninsula, Queens County, New York City [vii]

Age Subgroup	Rockaway Peninsula		Queens County		New York City	
	Total	**%**	**Total**	**%**	**Total**	**%**
Female	60,955	53%	1,150,919	52%	4,292,589	53%
Male	54,006	47%	1,079,803	48%	3,882,544	47%
Under 5 years	8,864	8%	132,464	6%	517,724	6%
5 to 19 years	25,172	22%	386,268	17%	1,477,146	18%
20 to 64 years	65,611	57%	1,425,844	64%	5,187,105	63%
65 years and over	15,314	13%	286,146	13%	993,158	12%
Total Population	**114,961**	**100%**	**2,230,722**	**100%**	**8,175,133**	**100%**
Median age (years)	36.7[viii]		37.2		35.5	

29. **Table 5** shows household statistics for Rockaway Peninsula, Queens, and New York City. According to the Statement of Community District Needs for FY2016, Rockaway Peninsula has 4,200 units of public housing, 5,400 adult and nursing home beds, over a dozen group homes, and four drug and alcohol rehabilitation centers. A homeless shelter was recently opened on Beach 65th Street.[ix] Populations residing in some types of group quarters are particularly vulnerable during times when evacuation is required. For example, medical needs and limited mobility of certain residents can reduce the speed with which facility staff can remove their residents. Specialized vehicles and/or additional staff are sometimes required. Many institutions are not prepared to evacuate a high volume of residents – some of whom may have special needs and/or disabilities - efficiently and effectively in a disaster situation.

Table 5: Household Statistics, Rockaway Peninsula, Queens County, New York City[x]

Household Category	Rockaway Peninsula		Queens County		New York City	
	Number	%	Number	%	Number	%
Total population	114,961	100%	8,175,133	100%	2,230,722	100%
In households	109,619	95%	7,989,603	98%	2,202,722	99%
In family households	93,531	81%	6,377,302	78%	1,870,964	84%
In nonfamily households	16,088	14%	1,612,301	20%	331,758	15%
In group quarters	5,342	5%	185,530	2%	28,000	1%

30. **Table 6** shows the percentage of the population receiving income support for Rockaway Peninsula, Queens, and New York City. Types of income support in the table include: cash assistance under the federal Temporary Assistance for Needy Families (TANF) program, where monthly cash benefits are provided to very low-income recipients as they transition to employment; Supplemental Security Income, a Federal program that provides stipends to low-income people who are either aged, blind, or disabled; and Medicaid, a Federal program for families and individuals whose income and resources are insufficient to pay for health care. For the Rockaways, the percentage of the population receiving income support declined slightly between 2005 and 2014 and is similar to the overall percentages in Queens County and the entire City of New York. Those with limited financial resources may lack sufficient funds required to evacuate. Transportation out of an evacuation zone is problematic for those who may not have access to a vehicle, or who may lack the funds to accommodate fuel costs, tolls, etc. Low-income persons are also more likely to lack the resources required to secure temporary housing once they have evacuated, and are more likely to require further financial assistance during the disaster recovery phase, particularly if they return to find their primary place of residence or place of employment has been damaged. Furthermore, disaster vulnerability tends to be higher for those with limited personal wealth, as limited resources drive housing affordability, and more affordable housing options often tend to be most vulnerable to damage during strong storms (for example, due to location, type of construction, quality of construction, etc.).

Table 6: Income Support, Rockaway Peninsula, Queens County, New York City[xi]

Type of Income Support	Rockaway Peninsula		Queens County		New York City	
	2005	2014	2005	2014	2005	2014
Cash Assistance (TANF)	6,663	6,406	50,625	44,700	414,093	336,299
Supplemental Security Income	9,050	8,893	74,162	75,670	400,988	420,087
Medicaid Only	21,740	23,461	484,601	604,025	1,750,938	2,050,286
Total Persons Assisted	37,453	38,760	609,388	724,395	2,566,019	2,806,672
Percent of Population Receiving Assistance	35.1	33.7	27.3	32.5	32	34.3

31. As compared to Queens County and New York City as a whole, the Rockaway Peninsula has a substantially lower percentage of its land presently built-out. **Table 7** summarizes the land use in the Rockaway Peninsula, Queens County and New York City, respectively. The vast majority of development consists of one to two family residential construction. Just over fifty percent of land on the peninsula is presently devoted to open space or recreation uses or is vacant land. While the present day population on the peninsula is 114,961 persons, there is still considerable room for new development to occur. Recent development trends show that there is a high demand for new development on the Rockaway Peninsula. This will put additional people and improved property at risk during future disasters, and will hamper future evacuation and recovery efforts on the peninsula.

Table 7: 2014 Land Use, Rockaway Peninsula, Queens County, New York City[xii]

Land Use	Rockaway Peninsula			Queens County			New York City		
	Number of Lots	Square Feet (1,000s)	%	Number of Lots	Square Feet (1,000s)	%	Number of Lots	Square Feet (1,000s))	%
1 - 2 Family Residential	10,856	62,282	29.8%	246,705	833,370	35.0%	564,723	1,829,877	27.0%
Multi-Family Residential	1,289	20,342	9.7%	36,804	257,245	10.8%	142,733	832,276	12.3%
Mixed Resid./ Commercial	169	1,096	0.5%	11,283	38,877	1.6%	48,836	203,787	3.0%
Commercial/ Office	229	3,618	1.7%	6,924	77,635	3.3%	24,650	274,143	4.1%
Industrial	54	1,109	0.5%	3,762	79,424	3.3%	11,464	235,407	3.5%
Transportation / Utility	166	3,450	1.7%	2,260	305,979	12.9%	6,679	512,765	7.6%
Institutions	208	9,038	4.3%	2,831	129,589	5.4%	12,246	460,941	6.8%
Open Space/ Recreation	209	80,963	38.7%	1,140	479,885	20.2%	5,007	1,819,726	26.9%
Parking Facilities	168	1,264	0.6%	3,667	27,243	1.1%	11,436	88,927	1.3%
Vacant Land	1,530	24,722	11.8%	8,444	141,083	5.9%	28,471	452,190	6.7%
Miscellaneous	86	1,179	0.6%	750	9,631	0.4%	3,315	56,930	0.8%
Total Built Out	**13,225**	**103,378**	**49.4%**	**314,986**	**1,758,993**	**73.8%**	**826,082**	**4,495,053**	**66.4%**
Total Open Space, Recreation, Vacant Land	**1,739**	**105,685**	**50.5%**	**9,584**	**620,968**	**26.1%**	**33,478**	**2,271,916**	**33.6%**

Parks and Recreation

32. Major parks on the Rockaway Peninsula include Rockaway Beach as well as parts of the Gateway National Recreation Area. Rockaway Beach, along the southern edge of the peninsula, is operated or under the authority of NYC Parks.[xiii] Located along the last stops of the A-line, the beach stretches from Beach 9th Street in Far Rockaway, to Beach 149th Street in Neponsit. It is open year round, but peak beach usage is between Memorial Day and Labor Day. During beach season, lifeguards are employed from 10 AM to 6 PM. Free parking is available in lots at Beach 11th to Beach 15th Street and Beach 95th Street. Street parking is also free. Amenities include concessions stands, mobile charging stations, a street hockey rink, a skate park, several play grounds, handball courts a boardwalk, and surf beaches. The City's only legal surfing beaches are on Rockaway Peninsula, between 67-69 Streets and 87-

92 Streets.[xiv]

33. Gateway National Recreation Area (GNRA) was established in 1972, and protects more than 26,000 acres of land and water in New York and New Jersey. Averaging about 7.6 million visitors per year, the recreation area is divided into three units: Jamaica Bay, Sandy Hook, and Staten Island.[xv] Each unit maintains its own managers and resources.[xvi] Several parks on the western portion of Rockaway Peninsula are within the Jamaica Bay unit of GNRA. These are Fort Tilden, Jacob Riis Park, and Breezy Point Tip.

34. Breezy Point Tip is a secluded 200-acre oceanfront park on the tip of Rockaway Peninsula. In addition to a popular fishing spot, it is an important nesting area for threatened bird species, and a stopover point for migrating shorebirds. [xvii] Fort Tilden is a decommissioned fortress that was erected to defend the New York City area from sea and air attack. Aside from a chapel that is currently used as a children's performing arts center, the buildings are unoccupied and in various states of decay. Visitors have access to the beach and picnic areas. Jacob Riis Park was constructed under Robert Moses during the New Deal. It features miles of beach and a historic Art Deco bathhouse. The park was designed to give New York City's growing immigrant population access to recreation and the beach. Jacob Riis Park is isolated from the city's public transportation system, so access is challenging for urban residents who lack personal vehicles.[xviii] The ocean front beaches stretching from Riis Beach to Breezy Point provide nesting habitat for several federally listed, endangered and threatened species of birds, and are key migratory waystations for dozens of other shorebird species.[xix] Fort Tilden and Jacob Riis Park are thought to have a great potential as archeological and cultural resources. However, a lack of funding has prevented significant study.[xx]

35. Social benefits are provided by the existing parks and recreation areas on the Rockaway Peninsula. These areas provide various recreation benefits to residents and visitors alike. Furthermore, the continued preservation of these relatively undeveloped parcels also works to preclude future development upon them and, in turn, limit the exposure of people and property to natural disasters.

36. Beach attendance data provided by the Department of Parks and Recreation (DPR), City of New York, indicates that approximately 7,738,500 beach visits per year occur on the Rockaway Peninsula at Rockaway Beach. The value per visit under existing conditions (January 2015) is estimated at $6.23 - more than $48.2 million per year for all visits combined. Additional details on Recreation use and valuation are located in SubAppendix C – Recreation Benefits Report.

DESCRIPTION OF THE PROBLEM

37. Storm damages on the Rockaway Peninsula are directly related to the region's topography, location and development. Most of the Rockaway Peninsula's dense urban population and infrastructure is relatively low-lying and vulnerable to storm surge inundation from both the ocean and bay. Damage along the shorefront has been caused by wave action, erosion and storm surges. Inland areas incur damage when high storm surge enters Jamaica Bay, which is made worse when tidal floodwaters overtop shorefront dunes or structures and quickly spread over the broad, low-lying floodplain. In portions of the study area, erosion has removed much of the beachfront and expedited deterioration of the existing coastal protection.

38. Erosion rates are estimated to be as high as 20 feet per year in portions of the study area. Long term erosion, reflecting the combined effects of sediment deficits, storm erosion, and sea level change, has increased the frequency and extent of storm damages over time. The continued erosion of beaches and dunes increases the exposure of development to flooding, waves and erosion and reduces the extent of protective beach features and limits recreational uses. Protective beach features work to mitigate coastal storm impacts such as storm surge flooding, wave action, and erosion damaging shorefront buildings and infrastructure. Other less dramatic but more widespread damages are incurred as a result of back-bay flooding as tides rise in Jamaica Bay, and associated cross-shore flows as the ocean and bay waters meet in extreme storm conditions.

39. In response, a long history of beach erosion and erosion control activities has been undertaken to replenish protective beach and dune systems. Between 1910 and 2004, over 25 million cubic yards of beach fill was placed on the Rockaway Peninsula's beaches and over 200 groins were constructed.

40. When Hurricane Sandy struck it had been eight years since the last re-nourishment under the USACE Section 934 program and Rockaway Beach did not have a dune system to manage the risk of flooding and wave action. Hurricane Sandy's storm surge and waves devastated Rockaway Beach. The review of Hurricane Sandy impacts below helps to understand the coastal storm risk management problems for Rockaway Beach.

41. Hurricane Sandy was one of the most damaging storms that have impacted the Rockaway Peninsula. On 29 October 2012, Hurricane Sandy made landfall approximately five miles south of Atlantic City, NJ, where it collided with a blast of arctic air from the north, creating conditions for an extraordinary and historic storm along the East Coast with the worst coastal impacts centered on the northern New Jersey, New York City, and the Long Island coastline.

Hurricane Sandy's unusual track and extraordinary size generated record storm surges and offshore wave heights in the New York Bight. The maximum water level at The Battery, NY peaked at +11.3 feet NAVD88, exceeding the previous record by over 4 feet. The tide gauge at Sandy Hook, NJ reached +10.4 feet NAVD88 before failing. USGS deployed storm tide sensors and high water marks surveyed by the USGS after the storm indicate that the maximum water levels during Sandy varied between +12.9 feet NAVD88 and +10.3 feet NAVD88 within the Project Area (USGS, 2013).

42. The Rockaway Peninsula was one of the hardest hit areas by Hurricane Sandy. An overview of the extent of flooding in the project area is shown in **Figure 2**. As the storm surge rose the peninsula was flooded first with water from the ocean and then later with water from the bay. Strong ocean waves and currents carried water, sediment, and debris across the peninsula leaving behind a wake of destruction (**Figure 3**). Many homes and other buildings, including the boardwalk, were destroyed by waves or flooding and many more were severely damaged (**Figure 4**). At least four people are known to have died in this area. In addition to the direct effects of flooding, the storm caused the outbreak of multiple fires in Rockaway caused by the interaction of electricity and sea water, including one in Breezy Point that destroyed over 100 homes. Critical services like electricity and water were knocked out leading to dangerous conditions, particularly in high-rise structures.
43. After the storm, Rockaway Beach was restored to an approximate width of 200 feet for recreation purposes. This restored beach is, however, eroding at an average rate of 10 feet per year and is expected to reach half of its present width by the year 2025. Erosion rates of as high as 20 feet per year have been observed in some portions of the study area, with episodic erosion during severe storms.

Figure 2: Hurricane Sandy Flood Inundation

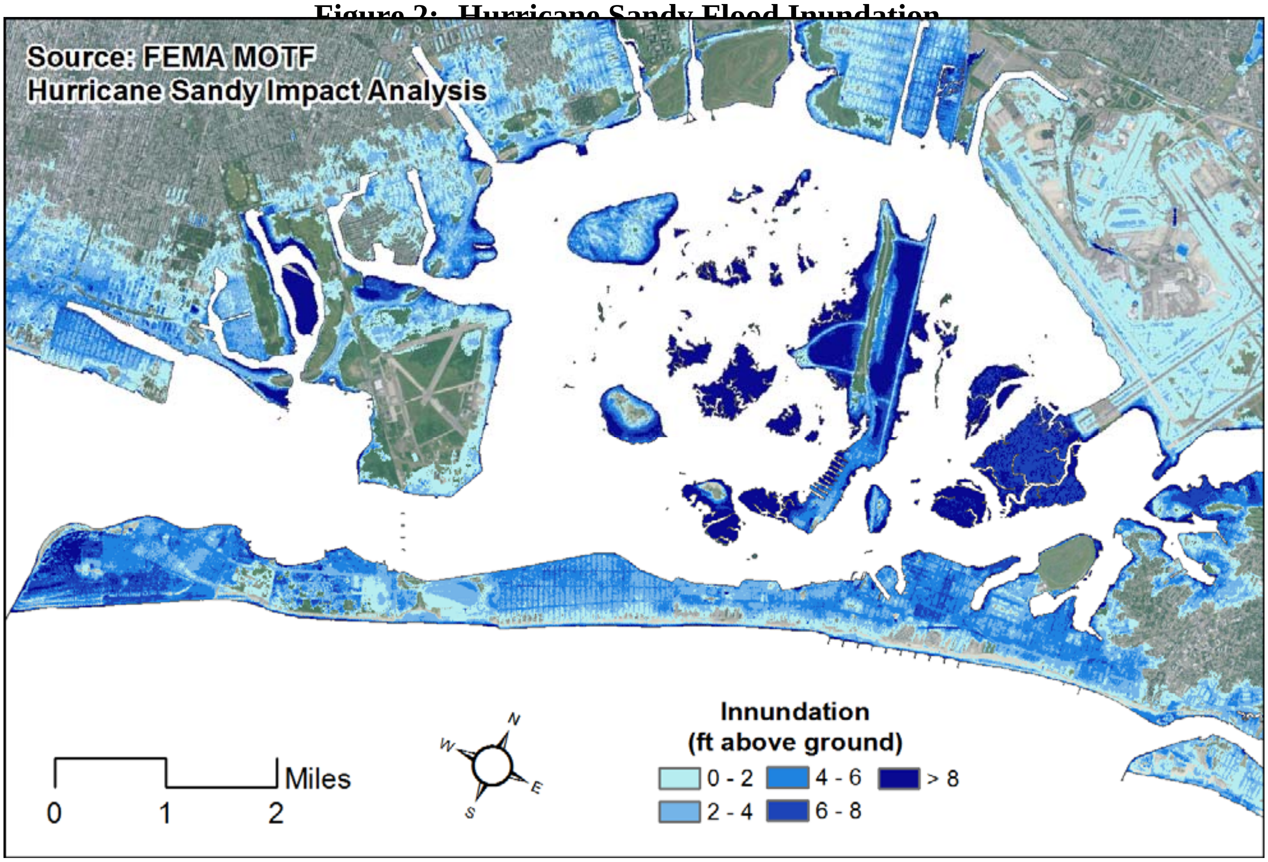


Figure 3: Pre- and Post-Sandy Comparison at Rockaway Beach

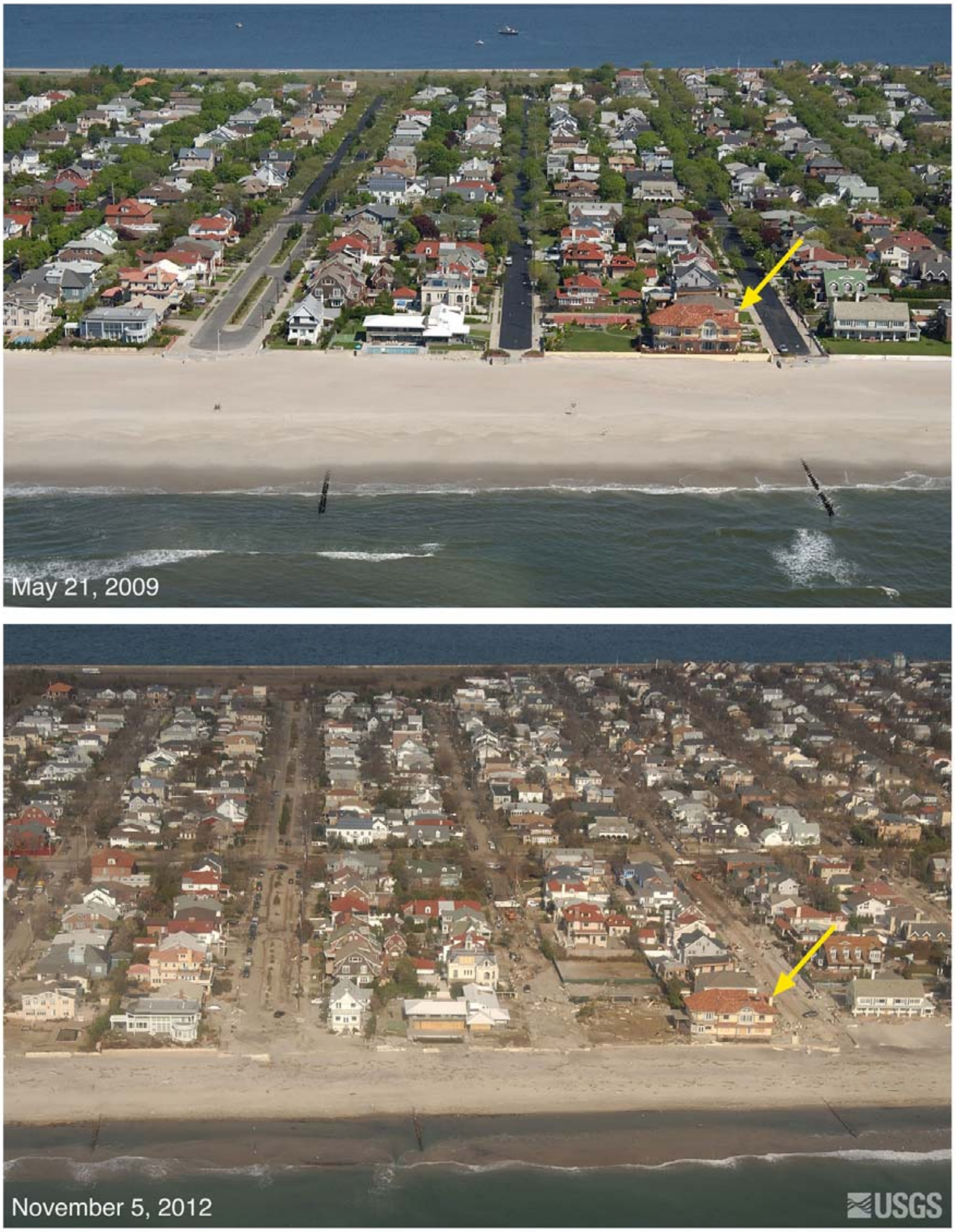


Figure 4: Rockaway Beach Structure Damaged by Hurricane Sandy

Figure 5: Before and After Photos of Rockaway Beach Structures Damaged by Hurricane Sandy

WITHOUT-PROJECT FUTURE CONDITIONS

44. The without-project future conditions for the Rockaway Peninsula have been identified as: (1) flooding and wave impacts from future storm events, (2) continued erosion of unprotected shorelines, and (3) continued development of low-lying flood prone areas.

45. Under the without-project future condition, erosion of beaches and dunes on the Rockaway Peninsula is expected to continue, with an associated increase in the vulnerability of people and property to the hazards of flooding, storm surge, wave action, and coastal erosion.

46. Future erosion rates under the without-project condition future are expected to mirror present-day rates of an averate of about 10 feet per year. Rates as high as 20 feet per year are expected to continue in some portions of the study area. Rockaway Beach - which was restored to a width of approximately 200 feet following Hurricane Sandy and is presently estimated to be at that same width - is expected to experience erosion at an average rate of about 10 feet per year under without project conditions, thereby reaching half of its present width by the year 2025. Visitation (which is presently estimated to be 7,738,500 visits per year under existing conditions) is expected to decrease with continued erosion, by almost 60% when the beach reaches half of its present width. In addition, the remaining visitors will experience a progressively smaller beach each year as erosion continues and the value of beach visits is expected to be substantially less under future without-project conditions. Additional information regarding the value of beach visits under the future without-project conditions is presented in SubAppendix C – Recreation Benefits Report.

47. Long-term erosion rates will be exacerbated by episodic erosion during severe storms. The combined effect of long-term erosion and storm erosion will result in narrower beaches and lower dunes under the future without project condition and, in turn, an expected increase in the exposure of development to the hazards of flooding, waves and erosion as well as a reduced extent of beaches available for recreation use.

48. In the absence of a Federal project, it is expected that local sponsors will continue to implement the type and frequency of projects that they have historically undertaken over the last century in response to the erosion problem on the Peninsula. These types of activities include limited and periodic placement of advance fill, and a limited response to rebuild dunes and beaches after storms. Lifecycle simulations estimate that, over time, an overall reduction in dune height and beach widths in the study area will still be observed despite implementation of small-scale local projects.

49. Tidal inundation is expected to increase gradually over time, in direct relation to the

anticipated rise in relative sea level. Based upon NOAA tide gauge readings at Sandy Hook, sea level has been increasing at an average rate of 0.013 feet per year. This is equivalent to a 0.7 foot increase in tidal stage over the 50-year period of analysis. In future years this will result in more frequent and higher stages of flooding. The analysis also considers two additional scenarios of accelerated sea level rise.

50. As part of the Federal Transit Administration (FTA) Emergency Relief Program & Disaster Relief Appropriations following Hurricane Sandy, New York City and the Metropolitan Transportation Authority (MTA) have requested and received significant funding to improve the resiliency of infrastructure and evacuation routes in the study area. These benefits are being addressed elsewhere, and are therefore not included in this analysis in order to avoid duplication of benefits across Federal programs.

General

51. The following basic steps were used in the analysis of inundation damage:
    - Assign evaluation reaches,
    - Inventory floodplain development,
    - Estimate depreciated replacement cost,
    - Assign generalized damage functions, and
    - Calculate aggregated stage versus damage relationships.
    - Model storm events and damage
    - Calculate average annual damage

52. Flood and other damage calculations for shorefront areas were performed using Version 1.0 of the Engineer Research and Development Center's Beach-*fx* coastal modeling tool, and flood damage calculations for the non-shorefront areas were calculated using Version 1.2.5a of the Hydrologic Engineering Center's Flood Damage Analysis computer program (HEC-FDA).

Economic Reaches

53. Flooding on the Rockaway Peninsula occurs under three main conditions: shorefront flooding along the Atlantic Ocean coastline due to storm surge; non-shorefront flooding attributed to storm surges in Jamaica Bay inundating the bay shorelines of Rockaway (back-bay flooding); and storm surges that overtop the high elevations located near the Rockaway beachfront and flow across the peninsula to meet the surge in Jamaica Bay (cross-shore flooding).

54. In order to evaluate damages from these three main flood sources and develop appropriate stage versus damage relationships, the study area was divided into a total of twelve primary economic reaches (**Figure 6**): six reaches SFR-1 through SFR-6 to evaluate shorefront flooding conditions, and six reaches BB-1 through BB-6 to evaluate non-shorefront (back bay and cross-shore) flooding conditions. Reaches SFR-1 through SFR-6 were further subdivided for purposes of improving economic assessments. The alternative plans offer full protection up to the easternmost project limit at Beach 19th Street. The study area includes a handful of structures in an area immediately to the east of Beach 19th Street that would also be affected by the project. Information detailing the value and flood vulnerability of development in each subreach is provided in **Subappendix A.**

Figure 6: Study Area Primary Economic Reaches

55. A total of 898 buildings or other facilities are located in the shorefront area potentially susceptible to erosion and wave action in addition to inundation; while an additional 6,263 buildings or other facilities were identified as potentially subject to damages from non-shorefront (back-bay or cross-shore) flooding. A summary of the 7,161 structures in the study area by economic reach is presented in **Tables 8 and 9**.

Table 8: Number of Structures, Shorefront Reaches

SF Project Reach	Number of Structures
SFR-1	0
SFR-2	7
SFR-3	492
SFR-4	266
SFR-5	86
SFR-6	47
Total, All SF Reaches	**898**

Table 9: Number of Structures, Back-bay Reaches

BB Project Reach	Number of Structures
BB-1	2,310
BB-2	572
BB-3	827
BB-4	1,542
BB-5	670
BB-6	342
Total, All BB Reaches	**6,263**

Economic Parameters

56. Estimates of damages are based on January 2015 price levels and a 50-year period of analysis. Damages have been annualized over the 50-year analysis period using the fiscal year 2015 discount rate of 3.375 percent.

Inventory Development

57. The shorefront and backbay structure inventory databases were generated by a “windshield survey” of the structures in the project area using topographic mapping with a 2-foot contour interval. The physical characteristics were 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. **Table 10** lists the physical characteristics obtained for the windshield building inventory or updated from aerial imagery.

Table 10: Information Recorded for Structures

1) Structure ID
2) Map Number
3) Type
4) Usage
5) Size
6) Storys
7) Foundation/Basement Type
8) Exterior Construction
9) Setback from Shoreline
10) Midpoint from Shoreline
11) Quality of Construction
12) Condition
13) Ground Elevation (NAVD 1988)
14) Main Floor Height Above Grade
15) Low Opening
16) Number of Attached Garage Openings

58. The structure inventory was compiled in three stages; during the first stage a field survey was conducted to collect the data described above for every structure in the shorefront zone, and to subsequently format this data for import to Beach-*fx*, the computational model selected for estimation of shorefront damages. The shorefront zone was delineated as the area in which structures could be reasonably expected to be impacted by the coastal damage mechanisms of erosion and wave impact in addition to inundation. In addition to the physical characteristics described above, GIS shape files in the form of MapPLUTO data from the New York City Department of Planning was used to derive footprint square footages for use in structure value estimations (see below) and key additional Beach-*fx* input data including structure centroid coordinates, and structure length and width. MapPLUTO merges tax lot data with tax lot features and data maintained by various City agencies clipped to the shoreline. It contains extensive land use and geographic data at the tax lot level in ESRI shape file format and dBase (.dbf) table format.

59. During the shorefront field survey 42 structures included in the GIS shape files were found to

be no longer in existence. These structures were mostly beachfront residences destroyed or damaged beyond repair by Hurricane Sandy. The final shorefront intentory compiled for input to the Beach-*fx* model ultimately consisted of 898 structures.

60. The second stage of the structure inventory compilation consisted of another windshield survey conducted to collect Table 10 data for a representative sample of the more than 6,200 structures in the backbay portion of the study area. The backbay area includes those structures in the study area which are not in the shorefront zone but are potentially vulnerable to flooding from Jamaica Bay and from cross-shore flooding following overtopping of the shorefont area. The representative sample consisted of 45 clusters of 10 structures, each centred on a "seed" structure chosen randomly from the full backbay population of more than 6,200, plus the 50 largest structures in the backbay area by footprint area, giving a total of 500 structures subject to the second windshield survey.

61. The third stage of the inventory compilation process required populating the inventory data for the approximately 5,700 structures in the backbay area which were not included in the representative sample due to schedule and budgetary constraints. During this exercise MapPLUTO data was used to determine structure use, foundation/basement type, and the number of floors for the non-surveyed structures. Additional key attributes such as the main floor height above grade were assigned based on the average values of the attribute for each structure usage type in the surveyed sample.

Structure Values

Approach

62. The depreciated structure replacement value was calculated for each structure residential structure surveyed in the field using a spreadsheet developed by USACE-NYD. The spreadsheet incorporates lookup tables of baseline square foot costs for residential structures of one to three stories with and without basements which vary with the total square footage of the structure. The spreadsheet uses this data to generate regression equations which enable the values to be calculated for residential structures of any combination of size, story, and basement type. The baseline square foot costs for finished living spaces and basements, plus unit costs for garages, were taken from *RS Means Square Foot Costs 2014* for average quality one to three story single-family residential structures and bi-level houses. All calculated values were adjusted for location using RS Means location factors and for depreciation using standard depreciation factors as applied in previous flood risk management projects for USACE-NYD.

63. The depreciated structure replacement value of non-residential structures in the windshield survey was also estimated using a spreadsheet, but via a much simpler methodology than for residential structures. A lookup table was compiled of square foot costs for every non-residential and apartment building usage. Each usage was assigned separate typical square foot costs for masonry and non-masonry construction from RS Means Square Foot Costs 2014. Since the square foot costs developed by RS Means vary with structure size, the lookup table was populated for the assumed typical size was selected for each usage, based on a combination of the average size of structures of that usage in the study area database and previous experience developing structure inventories for other flood risk reduction studies. All calculated values were adjusted for depreciation and location. Following calculation of an initial depreciated replacement cost for each structure, structures with sizes that deviated greatly from the assumed typical size were manually adjusted using a more appropriate square foot cost from RS Means.

64. Structures for which attributes were assigned from the MapPLUTO data and extrapolated from surveyed averages were assigned depreciated replacement values by applying a conversion factor to equalized assessed improvement values from MapPLUTO. The conversion factor was based on the average ratio of the depreciated structure replacement value from RS Means to the MapPluto improvement value for the set of 500 surveyed structures.

Shorefront and Near Shorefront Structures

65. A summary of the number of structures in the shorefront reaches and associated value is provided in **Table 11**. A breakdown of values by reach and stage is shown in **Table 12** through **Table 16**. These tables also present the total depreciated replacement value of boardwalks in each reach at a January 2014 price level. Stages are referenced to North Atlantic Vertical Datum of 1988 (NAVD88). For the purposes of the analysis each boardwalk section with a different setback distance from adjacent sections was considered to be a separate damage element in the Beach-*fx* model.

Table 11: Estimated Depreciated Structure Replacement Value in Shorefront Reaches

Shorefront Reaches	Structure Category						
	Residential		Non-Residential		Boardwalk	Totals	
	Number	Value ($,000)	Number	Value ($,000)	Value ($,000)	Number	Value ($,000)
SFR-1	0	-	0	-	-	0	-
SFR-2	0	-	7	$19,342	-	7	$19,342
SFR-3	484	$425,466	8	$28,522	-	492	$453,988
SFR-4	258	$262,314	8	$13,228	$66,119	266	$341,661
SFR-5	84	$331,601	2	$16,591	$53,784	86	$401,975
SFR-6	45	$142,203	2	$30,556	$15,889	47	$188,648
Total	**871**	**$1,161,584**	**27**	**$108,238**	**$135,792**	**898**	**$1,405,613**

Table 12: Estimated Depreciated Structure Replacement Value in Shorefront Reach SFR-2, by Stage

STAGE	Structure Category						
	Residential		Non-Residential		Boardwalk	Total	
	Count	Value ($,000)	Count	Value ($,000)	Value ($,000)	Count	Value ($,000)
10	0	$0	4	$6,954	$0	4	$6,954
11	0	$0	5	$11,271	$0	5	$11,271
12	0	$0	6	$16,271	$0	6	$16,271
13	0	$0	7	$19,342	$0	7	$19,342
14	0	$0	7	$19,342	$0	7	$19,342
15	0	$0	7	$19,342	$0	7	$19,342
16	0	$0	7	$19,342	$0	7	$19,342
17	0	$0	7	$19,342	$0	7	$19,342
18	0	$0	7	$19,342	$0	7	$19,342
19	0	$0	7	$19,342	$0	7	$19,342
20	0	$0	7	$19,342	$0	7	$19,342
21	0	$0	7	$19,342	$0	7	$19,342
22	0	$0	7	$19,342	$0	7	$19,342
23	0	$0	7	$19,342	$0	7	$19,342
24	0	$0	7	$19,342	$0	7	$19,342

Table 13: Estimated Depreciated Structure Replacement Value in Shorefront Reach SFR-3, by Stage

STAGE	Structure Category						
	Residential		Non-Residential		Boardwalk	Total	
	Count	Value ($,000)	Count	Value ($,000)	Value ($,000)	Count	Value ($,000)
10	30	$74,602	1	$8,238	$0	31	$82,840
11	71	$148,194	4	$8,587	$0	75	$156,780
12	164	$241,341	7	$10,173	$0	171	$251,514
13	260	$281,706	8	$28,522	$0	268	$310,229
14	373	$357,572	8	$28,522	$0	381	$386,094
15	428	$377,008	8	$28,522	$0	436	$405,530
16	459	$398,016	8	$28,522	$0	467	$426,538
17	468	$404,854	8	$28,522	$0	476	$433,377
18	475	$418,490	8	$28,522	$0	483	$447,013
19	478	$419,879	8	$28,522	$0	486	$448,401
20	483	$422,653	8	$28,522	$0	491	$451,175
21	483	$422,653	8	$28,522	$0	491	$451,175
22	484	$425,466	8	$28,522	$0	492	$453,988
23	484	$425,466	8	$28,522	$0	492	$453,988
24	484	$425,466	8	$28,522	$0	492	$453,988

Table 14: Estimated Depreciated Structure Replacement Value in Shorefront Reach SFR-4, by Stage

STAGE	Structure Category						
	Residential		Non-Residential		Boardwalk	Total	
	Count	Value ($,000)	Count	Value ($,000)	Value ($,000)	Count	Value ($,000)
10	16	$151,004	4	$9,890	$24,340	20	$185,234
11	45	$171,355	6	$11,373	$28,834	51	$211,562
12	162	$182,551	6	$11,373	$28,834	168	$222,757
13	182	$241,922	6	$11,373	$28,834	188	$282,128
14	195	$245,402	6	$11,373	$28,834	201	$285,609
15	217	$251,157	6	$11,373	$28,834	223	$291,364
16	225	$253,152	6	$11,373	$28,834	231	$293,358
17	230	$254,569	6	$11,373	$66,119	236	$332,061
18	236	$256,213	6	$11,373	$66,119	242	$333,705
19	245	$258,298	6	$11,373	$66,119	251	$335,790
20	250	$259,636	6	$11,373	$66,119	256	$337,128
21	251	$259,898	6	$11,373	$66,119	257	$337,391
22	251	$259,898	6	$11,373	$66,119	257	$337,391
23	253	$260,588	6	$11,373	$66,119	259	$338,081
24	258	$262,314	6	$11,373	$66,119	264	$339,806

Table 15: Estimated Depreciated Structure Replacement Value in Shorefront Reach SFR-5, by Stage							
STAGE	**Structure Category**						
	Residential		**Non-Residential**		**Boardwalk**	**Total**	
	Count	**Value ($,000)**	**Count**	**Value ($,000)**	**Value ($,000)**	**Count**	**Value ($,000)**
10	6	$168,981	1	$11,215	$0	7	$180,197
11	14	$206,989	1	$11,215	$0	15	$218,205
12	17	$207,433	1	$11,215	$0	18	$218,649
13	28	$210,452	2	$16,591	$0	30	$227,042
14	55	$225,591	2	$16,591	$0	57	$242,182
15	83	$331,470	2	$16,591	$0	85	$348,061
16	83	$331,470	2	$16,591	$0	85	$348,061
17	84	$331,601	2	$16,591	$53,784	86	$401,975
18	84	$331,601	2	$16,591	$53,784	86	$401,975
19	84	$331,601	2	$16,591	$53,784	86	$401,975
20	84	$331,601	2	$16,591	$53,784	86	$401,975
21	84	$331,601	2	$16,591	$53,784	86	$401,975
22	84	$331,601	2	$16,591	$53,784	86	$401,975
23	84	$331,601	2	$16,591	$53,784	86	$401,975
24	84	$331,601	2	$16,591	$53,784	86	$401,975

Table 16: Estimated Depreciated Structure Replacement Value in Shorefront Reach SFR-6, by Stage

STAGE	Structure Category						
	Residential		Non-Residential		Boardwalk	Total	
	Count	Value ($,000)	Count	Value ($,000)	Value ($,000)	Count	Value ($,000)
10	16	$2,264	1	$24,232	$0	17	$26,496
11	28	$46,400	1	$24,232	$0	29	$70,632
12	39	$62,179	2	$30,556	$0	41	$92,734
13	40	$62,207	2	$30,556	$0	42	$92,763
14	41	$91,344	2	$30,556	$0	43	$121,899
15	41	$91,344	2	$30,556	$0	43	$121,899
16	43	$91,949	2	$30,556	$0	45	$122,505
17	44	$127,801	2	$30,556	$15,889	46	$174,246
18	44	$127,801	2	$30,556	$15,889	46	$174,246
19	45	$142,203	2	$30,556	$15,889	47	$188,648
20	45	$142,203	2	$30,556	$15,889	47	$188,648
21	45	$142,203	2	$30,556	$15,889	47	$188,648
22	45	$142,203	2	$30,556	$15,889	47	$188,648
23	45	$142,203	2	$30,556	$15,889	47	$188,648
24	45	$142,203	2	$30,556	$15,889	47	$188,648

Non-Shorefront Structures

66. A summary of the number of structures in the backbay reaches and associated depreciated replacement value are provided in **Table 17**. A breakdown of values by reach and stage is shown in **Table 18** through **Table 23**.

Table 17: Estimated Depreciated Structure Replacement Value in Non-Shorefront (Backbay/Cross-Shore) Reaches

Cross-Shore/Backbay Flooding Reaches	Structure Category					
	Residential		Non Residential		Totals	
	Number	Value ($,000)	Number	Value ($,000)	Number	Value ($,000)
BB-1	2,265	881,970	45	120,443	2,310	$1,002,412
BB-2	470	300,551	102	297,965	572	$598,517
BB-3	729	845,274	98	378,158	827	$1,223,432
BB-4	1,457	1,250,598	85	290,240	1,542	$1,540,839
BB-5	620	5,595,684	50	245,915	670	$5,841,599
BB-6	330	817,140	12	962,028	342	$1,779,168
Total	**5,871**	**9,691,218**	**392**	**2,294,750**	**6,263**	**$11,985,968**

Table 18: Estimated Depreciated Structure Replacement Value in Backbay/Cross-Shore Reach BB-1, by Stage

Stage	Structure Category					
	Residential		Non-Residential		Total	
	Number	Value ($,000)	Number	Value ($,000)	Number	Value ($,000)
2	0	$0	0	$0	0	$0
3	0	$0	0	$0	0	$0
4	0	$0	0	$0	0	$0
5	0	$0	0	$0	0	$0
6	0	$0	0	$0	0	$0
7	5	$10,045	3	$19,416	8	$29,460
8	15	$28,735	11	$28,156	26	$56,891
9	36	$39,536	28	$53,918	64	$93,454
10	173	$92,508	35	$75,834	208	$168,342
11	765	$309,362	38	$86,446	803	$395,808
12	1466	$575,536	41	$110,086	1507	$685,622
13	1785	$701,001	44	$116,596	1829	$817,598
14	1916	$751,502	45	$120,443	1961	$871,944
15	2086	$810,950	45	$120,443	2131	$931,393
16	2211	$858,510	45	$120,443	2256	$978,952
17	2254	$877,016	45	$120,443	2299	$997,459
18	2261	$879,844	45	$120,443	2306	$1,000,286
19	2263	$881,094	45	$120,443	2308	$1,001,537
20	2264	$881,659	45	$120,443	2309	$1,002,101
21	2264	$881,659	45	$120,443	2309	$1,002,101
22	2265	$881,970	45	$120,443	2310	$1,002,412
23	2265	$881,970	45	$120,443	2310	$1,002,412
24	2265	$881,970	45	$120,443	2310	$1,002,412

Table 19: Estimated Depreciated Structure Replacement Value in Backbay/Cross-Shore Reach BB-2, by Stage						
Stage	**Structure Category**					
	Residential		**Non-Residential**		**Total**	
	Number	**Value ($,000)**	**Number**	**Value ($,000)**	**Number**	**Value ($,000)**
2	0	$0	0	$0	0	$0
3	0	$0	0	$0	0	$0
4	0	$0	0	$0	0	$0
5	0	$0	0	$0	0	$0
6	1	$4,138	6	$9,622	7	$13,761
7	30	$108,118	31	$70,015	61	$178,134
8	72	$153,232	58	$151,622	130	$304,854
9	103	$181,587	73	$204,888	176	$386,475
10	153	$196,946	84	$229,905	237	$426,851
11	295	$237,283	94	$288,012	389	$525,295
12	395	$281,167	99	$292,710	494	$573,876
13	435	$291,780	102	$297,965	537	$589,745
14	452	$296,168	102	$297,965	554	$594,133
15	465	$299,255	102	$297,965	567	$597,220
16	469	$300,327	102	$297,965	571	$598,293
17	469	$300,327	102	$297,965	571	$598,293
18	469	$300,327	102	$297,965	571	$598,293
19	470	$300,551	102	$297,965	572	$598,517
20	470	$300,551	102	$297,965	572	$598,517
21	470	$300,551	102	$297,965	572	$598,517
22	470	$300,551	102	$297,965	572	$598,517
23	470	$300,551	102	$297,965	572	$598,517
24	470	$300,551	102	$297,965	572	$598,517

Table 20: Estimated Depreciated Structure Replacement Value in Backbay/Cross-Shore Reach BB-3, by Stage						
Stage	**Structure Category**					
	Residential		**Non-Residential**		**Total**	
	Number	**Value ($,000)**	**Number**	**Value ($,000)**	**Number**	**Value ($,000)**
2	1	$190	0	$0	1	$190
3	5	$1,010	0	$0	5	$1,010
4	6	$1,260	0	$0	6	$1,260
5	9	$22,251	3	$18,163	12	$40,414
6	29	$102,579	30	$57,983	59	$160,562
7	71	$244,504	61	$161,704	132	$406,209
8	108	$293,943	72	$187,013	180	$480,956
9	151	$433,834	81	$199,391	232	$633,225
10	239	$478,233	88	$221,623	327	$699,856
11	397	$721,109	90	$228,361	487	$949,469
12	555	$762,537	94	$279,458	649	$1,041,994
13	630	$781,449	97	$312,983	727	$1,094,433
14	672	$820,439	97	$312,983	769	$1,133,422
15	693	$832,685	98	$378,158	791	$1,210,843
16	720	$844,359	98	$378,158	818	$1,222,517
17	727	$845,003	98	$378,158	825	$1,223,161
18	729	$845,274	98	$378,158	827	$1,223,432
19	729	$845,274	98	$378,158	827	$1,223,432
20	729	$845,274	98	$378,158	827	$1,223,432
21	729	$845,274	98	$378,158	827	$1,223,432
22	729	$845,274	98	$378,158	827	$1,223,432
23	729	$845,274	98	$378,158	827	$1,223,432
24	729	$845,274	98	$378,158	827	$1,223,432

Table 21: Estimated Depreciated Structure Replacement Value in Backbay/Cross-Shore Reach BB-4, by Stage

Stage	Structure Category					
	Residential		Non-Residential		Total	
	Number	Value ($,000)	Number	Value ($,000)	Number	Value ($,000)
2	0	$0	0	$0	0	$0
3	0	$0	1	$2,398	1	$2,398
4	0	$0	1	$2,398	1	$2,398
5	1	$221	6	$6,490	7	$6,711
6	4	$1,036	25	$63,528	29	$64,564
7	9	$19,568	49	$96,503	58	$116,071
8	34	$24,950	63	$139,452	97	$164,402
9	298	$83,456	74	$237,031	372	$320,487
10	616	$146,292	81	$254,808	697	$401,100
11	1020	$232,126	84	$260,016	1104	$492,142
12	1201	$490,681	84	$260,016	1285	$750,697
13	1292	$873,899	85	$290,240	1377	$1,164,139
14	1390	$1,239,446	85	$290,240	1475	$1,529,686
15	1423	$1,245,047	85	$290,240	1508	$1,535,288
16	1445	$1,249,063	85	$290,240	1530	$1,539,303
17	1453	$1,250,017	85	$290,240	1538	$1,540,257
18	1457	$1,250,598	85	$290,240	1542	$1,540,839
19	1457	$1,250,598	85	$290,240	1542	$1,540,839
20	1457	$1,250,598	85	$290,240	1542	$1,540,839
21	1457	$1,250,598	85	$290,240	1542	$1,540,839
22	1457	$1,250,598	85	$290,240	1542	$1,540,839
23	1457	$1,250,598	85	$290,240	1542	$1,540,839
24	1457	$1,250,598	85	$290,240	1542	$1,540,839

Table 22: Estimated Depreciated Structure Replacement Value in Backbay/Cross-Shore Reach BB-5, by Stage

Stage	Structure Category					
	Residential		Non-Residential		Total	
	Number	Value ($,000)	Number	Value ($,000)	Number	Value ($,000)
2	0	$0	0	$0	0	$0
3	0	$0	0	$0	0	$0
4	0	$0	0	$0	0	$0
5	0	$0	4	$6,016	4	$6,016
6	1	$739	14	$63,902	15	$64,641
7	4	$26,094	28	$87,979	32	$114,073
8	30	$173,849	36	$212,259	66	$386,108
9	150	$333,368	40	$239,347	190	$572,715
10	370	$996,300	42	$243,449	412	$1,239,750
11	453	$1,345,124	47	$244,107	500	$1,589,231
12	491	$4,101,421	49	$244,370	540	$4,345,790
13	553	$4,850,425	49	$244,370	602	$5,094,795
14	606	$4,854,095	50	$245,915	656	$5,100,010
15	615	$5,440,226	50	$245,915	665	$5,686,142
16	616	$5,440,325	50	$245,915	666	$5,686,240
17	616	$5,440,325	50	$245,915	666	$5,686,240
18	618	$5,440,592	50	$245,915	668	$5,686,507
19	618	$5,440,592	50	$245,915	668	$5,686,507
20	618	$5,440,592	50	$245,915	668	$5,686,507
21	619	$5,493,395	50	$245,915	669	$5,739,310
22	619	$5,493,395	50	$245,915	669	$5,739,310
23	620	$5,595,684	50	$245,915	670	$5,841,599
24	620	$5,595,684	50	$245,915	670	$5,841,599

Table 23: Value of Development in Backbay/Cross-Shore Reach BB-6, by Stage

Stage	Structure Category					
	Residential		Non-Residential		Total	
	Number	Value ($,000)	Number	Value ($,000)	Number	Value ($,000)
2	0	$0	0	$0	0	$0
3	0	$0	0	$0	0	$0
4	0	$0	0	$0	0	$0
5	0	$0	0	$0	0	$0
6	0	$0	0	$0	0	$0
7	6	$2,877	0	$0	6	$2,877
8	18	$10,932	3	$191,005	21	$201,937
9	44	$35,171	6	$393,577	50	$428,748
10	114	$72,442	11	$774,804	125	$847,246
11	194	$109,688	12	$962,028	206	$1,071,716
12	261	$230,525	12	$962,028	273	$1,192,553
13	299	$491,519	12	$962,028	311	$1,453,547
14	307	$591,842	12	$962,028	319	$1,553,870
15	309	$591,944	12	$962,028	321	$1,553,972
16	313	$592,187	12	$962,028	325	$1,554,215
17	317	$592,473	12	$962,028	329	$1,554,501
18	322	$592,880	12	$962,028	334	$1,554,908
19	323	$592,956	12	$962,028	335	$1,554,984
20	324	$593,029	12	$962,028	336	$1,555,057
21	325	$694,065	12	$962,028	337	$1,656,093
22	327	$694,221	12	$962,028	339	$1,656,249
23	330	$817,140	12	$962,028	342	$1,779,168
24	330	$817,140	12	$962,028	342	$1,779,168

Coastal Storm Data

Shorefront Reaches

67. Calculations of storm damage are specific to the physical conditions during the storm such a flood stage, wave height or the extent of erosion. Damages to shorefront structures were calculated using the USACE Certified Model Beach-*fx*. The Beach-*fx* Storm Response Database (SRD) is populated with SBEACH Global Export output data. A large number of storms are evaluated in SBEACH and specific information about profile change, flood stage and wave heights are collected for each storm. The data is imported after the creation of storms and profiles within a Beach-*fx* project. By importing the data sequentially, Beach-*fx*

sets up linkages between specific storms and the project's profiles.

68. Once the SBEACH data is imported, the SRD includes five tables, "tblSRDVersion", "tblStormResponse", "tblStormResponseDamageParameters", "tblStormResponseProfile", and "tblStormResponseProfileDescription". Together, these tables provide Beach-*fx* with the information necessary to link storms to the appropriate profile response, such as the post storm berm width, post storm dune width, post storm dune height, post storm upland width, eroded volume, and response type.

69. For the Rockaway Beach Project Beach-*fx* Analysis, three Beach-*fx* projects were created which utilized three distinct SRDs. The first SRD was built using the raw output data from the SBEACH Global Export. This SRD was used for the without project scenario and the three beach fill alternative scenarios. The SBEACH Global Export data for profiles R1T1, R1T2, R1T3, R2T1, R2T2, R2T3, and R2T4 totaled 62.25 gigabytes. This extensive amount of data required over 93 hours of import time, and required the SRD to be compacted and repaired between profile imports to provide sufficient space for all profiles.

70. The second and third SRDs were built using data that was modified by a coastal engineer after the SBEACH Global Export to reflect the presence of a buried or composite seawall. These SRDs were used for the seawall alternative scenarios. Despite compacting and repairing the seawall SRDs, there was not sufficient space for all of the profiles. As a result of the lack of space within the SRD, the seawall SRDs were created using only the R2T2 profile, which is the only profile where the seawall was implemented. Since the SRDs did not contain other profiles, output from reaches that utilized the R1T1, R1T2, R1T3, R2T1, R2T3, and R2T4 profiles had to be copied from the without project scenario and added to the seawall scenario damages manually in Microsoft Access after the simulation.

Non-shorefront Reaches

71. The non-shorefront reaches applied flood stage vs frequency relationships to assess the potential flood impacts. Flood depths for the non-shorefront reaches were calculated using the XBeach wave and hydrodynamic model. Water surface elevation model boundary conditions along the Atlantic Ocean and Jamaica Bay were based on preliminary FIS prepared by FEMA. **Tables 24 through 29** summarize the baseline external ocean and backbay stage versus frequency relationships used in the Stage Frequency HEC-FDA analyses. The XBeach model developed a two-dimensional grid of flood depths across the peninsula for each storm frequency. For each reach the path of cross shore flooding was identified and input to the HEC-FDA model as a flood profile. Each structure in the reach

was assigned a profile station to reproduce the actual flood elevation at that structure in the two-dimensional flood grid.

Table 24: Stage vs. Frequency Data in Backbay/Cross-Shore Reach BB-1

RETURN PERIOD (YEARS)	ELEVATION, EXISTING ATLANTIC OCEAN (FT NAVD88)	ELEVATION, EXISTING JAMAICA BAY (FT NAVD88)
3	5.90	4.30
5	7.70	5.50
10	9.00	6.60
25	10.20	7.90
50	11.40	8.80
100	12.70	9.80
250	15.00	11.10
500	16.70	12.30

Stillwater elevations obtained from FEMA (2015)

Table 25: Stage vs. Frequency Data in Backbay/Cross-Shore Reach BB-2

RETURN PERIOD (YEARS)	ELEVATION, EXISTING ATLANTIC OCEAN (FT NAVD88)	ELEVATION, EXISTING JAMAICA BAY (FT NAVD88)
3	5.70	4.30
5	7.50	5.50
10	8.90	6.60
25	10.30	7.90
50	11.60	8.80
100	12.90	9.80
250	15.10	11.10
500	16.70	12.30

Stillwater elevations obtained from FEMA (2015)

Table 26: Stage vs. Frequency Data in Backbay/Cross-Shore Reach BB-3

RETURN PERIOD (YEARS)	ELEVATION, EXISTING ATLANTIC OCEAN (FT NAVD88)	ELEVATION, EXISTING JAMAICA BAY (FT NAVD88)
3	7.40	4.30
5	8.90	5.50
10	10.10	6.60
25	11.00	7.90
50	12.00	8.80
100	13.00	9.80
250	15.10	11.10
500	16.60	12.30

Stillwater elevations obtained from FEMA (2015)

Table 27: Stage vs. Frequency Data in Backbay/Cross-Shore Reach BB-4

RETURN PERIOD (YEARS)	ELEVATION, EXISTING ATLANTIC OCEAN (FT NAVD88)	ELEVATION, EXISTING JAMAICA BAY (FT NAVD88)
3	5.20	4.30
5	7.20	5.50
10	8.70	6.60
25	10.70	7.90
50	12.20	8.80
100	13.70	9.80
250	15.70	11.10
500	17.20	12.30

Stillwater elevations obtained from FEMA (2015)

Table 28: Stage vs. Frequency Data in Backbay/Cross-Shore Reach BB-5		
RETURN PERIOD (YEARS)	**ELEVATION, EXISTING ATLANTIC OCEAN (FT NAVD88)**	**ELEVATION, EXISTING JAMAICA BAY (FT NAVD88)**
3	4.30	4.30
5	6.20	5.50
10	7.80	6.60
25	9.90	7.90
50	11.40	8.80
100	13.00	9.80
250	15.20	11.10
500	16.90	12.30

Stillwater elevations obtained from FEMA (2015)

Table 29: Stage vs. Frequency Data in Backbay/Cross-Shore Reach BB-6		
RETURN PERIOD (YEARS)	**ELEVATION, EXISTING ATLANTIC OCEAN (FT NAVD88)**	**ELEVATION, EXISTING JAMAICA BAY (FT NAVD88)**
3	4.30	4.30
5	5.50	5.50
10	6.60	6.60
25	8.60	7.90
50	10.50	8.80
100	12.30	9.80
250	14.80	11.10
500	16.60	12.30

Stillwater elevations obtained from FEMA (2015)

Damage Functions

72. The estimation of storm damages for this analysis was based on two sets of generalized damage functions that were selected to suit the modeling approach for the two components of the damage estimation, i.e. shorefront and backbay.

73. For the shorefront component of the analyses, appropriate damage functions for inundation, wave and erosion damages were selected from a range of available sources. These sources are listed in brief below, and their assignment to structure usages and types is presented in Table DF:

    - US Army Corps of Engineers (USACE) generic depth-damage functions for single-family residential and similar structures (see below for more details).
    - Generic functions developed by the ERDC Coastal and Hydraulics Laboratory (CHL) and the US Army Engineer Institute for Water Resources (IWR) specifically for Beach-fx and provided with the download version of the model.
    - Coastal storm damage relationships based on an expert opinion elicitation exercise facilitated by USACE/IWR in June 2002.
    - Coastal storm damage relationships based on an expert opinion elicitation exercise facilitated by USACE/URS in April 2014 as part of the North Atlantic Coastal Comprehensive Study (NACCS).
    - Custom location-specific functions based on detailed investigation of recent storm damage to distinct individual structure types in the study area.

74. The inundation, erosion, and wave damage functions used for the shorefront component of this analysis and listed in Table DF are presented in detail in Sub-Appendix B.

Table DF: Sources and Assignment of Damge Functions in Beach-fx

Damage Component		Structure Category/Usage	Source for Damage
Erosion	Contents	Apartments	2014 NACCS Exper
Erosion	Contents	High Rises	2014 NACCS Exper
Erosion	Contents	Single-Family Residences, Multi-Family Residences, Commercial	Beach-fx Generic
Erosion	Structure	Apartments	2014 NACCS Exper
Erosion	Structure	Single-Family Residences, Multi-Family Residences, Commercial	Beach-fx
Erosion	Structure	High Rises	2014 NACCS Exper
Inundation	Contents	Apartments	2014 NACCS Exper
Inundation	Contents	High Rises	2014 NACCS Exper
Inundation	Contents	Multi-Family Residences, Commercial	2002 IWR Expert O
Inundation	Contents	Single-Family Residences - no basement	USACE Generic
Inundation	Contents	Single-Family Residences - with basement	USACE Generic
Inundation	Structure	Multi-Family Residences, Commercial	Beach-fx Generic
Inundation	Structure	Single-Family Residences - no basement	USACE Generic
Inundation	Structure	Single-Family Residences - with basement	USACE Generic
Inundation	Structure	High Rises	2014 NACCS Exper
Inundation	Structure	Apartments	2014 NACCS Exper
Wave	Contents	Single-Family Residences, Multi-Family Residences, Commercial	Beach-fx Generic
Wave	Contents	Apartments	2014 NACCS Exper
Wave	Contents	High Rises	2014 NACCS Exper
Wave	Structure	Apartments	2014 NACCS Exper
Wave	Structure	Boardwalk	Custom: Project/Loc
Wave	Structure	High Rises	2014 NACCS Exper
Wave	Structure	Single-Family Residences, Multi-Family Residences, Commercial	Beach-fx Generic

75. For the backbay component of the damage estimation, since the structures in the inventory are only vulnerable to inundation, HEC-FDA was used to compute the damages, and hence only inundation damage functions that calculate damage by depth relative to the main floor elevation of the structure were required. For this component of the analysis, two separately developed classes of depth versus percent damage functions were used for all structures in the backbay area:

    - US Army Corps of Engineers generic damage functions for single-family residential and similar structures.
    - Passaic River Basin (PRB) Study damage functions for other residential structures and all non-residential structures.

76. The USACE depth versus damage functions for residential backbay structures were sourced from Economics Guidance Memoranda EGM 01-03 (December 2000) and EGM 04-01 (October 2003). The PRB damage functions were originally developed in 1982 and were updated in 1995. These damage functions were found to be applicable as originally formulated and no adjustments to the damage functions are recommended.

77. The PRB damage functions were also used for non-residential backbay structures; there are numerous PRB damage functions for specific non-residential usages, including commercial, industrial, municipal, and utility structures.

AVERAGE ANNUAL DAMAGES

General

78. The two damage components of the study (shorefront and backbay) were analyzed using two different software models, with the selection of modeling tool driven by the nature of the expected damage mechanisms and the available data for each component. The impacts of three different projections of sea level rise were also evaluated for each component of the study, also in accordance with current planning policy. **Table 30** provides a summary of the equivalent annual without project damages for all damage components in the study area.

Damage to Shorefront Structures

79. Damages to structures in the shorefront section of the study area were calculated using the USACE Certified Model Beach-*fx*. The model and supporting documentation are available at: (http://hera.pmcl.com/beachfx/default.aspx). For application to this study, the model developers have incorporated several refinements and revisions as Version 1.1, which is pending public release. The Beach-*fx* model uses an event-driven Monte Carlo approach, Geographic Information System (GIS) inventory of infrastructure and a comprehensive database of morphological responses to historically-based storm events. The analysis evaluates three damage mechanisms: inundation, wave-action and erosion, as well as how beach profile and damages change in response to long-term shoreline changes.

Damage to Non-shorefront Structures

80. Flood inundation damages for the non-shorefront section of the study area (i.e. due to cross-shore flooding from the ocean and from backbay flooding) were calculated using the the USACE Certified Model HEC-FDA Version 1.2.5a, with water surface profiles and flood depths for cross-shore flooding derived using the XBeach wave and hydrodynamic model.

Table 30: Equivalent Annual Without Project Damage, Low Sea Level Rise Scenario

Damage Component	Annual Damage
Shorefront Damages (Flooding, Erosion, Waves)	$15,782,000
Backbay Damages (Cross-shore Flooding)	$28,705,000
Backbay Damages (Flooding from Jamaica Bay)	$65,163,000
Total Damages	**$109,650,000**

Interest rate 3.375%, Period of Analysis 50 years

81. The calculated existing base year without-project condition expected annual damage for the approximately 7,200 structures in the study area is $15,300 per structure. Economic analysis results indicate that the average annual expected without-project damage to structures would increase to $18,220 per structure by the end of the 50-year analysis period, based on the Low Sea Level Rise scenario, which assumes a linear continuation of the historic rate of sea level rise observed in the study area.

82. The scenario analysis considers two additional accelerated sea level change conditions, accelerate sea level rise under intermediate (Modified NRC Curve 1) and high (Modified NRC Curve 3) scenarios, as required under current USACE guidance (EC 1165-2-211, July 2009).

Uncertainty

83. Backbay Reaches. Under current Corps' guidance, risk and uncertainty must be incorporated into flood risk management studies. The following areas of uncertainty were incorporated into the HEC-FDA models used to compute inundation damages in the non-shorefront sections of the study area.

- Stage versus frequency relationships
- Structure main floor elevation
- Structure value
- Content-to-structure value ratio
- Inundation depth-damage functions

84. Uncertainty was assigned to each of these uncertain parameters via normal distributions, with the variance for each assigned according to current guidance and accepted prior practice for sturdies of this nature.

85. Shorefront Reaches. The Beach-*fx* model allows for uncertainty to be applied to numerous paramters within the analysis, most notably

- Structure main floor elevation
- Structure value
- Contents value
- Rebuilding times
- Inundation depth-damage functions
- Wave impact damage functions
- Erosion-distance damage functions

86. Uncertainty was assigned to these parameters via triangular (define as high, medium, low) probability distributions in the Beach-*fx* input files.

Estimated Without-Project Damages

87. Estimated total equivalent annual damages are $15,783,000 for the shorefront reaches. The sub-reach with the highest damages is R3S2b, which accounts for 23.1% of total damages. Other significantly damaged sub-reaches include R4S1 at 19.3% of total damages, R4S2 at 13.0% of total damages, R4S2 at 11.4% of total damages, and R2S2a at 7.2% of total damages. The structure type with the highest damages are high-rises susceptible to wave damages, which account for 40.1% of total damages. A summary of equivalent annual shorefront damages by sub-reach is provided in Table 31.

Table 31: Summary of Without-Project Condition/ Base Year Average Annual Damage Non Shore Front Reaches

Economic Reach	Damage Categories	
	Annual Damage	%
R2S2a	$1,129,000	7%
R2S2b	$186,000	1%
R3S1a	$272,000	2%
R3S1b	$356,000	2%
R3S1c	$242,000	2%
R3S1d	$198,000	1%
R3S2a	$282,000	2%
R3S2b	$3,651,000	23%
R4S1	$3,049,000	19%
R4S2	$2,048,000	13%
R4S3	$1,795,000	11%
R5S1a	$411,000	3%
R5S1b	$153,000	1%
R5S1c	$158,000	1%
R5S1d	$151,000	1%
R5S2a	$371,000	2%
R5S1e	$413,000	3%
R6S2	$10,000	0%
R6S3a	$642,000	4%
R6S3b	$266,000	2%
Totals	**$15,783,000**	**100%**

88. Expected total annual damages for the without-project/base year condition, and for the without-project/future year conditions for the non-shorefront reaches are provided in Table 32 and Table 33, respectively. A summary of the equivalent annual damages for the non-shorefront reaches is provided in Table 34.

Table 32: Summary of Without-Project Condition/ Base Year Average Annual Damage Non Shore Front Reaches

Economic Reach	Damage Categories					Total
	Apartment	Commercial	Industrial	Municipal	Residential	
BB-1	$245,380	$526,900	$0	$136,710	$7,234,730	$8,143,720
BB-2	$1,652,570	$2,132,440	$0	$511,120	$2,353,070	$6,649,200
BB-3	$5,031,520	$2,146,560	$994,010	$603,390	$2,586,790	$11,362,270
BB-4	$3,021,110	$1,693,280	$830,750	$121,560	$5,036,200	$10,702,900
BB-5	$28,757,910	$2,013,820	$0	$888,330	$6,627,630	$38,287,690
BB-6	$2,869,370	$106,230	$0	$7,392,580	$1,958,930	$12,327,110
Totals	**$41,577,860**	**$8,619,230**	**$1,824,760**	**$9,653,690**	**$25,797,350**	**$87,472,890**

Table 33: Summary of Without-Project Condition/ Future Year Average Annual Damage Non Shorefront Reaches

Economic Reach	Damage Categories					Total
	Apartment	Commercial	Industrial	Municipal	Residential	
BB-1	$317,900	$647,380	$0	$148,460	$9,209,610	$10,323,350
BB-2	$2,220,180	$2,685,100	$0	$628,230	$2,902,390	$8,435,900
BB-3	$7,031,490	$2,907,910	$1,402,450	$838,960	$3,393,130	$15,573,940
BB-4	$3,483,810	$2,024,490	$1,028,080	$132,910	$6,104,750	$12,774,040
BB-5	$32,659,710	$2,551,010	$0	$1,074,620	$7,619,920	$43,905,260
BB-6	$3,454,420	$135,920	$0	$9,265,140	$2,426,780	$15,282,260
Totals	**$49,167,510**	**$10,951,810**	**$2,480,530**	**$12,088,320**	**$31,656,580**	**$106,294,750**

Table 34 **Summary of Without-Project Equivalent Annaul Damage** **Non Shorefront Reaches**		
Reach	**Residential**	**Non-Residential**
BB-1	$8,156,000	$708,000
BB-2	$4,381,000	$2,864,000
BB-3	$8,507,000	$4,182,000
BB-4	$8,601,000	$2,830,000
BB-5	$37,146,000	$3,154,000
BB-6	$5,199,000	$8,140,000
Totals	**$71,990,000**	**$21,878,000**
Grand Total	***$93,868,000***	

Sea Level Rise

89. Tidal inundation is expected to increase gradually over time, in direct relation to the anticipated rise in relative sea level. Based upon historic NOAA tide gauge readings at Sandy Hook, sea level has been increasing at an average rate of 0.013 feet per year. This is equivalent to a 0.7 foot increase in tidal stage over the 50-year period of analysis. In future years this will result in more frequent and higher stages of flooding, as shown in **Table 35**.

Table 35: Sea Level Rise – Low Historic Sea Level Changes									
Year	**SLR Historic Surcharge (feet)**	**Historic Curve Jamaica Back-Bay Stages (feet NAVD88)**							
		Return Period (Years)							
		3	**5**	**10**	**25**	**50**	**100**	**250**	**500**
2015	0.0	**4.3**	**5.5**	**6.6**	**7.9**	**8.8**	**9.8**	**11.1**	**12.3**
2019	0.1	4.4	5.6	6.7	8.0	8.9	9.9	11.2	12.4
2029	0.2	4.5	5.7	6.8	8.1	9.0	10.0	11.3	12.5
2039	0.3	4.6	5.8	6.9	8.2	9.1	10.1	11.4	12.6
2049	0.5	4.8	6.0	7.1	8.4	9.3	10.3	11.6	12.8
2059	0.6	4.9	6.1	7.2	8.5	9.4	10.4	11.7	12.9
2069	0.7	5.0	6.2	7.3	8.6	9.5	10.5	11.8	13.0

90. In future years, more frequent and higher-stage flooding is likely. The resulting reduction in protective beach features combined with continued increases in sea level is expected to

increase the frequency and extent of future storm damages. Sea level rise is potentially a significant factor contributing to future impacts of tidal inundation and wave action.

91. Two additional accelerated sea level change scenarios have been evaluated as required in accordance with USACE guidance (ER 1100-2-8162 and ETL 1100-2-1). Accelerated sea level rise has been assessed under intermediate (Curve 1) and high (Curve 3) scenarios, as shown in **Tables 36 and 37**, respectively. The relationship between Low Historic, Intermediate (Curve1) and High (Curve3) Sea Level Rise surcharge is presented in **Figure 7**.

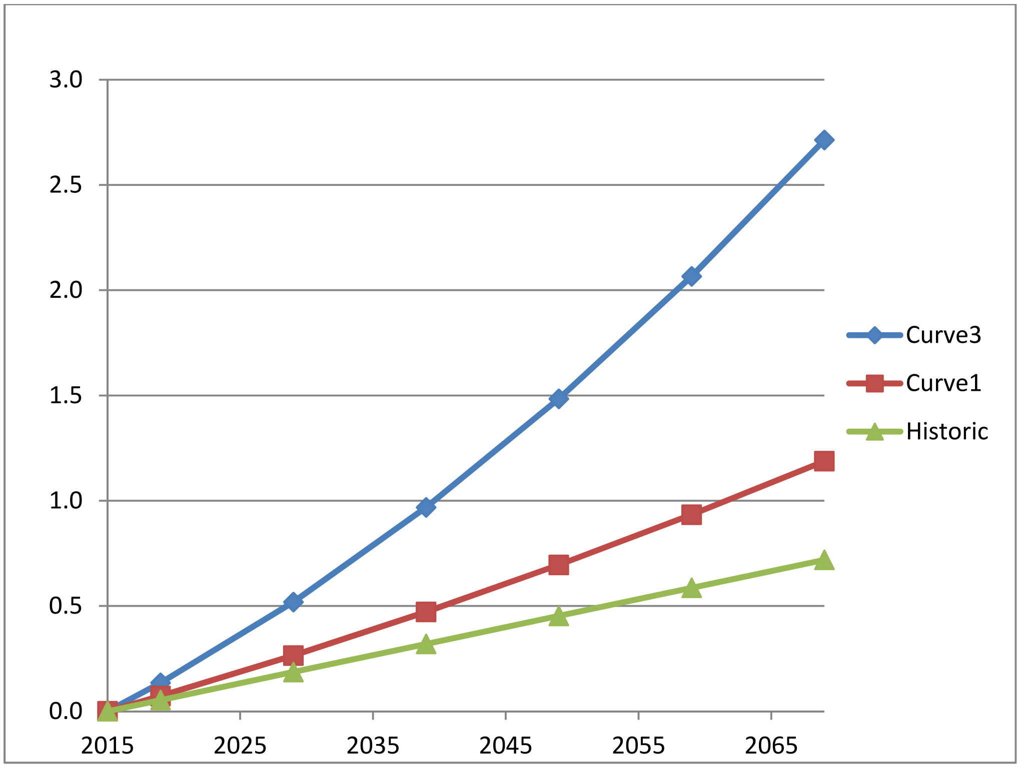
Table 36: Accelerated Sea Level Rise – Intermediate (Curve1) Sea Level Changes

Year	RSLR Curve 1 Surcharge (feet)	RSLR Curve 1 Jamaica Backbay Stages (feet NAVD88)							
		Return Period (Years)							
		3	5	10	25	50	100	250	500
2015	0.0	4.3	5.5	6.6	7.9	8.8	9.8	11.1	12.3
2019	0.1	4.4	5.6	6.7	8.0	8.9	9.9	11.2	12.4
2029	0.3	4.6	5.8	6.9	8.2	9.1	10.1	11.4	12.6
2039	0.5	4.8	6.0	7.1	8.4	9.3	10.3	11.6	12.8
2049	0.7	5.0	6.2	7.3	8.6	9.5	10.5	11.8	13.0
2059	0.9	5.2	6.4	7.5	8.8	9.7	10.7	12.0	13.2
2069	1.2	5.5	6.7	7.8	9.1	10.0	11.0	12.3	13.5

Table 37: Accelerated Sea Level Rise – High (Curve3) Sea Level Changes

Year	RSLR Curve 3 Surcharge (feet)	RSLR Curve 3 Jamaica Backbay Stages (feet NAVD88)							
		Return Period (Years)							
		3	5	10	25	50	100	250	500
2015	0.0	4.3	5.5	6.6	7.9	8.8	9.8	11.1	12.3
2019	0.1	4.4	5.6	6.7	8.0	8.9	9.9	11.2	12.4
2029	0.5	4.8	6.0	7.1	8.4	9.3	10.3	11.6	12.8
2039	1.0	5.3	6.5	7.6	8.9	9.8	10.8	12.1	13.3
2049	1.5	5.8	7.0	8.1	9.4	10.3	11.3	12.6	13.8
2059	2.1	6.4	7.6	8.7	10.0	10.9	11.9	13.2	14.4
2069	2.7	7.0	8.2	9.3	10.6	11.5	12.5	13.8	15.0

Figure 7: Sea Level Rise Relationships at Rockaway Beach NY



Calibration

Beach Fill and Seawall Calibration

92. The Rockaway Beach Project Beach-*fx* Analysis included three Beach-*fx* Projects that each required calibration. The first Beach-*fx* project was used for the without project scenario and the three beach fill alternative scenarios. The project was calibrated to each reach's target erosion rate, which were equal to the project area's historic erosion rates, to reflect realistic average erosion rates in the without project scenario (**Table 38**).

Table 38: Without Project and Beach Fill Calibration

Profiles	Reaches	Target Historical Rate	Storm Induced - Average Erosion Rate	Applied Erosion Rate	Average Erosion Rate	Differential from Target Historical Rate
R1T1	R1S1	10	-0.5	10.7400	10.0	0.0
R1T2	R1S2a	10	-0.5	10.7470	10.0	0.0
R1T3	R1S2b	10	-1.6	10.4540	10.0	0.0
R2T1	R2S2a	0	-2.5	1.3880	0.0	0.0
	R2S2b	0	-2.5	1.3880	0.0	0.0
R2T2	R3S1a	-2	-2.2	-0.7850	-2.0	0.0
	R3S1b	-2	-2.2	-0.7850	-2.0	0.0
	R3S1c	-2	-2.2	-0.7850	-2.0	0.0
	R3S1d	-2	-2.2	-0.7850	-2.0	0.0
	R3S2a	-2	-2.2	-0.7850	-2.0	0.0
	R3S2b	-10	-2.2	-9.0140	-10.1	0.1
	R4S1	-20	-2.2	-19.2655	-20.0	0.0
	R4S2	-20	-2.2	-19.2655	-20.0	0.0
	R4S3	-20	-2.2	-19.2655	-20.0	0.0
	R5S1a	-3	-2.2	-1.6890	-3.0	0.0
	R5S1b	-3	-2.2	-1.6890	-3.0	0.0
	R5S1c	-3	-2.2	-1.6890	-3.0	0.0
	R5S1d	-3	-2.2	-1.6890	-3.0	0.0
	R5S2b	-3	-2.2	-1.6890	-3.0	0.0
	R5S2a	-3	-2.2	-1.6890	-3.0	0.0
	R5S1e	-3	-2.2	-1.6890	-3.0	0.0
	R6S1a	-3	-2.2	-1.6890	-3.0	0.0
	R6S1b	-3	-2.2	-1.6890	-3.0	0.0
	R6S2	-3	-2.2	-1.6890	-3.0	0.0
	R6S3a	-3	-2.2	-1.6890	-3.0	0.0
	R6S3b	10	-2.2	11.2840	10.0	0.0
R2T3	R2S1	0	-2.5	1.2310	0.0	0.0
R2T4	R1S3	10	-2.5	10.9490	10.0	0.0

93. The remaining two Beach-*fx* projects were used for the seawall alternative scenarios. The calibrated applied erosion rates from the without project scenario were used for each seawall Beach-*fx* project. However, the projects were not re-calibrated as project engineers determined that it would be inappropriate to calibrate after modifying the storm response inputs. Despite reusing the initial applied erosion rates, the calibration results for the seawall alternatives produced reasonable average erosion rates (**Table 39**).

Table 39: Seawall Calibration

Profiles	Reaches	Target Historical Rate	Storm Induced - Average Erosion Rate	Applied Erosion Rate	Buried Seawall		Composite Seawall	
					Average Erosion Rate	Differential from Target Historical Rate	Average Erosion Rate	Differential from Target Historical Rate
R1T1	R1S1	10	-0.5	10.7400	N/A	N/A	N/A	N/A
R1T2	R1S2a	10	-0.5	10.7470	N/A	N/A	N/A	N/A
R1T3	R1S2b	10	-1.6	10.4540	N/A	N/A	N/A	N/A
R2T1	R2S2a	0	-2.5	1.3880	N/A	N/A	/A	N/A
	R2S2b	0	-2.5	1.3880	N/A	N/A	N/A	N/A
R2T2	R3S1a	-2	-2.2	-0.7850	-1.5	-0.5	-1.4	-0.6
	R3S1b	-2	-2.2	-0.7850	-1.5	-0.5	-1.4	-0.6
	R3S1c	-2	-2.2	-0.7850	-1.5	-0.5	-1.4	-0.6
	R3S1d	-2	-2.2	-0.7850	-1.5	-0.5	-1.4	-0.6
	R3S2a	-2	-2.2	-0.7850	-1.5	-0.5	-1.4	-0.6
	R3S2b	-10	-2.2	-9.0140	-8.6	-1.4	-8.6	-1.4
	R4S1	-20	-2.2	-19.2655	-18.1	-1.9	-18.1	-1.9
	R4S2	-20	-2.2	-19.2655	-18.1	-1.9	-18.1	-1.9
	R4S3	-20	-2.2	-19.2655	-18.1	-1.9	-18.1	-1.9
	R5S1a	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R5S1b	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R5S1c	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R5S1d	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R5S2b	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R5S2a	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R5S1e	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R6S1a	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R6S1b	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R6S2	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8
	R6S3a	-3	-2.2	-1.6890	-2.3	-0.7	-2.2	-0.8

	R6S3b	10	-2.2	11.2840	9.9	0.1	9.9	0.1
R2T3	R2S1	0	-2.5	1.2310	N/A	N/A	N/A	N/A
R2T4	R1S3	10	-2.5	10.9490	N/A	N/A	N/A	N/A

Planform Rates

94. After calibration, planform rates, or project-induced shoreline rates of change, were used to adjust the average erosion rate to consider planned nourishment efforts. For the Rockaway Beach Project, it was determined that there should be a 0 feet per year erosion rate in Reach 3a after planned nourishment has occurred. Additionally, the erosion rates in Reaches 3b, 4, 5, and 6a should be adjusted by -1.7 feet per year. There should be no change to the erosion rates in Reach 6b. The project's planform rates adjust the applied erosion rates according to the cycle of planned nourishment. Beach fill planform rates are shown in **Table 40**.

Table 40: Beach Fill Planform Rates

Profiles	Reaches	Without Project Target Historical Rate	With project Target	Planform Rates: Differential from Without Project
R1T1	R1S1	10	10	0
R1T2	R1S2a	10	10	0
R1T3	R1S2b	10	10	0
R2T1	R2S2a	0	0	0
	R2S2b	0	0	0
R2T2	R3S1a	-2	0	2
	R3S1b	-2	0	2
	R3S1c	-2	0	2
	R3S1d	-2	0	2
	R3S2a	-2	0	2
	R3S2b	-10	-11.7	-1.7
	R4S1	-20	-21.7	-1.7
	R4S2	-20	-21.7	-1.7
	R4S3	-20	-21.7	-1.7
	R5S1a	-3	-4.7	-1.7
	R5S1b	-3	-4.7	-1.7
	R5S1c	-3	-4.7	-1.7
	R5S1d	-3	-4.7	-1.7
	R5S2b	-3	-4.7	-1.7
	R5S2a	-3	-4.7	-1.7
	R5S1e	-3	-4.7	-1.7
	R6S1a	-3	-4.7	-1.7
	R6S1b	-3	-4.7	-1.7
	R6S2	-3	-4.7	-1.7
	R6S3a	-3	-3	0

	R6S3b	10	10	0
R2T3	R2S1	0	0	0
R2T4	R1S3	10	10	0

Introduction

95. Five coastal storm risk management alternative plans have been formulated and analyzed for the study area, including three design beach profiles and two reinforced dune concepts. Alternative plans considered are listed below.

- 16 Foot Dune. Beach restoration and construction of a dune to a height of +16 feet NAVD88, with a design berm width of 60 feet.
- 18 Foot Dune. Beach restoration and construction of a dune to a height of +18 feet NAVD88, with a design berm width of 80 feet.
- 20 Foot Dune. Beach restoration and construction of a dune to a height of +20 feet NAVD88, with a design berm width of 100 feet.
- Buried Seawall. Beach restoration and construction of a dune to a height of +18 feet NAVD88 with a reinforced rubble mound core of +16 feet NAVD88 and a design berm width of 60 feet.
- Composite Seawall. Beach restoration and construction of a dune to a height of +18 feet NAVD88 with an impermeable core (i.e., steel sheet pile protected by armor stone) and a design berm width of 60 feet.

96. Additional information on each alternative plan can be found in the Engineering Appendix.

97. This Benefits Appendix evaluates shorefront, cross-shore, and back-bay benefits of each alternative plan under three alternative sea level rise scenarios for future conditions. It considers

Approach and Assumptions

98. Benefits from the five alternative plans of improvement were estimated by evaluating the shorefront, cross shore, and back-bay damages with and without the alternative measures in place, under existing and future conditions. Benefit categories that were considered include flood damage reduction, emergency nourishment costs avoided, recreation benefits, and reduced FIA administrative costs. Benefit categories such as infrastructure benefits, reoccupation benefits, evacuation benefits, etc. were not evaluated in economic terms at this stage; however, qualitatively, the proposed plans of improvement are each expected to provide some benefit in these categories.

99. For each of the five alternative plans of improvement, three alternative future condition scenarios were considered in the analysis based on varying assumptions of the rate of future sea level rise as compared to observed historic conditions. Low, intermediate, and

high sea level rise rates were used to calculate the impact of these potential future conditions on both net benefits and overall cost effectiveness, for each of the proposed plans of improvement.

100. The low sea level rise scenario, which is based on historic sea level rise, was input at 0.013 feet per year sea level change rate. This rate was taken from the NOAA gauge at Sandy Hook, NJ. There were several sea level change gauges within the near vicinity of Rockaway Peninsula, including The Battery and Montauk, NY. However, the gauge at Sandy Hook, NY was the nearest ocean front gauge to the Project and was determined to best reflect shore front sea level rise on Rockaway Peninsula. The rate of 0.013 feet per year (0.01280 feet per year rounded as needed by Beach-*fx*) was the historic average for 81 years from 11/01/1932 to 08/01/2013.

101. The intermediate and high sea level rise scenarios utilize the USACE Intermediate Curve (NRC Curve I) and USACE High Curve (NRC Curve III), respectively, within Beach-*fx* based on the low sea level rise input. The model and supporting documentation are available at: (http://hera.pmcl.com/beachfx/default.aspx).

102. The assessment of sea level rise impacts included a technical analysis of the adaptability of each alternative to accommodate sea level rise under low (historic), intermediate (Curve 1), and high (Curve 3) scenarios. Annual costs and benefits under these scenarios were recalculated to allow an assessment of whether the plans identified under the low sea level rise scenario remain appropriate and cost effective under accelerated sea level rise scenarios.

103. The analysis of sea level rise included the average annual costs of future plan adaptations and the change in with- and without- project damage and benefits associated with higher water levels and higher rates of shoreline change. Shorefront benefits under these scenarios were recalculated in Beach-*fx*. Back bay inundation damages were estimated to increase in response to higher flood levels in Jamaica Bay. Because of the higher flood levels in Jamaica Bay, the area subject to cross shore flooding becomes smaller in the accelerated sea level rise scenarios. As a result, the damages and benefits associated with cross shore flooding become smaller as sea level rise increases.

Storm Damage Without Project

104. The analysis of without project storm damages reflects future conditions based on the low sea level rise scenario assumes a continuation of historic sea level changes (0.013 feet per year). The scenario analysis considers two additional accelerated sea level change

conditions, under intermediate (Curve 1) and high (Curve 3) scenarios, as required under USACE guidance (ER 1100-2-8162 and ETL 1100-2-1).

105. After severe storms, relevant local authorities provide emergency nourishment to the Rockaway beaches. It is estimated that the average annual cost of emergency nourishment is $881,000.

106. As described earlier in this appendix, without project equivalent annual damages under the low sea level rise scenario are estimated to be $109,650,000. Under the intermediate sea level rise scenario, they are expected to be approximately $113,918,000 and under the high sea level rise scenario, they are expected to be approximately $130,502,000.

Storm Damage With Plans

107. The storm damage reduction plans evaluated as part of this study included construction of a dune (16, 18, and 20 foot dune height alternatives), as well as a buried seawall alternative and composite seawall alternative. Alternative storm damage reduction plans do not provide 100 percent damage reduction for all properties. The residual damages of each alternative have been evaluated for the low, intermediate, and high sea level rise scenarios.

108. Residual damages range from a low of $73.4 million for the composite seawall under the low sea level rise scenario to a high of $118.8 million for the 16 foot dune under the high sea level rise scenario.

Reduced FIA Administrative Costs

109. Due to the remaining risk with structural measures, it is anticipated that a significant portion of the population will continue to purchase flood insurance under each of the five alternative plans, with no significant decrease in policyholders as a result of project implementation. As such, Flood Insurance Administration (FIA) administrative costs under the with-project condition are assumed to be equal to the costs incurred under the without project condition, with no net benefits from the FIA benefits point of view.

Emergency Nourishment Costs Avoided

110. After severe storms, relevant local authorities provide emergency nourishment to the Rockaway beaches. It is estimated that the average annual cost of emergency nourishment is $881,000 and it is anticipated that relevant local authorities will continue to provide emergency nourishment under these circumstances in the future without project condition. Under each of the five with-project conditions, the emergency nourishment cost becomes a

cost avoided, as scheduled nourishment activities become part of the maintenance of any approved plan of protection.

RECREATION BENEFITS

111. The NED Recreation Benefit Report for Rockaway Beach, NY (included herein as Sub-Appendix C) evaluated recreation benefits by estimating the number of beach visits under with-project conditions where the beach is maintained at a width of 200 feet, versus the number of beach visits under without-project future conditions where the beach experiences continued erosion.

112. Under existing conditions, Rockaway Beach is approximately 200 feet in width. A total of 7,738,500 total beach visits are estimated to occur per year at this beach width. Based on survey results, users are willing to pay $4.94 per visit under these conditions.

113. Under the with-project conditions, implementation of a beach restoration project maintains the width of existing beaches within the study area that were restored after Hurricane Sandy. Maintaining a 200-foot wide beach creates an enhanced recreation experience, which is reflected in an increase in willingness to pay (WTP) for the recreation experience and an increase in visitation. The number of annual beach visits will continue at 7,738,500 per year, with an average value per visit of $4.94.

114. The benefits analysis calculates the NED recreation benefits by assuming a ten-year period during which the beach erodes to the without project condition of half its present width. In year 10, 50% of the beach width is lost and based on the user surveys, 4,512,512 annual visits are lost. The remaining 3,225,988 annual visits are assumed to provide a reduced value for the user because of the depleted beach width. The 4,512,512 lost annual visits at year 10 are assumed to be distributed linearly over the ten-year timeline for the purposes of this analysis with 10% (451,251 visits) lost in year 1, 20% (902,502 visits) lost in year 2, 30% (1,353,754 visits) lost in year 3, and so on. The 3,224,988 remaining visits in year 10 that are assumed to provide a reduced value are also distributed linearly over the ten-year timeline, with 90% of existing visitors attending in year 1(7,287,249), 80% attending in year 2 (6,835,998), 70% attending in year 3 (6,384,746), and so on.

115. The without-project future condition assumes the lack of beach maintenance against erosion. Rockaway Beach would continue to experience erosion at a rate of about 10 feet per year. Based on responses to beach surveys completed in the summer of 2015, it is estimated that a 50 percent reduction in beach width would reduce the annual number of visits to Rockaway Beach by 4,512,512 visits. Beach visits per year were interpolated between these two points based on survey responses. The reduced beach width would, in

turn, reduce the user willingness to pay for the remaining 3,225,988 visits to a substantially lower $3.03 per visit. The user willingness to pay was also interpolated between these two points.

116. Present worth factors applied were calculated using the following formula (where ‘n’ is the number of years from 2015 and ‘i’ represents a fiscal year 2015 discount rate of 3.375%):

$$\textit{present worth factor} = \textit{present worth}/\ \textit{future worth} = 1/(1+i)^n$$

117. The present value and equivalent annual value of lost visits are shown in **Table 41**, while **Table 42** shows the present value and equivalent annual value of remaining reduced-value visits.

Table 41 – Present Value of Lost Visits by Year, Rockaway Beach, Without Project

Year	Number of Lost Visits	Value Per Lost Visit	Value of all Visits Lost	Present Worth Factor	Present Value of Lost Visits
1	451,251	$4.94	$2,229,180	0.96735	$2,156,402
2	902,502	$4.94	$4,458,360	0.93577	$4,171,998
3	1,353,754	$4.94	$6,687,545	0.90522	$6,053,690
4	1,805,005	$4.94	$8,916,725	0.87566	$7,808,063
5	2,256,256	$4.94	$11,145,905	0.84708	$9,441,429
6	2,707,507	$4.94	$13,375,085	0.81942	$10,959,820
7	3,158,758	$4.94	$15,604,265	0.79267	$12,369,002
8	3,610,010	$4.94	$17,833,450	0.76679	$13,674,491
9	4,061,261	$4.94	$20,062,630	0.74175	$14,881,549
10	4,512,512	$4.94	$22,291,810	0.71754	$15,995,216
11-49	*Years 11-49 not reproduced here; trend shown above continues.*				
50	4,512,512	$4.94	$22,291,810	0.19021	$4,240,033
Sum of present values of reduced value visits, Years 1 through 50					$445,813,371
Capital Recovery Factor					0.0416773
Equivalent Annual Value of Lost Visits					**$18,580,298**

Table 42 – Present Value of Reduced Value Visits by Year, Rockaway Beach, Without Project

Year	Number of Reduced Value Visits	Loss in Value Per Remaining Visit	Value of Reduced Value Visits	Present Worth Factor	Present Value of Reduced Value Visits
1	7,287,249	$0.32	$2,361,069	0.96735	$2,283,984
2	6,835,998	$0.65	$4,429,726	0.93577	$4,145,204
3	6,384,746	$0.97	$6,205,974	0.90522	$5,617,762
4	5,933,495	$1.30	$7,689,810	0.87566	$6,733,696
5	5,482,244	$1.62	$8,881,235	0.84708	$7,523,081
6	5,030,993	$1.94	$9,780,250	0.81942	$8,014,138
7	4,579,742	$2.27	$10,386,854	0.79267	$8,233,327
8	4,128,490	$2.59	$10,701,047	0.76679	$8,205,444
9	3,677,239	$2.92	$10,722,830	0.74175	$7,953,709
10	3,225,988	$3.03	$9,774,744	0.71754	$7,013,748
11-49	*Years 11-49 not reproduced here; trend shown above continues.*				
50	3,225,988	$3.03	$9,774,744	0.19021	$1,859,214
Sum of present values of reduced value visits, Years 1 through 50					$218,440,210
Capital Recovery Factor					0.0416773
Equivalent Annual Value of Reduced Value Visits					**$9,103,999**

118. NED recreation benefits over each year of the project timeline were calculated as the sum of the present value of lost visits plus the present value of the remaining reduced-value visits. **Table 43** documents the present value of NED recreation benefits by year, as well as equivalent annual NED recreation benefits.

Table 43 – NED Recreation Benefits, Rockaway Beach, Without Project

Year	Present Value of Lost Visits	Present Value of Reduced Value Visits	NED Recreation Benefits
1	$2,719,511	$2,283,984	$5,003,496
2	$5,261,449	$4,145,204	$9,406,653
3	$7,634,509	$5,617,762	$13,252,271
4	$9,847,009	$6,733,696	$16,580,705
5	$11,906,903	$7,523,081	$19,429,984
6	$13,821,798	$8,014,138	$21,835,936
7	$15,598,966	$8,233,327	$23,832,293
8	$17,245,358	$8,205,444	$25,450,803
9	$18,767,621	$7,953,709	$26,721,330
10	$20,172,104	$7,499,849	$27,671,953
11-49	*Years 11-49 not reproduced here; trend shown above continues.*		
50	$5,347,248	$1,988,070	$7,335,317
Sum of present values of NED Benefits, Years 1 through 50			$791,752,400
Capital Recovery Factor			0.0416773
Equivalent Annual Benefits			**$32,998,069**

SUMMARY OF COASTAL RISK MANAGEMENT BENEFITS

119. Flood damage reduction benefits were calculated based on a comparison of annual damages under the without-project future condition and five alternative with-project conditions under low, intermediate, and high sea level rise scenarios. Costs, damages, and benefits for the low, intermediate, and high sea level rise scenarios are summarized in **Tables 44 through 46**. All analyses were based on a 50-year period and an interest rate of 3.375%.

120. Each of the five alternative plans of improvement is cost effective under all three sea level rise scenarios that were evaluated. Because of the high cost of modifying the structural alternatives and the reduction in cross-shore flood benefits, the seawall alternatives are relatively less cost effective than the beach and dune restoration alternatives. Under the intermediate sea level rise scenario, the composite seawall plan continues to provide the overall highest net benefits, while the highest net benefits of the dune and beach restoration plans is provided by the 20 foot dune alternative. Under the high sea level rise scenario, the composite seawall plan continues to provide the overall highest net benefits while the 20 foot dune alternative provides slightly higher net benefits than the composite seawall alternative.

121. Based on ER 1105-2-100 Chapter 3 Paragraph 3-7(7), the recreation benefits that are required for justification must be less than an amount equal to 50 percent of the project costs. Because each alternative plan of improvement is cost-justified based on storm damage reduction benefits alone, the full value of the recreation benefits have been included to calculate the BCRs.

122. Detailed costs of the each alternative plan of improvement, maintenance, and renourishment can be found in the Cost Appendix.

Table 44: Cost, Damages and Benefits Summary for Low Sea Level Rise Scenario

Rockaway Beach Formulation Summary		**Low SLR**					
		Without Project	**16 Foot Dune**	**18 Foot Dune**	**20 Foot Dune**	**Buried Seawall**	**Composite Seawall**
Initial Cost	Initial Construction	$0	$60,801,000	$84,535,000	$134,540,000	$142,487,000	$205,872,000
	IDC	$0	$1,273,000	$2,088,000	$3,637,000	$4,205,000	$7,707,000
	Investment Cost	**$0**	**$62,074,000**	**$86,623,000**	**$138,177,000**	**$146,692,000**	**$213,579,000**
Annualized Cost	Initial Construction	$0	$2,587,000	$3,610,000	$5,759,000	$6,114,000	$8,901,000
	Renourishment (Planned/Emergency)	$812,000	$5,740,000	$6,167,000	$6,589,000	$5,740,000	$5,740,000
	O&M	$0	$573,000	$592,000	$614,000	$718,000	$822,000
	Major Rehab	$0	$332,000	$332,000	$332,000	$332,000	$332,000
	SLR Adaptation	$0	$0	$0	$0	$0	$0
	Total Annual Cost	**$812,000**	**$9,232,000**	**$10,701,000**	**$13,294,000**	**$12,904,000**	**$15,795,000**
Damages	Damages - Shore Front	$15,782,000	$7,886,000	$4,909,000	$2,617,000	$4,831,000	$1,886,000
	Damages - Cross Shore Flood Damages	$28,705,000	$26,491,000	$19,422,000	$15,467,000	$19,422,000	$11,396,000
	Back Bay Damages	$65,163,000	$65,163,000	$65,163,000	$65,163,000	$65,163,000	$65,163,000
	Total Damages	**$109,650,000**	**$99,540,000**	**$89,494,000**	**$83,247,000**	**$89,416,000**	**$78,445,000**
Benefits	Total Benefits (Reduced Damages)	$0	$7,896,000	$10,873,000	$13,165,000	$10,951,000	$13,896,000
	Cost Avoided (Emergency Nourishment)	$0	$812,000	$812,000	$812,000	$812,000	$812,000
	Shorefront Benefit (Reduced Damage Plus Cost Avoided)	$0	$8,708,000	$11,685,000	$13,977,000	$11,763,000	$14,708,000
	Cross Shore Flood Damage Reduced	$0	$2,214,000	$9,283,000	$13,238,000	$9,283,000	$17,309,000
	Total Storm Damage Reduction Benefits	$0	$10,922,000	$20,968,000	$27,215,000	$21,046,000	$32,017,000
	Recreation Benefits	**$0**	**$32,998,000**	**$32,998,000**	**$32,998,000**	**$32,998,000**	**$32,998,000**
	Total Benefits	**$0**	**$43,920,000**	**$53,966,000**	**$60,213,000**	**$54,044,000**	**$65,015,000**
	Net Benefits (Damage Reduction Only)	**$0**	**$34,688,000**	**$43,265,000**	**$46,919,000**	**$41,140,000**	**$49,220,000**
BCR		**--**	**4.76**	**5.04**	**4.53**	**4.19**	**4.12**

Table 45: Cost, Damages and Benefits Summary for Intermediate Sea Level Rise Scenario

Rockaway Beach Formulation Summary		**Intermediate SLR**					
		Without Project	**16 Foot Dune**	**18 Foot Dune**	**20 Foot Dune**	**Buried Seawall**	**Composite Seawall**
Initial Cost	Initial Construction	$0	$60,801,000	$84,535,000	$134,540,000	$142,487,000	$205,872,000
	IDC	$0	$1,273,000	$2,088,000	$3,637,000	$4,205,000	$7,707,000
	Investment Cost	**$0**	**$62,074,000**	**$86,623,000**	**$138,177,000**	**$146,692,000**	**$213,579,000**
Annualized Cost	Initial Construction	$0	$2,587,000	$3,610,000	$5,759,000	$6,114,000	$8,901,000
	Renourishment (Planned/Emergency)	$881,000	$6,140,000	$6,562,000	$6,989,000	$6,140,000	$6,140,000
	O&M	$0	$573,000	$592,000	$614,000	$718,000	$822,000
	Major Rehab	$0	$332,000	$332,000	$332,000	$332,000	$332,000
	SLR Adaptation	$0	$188,000	$335,000	$338,000	$915,000	$1,303,000
	Total Annual Cost	**$881,000**	**$9,820,000**	**$11,431,000**	**$14,032,000**	**$14,219,000**	**$17,498,000**
Damages	Damages - Shore Front	$16,676,000	$8,117,000	$5,113,000	$2,766,000	$5,009,000	$2,351,000
	Damages - Cross Shore Flood Damages	$27,419,000	$25,357,000	$18,631,000	$14,884,000	$18,631,000	$11,005,000
	Back Bay Damages	$69,823,000	$69,823,000	$69,823,000	$69,823,000	$69,823,000	$69,823,000
	Total Damages	**$113,918,000**	**$103,297,000**	**$93,567,000**	**$87,473,000**	**$93,463,000**	**$83,179,000**
Benefits	Total Benefits (Reduced Damages)	-	$8,559,000	$11,563,000	$13,910,000	$11,667,000	$14,325,000
	Cost Avoided (Emergency Nourishment)	-	$881,000	$881,000	$881,000	$881,000	$881,000
	Shorefront Benefit (Reduced Damage Plus Cost Avoided)	-	$9,440,000	$12,444,000	$14,791,000	$12,548,000	$15,206,000
	Cross Shore Flood Damage Reduced	-	$2,062,000	$8,788,000	$12,535,000	$8,788,000	$16,414,000
	Total Storm Damage Reduction Benefits	-	$11,502,000	$21,232,000	$27,326,000	$21,336,000	$31,620,000
	Recreation Benefits	$0	$32,998,000	$32,998,000	$32,998,000	$32,998,000	$32,998,000
	Total Benefits	-	**$44,500,000**	**$54,230,000**	**$60,324,000**	**$54,334,000**	**$64,618,000**
	Net Benefits (Damage Reduction Only)	-	**$34,680,000**	**$42,799,000**	**$46,292,000**	**$40,115,000**	**$47,120,000**
BCR		-	**4.53**	**4.74**	**4.30**	**3.82**	**3.69**

Table 46: Cost, Damages and Benefits Summary for High Sea Level Rise Scenario

Rockaway Beach Formulation Summary		High SLR					
		Without Project	**16 Foot Dune**	**18 Foot Dune**	**20 Foot Dune**	**Buried Seawall**	**Composite Seawall**
Initial Cost	Initial Construction	$0	$60,801,000	$84,535,000	$134,540,000	$142,487,000	$205,872,000
	IDC	$0	$1,273,000	$2,088,000	$3,637,000	$4,205,000	$7,707,000
	Investment Cost	**$0**	**$62,074,000**	**$86,623,000**	**$138,177,000**	**$146,692,000**	**$213,579,000**
Annualized Cost	Initial Construction	$0	$2,587,000	$3,610,000	$5,759,000	$6,114,000	$8,901,000
	Renourishment (Planned/Emergency)	$1,165,000	$7,397,000	$7,823,000	$8,244,000	$7,397,000	$7,397,000
	O&M	$0	$573,000	$592,000	$614,000	$718,000	$822,000
	Major Rehab	$0	$332,000	$332,000	$332,000	$332,000	$332,000
	SLR Adaptation	$0	$553,000	$842,000	$852,000	$2,225,000	$2,317,000
	Total Annual Cost	**$1,165,000**	**$11,442,000**	**$13,199,000**	**$15,801,000**	**$16,786,000**	**$19,769,000**
Damages	Damages - Shore Front	$19,318,000	$8,931,000	$5,928,000	$3,478,000	$5,734,000	$3,088,000
	Damages - Cross Shore Flood Damages	$22,904,000	$21,629,000	$16,151,000	$13,135,000	$16,151,000	$9,804,000
	Back Bay Damages	$88,280,000	$88,280,000	$88,280,000	$88,280,000	$88,280,000	$88,280,000
	Total Damages	**$130,502,000**	**$118,840,000**	**$110,359,000**	**$104,893,000**	**$110,165,000**	**$101,172,000**
Benefits	Total Benefits (Reduced Damages)	-	$10,387,000	$13,390,000	$15,840,000	$13,584,000	$16,230,000
	Cost Avoided (Emergency Nourishment)	-	$1,165,000	$1,165,000	$1,165,000	$1,165,000	$1,165,000
	Shorefront Benefit (Reduced Damage Plus Cost Avoided)	-	$11,552,000	$14,555,000	$17,005,000	$14,749,000	$17,395,000
	Cross Shore Flood Damage Reduced	-	$1,275,000	$6,753,000	$9,769,000	$6,753,000	$13,100,000
	Total Storm Damage Reduction Benefits	-	$12,827,000	$21,308,000	$26,774,000	$21,502,000	$30,495,000
	Recreation Benefits	$0	$32,998,000	$32,998,000	$32,998,000	$32,998,000	$32,998,000
	Total Benefits	-	**$45,825,000**	**$54,306,000**	**$59,772,000**	**$54,500,000**	**$63,493,000**
	Net Benefits (Damage Reduction Only)	-	**$34,383,000**	**$41,107,000**	**$43,971,000**	**$37,714,000**	**$43,724,000**
BCR		-	**4.00**	**4.11**	**3.78**	**3.25**	**3.21**

SUB-APPENDIX A - VALUE OF DEVELOPMENT BY SUB-REACHES

Value of Development by Subreaches

1. The location of shorefront subreaches is shown in **Table A-1**. The value of development in each sub-reach is shown in **Table A-2**. A breakdown of values by sub-reach and stage (Feet, NAVD88) is shown in **Table A-3** through **Table A-25**. These tables also present the total depreciated replacement value of boardwalks in each reach. Each boardwalk section with a different setback distance from adjacent sections was considered to be a separate damage element in the Beach-*fx* model.

Table A-1: Location of Shorefront Reaches and Subreaches

Reach	Sub-Reach	Description
SFR-2	R2S2a	Jacob Riis Park
	R2S2b	Old Neponsit HC Center
SFR-3	R3S1a	Beach 142 Street - Beach 149 Street
	R3S1b	Beach 135 - Beach 142
	R3S1c	Beach 130 - Beach 135
	R3S1d	Beach 126 - Beach 130
	R3S2a	Beach 121 - Beach 126
	R3S2b	Beach 109 - Beach 121
SFR-4	R4S1	Beach 102 - Beach 109
	R4S2	Beach 92 - Beach 102
	R4S3	Beach 86 - Beach 92
SFR-5	R5S1a	Beach 84 - Beach 86
	R5S1b	Beach 81 - Beach 84
	R5S1c	Beach 77 - Beach 81
	R5S1d	Beach 74 - Beach 77
	R5S1e	Beach 60 - Beach 74
	R5S2a	Beach 56 - Beach 60
	R5S2b	Beach 43 - Beach 56
SFR-6	R6S1a	Beach 36 - Beach 43
	R6S1b	Beach 32 - Beach 36
	R6S2	Beach 29 - Beach 32
	R6S3a	Beach 24 - Beach 28
	R6S3b	Beach 19 - Beach 24

Table A-2: Value of Development in Shorefront Sub-Reaches

Reach	**Sub-Reach**	**Residential**		**Nonresidential**		**Boardwalk**	***Totals***	
		No.	Value	No.	Value	Value	No.	*Value*
SFR-2	**R2S2a**	0	$0	4	$6,953,977	$0	*4*	*$6,953,977*
	R2S2b	0	$0	3	$12,387,784	$0	*3*	*$12,387,784*
SFR-2 Total		**0**	**$0**	**7**	**$19,341,761**	**$0**	**7**	**$19,341,761**
SFR-3	**R3S1a**	83	$30,612,000	0	$0	$0	*83*	*$30,612,002*
	R3S1b	**124**	$38,684,772	0	$0	$0	*124*	*$38,684,772*
	R3S1c	95	$27,743,620	0	$0	$0	*95*	*$27,743,620*
	R3S1d	74	$21,909,548	0	$0	$0	*74*	*$21,909,548*
	R3S2a	59	$103,114,949	0	$0	$0	*59*	*$103,114,949*
	R3S2b	49	$203,401,055	8	$28,522,290	$0	*57*	*$231,923,345*
SFR-3 Total		**484**	**$425,465,946**	**8**	**$28,522,290**	**$0**	**492**	**$453,988,236**
SFR-4	**R4S1**	133	$142,269,885	2	$809,738	$23,209,000	*135*	*$166,288,623*
	R4S2	98	$39,414,039	4	$10,563,177	$24,340,000	*102*	*$74,317,216*
	R4S3	27	$80,629,835	0	$0	$18,570,300	*27*	*$99,200,135*
SFR-4 Total		**258**	**$262,313,759**	**6**	**$11,372,915**	**$66,119,300**	**264**	**$339,805,974**
SFR-5	**R5S1a**	1	$26,407,567	2	$16,590,520	$5,752,100	*3*	*$48,750,187*
	R5S1b	2	$55,853,400	0	$0	$2,184,000	*2*	*$58,037,400*
	R5S1c	2	$58,041,761	0	$0	$4,235,000	*2*	*$62,276,761*
	R5S1d	2	$58,280,240	0	$0	$2,520,000	*2*	*$60,800,240*
	R5S1e	63	$31,277,875	0	$0	$15,916,500	*63*	*$47,194,375*
	R5S2a	14	$101,739,951	0	$0	$6,523,100	*14*	*$108,263,051*
	R5S2b	0	$0	0	$0	$16,653,000	*0*	*$16,653,000*
SFR-5 Total		**84**	**$331,600,794**	**2**	**$16,590,520**	**$53,783,700**	**86**	**$401,975,014**
SFR-6	**R6S1a**	0	$0	0	$0	$9,105,000	*0*	*$9,105,000*
	R6S1b	0	$0	0	$0	$4,404,400	*0*	*$4,404,400*
	R6S2	3	$852,582	0	$0	$2,379,600	*3*	*$3,232,182*
	R6S3a	35	$42,442,111	1	$24,231,965	$0	*36*	*$66,674,076*
	R6S3b	7	$98,908,396	1	$6,323,703	$0	*8*	*$105,232,099*
SFR-6 Total		**45**	**$142,203,089**	**2**	**$30,555,668**	**$15,889,000**	**47**	**$188,647,757**
Grand Total		**871**	**$1,161,583,588**	**25**	**$106,383,154**	**$135,792,000**	**896**	**$1,403,758,742**

Table A-3: Value of Development in R2S2a, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	4	$6,953,977	$0	4	$6,953,977
11	0	$0	4	$6,953,977	$0	4	$6,953,977
12	0	$0	4	$6,953,977	$0	4	$6,953,977
13	0	$0	4	$6,953,977	$0	4	$6,953,977
14	0	$0	4	$6,953,977	$0	4	$6,953,977
15	0	$0	4	$6,953,977	$0	4	$6,953,977
16	0	$0	4	$6,953,977	$0	4	$6,953,977
17	0	$0	4	$6,953,977	$0	4	$6,953,977
18	0	$0	4	$6,953,977	$0	4	$6,953,977
19	0	$0	4	$6,953,977	$0	4	$6,953,977
20	0	$0	4	$6,953,977	$0	4	$6,953,977
21	0	$0	4	$6,953,977	$0	4	$6,953,977
22	0	$0	4	$6,953,977	$0	4	$6,953,977
23	0	$0	4	$6,953,977	$0	4	$6,953,977
24	0	$0	4	$6,953,977	$0	4	$6,953,977

Table A-4: Value of Development in R2S2b, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	0	$0	1	$4,317,343	$0	1	$4,317,343
12	0	$0	2	$9,317,275	$0	2	$9,317,275
13	0	$0	3	$12,387,784	$0	3	$12,387,784
14	0	$0	3	$12,387,784	$0	3	$12,387,784
15	0	$0	3	$12,387,784	$0	3	$12,387,784
16	0	$0	3	$12,387,784	$0	3	$12,387,784
17	0	$0	3	$12,387,784	$0	3	$12,387,784
18	0	$0	3	$12,387,784	$0	3	$12,387,784
19	0	$0	3	$12,387,784	$0	3	$12,387,784
20	0	$0	3	$12,387,784	$0	3	$12,387,784
21	0	$0	3	$12,387,784	$0	3	$12,387,784
22	0	$0	3	$12,387,784	$0	3	$12,387,784
23	0	$0	3	$12,387,784	$0	3	$12,387,784
24	0	$0	3	$12,387,784	$0	3	$12,387,784

Table A-5: Value of Development in R3S1a, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	1	$326,123	0	$0	$0	1	$326,123
11	3	$1,073,437	0	$0	$0	3	$1,073,437
12	10	$3,267,569	0	$0	$0	10	$3,267,569
13	27	$9,622,670	0	$0	$0	27	$9,622,670
14	64	$23,081,819	0	$0	$0	64	$23,081,819
15	74	$26,335,373	0	$0	$0	74	$26,335,373
16	78	$28,171,987	0	$0	$0	78	$28,171,987
17	80	$29,126,408	0	$0	$0	80	$29,126,408
18	82	$30,134,943	0	$0	$0	82	$30,134,943
19	82	$30,134,943	0	$0	$0	82	$30,134,943
20	83	$30,612,002	0	$0	$0	83	$30,612,002
21	83	$30,612,002	0	$0	$0	83	$30,612,002
22	83	$30,612,002	0	$0	$0	83	$30,612,002
23	83	$30,612,002	0	$0	$0	83	$30,612,002
24	83	$30,612,002	0	$0	$0	83	$30,612,002

Table A-6: Value of Development in R3S1b, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	3	$814,244	0	$0	$0	3	$814,244
11	15	$4,110,930	0	$0	$0	15	$4,110,930
12	37	$11,010,383	0	$0	$0	37	$11,010,383
13	78	$22,836,839	0	$0	$0	78	$22,836,839
14	103	$31,414,993	0	$0	$0	103	$31,414,993
15	117	$36,483,642	0	$0	$0	117	$36,483,642
16	123	$38,277,279	0	$0	$0	123	$38,277,279
17	124	$38,684,772	0	$0	$0	124	$38,684,772
18	124	$38,684,772	0	$0	$0	124	$38,684,772
19	124	$38,684,772	0	$0	$0	124	$38,684,772
20	124	$38,684,772	0	$0	$0	124	$38,684,772
21	124	$38,684,772	0	$0	$0	124	$38,684,772
22	124	$38,684,772	0	$0	$0	124	$38,684,772
23	124	$38,684,772	0	$0	$0	124	$38,684,772

Table A-7: Value of Development in R3S1c, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	1	$337,602	0	$0	$0	1	$337,602
12	35	$9,793,444	0	$0	$0	35	$9,793,444
13	55	$15,495,109	0	$0	$0	55	$15,495,109
14	82	$23,164,858	0	$0	$0	82	$23,164,858
15	90	$26,067,438	0	$0	$0	90	$26,067,438
16	94	$27,285,028	0	$0	$0	94	$27,285,028
17	94	$27,285,028	0	$0	$0	94	$27,285,028
18	94	$27,285,028	0	$0	$0	94	$27,285,028
19	95	$27,743,620	0	$0	$0	95	$27,743,620
20	95	$27,743,620	0	$0	$0	95	$27,743,620
21	95	$27,743,620	0	$0	$0	95	$27,743,620
22	95	$27,743,620	0	$0	$0	95	$27,743,620
23	95	$27,743,620	0	$0	$0	95	$27,743,620
24	95	$27,743,620	0	$0	$0	95	$27,743,620

Table A-8: Value of Development in R3S1d, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	6	$2,648,574	0	$0	$0	6	$2,648,574
11	17	$5,155,193	0	$0	$0	17	$5,155,193
12	37	$9,869,704	0	$0	$0	37	$9,869,704
13	48	$13,411,628	0	$0	$0	48	$13,411,628
14	59	$17,077,150	0	$0	$0	59	$17,077,150
15	66	$19,098,007	0	$0	$0	66	$19,098,007
16	71	$20,702,167	0	$0	$0	71	$20,702,167
17	71	$20,702,167	0	$0	$0	71	$20,702,167
18	71	$20,702,167	0	$0	$0	71	$20,702,167
19	73	$21,632,169	0	$0	$0	73	$21,632,169
20	74	$21,909,548	0	$0	$0	74	$21,909,548
21	74	$21,909,548	0	$0	$0	74	$21,909,548
22	74	$21,909,548	0	$0	$0	74	$21,909,548
23	74	$21,909,548	0	$0	$0	74	$21,909,548
24	74	$21,909,548	0	$0	$0	74	$21,909,548

Table A-9: Value of Development in R3S2a, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	5	$17,672,854	0	$0	$0	5	$17,672,854
11	17	$25,647,893	0	$0	$0	17	$25,647,893
12	19	$44,812,825	0	$0	$0	19	$44,812,825
13	20	$45,222,481	0	$0	$0	20	$45,222,481
14	30	$86,437,959	0	$0	$0	30	$86,437,959
15	42	$90,948,755	0	$0	$0	42	$90,948,755
16	51	$93,972,113	0	$0	$0	51	$93,972,113
17	56	$99,131,688	0	$0	$0	56	$99,131,688
18	57	$99,370,576	0	$0	$0	57	$99,370,576
19	57	$99,370,576	0	$0	$0	57	$99,370,576
20	58	$100,301,569	0	$0	$0	58	$100,301,569
21	58	$100,301,569	0	$0	$0	58	$100,301,569
22	59	$103,114,949	0	$0	$0	59	$103,114,949
23	59	$103,114,949	0	$0	$0	59	$103,114,949
24	59	$103,114,949	0	$0	$0	59	$103,114,949

Table A-10: Value of Development in R3S2b, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	15	$53,139,982	1	$8,237,980	$0	16	$61,377,962
11	18	$111,868,531	4	$8,586,715	$0	22	$120,455,246
12	26	$162,587,108	7	$10,172,691	$0	33	$172,759,799
13	32	$175,117,766	8	$28,522,290	$0	40	$203,640,056
14	35	$176,395,399	8	$28,522,290	$0	43	$204,917,689
15	39	$178,074,345	8	$28,522,290	$0	47	$206,596,635
16	42	$189,607,114	8	$28,522,290	$0	50	$218,129,404
17	43	$189,924,431	8	$28,522,290	$0	51	$218,446,721
18	47	$202,312,970	8	$28,522,290	$0	55	$230,835,260
19	47	$202,312,970	8	$28,522,290	$0	55	$230,835,260
20	49	$203,401,055	8	$28,522,290	$0	57	$231,923,345
21	49	$203,401,055	8	$28,522,290	$0	57	$231,923,345
22	49	$203,401,055	8	$28,522,290	$0	57	$231,923,345
23	49	$203,401,055	8	$28,522,290	$0	57	$231,923,345
24	49	$203,401,055	8	$28,522,290	$0	57	$231,923,345

Table A-11: Value of Development in R4S1, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	3	$74,205,376	1	$599,400	$0	4	$74,804,776
11	6	$74,435,071	2	$809,738	$0	8	$75,244,809
12	114	$83,938,860	2	$809,738	$0	116	$84,748,598
13	128	$141,620,714	2	$809,738	$0	130	$142,430,452
14	128	$141,620,714	2	$809,738	$0	130	$142,430,452
15	131	$142,039,072	2	$809,738	$0	133	$142,848,810
16	133	$142,269,885	2	$809,738	$0	135	$143,079,623
17	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623
18	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623
19	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623
20	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623
21	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623
22	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623
23	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623
24	133	$142,269,885	2	$809,738	$23,209,000	135	$166,288,623

Table A-12: Value of Development in R4S2, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	10	$4,720,777	3	$9,290,797	$24,340,000	13	$38,351,574
11	32	$21,152,051	4	$10,563,177	$24,340,000	36	$56,055,228
12	35	$21,914,728	4	$10,563,177	$24,340,000	39	$56,817,905
13	41	$23,603,801	4	$10,563,177	$24,340,000	45	$58,506,978
14	51	$26,231,658	4	$10,563,177	$24,340,000	55	$61,134,835
15	65	$30,026,916	4	$10,563,177	$24,340,000	69	$64,930,093
16	69	$31,274,976	4	$10,563,177	$24,340,000	73	$66,178,153
17	73	$32,345,408	4	$10,563,177	$24,340,000	77	$67,248,585
18	77	$33,415,841	4	$10,563,177	$24,340,000	81	$68,319,018
19	85	$35,397,893	4	$10,563,177	$24,340,000	89	$70,301,070
20	90	$36,735,945	4	$10,563,177	$24,340,000	94	$71,639,122
21	91	$36,998,608	4	$10,563,177	$24,340,000	95	$71,901,785
22	91	$36,998,608	4	$10,563,177	$24,340,000	95	$71,901,785
23	93	$37,688,730	4	$10,563,177	$24,340,000	97	$72,591,907
24	98	$39,414,039	4	$10,563,177	$24,340,000	102	$74,317,216

Table A-13: Value of Development in R4S3, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	3	$72,078,041	0	$0	$0	3	$72,078,041
11	7	$75,768,103	0	$0	$4,493,500	7	$80,261,603
12	13	$76,697,477	0	$0	$4,493,500	13	$81,190,977
13	13	$76,697,477	0	$0	$4,493,500	13	$81,190,977
14	16	$77,550,018	0	$0	$4,493,500	16	$82,043,518
15	21	$79,091,112	0	$0	$4,493,500	21	$83,584,612
16	23	$79,606,730	0	$0	$4,493,500	23	$84,100,230
17	24	$79,953,618	0	$0	$18,570,300	24	$98,523,918
18	26	$80,526,844	0	$0	$18,570,300	26	$99,097,144
19	27	$80,629,835	0	$0	$18,570,300	27	$99,200,135
20	27	$80,629,835	0	$0	$18,570,300	27	$99,200,135
21	27	$80,629,835	0	$0	$18,570,300	27	$99,200,135
22	27	$80,629,835	0	$0	$18,570,300	27	$99,200,135
23	27	$80,629,835	0	$0	$18,570,300	27	$99,200,135
24	27	$80,629,835	0	$0	$18,570,300	27	$99,200,135

Table A-14: Value of Development in R5S1a, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	1	$26,407,567	1	$11,215,498	$0	2	$37,623,065
11	1	$26,407,567	1	$11,215,498	$0	2	$37,623,065
12	1	$26,407,567	1	$11,215,498	$0	2	$37,623,065
13	1	$26,407,567	2	$16,590,520	$0	3	$42,998,087
14	1	$26,407,567	2	$16,590,520	$0	3	$42,998,087
15	1	$26,407,567	2	$16,590,520	$0	3	$42,998,087
16	1	$26,407,567	2	$16,590,520	$0	3	$42,998,087
17	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187
18	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187
19	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187
20	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187
21	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187
22	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187
23	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187
24	1	$26,407,567	2	$16,590,520	$5,752,100	3	$48,750,187

Table A-15: Value of Development in R5S1b, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	2	$55,853,400	0	$0	$0	2	$55,853,400
11	2	$55,853,400	0	$0	$0	2	$55,853,400
12	2	$55,853,400	0	$0	$0	2	$55,853,400
13	2	$55,853,400	0	$0	$0	2	$55,853,400
14	2	$55,853,400	0	$0	$0	2	$55,853,400
15	2	$55,853,400	0	$0	$0	2	$55,853,400
16	2	$55,853,400	0	$0	$0	2	$55,853,400
17	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400
18	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400
19	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400
20	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400
21	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400
22	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400
23	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400
24	2	$55,853,400	0	$0	$2,184,000	2	$58,037,400

Table A-16: Value of Development in R5S1c, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	2	$58,041,761	0	$0	$0	2	$58,041,761
11	2	$58,041,761	0	$0	$0	2	$58,041,761
12	2	$58,041,761	0	$0	$0	2	$58,041,761
13	2	$58,041,761	0	$0	$0	2	$58,041,761
14	2	$58,041,761	0	$0	$0	2	$58,041,761
15	2	$58,041,761	0	$0	$0	2	$58,041,761
16	2	$58,041,761	0	$0	$0	2	$58,041,761
17	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761
18	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761
19	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761
20	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761
21	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761
22	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761
23	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761
24	2	$58,041,761	0	$0	$4,235,000	2	$62,276,761

Table A-17: Value of Development in R5S1d, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	1	$28,678,621	0	$0	$0	1	$28,678,621
11	2	$58,280,240	0	$0	$0	2	$58,280,240
12	2	$58,280,240	0	$0	$0	2	$58,280,240
13	2	$58,280,240	0	$0	$0	2	$58,280,240
14	2	$58,280,240	0	$0	$0	2	$58,280,240
15	2	$58,280,240	0	$0	$0	2	$58,280,240
16	2	$58,280,240	0	$0	$0	2	$58,280,240
17	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240
18	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240
19	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240
20	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240
21	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240
22	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240
23	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240
24	2	$58,280,240	0	$0	$2,520,000	2	$60,800,240

Table A-18: Value of Development in R5S1e, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	7	$8,406,048	0	$0	$0	7	$8,406,048
12	8	$8,543,903	0	$0	$0	8	$8,543,903
13	18	$11,372,819	0	$0	$0	18	$11,372,819
14	44	$24,001,093	0	$0	$0	44	$24,001,093
15	62	$31,147,507	0	$0	$0	62	$31,147,507
16	62	$31,147,507	0	$0	$0	62	$31,147,507
17	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375
18	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375
19	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375
20	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375
21	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375
22	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375
23	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375
24	63	$31,277,875	0	$0	$15,916,500	63	$47,194,375

Table A-19: Value of Development in R5S2a, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	0	$0	0	$0	$0	0	$0
12	2	$306,395	0	$0	$0	2	$306,395
13	3	$495,774	0	$0	$0	3	$495,774
14	4	$3,007,243	0	$0	$0	4	$3,007,243
15	14	$101,739,951	0	$0	$0	14	$101,739,951
16	14	$101,739,951	0	$0	$0	14	$101,739,951
17	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051
18	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051
19	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051
20	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051
21	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051
22	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051
23	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051
24	14	$101,739,951	0	$0	$6,523,100	14	$108,263,051

Table A-20: Value of Development in R5S2b, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	0	$0	0	$0	$0	0	$0
12	0	$0	0	$0	$0	0	$0
13	0	$0	0	$0	$0	0	$0
14	0	$0	0	$0	$0	0	$0
15	0	$0	0	$0	$0	0	$0
16	0	$0	0	$0	$0	0	$0
17	0	$0	0	$0	$16,653,000	0	$16,653,000
18	0	$0	0	$0	$16,653,000	0	$16,653,000
19	0	$0	0	$0	$16,653,000	0	$16,653,000
20	0	$0	0	$0	$16,653,000	0	$16,653,000
21	0	$0	0	$0	$16,653,000	0	$16,653,000
22	0	$0	0	$0	$16,653,000	0	$16,653,000
23	0	$0	0	$0	$16,653,000	0	$16,653,000
24	0	$0	0	$0	$16,653,000	0	$16,653,000

Table A-21: Value of Development in R6S1a, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	0	$0	0	$0	$0	0	$0
12	0	$0	0	$0	$0	0	$0
13	0	$0	0	$0	$0	0	$0
14	0	$0	0	$0	$0	0	$0
15	0	$0	0	$0	$0	0	$0
16	0	$0	0	$0	$0	0	$0
17	0	$0	0	$0	$9,105,000	0	$9,105,000
18	0	$0	0	$0	$9,105,000	0	$9,105,000
19	0	$0	0	$0	$9,105,000	0	$9,105,000
20	0	$0	0	$0	$9,105,000	0	$9,105,000
21	0	$0	0	$0	$9,105,000	0	$9,105,000
22	0	$0	0	$0	$9,105,000	0	$9,105,000
23	0	$0	0	$0	$9,105,000	0	$9,105,000
24	0	$0	0	$0	$9,105,000	0	$9,105,000

Table A-22: Value of Development in R6S1b, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	0	$0	0	$0	$0	0	$0
12	0	$0	0	$0	$0	0	$0
13	0	$0	0	$0	$0	0	$0
14	0	$0	0	$0	$0	0	$0
15	0	$0	0	$0	$0	0	$0
16	0	$0	0	$0	$0	0	$0
17	0	$0	0	$0	$4,404,400	0	$4,404,400
18	0	$0	0	$0	$4,404,400	0	$4,404,400
19	0	$0	0	$0	$4,404,400	0	$4,404,400
20	0	$0	0	$0	$4,404,400	0	$4,404,400
21	0	$0	0	$0	$4,404,400	0	$4,404,400
22	0	$0	0	$0	$4,404,400	0	$4,404,400
23	0	$0	0	$0	$4,404,400	0	$4,404,400
24	0	$0	0	$0	$4,404,400	0	$4,404,400

Table A-23: Value of Development in R6S2, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	1	$246,985	0	$0	$0	1	$246,985
12	1	$246,985	0	$0	$0	1	$246,985
13	1	$246,985	0	$0	$0	1	$246,985
14	1	$246,985	0	$0	$0	1	$246,985
15	1	$246,985	0	$0	$0	1	$246,985
16	3	$852,582	0	$0	$0	3	$852,582
17	3	$852,582	0	$0	$2,379,600	3	$3,232,182
18	3	$852,582	0	$0	$2,379,600	3	$3,232,182
19	3	$852,582	0	$0	$2,379,600	3	$3,232,182
20	3	$852,582	0	$0	$2,379,600	3	$3,232,182
21	3	$852,582	0	$0	$2,379,600	3	$3,232,182
22	3	$852,582	0	$0	$2,379,600	3	$3,232,182
23	3	$852,582	0	$0	$2,379,600	3	$3,232,182
24	3	$852,582	0	$0	$2,379,600	3	$3,232,182

Table A-24: Value of Development in R6S3a, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	16	$2,264,293	1	$24,231,965	$0	17	$26,496,258
11	23	$4,695,547	1	$24,231,965	$0	24	$28,927,512
12	33	$6,561,667	1	$24,231,965	$0	34	$30,793,632
13	34	$6,590,377	1	$24,231,965	$0	35	$30,822,342
14	34	$6,590,377	1	$24,231,965	$0	35	$30,822,342
15	34	$6,590,377	1	$24,231,965	$0	35	$30,822,342
16	34	$6,590,377	1	$24,231,965	$0	35	$30,822,342
17	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076
18	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076
19	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076
20	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076
21	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076
22	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076
23	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076
24	35	$42,442,111	1	$24,231,965	$0	36	$66,674,076

Table A-25: Value of Development in R6S3b, by Stage

Stage	Structure Category						
	Residential		Nonresidential		Boardwalk	Totals	
	Number	Value	Number	Value	Value	Number	Value
10	0	$0	0	$0	$0	0	$0
11	4	$41,457,869	0	$0	$0	4	$41,457,869
12	5	$55,370,015	1	$6,323,703	$0	6	$61,693,718
13	5	$55,370,015	1	$6,323,703	$0	6	$61,693,718
14	6	$84,506,216	1	$6,323,703	$0	7	$90,829,919
15	6	$84,506,216	1	$6,323,703	$0	7	$90,829,919
16	6	$84,506,216	1	$6,323,703	$0	7	$90,829,919
17	6	$84,506,216	1	$6,323,703	$0	7	$90,829,919
18	6	$84,506,216	1	$6,323,703	$0	7	$90,829,919
19	7	$98,908,396	1	$6,323,703	$0	8	$105,232,099
20	7	$98,908,396	1	$6,323,703	$0	8	$105,232,099
21	7	$98,908,396	1	$6,323,703	$0	8	$105,232,099
22	7	$98,908,396	1	$6,323,703	$0	8	$105,232,099
23	7	$98,908,396	1	$6,323,703	$0	8	$105,232,099
24	7	$98,908,396	1	$6,323,703	$0	8	$105,232,099

SUB APPENDIX B – SHOREFRONT DAMAGE FUNCTIONS

See Paragraphs 73-74 for the sources from which applied shorefront damage functions were drawn.

Table B-1: Erosion Contents Apartment

X	YMin	YMostLikely	YMax
0	0	0	0
0.1	0.05	0.17	0.3
0.2	0.15	0.32	0.5
0.3	0.3	0.5	0.75
0.4	0.4	0.7	1
0.5	0.5	0.86	1
0.6	0.6	0.89	1
0.7	0.7	0.92	1
0.8	0.8	0.94	1
0.9	0.9	0.97	1
1	1	1	1

Table B-2: Erosion Contents High-Rise

X	YMin	YMostLikely	YMax
0	0	0	0
0.1	0	0	0.005
0.2	0.005	0.01	0.0225
0.3	0.005	0.0175	0.045
0.4	0.005	0.047	0.055
0.5	0.0075	0.048	0.065
0.6	0.0075	0.05	0.08
0.7	0.0075	0.0725	0.09
0.8	0.01	0.0785	0.1
0.9	0.02	0.08	0.11
1	0.035	0.08	0.11

Table B-3: Erosion Contents Single Family Residence, Multi Family Residence, Commercial Buildings

X	YMin	YMostLikely	YMax
0	0	0	0
0.1	0.05	0.2	0.25
0.2	0.2	0.4	0.6
0.3	0.3	0.6	1
0.4	0.5	0.8	1
0.5	0.7	1	1
0.6	0.8	1	1
0.7	0.9	1	1
0.8	1	1	1
0.9	1	1	1
1	1	1	1

Table B-4: Erosion Structure Apartments

X	YMin	YMostLikely	YMax
0	0	0	0
0.1	0.05	0.17	0.3
0.2	0.15	0.32	0.5
0.3	0.3	0.5	0.75
0.4	0.4	0.7	1
0.5	0.5	0.86	1
0.6	0.6	0.89	1
0.7	0.7	0.92	1
0.8	0.8	0.94	1
0.9	0.9	0.97	1
1	1	1	1

Table B-5: Erosion Structure Single Family Residence, Multi Family Residence, Commercial Buildings

X	YMin	YMostLikely	YMax
0	0	0	0
0.1	0.05	0.2	0.25
0.2	0.2	0.4	0.6
0.3	0.3	0.6	1
0.4	0.5	0.8	1
0.5	0.7	1	1
0.6	0.8	1	1
0.7	0.9	1	1
0.8	1	1	1
0.9	1	1	1
1	1	1	1

Table B-6: Erosion Structure High Rise

X	YMin	YMostLikely	YMax
0	0	0	0
0.1	0.0005	0.01025	0.025
0.2	0.0015	0.035	0.04
0.3	0.01	0.03	0.05
0.4	0.02	0.045	0.065
0.5	0.03	0.058	0.075
0.6	0.0325	0.065	0.075
0.7	0.035	0.081	0.087
0.8	0.035	0.083	0.09
0.9	0.04	0.09	0.1
1	0.04	0.095	0.11

Table B-7: Inundation Contents Apartment

X	YMin	YMostLikely	YMax
-0.5	0	0	0
0	0.003333	0.02	0.065
0.5	0.05	0.1	0.15
1	0.075	0.135	0.19
2	0.125	0.2	0.245
3	0.19	0.245	0.29
5	0.233333	0.293333	0.313333
7	0.3	0.335	0.4

Table B-8: Inundation Contents High-Rise

X	YMin	YMostLikely	YMax
-0.5	0	0	0
0	0	0	0.015
0.5	0.005	0.02	0.05
1	0.01	0.04	0.055
2	0.015	0.045	0.065
3	0.02	0.055	0.08
5	0.02	0.07	0.095
7	0.02	0.085	0.1
10	0.025	0.09	0.1

Table B-9: Inundation Contents Multi Family Residence, Commercial Buildings

X	YMin	YMostLikely	YMax
-2	0	0	0
-1	0.0075	0.06	0.1125
0	0.165	0.2025	0.24
1	0.3025	0.3275	0.3625
2	0.4175	0.4475	0.4775
3	0.515	0.55	0.585
4	0.605	0.6425	0.68
5	0.68	0.72	0.76
6	0.7475	0.7875	0.8275
7	0.8025	0.845	0.8875
8	0.8475	0.8925	0.9375
9	0.8825	0.93	0.9775
10	0.9075	0.96	1
11	0.9225	0.98	1
12	0.9275	0.9925	1
13	0.9275	1	1
14	0.9275	1	1
15	0.9275	1	1
16	0.9275	1	1

Table B-10: Inundation Contents Single Family Residence, NB (No Basement)

X	YMin	YMostLikely	YMax
-2	0	0	0
-1	0.01	0.01	0.0625
0	0.0065	0.05	0.0935
1	0.048	0.087	0.126
2	0.0845	0.122	0.1595
3	0.1175	0.155	0.1925
4	0.1445	0.185	0.2255
5	0.168	0.213	0.258
6	0.191	0.239	0.287
7	0.2135	0.263	0.3125
8	0.233	0.284	0.335
9	0.2505	0.303	0.3555
10	0.2675	0.32	0.3725
11	0.2815	0.334	0.3865
12	0.2945	0.347	0.3995
13	0.3035	0.356	0.4085
14	0.31	0.364	0.418
15	0.312	0.369	0.426
16	0.309	0.372	0.435

Table B-11: Inundation Contents Single Family Residence, WB (With Basement)

X	YMin	YMostLikely	YMax
-4	0	0	0
-3	0.04865	0.068	0.08735
-2	0.06585	0.084	0.10215
-1	0.08405	0.101	0.11795
0	0.10265	0.119	0.13535
1	0.12135	0.138	0.15465
2	0.13855	0.157	0.17545
3	0.15555	0.177	0.19845
4	0.17295	0.198	0.22305
5	0.1912	0.22	0.2488
6	0.21075	0.243	0.27525
7	0.2316	0.267	0.3024
8	0.2526	0.291	0.3294
9	0.2756	0.317	0.3584
10	0.2984	0.344	0.3896
11	0.3201	0.372	0.4239
12	0.3382	0.4	0.4618
13	0.3538	0.43	0.5062
14	0.36515	0.461	0.55685
15	0.3718	0.493	0.6142
16	0.37375	0.526	0.67825

Table B-12: Inundation Structure Multi Family Residence, Commercial Buildings

X	YMin	YMostLikely	YMax
-2	0	0	0
-1	0	0.02	0.05
0	0.1	0.11	0.12
1	0.2	0.28	0.41
2	0.3	0.38	0.47
3	0.35	0.43	0.53
4	0.39	0.46	0.54
5	0.49	0.56	0.73
6	0.53	0.59	0.73
7	0.56	0.61	0.73
8	0.59	0.63	0.73

Table –B13: Inundation Structure Single Family Residence, NB (No Basement)

X	YMin	YMostLikely	YMax
-2	0	0	0
-1	0.03	0.03	0.0915
0	0.042	0.093	0.144
1	0.107	0.152	0.197
2	0.167	0.209	0.251
3	0.2195	0.263	0.3065
4	0.266	0.314	0.362
5	0.311	0.362	0.413
6	0.3515	0.407	0.4625
7	0.3905	0.449	0.5075
8	0.428	0.488	0.548
9	0.4625	0.524	0.5855
10	0.494	0.557	0.62
11	0.524	0.587	0.65
12	0.551	0.614	0.677
13	0.575	0.638	0.701
14	0.5945	0.659	0.7235
15	0.608	0.677	0.746
16	0.617	0.692	0.767

Table B-14: Inundation Structure Single Family Residence, WB (With Basement)

X	YMin	YMostLikely	YMax
-4	0	0	0
-3	0.0486	0.072	0.0954
-2	0.07995	0.102	0.12405
-1	0.11845	0.139	0.15955
0	0.1592	0.179	0.1988
1	0.20275	0.223	0.24325
2	0.2475	0.27	0.2925
3	0.29275	0.319	0.34525
4	0.3384	0.369	0.3996
5	0.3839	0.419	0.4541
6	0.42955	0.469	0.50845
7	0.47465	0.518	0.56135
8	0.51705	0.564	0.61095
9	0.5573	0.608	0.6587
10	0.59235	0.648	0.70365
11	0.6207	0.684	0.7473
12	0.6387	0.714	0.7893
13	0.64415	0.737	0.82985
14	0.63715	0.754	0.87085
15	0.6164	0.764	0.9116
16	0.5786	0.764	0.9494

Table B-15: Inundation Structure High-Rise

X	YMin	YMostLikely	YMax
0	0	0	0
0.5	0.0075	0.0225	0.0425
1	0.02	0.045	0.075
2	0.035	0.07	0.12
3	0.045	0.0775	0.14
5	0.055	0.115	0.15
7	0.065	0.1275	0.1725
10	0.075	0.165	0.2

Table B-16: Inundation Structure Apartment

X	YMin	YMostLikely	YMax
-0.5	0	0	0
0	0	0.05	0.075
0.5	0.045	0.075	0.11
1	0.065	0.17	0.225
2	0.1	0.225	0.27
3	0.165	0.245	0.3
5	0.2	0.315	0.42
7	0.3	0.45	0.5

Table B-17: Wave Damage Contents Single Family Residence, Multi Family Residence, Commercial Buildings

X	YMin	YMostLikely	YMax
0	0	0	0
0.5	0.2	0.33	0.5
1	0.4	0.66	1
1.5	0.6	1	1
2	0.8	1	1
2.5	0.9	1	1
3	1	1	1
3.5	1	1	1
4	1	1	1

Table B-18: Wave Contents Apartment

X	YMin	YMostLikely	YMax
-0.5	0	0	0
0	0.05	0.2	0.25
1	0.2	0.3	0.35
2	0.35	0.5	1
3	0.4	0.8	1
5	0.6	1	1

Table B-19: Wave Contents High-Rise

X	YMin	YMostLikely	YMax
-1	0	0	0
0	0	0.005	0.02
1	0.0125	0.02	0.04
2	0.0175	0.05	0.06
3	0.02	0.06	0.09
5	0.02	0.08	0.1
7	0.02	0.08	0.1
10	0.035	0.1	0.115

Table B-20: Wave Structure Apartment

X	YMin	YMostLikely	YMax
-0.5	0	0	0
0	0.05	0.1	0.15
1	0.15	0.2	0.3
2	0.25	0.35	0.5
3	0.4	0.7	1
5	0.5	1	1

Table B-21: Wave Structure Boardwalk

X	YMin	YMostLikely	YMax
0	0	0	0
15	0	0	0
16	0	0	0.25
17	0	0.25	0.5
18	0.25	0.5	0.75
19	0.5	0.75	1
20	0.75	0.75	1

Table B-22: Wave Structure High-Rise

X	YMin	YMostLikely	YMax
-1	0	0	0
0	0	0.015	0.025
1	0.0175	0.05	0.1
2	0.025	0.075	0.12
3	0.035	0.11	0.14
5	0.05	0.14	0.175
7	0.06	0.16	0.24
10	0.06	0.205	0.3

Table B-23: Wave Structure Single Family Residence, Multi Family Residence, Commercial Buildings

X	YMin	YMostLikely	YMax
0	0	0	0
0.5	0.2	0.33	0.5
1	0.4	0.66	1
1.5	0.6	1	1
2	0.8	1	1
2.5	0.9	1	1
3	1	1	1
3.5	1	1	1
4	1	1	1

SUB-APPENDIX C - RECREATION BENEFITS REPORT

SUB-APPENDIX – PURPOSE AND OVERVIEW

I. PURPOSE AND OVERVIEW

1. Project Description

Location.

The study area are the municipal public recreation beach facilities located on the peninsula commonly referred to as the Rockaways, located entirely with the Borough of Queens, New York City. The peninsula extends from Rockaway Inlet to East Rockaway Inlet, approximately 10 miles in length, and separates the Atlantic Ocean from Jamaica Bay immediately to the north. The municipal recreation facilities evaluated in this study are located on the ocean side of the peninsula, and are under the authority of the City of New York, Department of Parks and Recreation.

The communities located on the Rockaway peninsula from west to east include Breezy Point, Roxbury, Neponsit, Belle Harbor, Rockaway Park, Seaside, Hammel, Arverne, Edgemere and Far Rockaway. The former Fort Tilden Military Reservation and the Jacob Riis Park (part of the National Park Service's Gateway National Recreation Area) are located in the western half of the peninsula between Breezy Point and Neponsit. The characteristics of nearly all of the communities on the Rockaway peninsula are similar. Ground elevations rarely exceed 10 feet, except within the existing dune field. Elevations along the Jamaica Bay shoreline side of the peninsula generally range from 5 feet, increasing to 10 feet further south toward the Atlantic coast. An estimated 7,900 residential and commercial structures on the peninsula fall within the Special Flood Hazard Area (SFHA) floodplain regulated by the National Flood Insurance Program (NFIP).

Figure 2-Study Area

Recreation Usage.

2. Purpose of the analysis

The purpose of this study is to develop estimates of National Economic Development (NED) recreational benefits produced by a beach restoration project that covers Rockaway Beach, New York.

Implementation of the project will maintain the beaches within the study area that were restored and renourished after Superstorm Sandy in 2012. Maintaining the width of existing beaches will create an enhanced recreation experience (relative to the future condition of the beach without maintenance) which is reflected in an increase in willingness to pay (WTP) for the recreation experience and an increase in visitation.

3. Statement of the 'future without project condition' and 'with-project' condition

The "future without project condition”, or FWOPC, is to not maintain the beaches at present beach widths. The beach will experience erosion and eventually be half the width of the existing beach. The "with project" condition is to maintain the beaches in the study area against erosion, to a width of approximately 200 feet of beach.

4. Recreation Market for Rockaway Beach.

The impact of beach nourishment relates to the geographic recreation "market". The market is defined by the location of the potential user population. The potential user population is delineated as people now using the beach parks in Rockaway Beach, New York.

5. Introduction to Methodology

Travel Cost Method

The Travel Cost Method (TCM) is used to estimate economic use values associated with sites that are used for recreation. The basic premise of the TCM is that the time and travel cost expenses that people incur to visit a site represent the ‘price’ of access to the site. Thus, peoples’ willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs. This is analogous to estimating peoples’ willingness to pay for marketed goods based on the quantity demanded at different prices.

An individual TCM approach is used, based on survey data from individual users at Rockaway Beach. Data was gathered on the location of the visitor’s home ZIP Code, how far they traveled to the site, how many times they visited the site during the season, the length of the trip, travel expenses, the method of travel to the site, the person’s income and other socioeconomic characteristics. The questionnaire is attached in Appendix A.

Using the survey data about visitors, a regression model is estimated between the number of visits and travel costs and other relevant variables. The regression equation gives us the demand function of the ‘average’ visitor to the site, and the area below this demand curve gives the average consumer surplus. Consumer surplus is the amount a buyer is willing to pay for a good minus the amount the buyer actually pays for it. In the case of visitors to Rockaway Beach, the use of the beach is free, so the amount the buyer actually pays is zero. Consumer surplus is thus the entire area under the demand curve. The consumer surplus for the average visitor is divided by the number of visits at the zero price to give consumer surplus per visit. This is multiplied by the total number of visits to the site to estimate total consumer surplus. The model estimated with existing visits to Rockaway beach is used to estimate the 'with-project' condition value. The model estimated with reduced visits to the site under the 'future without-project' condition is used to estimate the 'without-project' value.

The TCM assumes that people perceive and respond to changes in travel costs in the same way that they would respond to changes in admission price. The TCM may not be well suited for sites like Rockaway Beach near major population centers where many visitations are from origin zones that are quite close to one another. This may limit the differences in travel costs to affect the number of trips made, and thus understating the impact of travel costs on visits. Further, some visitors to Rockaway Beach may choose to live nearby. In this instance, they will have low travel costs, but high values for the site that are not captured.

The information necessary to develop a simulated demand curve was obtained from a survey conducted during June through August, 2015. Respondents were asked about their 'without' and 'with-project' beach visitation.

II. SAMPLE DESIGN AND EVALUATION

The sample design specifies the location and number of questionnaires completed, and how respondents are selected. Respondents on the beach were selected using random numbers. The number of questionnaires completed and dates are displayed in Table II-A. Table II-B provides the number of interviews conducted on weekdays and weekends.

Table II-A.

Completion Rate: The Number of Questionnaires by Date

DATES (2015)	NUMBER OF INTERVIEWS
July 2	22
July 5	25
July 6	47
July 10	53
July 12	52
July 13	21
July 14	21
July 17	28
July 19	26
July 20	27
July 22	26
July 24	48
July 25	51
July 27	20
July 28	19
July 31	50
August 1	25
August 2	25
August 8	25
August 9	52
TOTAL	**663**

Table II-B.

Completion Rate: The Number of Interviews by Day

LOCATION	**Total # of Interviews Completed**	
	Weekday	**Weekend**
Rockaway Beach	360 [54%]	303 [46%]

III. DESCRIPTIVE STATISTICS

1. Trip Bias and Weighting Corrections

The sample distribution of visits (from the survey) does not correspond to the population distribution of visits (actual visits). Persons going to the beach more often are more likely to be selected as survey respondents, a factor which is known as ‘trip bias’.

The correction for the trip bias is to estimate the population’s average visitation from the sample data. The procedure is to divide the sample size by the sum of the inverse of visits for each case across all respondents in the sample.

The formula is:

$$Avg = [n / \sum (1 / v_i)]$$

Where Avg is the average number of visits corrected for trip bias
n is the sample size
v_i is the number of visits for respondent *i*.

The correction for trip bias is presented in Table III-A. The adjustment for trip bias was performed based on a respondent's summer 2015 visitation to Rockaway Beach. The sample mean visitation, as expected due to trip bias, is substantially larger than the mean visitation corrected for trip bias (the estimate of the population mean visits).

Table III-A*: Mean Number of Visits per Person to Rockaway Beach (Summer of 2015)*

	ROCKAWAY BEACH MEAN VISITS
From Survey	16.07
Corrected for Trip Bias	5.63

The existence of trip bias required that the survey information be adjusted for over-representation of respondents that visit frequently. The correction was to weight the data items from each respondent by the inverse of visitation [1/vi], where vi is the summer 2015 visitation to Rockaway Beach for each respondent. The weighting by the inverse of the summer 2015 visitation to Rockaway Beach corrects the sample data for over representation of respondents that visit the beach frequently.

2. Descriptive Statistics

Descriptive statistics, sample means, standard deviations, and demographic characteristics for the respondents are displayed in Table III-B.

Table III-B*: Summary Statistics for Travel Cost Method Survey at Rockaway Beach*

TYPE OF QUESTION	Sample means adjusted for trip bias with standard deviation in parenthesis
BEACH TRIP CHARACTERISTICS & VISITATION	
% Drove a Car/Passenger in Car	61.2%
% Bus/Subway	31.6%
% Walked/Rode a Bike	7.2%
% Visit Weekdays	46.6%
% Visit Weekends	24.8%
% Visit Both Weekdays & Weekends	28.6%
Travel Time to Beach	46.1 Minutes [32.7]
Tolls or Bus/Subway Fees	$3.99 [3.24]

Summer 2015 Visits to Rockaway Beach	5.63 [7.698]
Visits to Rockaway Beach if Beach Not Maintained	2.44 [6.227]
% Certain of Answers	97.7%

DEMOGRAPHIC CHARACTERISTICS OF SURVEY RESPONDENTS

% Female	62.2%
% Completed College	54.3%
% Employed Full-time	65.8%
% Household Income > $ 100,000	29.2%
% With Children at Beach	25.8%
Age	37.6 [13.5]

IV. BEACH ATTENDANCE

1. Estimated Beach Usage.

Beach attendance data was provided by the Department of Parks and Recreation (DPR), City of New York. The methodology provided by DPR is as follows: The protocol for all City beaches is to take two crowd estimates daily – at 11 a.m. and 4 p.m. – then add the two together to get the daily number. Beach, boardwalk, concessions, adjacent playgrounds are all included in the count. Counts are made at various beach sections that tend to draw similar crowds. Counts at various beach locations for a single block are multiplied by the number of similar blocks.

Based on the total Rockaway Beach visitation provided by DPR, and information from the survey (corrected for trip bias), 2015 beach attendance by method of travel to the beach is provided below using the following algorithms:

Beach Attendance by Method of Travel = (% of respondents arriving by method of travel from survey)* (DPR Rockaway Beach Attendance Estimate for 2015).

# of Visitors = Visits/Average Visits.

Table IV-A :2015 Beach Attendance at Rockaway Beach

METHOD OF TRAVEL	VISITS	AVERAGE # OF VISITS FROM SURVEY	# OF VISITORS
WALK/BIKE	557,172	12.85	43,360
CAR	4,735,962	5.72	827,965
BUS/SUBWAY	2,445,366	4.05	603,794
TOTAL	7,738,500		1,475,119

The results above in Table IV-A are consistent with reasonable expectations about visits to Rockaway Beach. Those visitors who walk or bike to the beach and live close to the beach visit substantially more frequently than those that drive or take the subway/bus. These visitors make up 3 percent of visitors and 7.2 percent of visits, which is reasonable, given the larger number of potential visitors who can drive or take the bus/subway to Rockaway Beach compared to those that are within walking or biking distance.

Beach attendance under the without-project condition is estimated using responses from the survey regarding expected beach attendance if Rockaway Beach is not maintained against erosion resulting in a beach width approximately half to the existing beach width. The following algorithms are used:

Beach Attendance by Method of Travel for Without Project Condition = [(% of respondents arriving by method of travel from survey that will have positive visits under without project condition)* (Number of Visitors from Table IV-A)] * (Average # of Visits).

Table IV-B: Percentage of Current Rockaway Beach Users that will Visit Under Future Without Project Condition

METHOD OF TRAVEL	% VISITING
WALK/BIKE	84%
CAR	47%
BUS/SUBWAY	45%

Table IV-C: **Without Project Beach Attendance at Rockaway Beach**

METHOD OF TRAVEL	VISITS	AVERAGE # OF VISITS	# OF VISITORS
WALK/BIKE	397,364	10.91	36,422
CAR	1,891,235	4.86	389,143
BUS/SUBWAY	937,389	3.45	271,707
TOTAL	3,225,988		697,272

The without project condition of not maintaining Rockaway Beach against erosion results in a substantial number of existing beach goers not willing to visit. Beach visitors arriving by walking or biking have the highest percentage continuing to visit under the without project condition at 84 percent. More than 50 percent of visitors arriving by car or subway/bus are not willing to visit Rockaway Beach under the without project condition. Those willing to visit under the without project condition slightly reduce their number of beach visits compared with their existing beach visits. The number of visits not taking place under the without project condition at Rockaway Beach is 4,512,512. Some of these visits will likely take place at alternative beaches such as Long Beach, Jones Beach and Coney Island.

Table IV-D: County of Residence of Rockaway Beach Users

COUNTY	PERCENTAGE OF BEACH VISITORS	AVERAGE VISITS
Bronx, N.Y.	2.8%	4.32
Brooklyn, N.Y.	18.9%	4.94
Nassau, N.Y.	3.1%	5.83
New York, N.Y.	12.7%	3.85
Queens, N.Y.	54.0%	6.99
Other	8.5%	2.65

Visitors to Rockaway Beach currently use other beaches in the area: Coney Island, Long Beach, and Jones Beach. Table IV-E shows the use of other beaches by origin county of Rockaway Beach users.

TABLE IV-E: Rockaway Beach Visitors Using Other Beaches [Percentage of Respondents Visiting other Beaches and Average Number of Visits]

	Other Beaches Visited		
Origin of Rockaway Beach Visitor	Coney Island	Long Beach	Jones Beach
New York, NY	20% 2.3 visits	20% 3.8 visits	27% 1.9 visits
Brooklyn	36% 4.0 visits	32% 3.5 visits	24% 1.8 visits
Queens	26% 2.0 visits	40% 3.7 visits	18% 2.5 visits

V. PROJECT BENEFITS

Simulated Demand Curves

The procedure for estimating the use value at Rockaway Beach is to develop "simulated" demand curves. These demand curves are referred to as "simulated" since they are not based on actual market behavior, but on behavior using travel cost to simulate price. The concept of demand describes the relationship between the number of yearly visits (quantity demanded) that people are willing to make at each travel cost (price). The approach used to obtain the relationship between travel costs and annual visits is a regression model.

With-Project Condition Use Value

The regression model estimated for the with-project benefits is:

Equation 1:
Existing Annual Visits = 12.573 – 2.159 [ln Travel Cost]
2.787) (.847)

The regression model in Equation 1 estimates the existing annual visits to Rockaway Beach for the average person using the beach. The constant term is 12.573, which is interpreted as the estimated number of visits if travel costs (price) are zero. The estimated coefficient for travel cost is -2.159 which shows the change in annual visits when travel cost increases. The natural logarithum of travel costs is used since the relationship between travel costs and annual visit is not linear. The standard errors of the regression coefficients are in parenthesis. The travel cost estimated regression coefficient is statistically different from zero at the 5-percent level or better, and has the expected negative sign. The R-square for equation 1 is .071. The number of observations are 86.

Annual visits are those reported by respondents adjusted for trip bias.

Travel cost is composed of three components discussed below.

First is the opportunity cost of travel time to Rockaway Beach. It is estimated as the travel time to the beach in hours times the hourly income of the respondent. The average travel time to the beach is 46 minutes; the median travel time is 40 minutes. Hourly income of respondent is estimated by taking the mid-point of the income categories from the questionnaire and dividing by 2,080, or the annual number of hours for a full-time employee (52 weeks x 40 hours/week). The average hourly income is $41.85; the median is $36.06. The value of hourly family income for a recreation trip is 60 percent of family income (ER 1105-2-100; Appendix D, Amendment #1; 30 June 2004). Note that adjusting the opportunity cost of travel time by a constant amount (.6) will have minmal impact on the resulting travel cost regression coefficient because the variation in travel cost per respondent is not substantially altered. The average opportunity cost of travel time to Rockaway Beach is $19.25.

Second is the cost associated with driving a vehicle. Travel time to Rockaway Beach from the survey was converted to mileage at the rate of 40 miles per hour. The IRS mileage charge of $.56 a mile was used. The average vehicle costs of driving to Rockaway Beach is $14.49; the median is $13.06. This driving cost is applied only to those visitors that drove a car to Rockaway Beach. The driving cost is divided by the number of passengers in the vehicle to arrive at driving costs per person.

Third, the tolls and bus/subway fees are included, and tolls are divided by the number of passengers in a vehicle to arrive at tolls and bus/subway fees on a per person basis.

The total average travel costs to Rockaway Beach (the sum of opportunity cost of travel time, driving costs per person, and tolls/fees per person) is $31.24.

The number of observations available for the analysis is 513 rather than 663, as some respondents are lost from the sample pool, due to refusing to report their income. Income is necessary in the calculation of travel cost. The regression model uses the trip bias adjusted information, weighting all variables by the inverse of 2015 beach visitation. This statistical procedure reduces the number of observations in the regression to 86, but importantly removes trip bias from the analysis. Adding other variables to the model improves the overall performance but diminishes the statistical significance of travel cost.

Travel cost in this model is likely understated due to fact that most visitors to Rockaway Beach come from locations that are near and equal distanced, and those within walking distance or biking travel costs do not accurately reflect their beach valuation. These individuals beach value will be understated by travel costs, their valuation is more likely reflected in real estate values for owners or rental rates for those on vacation.

The use value for the existing condition at Rockaway Beach is calculated by measuring the area under the demand curve represented by regression equation 1. The estimated demand curve is displayed in Figure 1. A demand curve is shown by varying Travel Cost and calculating how annual visits change (Table V-A).

In making this calculation, we used the actual average trip bias adjusted visits to Rockaway Beach in 2015 to set the number of visits at zero price, or 5.63. Equation 1 then becomes:

Existing Average Annual Visits to Rockaway Beach = 5.63 – 2.159 [ln Travel Costs]. [Equation 1A]

The calculated area under the demand curve is $27.85, or $4.94 per average visit in use value or consumer surplus. For example, at a price of $5, the estimated number of visits is:

Existing Average Annual Visits to Rockaway Beach = 5.63 – 2.159[ln $5].

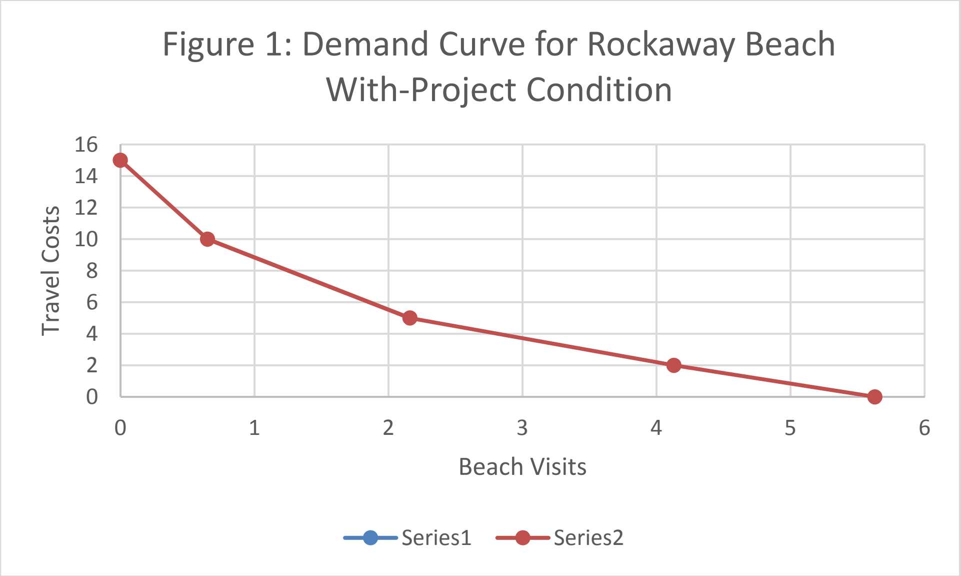
Taking the antilog of $5, this equation becomes:

Existing Average Annual Visits to Rockaway Beach = 5.63 –2.159 [1.609]; or 5.63 – 3.473; resulting in existing annual average visits to Rockaway Beach of 2.16 at a price (travel cost) of $5.

Table V-A: With-Project Condition: Estimated Demand Curve & Consumer Surplus

Change in Travel Costs	Estimated Number of Visits	Area Under Demand Curve
$20.00	0	0
$15.00	0	0
$10.00	.65	8.125
$5.00	2.16	11.325
$2.00	4.13	6.895
$0.00	5.63	1.5

Consumer Surplus	$27.845
Consumer Surplus per Visit	$4.94



Without Project Condition Use Value

The without project condition use value is estimated using a travel cost regression model similar to Equation 1, substituting visits under the without project condition for existing visits as the dependent variable. Only respondents that had positive without project visits can be used; reducing the number of observations to 38.

Equation 2:

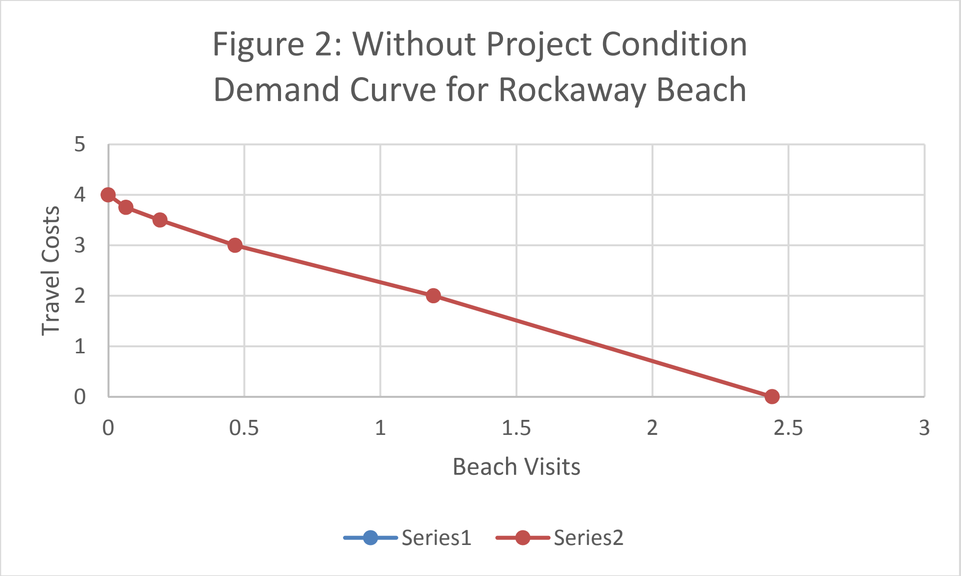
Without Project Annual Visits = 10.537 – 1.797 [ln Travel Cost]
(3.525) (1.135)

R-square =.064

Following the procedure used in calculating the with-project use value, we substitute the actual without project average visits, 2.44, for the constant in equation 2. The calculation of the demand curve and consumer surplus is presented below.

TABLE V-B: Without Project Condition: Estimated Demand Curve & Consumer Surplus

Change in Travel Costs	**Estimated Number of Visits**	**Area Under Demand Curve**
$ 4.00	0.00	0.00
$ 3.75	0.07	0.25
$ 3.50	0.19	0.45
$ 3.00	0.47	0.90
$ 2.00	1.20	1.82
$ 0.00	2.44	1.25
	Consumer Surplus	**$ 4.67**
	Consumer Surplus per Visit	**$ 1.91**



The with and without project use values are summarized in Table V-C.

TABLE V-C: With and Without Project Use Values for Rockaway Beach

Use Value	With Project Value	Without Project Value	Difference
Reduction in Annual Visits (visits not taken)	$4.94 per visit (from TCM)	$0	$4.94
Reduced Value for Visits	$4.94	$1.91 (from TCM)	$3.03

An alternative to the travel cost model for the without project condition difference in use value is to use the incremental use value per visits from the Long Beach, NY and Orchard Beach, NY contingent valuation studies. Both Orchard Beach and Long Beach projects used incremental contingent valuation rather than travel cost to arrive at a project use value of $3.31 per visit for Orchard Beach and $3.17 per visit for Long Beach. These figures are the area under the demand curve or consumer surplus divided by the number of annual visits from those studies, and are presented below. The average of those two estimates is $3.24. This estimate is close to the travel cost estimate of $3.03.

TABLE V-D*:* Alternative Use Value per Visit: Without Project Condition

Beach	Year	Method	Incremental Use Value per Visit
Orchard Beach, NY	2001	Contingent Valuation	$3.31
Long Beach, NY	1992	Contingent Valuation	$3.17

Annual Rockaway Beach Project Benefits

The annual Rockaway Beach project benefits are estimated by applying the with project use value per visit of $4.94 to the reduction in annual visitation under the With and Without Project conditions from Tables IV-A and IV-C, or 4,512,512.

The increase in visits to Rockaway Beach if the beach is maintained in its present condition, compared with erosion occurring that reduces the beach width by about half, is 4,512,512 visits. Using the average use value or consumer surplus per visit of $4.94, results in an annual project benefit of $22.3 million dollars. These annual benefits would be reduced if those people currently using Rockaway Beach and not willing to use it under the without project benefit used alternative beaches such as Long Beach and Coney Island.

In addition, the remaining visits under the without project condition of 3,225,988 will have a lower value per visit than under the with project condition. Applying the incremental value from Table V-C of $3.03, these continuing visits to Rockaway Beach under the without project condition have an annual value of $9.8 million dollars.

The total annual Rockaway Beach project recreation benefits are $32 million dollars. The annual benefits are summarized in Table V-E.

TABLE V-E: Annual Rockaway Beach NED Benefits

Benefit Category	With – Without Project Use Value	Annual Visits	Annual NED Benefits
Reduction in Annual Visits	$4.94	4,512,512	$22 million
Reduced Value for Visits	$3.03	3,225,988	$10 million
Total		**7,738,500**	**$32 million**

VI. IMPACT OF ROCKAWAY BEACH EROSION TIMELINE

Recreation benefits have been evaluated by estimating the number of beach visits under with-project conditions where the beach is maintained at an approximate width of 200 feet, versus the number of beach visits under without-project future conditions where the beach would experience continued erosion.

Under existing conditions, Rockaway Beach is approximately 200 feet in width. A total of 7,738,500 total beach visits are estimated to occur per year at this beach width. Based on survey results, users are willing to pay $4.94 per visit under these conditions.

Under the with-project conditions, implementation of a beach restoration project maintains the width of existing beaches within the study area that were restored after Superstorm Sandy. Maintaining a 200 foot wide beach creates an enhanced recreation experience, which is reflected in an increase in willingness to pay (WTP) for the recreation experience and an increase in visitation. The number of annual beach visits will continue at 7,738,500 per year, with an average value per visit of $4.94.

The benefits analysis calculates the NED recreation benefits by assuming a ten-year period during which the beach erodes to the without project condition of half its present width. In year 10, 50% of the beach width is lost and based on the user surveys, 4,512,512 annual visits are lost. The remaining 3,225,988 annual visits are assumed to provide a reduced value for the user because of the depleted beach width. The 4,512,512 lost annual visits at year 10 are assumed to be distributed linearly over the ten-year timeline for the purposes of this analysis with 10% (451,251 visits) lost in year 1, 20% (902,502 visits) lost in year 2, 30% (1,353,754 visits) lost in year 3, and so on. The 3,224,988 remaining visits in year 10 that are assumed to provide a reduced value are also distributed linearly over the ten-year timeline, with 90% of existing visitors attending in year 1(7,287,249), 80% attending in year 2 (6,835,998), 70% attending in year 3 (6,384,746), and so on.

The without-project future condition assumes the lack of beach maintenance against erosion. Rockaway Beach would continue to experience erosion at a rate of about 10 feet per year. Based on responses to beach surveys completed in the summer of 2015, it is estimated that a 50 percent reduction in beach width would reduce the annual number of visits to Rockaway Beach by 4,512,512 visits. Beach visits per year were interpolated between these two points based on survey responses. The reduced beach width would, in turn, reduce the user willingness to pay for the remaining 3,225,988 visits to a substantially lower $3.03 per visit. The user willingness to pay was also interpolated between these two points.

Present worth factors applied were calculated using the following formula (where ‘n’ is the number of years from 2015 and ‘i’ represents a fiscal year 2015 discount rate of 3.375%):

$$\textit{present worth factor} = \textit{present worth}/\textit{future worth} = 1/(1+i)^n$$

The present value and equivalent annual value of lost visits are shown in **Table VI.A**, while **Table VI.B** shows the present value and equivalent annual value of remaining reduced-value visits.

Table VI.A – Present Value of Lost Visits by Year, Rockaway Beach, Without Project

Year	Number of Lost Visits	Value Per Lost Visit	Value of all Visits Lost	Present Worth Factor	Present Value of Lost Visits
1	451,251	$4.94	$2,811,295	0.96735	$2,719,511
2	902,502	$4.94	$5,622,590	0.93577	$5,261,449
3	1,353,754	$4.94	$8,433,885	0.90522	$7,634,509
4	1,805,005	$4.94	$11,245,180	0.87566	$9,847,009
5	2,256,256	$4.94	$14,056,475	0.84708	$11,906,903
6	2,707,507	$4.94	$16,867,770	0.81942	$13,821,798
7	3,158,758	$4.94	$19,679,065	0.79267	$15,598,966
8	3,610,010	$4.94	$22,490,360	0.76679	$17,245,358
9	4,061,261	$4.94	$25,301,655	0.74175	$18,767,621
10	4,512,512	$4.94	$28,112,950	0.71754	$20,172,104
11-49	*Years 11-49 not reproduced here; trend shown above continues.*				
50	4,512,512	$4.94	$28,112,950	0.19021	$5,347,248
Sum of present values of reduced value visits, Years 1 through 50					$562,230,223
Capital Recovery Factor					0.0416773
Equivalent Annual Value of Lost Visits					**$23,432,214**

Table VI.B – Present Value of Reduced Value Visits by Year, Rockaway Beach, Without Project

Year	Number of Reduced Value Visits	Loss in Value Per Remaining Visit	Value of Reduced Value Visits	Present Worth Factor	Present Value of Reduced Value Visits
1	7,287,249	$0.32	$2,361,069	0.96735	$2,283,984
2	6,835,998	$0.65	$4,429,726	0.93577	$4,145,204
3	6,384,746	$0.97	$6,205,974	0.90522	$5,617,762
4	5,933,495	$1.30	$7,689,810	0.87566	$6,733,696
5	5,482,244	$1.62	$8,881,235	0.84708	$7,523,081
6	5,030,993	$1.94	$9,780,250	0.81942	$8,014,138
7	4,579,742	$2.27	$10,386,854	0.79267	$8,233,327
8	4,128,490	$2.59	$10,701,047	0.76679	$8,205,444
9	3,677,239	$2.92	$10,722,830	0.74175	$7,953,709
10	3,225,988	$3.03	$10,452,201	0.71754	$7,499,849
11-49	*Years 11-49 not reproduced here; trend shown above continues.*				
50	3,225,988	$3.03	$10,452,201	0.19021	$1,988,070
Sum of present values of reduced value visits, Years 1 through 50					$229,522,177
Capital Recovery Factor					0.0416773
Equivalent Annual Value of Reduced Value Visits					**$9,565,855**

NED recreation benefits over each year of the project timeline were calculated as the sum of the present value of lost visits plus the present value of the remaining reduced-value visits. **Table VI.C** documents the present value of NED recreation benefits by year, as well as equivalent annual NED recreation benefits.

Table VI.C – NED Recreation Benefits, Rockaway Beach, Without Project

Year	**Present Value of Lost Visits**	**Present Value of Reduced Value Visits**	**NED Recreation Benefits**
1	$2,719,511	$2,283,984	$5,003,496
2	$5,261,449	$4,145,204	$9,406,653
3	$7,634,509	$5,617,762	$13,252,271
4	$9,847,009	$6,733,696	$16,580,705
5	$11,906,903	$7,523,081	$19,429,984
6	$13,821,798	$8,014,138	$21,835,936
7	$15,598,966	$8,233,327	$23,832,293
8	$17,245,358	$8,205,444	$25,450,803
9	$18,767,621	$7,953,709	$26,721,330
10	$20,172,104	$7,499,849	$27,671,953
11-49	*Years 11-49 not reproduced here; trend shown above continues.*		
50	$5,347,248	$1,988,070	$7,335,317
Sum of present values of NED Benefits, Years 1 through 50			$791,752,400
Capital Recovery Factor			0.0416773
Equivalent Annual Benefits			**$32,998,069**

ATTACHMENT A: INTERVIEW FORM

ROCKAWAY BEACH –SURVEY 1- OMB# 0710-00001 Expires: 12/31/2016 ID
DATE INTERVIEWER START TIME
LOCATION

---READ INTRO on NARRATIVE---

SECTION A – BEACH TRIP CHARACTERISTICS

1. HOW DID YOU GET TO ROCKAWAY BEACH TODAY?

1. ☐ DROVE A CAR 3. ☐ RODE A BIKE 5. ☐ BUS/SUBWAY
2. ☐ WALKED 4. ☐ PASSENGER IN A CAR 6. ☐ OTHER______________

1A. HOW MUCH TIME DID THE TRIP TO THE BEACH TAKE TODAY (record in minutes)? ______________

1B. HOW MUCH DID YOU PAY IN TOLLS OR BUS/SUBWAY FEES TO GET TO THE BEACH TODAY? $____________

2. IF ARRIVED BY CAR, HOW MANY PASSENGERS, INCLUDING YOU, WERE IN THE CAR? ___

3. WHERE IS THE CAR PARKED?

1. ☐ FREE PARKING LOT 2. ☐ ON THE STREET

4. WHEN DO YOU NORMALLY VISIT ROCKAWAY BEACH?
1. ☐ WEEKDAYS 2. ☐ WEEKENDS 3. ☐ BOTH

SECTION B: BEACH VISITATION PER SUMMER AND WTP

See Narrative for Question 5

5. Existing (#)
[ ] ROCKAWAY BEACH ________
See Narrative for Question 6

6. W-out/Project Reduced Visits (#)
Yes ☐ **No** ☐
If Yes - ________
Total RB Visitation w-out/Project
(Sum #5 and #6)

7. WHICH OF THE FOLLOWING OTHER BEACHES DO YOU VISIT IN THE SUMMER AND HOW MANY VISITS DO YOU TYPICALLY MAKE?
[ ] CONEY ISLAND _________
[ ] LONG BEACH _________

8. WHICH OF THE FOLLOWING STATEMENTS BEST DESCRIBES YOUR ANSWERS TO THE QUESTIONS ABOUT BEACH VISITATION?
1. ☐ THERE WAS SOME UNCERTAINTY IN MY ANSWERS
2. ☐ I WAS CERTAIN OF MY ANSWERS.
3. ☐ I WAS UNCERTAIN OF MY ANSWERS.

SECTION C: BACKGROUND INFORMATION: THE FOLLOWING INFORMATION WILL HELP OUR RESEARCH STAFF PROPERLY ANALYZE THE RESULTS OF THE STUDY.

9. WHAT IS YOUR HOME ZIP CODE? _____________

10. WHAT IS YOUR AGE? _____________

11. HOW MANY CHILDREN UNDER THE AGE OF 13 ARE WITH YOU AT THE BEACH TODAY? _________

12. WHICH OF THE FOLLOWING BEST DESCRIBES YOUR PRESENT EMPLOYMENT STATUS (REFER TO FLIP CARD 1)?
1. ☐ EMPLOYED FULL TIME 4. ☐ NOT EMPLOYED 6. ☐ A HOMEMAKER
2. ☐ EMPLOYED PART TIME 5. ☐ A STUDENT 7. ☐ OTHER ______________
3. ☐ RETIRED 8. ☐ REFUSED

13. WHAT WAS THE LAST GRADE OF REGULAR SCHOOL THAT YOU COMPLETED (REFER TO FLIP CARD 2)?
1. ☐ NO FORMAL EDUCATION 6. ☐ SOME COLLEGE
2. ☐ SOME GRADE SCHOOL 7. ☐ COMPLETED COLLEGE
3. ☐ COMPLETED GRADE SCHOOL 8. ☐ SOME GRADUATE SCHOOL
4. ☐ SOME HIGH SCHOOL 9. ☐ COMPLETED GRADUATE SCHOOL
5. ☐ COMPLETED HIGH SCHOOL 10. ☐ REFUSED

14. WHAT BEST DESCRIBES YOUR COMBINED HOUSEHOLD INCOME LAST YEAR (REFER TO FLIP CARD 3)?

A. Less than $15,000

B. $15,000-$19,999

C. $20,000-$24,999

D. $25,000-$29,999

E. $30,000-$34,999

F. $35,000-$39,999

G. $40,000-$44,999

H. $45,000-$49,999

I. $50,000-$54,999

J. $55,000-$59,999

K. $60,000-$64,999

L. $65,000-$69,999

M. $70,000-$79,999

N. $80,000-$99,999

O. $100,000 - $149,999

P. $150,000 - $199,999

Q. $200,000 - $249,999

R. $250,000 or more

S. Refused / did not know

16. RECORD LANGUAGE OF INTERVIEW ☐ ENGLISH ☐ SPANISH
17. RECORD GENDER OF RESPONDENT ☐ MALE ☐ FEMALE

THANK YOU FOR YOUR PARTICIPATION! **STOP TIME_______**

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Notes and References

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[i] http://www.nyc.gov/html/dcp/pdf/neigh_info/profile/qn14_profile.pdf

[ii] http://www.nyc.gov/html/dcp/pdf/lucds/qn14profile.pdf

[iii] http://www.nyc.gov/html/dcp/html/neigh_info/qn14_info.shtml - Profile sheets for QN`4, Queens, & NYC

[iv] http://www.nyc.gov/html/dcp/pdf/neigh_info/census_tract/qn14_census_tract.pdf.
Community District 14 is subdivided into three Neighborhood Tabulation Areas (NTAs). From West to East, these are Breezy Point-Belle Harbor-Rockaway Park-Broad Channel (QN10), Hammels-Arverne-Edgemere (QN12), and Far Rockaway-Bayswater (QN15). Only part of QN10 and QN15 are located in the study area. The peninsula is further subdivided into 24 census tracts. The study area encompasses 15 of these tracts: 922, 928, 934.01, 934.02, 938, 942.01, 942.02, 942.03, 954, 964, 972.02, 972.03, 972.04, 992, and 998.02.

[v] Census 2010, Queens County

[vi] Census 2010, Queens County

[vii] http://www.nyc.gov/html/dcp/pdf/neigh_info/socio_demo/qn14_socio_demo.pdf

[viii] This number represents the average of the medians for the three Neighborhood Tabulation Areas of Rockaway Peninsula. The median ages are as follows: QN10 – 44.8 years, QN12 – 33 years, and QN15 – 32.5 years.

[ix] http://www.nyc.gov/html/dcp/pdf/neigh_info/statement_needs/qn14_statement.pdf

[x] http://www.nyc.gov/html/dcp/pdf/census/acs_econo_char_08to12_ntas.pdf

[xi] http://www.nyc.gov/html/dcp/html/neigh_info/qn14_info.shtml - Profile sheets for QN14, Queens, & NYC

[xii] http://www.nyc.gov/html/dcp/html/neigh_info/qn14_info.shtml - Profile sheets for QN14, Queens, & NYC

[xiii] http://www.nycgovparks.org/pagefiles/71/Conceptual-Plan-Final-Report.pdf, B13

[xiv] http://www.nycgovparks.org/parks/rockaway-beach-and-boardwalk

[xv] http://www.npca.org/about-us/center-for-park-research/stateoftheparks/gateway/Gateway_CSOTP_NPCA.pdf, p2
https://irma.nps.gov/Stats/Reports/Park

[xvi] http://www.npca.org/about-us/center-for-park-research/stateoftheparks/gateway/Gateway_CSOTP_NPCA.pdf, 10

[xvii] http://www.nyharborparks.org/visit/brpo.html

[xviii] http://www.npca.org/about-us/center-for-park-research/stateoftheparks/gateway/Gateway_CSOTP_NPCA.pdf, 12

[xix] http://www.npca.org/about-us/center-for-park-research/stateoftheparks/gateway/Gateway_CSOTP_NPCA.pdf, 18

[xx] http://www.npca.org/about-us/center-for-park-research/stateoftheparks/gateway/Gateway_CSOTP_NPCA.pdf, 18

US Army Corps
of Engineers
New York District

Economic Benefits Appendix

Jamaica Bay Planning Reach

Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet and Jamaica Bay

Draft Integrated Hurricane Sandy General Reevaluation Report and Environmental Impact Statement

June 2016

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1 Introduction

This appendix provides the benefits and associated analysis procedures used in the determination of the economic viability for Federal participation in shore protection and storm damage reduction for the Atlantic Coast of New York, East Rockaway Inlet to Rockaway Inlet and Jamaica Bay project. Since each planning reach within the larger study area is subjected to distinct risks and requires evaluation with different models, specific information in this appendix, relates only to the Jamaica Bay planning reach. This document, which is an appendix to the Hurricane Sandy General Reevaluation Report (HSGRR), evaluates existing and future without-project conditions, as well as alternative plans and the Tentatively Selected Plan (TSP). Coastal storm risk benefits of the proposed features within the Atlantic Shoreline Planning Reach are presented in another Appendix, and the combination of benefits is presented in the Main Report.

Estimates of current damages are based on January 2016 price levels and a 50-year period of economic analysis, and reflect the economic condition of the study area as of December 2016. 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 2020 (projected project completion year), and the 50-year period of analysis is 2020 to 2070.

1.1 Description of the Study Area

The study area consists of water and lands within and surrounding Jamaica Bay, New York. The greater portion of Jamaica Bay lies in the Boroughs of Brooklyn and Queens, New York City, and a section at the eastern end, known as Head of Bay, lies in Nassau County (Figure 1). More than 41,000 residential and commercial structures in the study area fall within the Federal Emergency Management Agency (FEMA) regulated 100-year floodplain.

Jamaica Bay is the largest estuarine waterbody in the New York City metropolitan area covering an approximately 20,000 acres (17,200 of open water and 2,700 acres of upland islands and salt marsh). Jamaica Bay measures approximately 10 miles at its widest point east to west, and four miles at the widest point north to south, including approximately 26 square miles in total. The mean depth of the bay is approximately 13 feet with maximum depths of 60 feet in the deepest borrow pits. Navigation channels within the bay are authorized to a depth of 20 feet. Jamaica Bay has a typical tidal range of five to six feet. The portions of New York City and Nassau County surrounding the waters of Jamaica Bay are urbanized, densely populated, and very susceptible to flooding.

Figure 1
Study Area – Map of Rockaway Peninsula and Jamaica Bay

1.1.1 Socioeconomic Considerations

The NYSDEC identifies “Potential Environmental Justice Areas (PEJAs)” as census block groups meeting one or more of the following NYSDEC criteria in the 2000 U.S. Census:

- 51.1% or more of the population are members of minority groups in an urban area;
- 33.8% or more of the population are members of minority groups in a rural area, or;
- 23.59% or more of the population in an urban or rural area have incomes below the federal poverty level.

The NYSDEC publishes county maps identifying PEJAs, including Kings, Queens, and Nassau counties. The following section discusses the NYSDEC PEJAs for the Atlantic Shoreline Planning Reach and the Jamaica Bay Planning Reach. Figure 2 identifies the proportion of persons below the poverty level for census blocks within project area communities.

The Jamaica Bay Planning Reach located in portions of Kings, Queens, and Nassau Counties contains several PEJAs identified by the NYSDEC. In Nassau County, a small PEJA is present the municipality of Hempstead, west of the Valley Stream neighborhood; however, the area south of Route 27 within the Jamaica Bay Planning Reach appears to contain few if any residences. In Queens County, the majority of the Jamaica Bay Planning Reach north and east of JFK airport is identified as a PEJA, while the neighborhoods west of JFK airport are not (Howard Beach, Lindenwood, Hamilton Beach). Likewise, the majority of the Jamaica Bay Planning Reach within Kings County is identified as a PEJA, including the communities surrounding the Gateway National Recreation Area, a large portion of Coney Island, and in and around the Fort Hamilton municipality.

Figure 2
Persons Below Poverty Level

Source: American Community Survey 2006-2010

Map created by the Science and Resilience Institute

1.1.2 Economy

Table 1 shows income levels for the study area, which generally track those of Kings and Queens Counties. Study area incomes are low to moderate in comparison to Nassau County and the State. Study area median household income is $54,800 and per capita income is $25,500, both of which are lower than for the State. However, the percent of persons below the poverty line is 20.4 percent in the study area, versus 23.4 percent in the Kings County, 15.4 percent in Queens County, 6.7 percent in Nassau County, and 15.9 percent in the State.

Table 1
Income Levels in the Study Area

	Study Area	Kings County	Queens County	Nassau County	NY State
Median Household Income	$54,800	$49,950	$57,200	$98,400	58,700
Per Capita Income, last 12 months	$25,500	$25,950	$26,600	$42,950	$32,850
Persons below poverty level	20.4%	23.4%	15.4%	6.7%	15.9%

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

Table 2 shows the breakdown of civilian employment by industry in the study area, Kings, Queens, and Nassau Counties, and New York State. The largest employment industry for both is Educational Services, Health Care and Social Assistance, which employs 33 percent of persons in the study area and 28 to 29 percent of persons in the counties and state. The next largest employment industries in the study area are professional, scientific, and management (10 percent) and retail trade (10 percent).

Table 2
Percent of Civilian Employment by Industry for Study Area and Counties

	Study Area	Kings CO	Queens CO	Nassau CO	NY State
Agriculture, forestry, fishing and hunting, and mining	0	0	0	0	1
Construction	6	5	6	6	6
Manufacturing	4	4	5	5	7
Wholesale trade	3	2	3	3	2
Retail trade	9	10	11	11	11
Transportation and warehousing, and utilities	8	6	5	5	5
Information	2	4	3	3	3
Finance, insurance, real estate and rental and leasing	8	8	10	10	8
Professional, scientific, and managemen	10	12	13	13	11
Educational services/health care/social assistance	33	29	28	28	28
Arts, entertainment, recreation, accom and food services	7	10	7	7	9
Other services, except public administration	5	5	5	5	5
Public administration	5	4	5	5	5

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

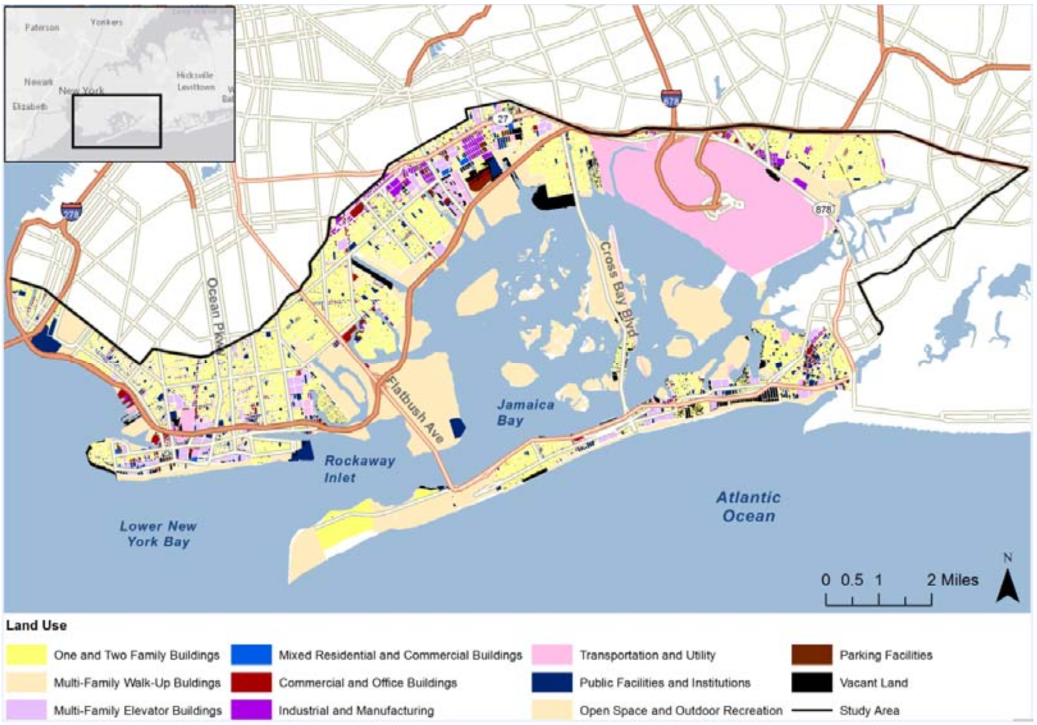
1.1.3 Land Use

The majority of land in the immediate study area contains residential development with commercial development concentrated within residential areas and extensively in designated business zones. The majority of land development within the study area is more than 25 years old. Figure 3 shows a map of land use within the study area, and Table 3 shows land use in the study area broken down by category and percent of land coverage. Open space and outdoor recreation is the most prevalent land use, at 33.6 percent of land coverage, which includes substantial terrestrial areas within Jamaica Bay itself. Residential land coverage is the next highest category with 31.9 percent of all acreage within the study area.

Table 3
Study Area Land Use

Residential	31.9%
Mixed Residential and Commercial	1.2%
Commercial and Office	2.5%
Public Facilities and Institutions	4.1%
Parking Facilities	1.2%
Industrial and Manufacturing	1.5%
Transportation and Utility	19.6%
Open Space and Outdoor Recreation	33.6%
Vacant Land	4.1%

Figure 3
Land Use within the Study Area



2 Description of the Problem

The general problem within the Jamaica Bay planning reach is that the combination of naturally low-lying topography, densely populated areas, extensive low-lying infrastructure, and degraded coastal ecosystems have resulted in communities that are vulnerable to extensive inundation during storm surges. In addition, projected future climate changes are expected to exacerbate existing problems. Projected future climate changes, including sea level rise and precipitation increase will increase coastal storm flooding, erosion and wetland loss.

In this analysis, opportunities exist to avoid, reduce/minimize, or mitigate storm related flooding impacts in and around Jamaica Bay.

2.1 Without-project Future Conditions

Frequent and severe damage from tidal inundation at the inland areas surrounding Jamaica Bay has long been identified as a problem for the planning reach. Historical flood impacts include evacuations during times of flood and extensive property damage in communities along the low-lying areas of Jamaica Bay. The entire Jamaica Bay planning reach area, with the exception of JFK Airport, is designated as either Evacuation Zone 1 or Evacuation Zone 2, the most at-risk zones, by the New York City Office of Emergency Management.

Coastal storm surges in the study area occur from hurricanes, tropical storms, and winter storms known as "nor'easters". High tide combined with storm surge and wind speed increases flooding. There are no long-term historical tide gauge data for Jamaica Bay, however; 23 major storms have been identified as impacting the New York City region since 1815 with impacts including fatalities, widespread structural damage, and the obliteration and removal of Hog Island from offshore of the Rockaway coast.

Figure 4 shows historical extreme tide gauge readings for the Battery off of Manhattan Island in New York Harbor. Although there are no data identifying the areas of inundation in Jamaica Bay associated with most of the storm events identified in Figure 4, one reference point is the inundation that occurred during Hurricane Sandy (October 2012), which is associated with a tide gauge reading of 13.986 feet above MLLW at the Battery. Acknowledging that associating tide gauge readings at the Battery with inundation at Jamaica Bay is an approximation at best, Figure 5 shows approximate inundation at Jamaica Bay based on two foot increments in tide gauge height at the Battery from 6 feet above MLLW to 14 feet above MLLW. Although a rough approximation, Figure 5 nevertheless demonstrates the susceptibility of the study area to tidal inundation.

Figure 4
Battery New York Extreme Tide Gauge Heights

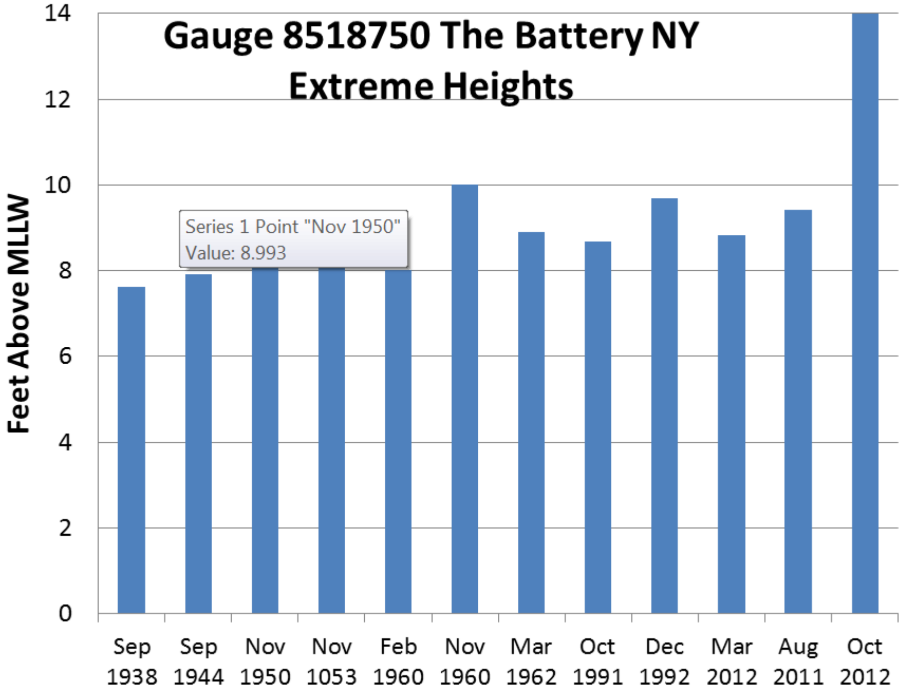
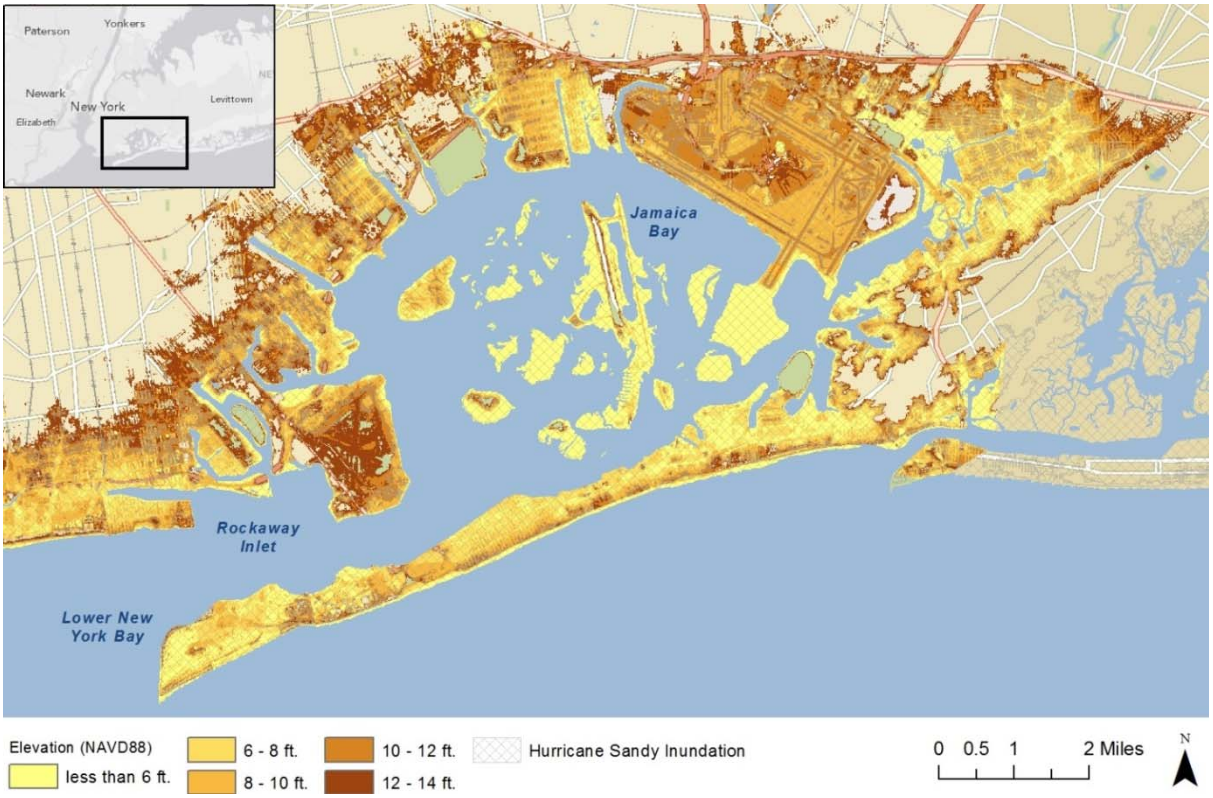


Figure 5
Approximate Historical Study Area Inundation at Various Water Elevations



3 Coastal Storm Risk Analysis

Flood damage calculations were performed using Version 1.4 of the Hydrologic Engineering Center's Flood Damage Analysis computer program (HEC-FDA, September 2014). 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 analysis of with-project Alternative Plans.

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, and
- Calculate aggregated stage vs. damage relationships.

3.1 Economic Reaches

In order to develop alternative plans and to evaluate the risk reduction provided by those plans, the Jamaica Bay planning reach was configured into six economic reaches that are defined by a common inundation elevation and existing community designations (Figure 6). For the development and preliminary screening of alternatives, each economic reach was defined as an area (*i.e.*, a GIS polygon) which would be inundated at a stillwater elevation of +11 feet (NAVD88). Eleven feet is generally equivalent to the stillwater elevation for a storm event with 1% probability of annual occurrence in 2070 including mid-range sea level rise.

Six reaches sufficiently define the project area because much of the shoreline and adjacent uplands that surround Jamaica Bay are low-elevation permeated with numerous basins, tidal creeks, and inlets, which provide little proximate access to areas of high ground. Configuring the reaches defined by a common inundation elevation resulted in six separable reaches. Individual plans were developed for each of the six reaches. Structures within low-lying areas shoreward of the adjacent uplands were assigned to these distinct reaches so that coastal storm damages may be estimated for each reach.

JFK Airport was not included within any of the economic reaches for which stand-alone alternatives were developed[1]. Federal Aviation Administration regulations preclude the construction of barriers (e.g., floodwalls and levees) on airport property, which renders any alternative to directly protect the airport infeasible on an institutional basis. In addition, the airport is on relatively high ground, and nonstructural solutions may be a more appropriate solution for any flooding problems. Nevertheless, the Port Authority of New York and New Jersey has been, and will continue to be, consulted throughout the plan formulation process.

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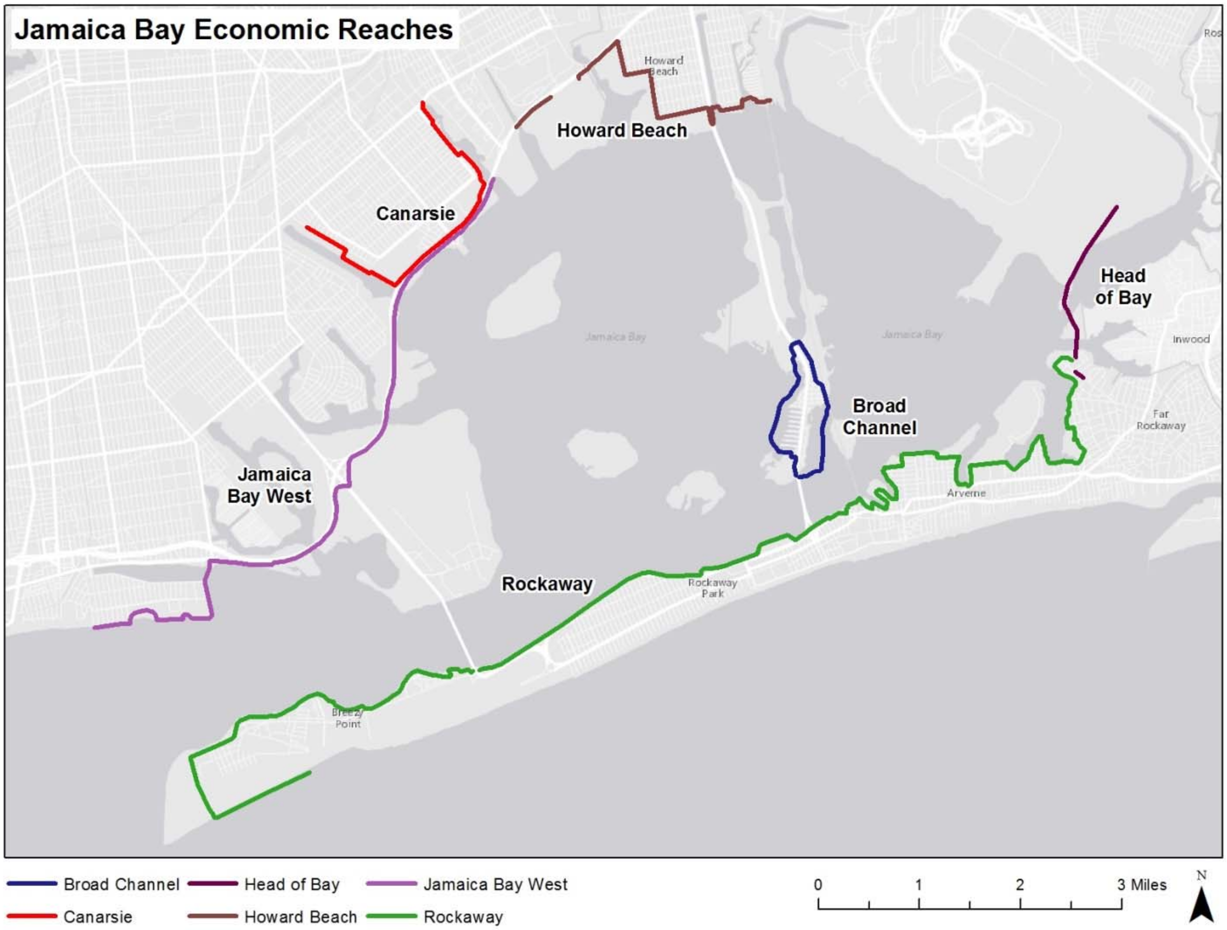
[1] It is important to note that economic benefits of protecting JFK Airport are included for the inlet barrier alternatives

Figure 6
Economic Reaches – Jamaica Bay



3.2 Emergency Services and Emergency Costs

Emergency costs include those expenses that result from a flood and not from just the risk of flooding. Emergency costs include expenses for emergency evacuation, flood fighting, administrative costs of disaster relief, public clean-up costs, and increased costs of police, .fire and military patrol. While the NED analysis conducted for this HSGRR focuses on direct physical flood damages, the emergency services and costs incurred in the study area during Hurricane Sandy are significant. Emergency services costs were obtained from FEMA for zip codes represented within the study area, and costs represent the full project cost, not merely the Federal share of the costs. Emergency services costs are provided in Table 4 below.

Table 4
Emergency Services Costs from Hurricane Sandy

Emergency Services Cost Category	Cost
Debris Removal	10,420,000
Emergency Protective Measures & Services	35,530,000
Public Facilities and Security	40,810,000
Utilities and Temporary Service Measures	12,240,000
TOTAL	**99,000,000**

3.3 Inventory Methodology

In the typical flood damage reduction study, every potentially damageable floodplain property is inventoried on-site in order to establish structure type, physical characteristics, and approximate values and elevations. Surveys of all residential properties are conducted in many studies, and representative samples in most others. Industrial, public and unique commercial properties typically require 100% sampling and more detailed on-site inspections. Given the scope and scale of the Jamaica Bay planning reach, on-site inspection or even viewing of all, or a significant percentage of, floodplain properties at this stage of the analysis was not feasible. However, GIS-based structure location data and complete aerial imagery provides much of the data[2] gathered in a typical Corps flood damage reduction on-site survey.

Structures are defined as permanent buildings and everything permanently attached to them. Floodplain structures are further categorized into groups having a similar susceptibility to flooding, and susceptibility is in turn determined by structural use and physical characteristics.

The principal sources of data were used for the classification of structure types within the study area were assessor databases and geographic information system data obtained for Kings County, Queens County, and Nassau County.

The first segmentation, property classification, includes the description of property types, which are broadly defined as residential or non-residential (institutional, commercial, or industrial). The most common major classifications of floodplain properties are:

- Single family residential dwellings;
- Multi-family residential dwellings;
- Commercial structures;

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[2] In terms of elevation and physical location of the structures in the floodplain, GIS data provides more information than is typically gathered, and to a much higher degree of accuracy.

- Industrial structures; and
- Institutional structures.

The broad property classifications are further divided into occupancy types, which identify specific depth-damage relationships to be used in damage modeling routines.

3.3.1 Single-Family Residential Dwellings

Single family residential dwellings were sub-categorized by common types, which correspond directly to those specified in Economic Guidance Memorandum EGM 03-01, Generic Depth-Damage Relationships for Residential Structures with Basements and Economic Guidance Memorandum EGM 01-03, Generic Depth-Damage Relationship.

3.3.2 Multi-Family Residential Dwellings

Multi-family residential dwellings have typically been sub-categorized based on structure height and/or number of units. Many Corps of Engineers flood damage reduction studies have used a height based classification, though the Corps has not issued standardized depth-damage relationships that can be used for multi-family residential dwellings. Depth-damage relationships for several classes of multi-family residential dwellings were used in this analysis, with each category representing a different scale of housing units within the dwelling.

3.3.3 Commercial and Industrial Structures

Commercial and Industrial structure classifications are based on various aspects of damage susceptibility, including number of stories, relative size, building material type, and anticipation of similar structure-to-content value relationships. A variety of different groupings have been established in previous flood damage investigations over the years; though most now are grouped roughly according to 2 digit SIC code. Generalized depth-damage relationships for commercial structures have not been formally issued by the Corps, though many studies rely on an extensive study conducted by the Galveston District, USACE.

3.3.4 Institutional Structures

Institutional structures are buildings defined as in public use, rather than publicly owned. Institutional structures typically are sub-categorized into: public/government offices, schools, libraries, public recreation facilities, hospitals, and churches, and nursing homes.

3.3.5 Study Area Structures by Category

The analysis of Kings, Queens, and Nassau County property data was overlaid by the study area boundaries in a GIS model, which resulted in a total structure count of over 96,000. Category classification for these structures is provided in Table 5 below.

Table 5
Structures Analyzed and Categorized in the Study Area

	Structures Evaluated	100-Year Floodplain
Residential	**85,964**	**47,440**
Single Family Residential	47,804	29,154
Multi Family Residential	38,077	18,237
Hotels / Motels	9	6
Residential Housing - Shelters	24	13
Nursing Homes and Institutions	50	30
Commercial	**4,185**	**2,220**
Retail Trade	2,789	1513
Wholesale Trade (Warehouses)	172	89
Personal & Repair Services	149	64
Professional/Technical Services (Offices)	631	340
Banks	52	24
Hospital	5	2
Medical Office/Clinics	65	13
Entertainment, Recreation, Restaurants, Bars	163	90
Theaters	4	3
Multi-Unit Parking Garages	155	82
Industrial	**432**	**205**
Heavy Industrial	69	29
Light Industrial	363	176
Government and Institutional	**571**	**356**
Government General Services (Office)	14	6
Government Emergency Response	34	24
Grade Schools	194	110
Colleges/Universities	3	0
Church/Non-Profit	326	216
Total	**96,340**	**53,002**

3.3.6 Estimate Structure Depreciated Replacement Values

Depreciated replacement values for structures in the study area were taken from the Assessed Valuation Rolls for New York City and Nassau County, and are representative of the full market value of improvements values parcels as of January 2016. It should be noted that the valuation of land was not included in the assignment of depreciated replacement values.

The valuation of the 100-year floodplain inventory is shown in Table 6

Table 6
Inventory Valuation of 100-Year Floodplain

	Structures in 100-Year Floodplain	Floodplain Total Value ($ Thousands)	Floodplain Average Value
Residential	**47,440**	**15,903,876**	**335,200**
Single Family Residential	29,154	8,204,839	281,400
Multi Family Residential	18,237	7,413,916	406,500
Hotels / Motels	6	26,138	4,356,300
Residential Housing - Shelters	13	64,572	4,967,100
Nursing Homes and Institutions	30	194,412	6,480,400
Commercial	**2,220**	**2,228,178**	**1,003,700**
Retail Trade	1,513	1,319,075	871,800
Wholesale Trade (Warehouses)	89	132,165	1,485,000
Personal & Repair Services	64	30,804	481,300
Professional/Technical Services (Offices)	340	431,595	1,269,400
Banks	24	26,399	1,100,000
Hospital	2	51,962	25,981,000
Medical Office/Clinics	13	12,848	988,300
Entertainment, Recreation, Restaurants, Bars	90	180,554	2,006,200
Theaters	3	19,098	6,366,000
Multi-Unit Parking Garages	82	23,678	288,800
Industrial	**205**	**175,537**	**856,300**
Heavy Industrial	29	9,164	316,000
Light Industrial	176	166,372	945,300
Government and Institutional	**356**	**1,180,278**	**3,315,400**
Government General Services (Office)	6	4,824	804,000
Government Emergency Response	24	42,410	1,767,100
Grade Schools	110	858,913	7,808,300
Colleges/Universities	0	0	
Church/Non-Profit	216	274,131	1,269,100
Total	**53,002**	**23,071,861**	**453,300**

3.4 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 (NAVD88) vs. damage relationships. Damages for individual structures at various stages were aggregated according to structure type (residential, apartment, commercial, etc.) and location (reach).

3.4.1 Generalized Depth-Damage Functions

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

Residential Structures

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. These documents summarize data developed by the Institute for Water Resources (IWR) using post-flood residential damage claim records provided by the Federal Emergency Management Agency (FEMA). The functions account for both structural and content damage to homes.

This approach was used for the 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.

For the Jamaica Bay study, the depth-damage curves from EGM 04-01 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 depth-damage curves of EGM 01-03, which only provide a standard deviation around the mean.

Non-residential Structures

Galveston District, USACE began keeping a large file of flood damage records in 1968 under a contract with the Federal Insurance Administration, using FIA claim forms. The initial survey was very comprehensive, with 10,000 properties included. A thorough room-by-room survey was made for every building. The damage functions that were computed have been continuously kept up-to-date with new flood damage information, including a survey of the 1979 study of flood damages from Hurricane Claudette. Galveston maintains 145 different types of nonresidential flood damage functions, 85 of which are business curves. The rest are public and institutional property. There are separate functions for structure, fixtures and inventory. The condition and age of all property is considered in application of all damage functions. These functions are segmented by the classification codes (2-digit SIC) listed in the discussion above, and were used for all non-residential structures in the study area.

3.5 Structure First Floor Elevations

A Digital Elevation Model (DEM) was developed from the LiDAR, which was used to generate contour mapping and to extract ground elevation measurements for all structures within the study area floodplain. While the LiDAR provides locations of structures and elevation data, the structure inventory database requires an elevation at which flood damages begin for each structure. As such, ground elevations at the structure are not sufficient for classifying the elevation at which damages begin. In addition, all depth-damage curves used in this analysis require elevation information of the structure’s first floor. Remote and on-the-ground surveys were conducted throughout the study area to establish a first floor elevation frequency curve for each structure classification type (all residential and non-residential).

Given the geographic extent of the study area, general foundation heights were assigned by structure class. Single family residential structures with basements were assigned a foundation height of 2.5 feet above ground elevation, residential structures without basements were assigned a foundation height of 1.0 foot above ground elevation, and non-residential structures were assigned a foundation height of 0.5 feet above ground elevation. To account for uncertainty and inherent inaccuracy involved in such a broad-scale application of foundation height, within the HEC-FDA model runs, foundation height (ground elevation + first floor elevation from ground) was given a distribution of 150 percent around the estimate, bounding the low estimate at 0.5 feet.

3.6 Relative Sea Level Change

Relative sea-level change (SLC) was considered in the preliminary screening of measures based on the guidance contained in the most recent Engineering Regulation (ER) 1100-2-8162 (USACE 2013e), which is the successor to the Engineering Circular (EC) 1165-2-212 (USACE 2011).

For the purposes of the economic analyses, the year of construction is assumed to be 2020, with a 50-year period of analysis. Table 7 shows the USACE SLC change for 2010 to 2100 at The Battery, NY based on ER 1100-2-8162. The intermediate SLC rate is considered for this phase of the study. Hence, a SLC of 1.3 feet in 2070, as compared to the 1992 sea level values, or slightly greater than one foot as compared to the 2014 sea level value, is added to the FEMA preliminary FIRM 100-year elevations to identify future inundation elevations.

Table 7
USACE SLC Projections (feet) at The Battery, NY

Year	Low	Intermediate	High
2010	0.17	0.20	0.29
2015	0.22	0.27	0.42
2020	0.27	0.34	0.56
2025	0.32	0.41	0.72
2030	0.36	0.49	0.90
2035	0.41	0.58	1.10
2040	0.46	0.66	1.31
2045	0.51	0.76	1.55
2050	0.56	0.85	1.80
2055	0.60	0.96	2.07
2060	0.65	1.06	2.37
2065	0.70	1.17	2.67
2070	0.75	1.29	3.00
2075	0.80	1.41	3.35
2080	0.84	1.53	3.71
2085	0.89	1.66	4.10
2090	0.94	1.79	4.50
2095	0.99	1.93	4.92
2100	1.03	2.07	5.36

3.7 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.

3.7.1 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.

3.7.2 Without-Project Nominal Damages

For this analysis, estimated storm damages include structure, content and other damages for residential and non-residential buildings.

Based on the type, usage and size of each structure included in the GIS data base (over 90,000 for this analysis) damages were calculated relative to the main floor elevation of the structure. Using structure and ground elevation data, the depth vs. damage relationships were converted to corresponding stage (NAVD88) vs. damage relationships. Generalized depth-percent damage functions for structure, structure content and other items were applied to structures for calculation of inundation damage, as noted above.

Damages for the modeled 10-year, 100-year, and 500-year events for the future year condition (2070), are provided in Table 8 below. As shown in the table, total damages from a 10-year event are equal to roughly $10.9 billion, which accounts for sea level change applied to year 2070. Total damages from a 100-year and 500-year event are modeled at $10.5 billion and $23.6 billion, respectively.

Table 8
Damages from 10-Yr, 100-Yr, and 500-Yr Flood Events ($ thousands)

	Total Damages 10-Year Event	Total Damages 100-Year Event	Total Damages 500-Year Event
Residential	**1,361,700**	**6,178,500**	**13,302,000**
Single Family Residential	820,300	3,177,100	6,115,000
Multi Family Residential	518,800	2,906,000	6,977,300
Hotels / Motels	900	4,300	8,400
Residential Housing - Shelters	7,500	27,800	57,700
Nursing Homes and Institutions	14,200	63,200	143,600
Commercial	**532,200**	**1,403,400**	**3,616,200**
Retail Trade	397,000	921,900	1,605,100
Wholesale Trade (Warehouses)	17,300	55,900	106,700
Personal & Repair Services	3,700	19,200	39,100
Professional/Technical Services (Offices)	65,900	221,300	1,459,900
Banks	3,400	20,400	40,400
Hospital	-	19,600	128,400
Medical Office/Clinics	4,200	11,900	22,200
Entertainment, Recreation, Restaurants, Bars	39,300	128,800	201,400
Theaters	-	800	2,700
Multi-Unit Parking Garages	1,300	3,800	10,100
Industrial	**15,800**	**79,300**	**228,600**
Heavy Industrial	2,800	6,800	20,900
Light Industrial	13,000	72,600	207,700
Government and Institutional	**229,900**	**688,100**	**1,296,100**
Government General Services (Office)	2,500	4,900	8,800
Government Emergency Response	4,900	26,100	56,400
Grade Schools	130,800	441,200	843,300
Colleges/Universities	-	-	59,400
Church/Non-Profit	91,700	215,900	328,300
Total	**2,917,400**	**10,520,300**	**23,583,700**

3.7.3 Without-Project Equivalent Annual Damages

Without-Project equivalent annual damages (EADs), annualized over the 50-year period of economic analysis using a $3^{1/8}$ percent discount rate, are summarized in Table 9. As shown in the table, equivalent annual damages for the study area are equal to roughly $751 million. Care should be taken when comparing numbers from Table 9 to those shown on Table 8. For example, the EAD for without-project conditions is not equal to damages incurred by a structure from any given flood event (e.g., the 10-,100-, or 500-year event). Rather, the EAD reflects the probabilities of various levels of flood events and the associated damages from those events in its calculation.

Table 9
Without-Project Equivalent Annual Damages from All Flood Events ($ thousands)

	Equivalent Annual Damages
Residential	**482,759**
Single Family Residential	234,231
Multi Family Residential	240,941
Hotels / Motels	315
Residential Housing - Shelters	2,154
Nursing Homes and Institutions	5,119
Commercial	**178,124**
Retail Trade	92,553
Wholesale Trade (Warehouses)	5,694
Personal & Repair Services	1,962
Professional/Technical Services (Offices)	55,300
Banks	2,032
Hospital	7,027
Medical Office/Clinics	1,212
Entertainment, Recreation, Restaurants, Bars	11,696
Theaters	166
Multi-Unit Parking Garages	481
Industrial	**6,763**
Heavy Industrial	637
Light Industrial	6,126
Government and Institutional	**63,047**
Government General Services (Office)	438
Government Emergency Response	2,362
Grade Schools	38,247
Colleges/Universities	4,816
Church/Non-Profit	17,185
Total	**730,693**

3.7.4 With-Project Expected Annual Damages

Storm damages were modeled for the Alternatives C1-E, C2, and D, as described in the HSGRR. Each of the alternatives was designed to provide damage reduction for storms up to a 1 percent chance exceedance event (100-year level of protection). Residual EADs, annualized over the 50-year period of economic analysis using a $3^{1/8}$ percent discount rate, are summarized in Table 10.

Table 10
With-Project Residual Equivalent Annual Damages ($ thousands)

	Alternative C1-E	Alternative C2	Alternative D
Residential	**184,031**	**184,031**	**195,001**
Single Family Residential	45,157	45,157	55,322
Multi Family Residential	134,115	134,115	134,921
Hotels / Motels	3	3	3
Residential Housing - Shelters	1,867	1,867	1,867
Nursing Homes and Institutions	2,889	2,889	2,889
Commercial	**76,837**	**76,837**	**77,114**
Retail Trade	16,183	16,183	16,428
Wholesale Trade (Warehouses)	2,169	2,169	2,169
Personal & Repair Services	990	990	994
Professional/Technical Services (Offices)	42,825	42,825	42,830
Banks	1,046	1,046	1,046
Hospital	6,662	6,662	6,662
Medical Office/Clinics	618	618	618
Entertainment, Recreation, Restaurants, Bars	5,826	5,826	5,843
Theaters	152	152	152
Multi-Unit Parking Garages	365	365	373
Industrial	**3,103**	**3,103**	**3,175**
Heavy Industrial	572	572	572
Light Industrial	2,531	2,531	2,603
Government and Institutional	**22,504**	**22,504**	**22,835**
Government General Services (Office)	240	240	240
Government Emergency Response	1,512	1,512	1,532
Grade Schools	14,018	14,018	14,075
Colleges/Universities	4,695	4,695	4,695
Church/Non-Profit	2,040	2,040	2,295
Total	**286,475**	**286,475**	**298,125**

4 Project Benefits

Corps procedures calculate storm risk reduction benefits based on the difference between EADs under with- and without-alternative flood risk mitigation plans. The implicit assumption incorporated into this procedure is that a reduction in flood damages is directly translatable into increased net income to floodplain land uses. Without-project EADs and with-project EADs are shown in Tables 9 and 10, respectively. Average annual benefits of the alternatives, which are equal to the difference between residual damages under each alternative and damages under the without project condition are shown in Table 11, and are reflected in the HSGRR.

Table 11
Flood Risk Management Benefits of Alternatives C1E, C2, and D ($ thousands)

	Alternative C1-E	Alternative C2	Alternative D
Residential	**298,728**	**298,728**	**287,758**
Single Family Residential	189,074	189,074	178,909
Multi Family Residential	106,826	106,826	106,020
Hotels / Motels	312	312	312
Residential Housing - Shelters	287	287	287
Nursing Homes and Institutions	2,230	2,230	2,230
Commercial	**101,287**	**101,287**	**101,010**
Retail Trade	76,370	76,370	76,125
Wholesale Trade (Warehouses)	3,525	3,525	3,525
Personal & Repair Services	972	972	968
Professional/Technical Services (Offices)	12,475	12,475	12,470
Banks	986	986	986
Hospital	365	365	365
Medical Office/Clinics	594	594	594
Entertainment, Recreation, Restaurants, Bars	5,870	5,870	5,853
Theaters	14	14	14
Multi-Unit Parking Garages	116	116	108
Industrial	**3,660**	**3,660**	**3,588**
Heavy Industrial	65	65	65
Light Industrial	3,595	3,595	3,523
Government and Institutional	**40,543**	**40,543**	**40,212**
Government General Services (Office)	198	198	198
Government Emergency Response	850	850	830
Grade Schools	24,229	24,229	24,172
Colleges/Universities	121	121	121
Church/Non-Profit	15,145	15,145	14,890
Total	**444,218**	**444,218**	**432,567**