North Shore of Long Island
Bayville, New York
Coastal Storm Risk Management
Feasibility Study

Appendix C: Economics

February 2016

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VILLAGE OF BAYVILLE FEASIBILITY STUDY
Economics Appendix

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INTRODUCTION

Purpose

1. This appendix documents economic analysis procedures used to evaluate alternative plans for their contribution to National Economic Development (NED). As explained in the analysis, alternative 4 is identified as the NED plan to be further developed for implementation. The report estimates potential flood damages and the economic effectiveness of coastal storm risk management measures within the study area. Descriptions are provided for the processes used to conduct the economic base study, compile a structure inventory and value survey, and develop structure damage functions used in the storm damage analysis. The storm damage analysis quantified without-project equivalent annual damages (EAD) and the with-project EAD over a 50-year period of analysis. The study area includes more than 6,000 feet of coastline on Long Island Sound in the Village of Bayville, which is located in the Town of Oyster Bay, New York.

2. The economic analysis includes a description of the study area in terms of its existing development, local economy, population, income, and employment. The structure survey includes an update to a previously prepared inventory of the structures within the 500-year floodplain, to determine residential and non-residential structure characteristics. Estimates for content values and modified stage-damage curves were assigned according to building type. Storm damage reduction benefits were estimated for current design plans, and were used to determine if there is federal financial interest in a storm risk management project.

3. Benefits were calculated as a reduction in storm damages from the without-project condition. The without-project damage analysis considers wave and flood impacts to structures located along the Long Island Sound and flood impacts to structures located farther landward. Because numerous seawalls cover large portions of the Sound-facing shoreline, erosion is not considered a major source of storm damage in the study area, and has not been quantified at this time. Both structural and nonstructural risk reduction alternatives have been considered. The technology utilized would vary between alternatives. However, each of the structural alternatives are designed to provide an equal level of risk reduction, and the reliability of each alternative is considered equivalent. The evaluation of residual

damage with the structural plan in place considered both the possible overtopping of the structure and the impact of runoff potentially ponding within the interior side of the risk management structure.

Benefit Types

4. The potential range of benefits to be derived from proposed structural and/or nonstructural measures include:

- reduced inundation damage to buildings and contents
- reduced wave damage to buildings
- reduced erosion damage to buildings
- reduced damage to coastal structures (e.g., bulkheads)
- reduced public emergency and evacuation costs

Direct damage to buildings and contents from inundation are the primary damage types quantified in this report.

Conditions

5. The building structure and content values of the original inventory were based on a survey with October 2010 price levels. These original inventory values were then updated to the depreciated replacement values in October 2015, using RS Means historical cost indices to determine the update factor. The building stock remained intact after the passage of Hurricane Sandy, and there was no resulting change in the number of structures contained in the inventory. The study has used a base year of 2021 for a 50-year period of analysis, and the fiscal year 2016 discount rate of 3.125%.

Exclusions

6. The structural alternatives evaluated will not reduce risk against a 1 percent flood (1% exceedance probability storm event), and thus the requirement for insurance coverage under the National Flood Insurance Program (NFIP) for area property owners and residents may not be reduced. Accordingly, there will be no reduction in flood insurance coverage or the number of policies, and associated administrative costs.

7. To manage risk on the sound front, the proposed plans rely primarily on hardened structures, such as seawalls or revetments, as opposed to vegetative cover or expansive buffer areas. Soft structural designs, such as buried floodwalls with vegetation caps, are proposed for beachfront areas with existing dunes. Many hardened structures will be buried in sand to prevent creating a hazard to beach users. The structures will not significantly increase nor decrease the value of recreation resources. Thus, no recreation benefits have been included in the analysis.

8. Under without-project future conditions, it is anticipated that bulkheads or other structures will be procured locally to prevent any long-term loss of backshore lands. Accordingly, no benefits were credited from the prevention of the loss of land.

9. Passaic River damage functions were used for nonresidential structures, while Institute for Water Resources damage functions were used for residential structures. Passaic River damage functions include estimates for structures, contents, and other damages such as damage to landscaping, out buildings, evacuation, and clean-up costs. However, the Institute for Water Resources (IWR) damage functions do not contain estimates for these other types of damages. IWR damage functions only include depth-damage estimates for structures and contents.

10. At this stage of the analysis, damages were not calculated for coastal risk management structures, roads and utilities. These damages could be quantified if necessary in later stages of the project. With the quantification of structures and contents alone, there are enough potential damages avoided to justify the project costs and Federal interest in the project.

11. The with-project updated designs for addressing interior drainage issues have been determined to effectively eliminate the risk of significant interior drainage damages. As a result, interior drainage damage estimates will not be calculated until the plan optimization phase, after plans for the interior drainage facilities have been refined and finalized.

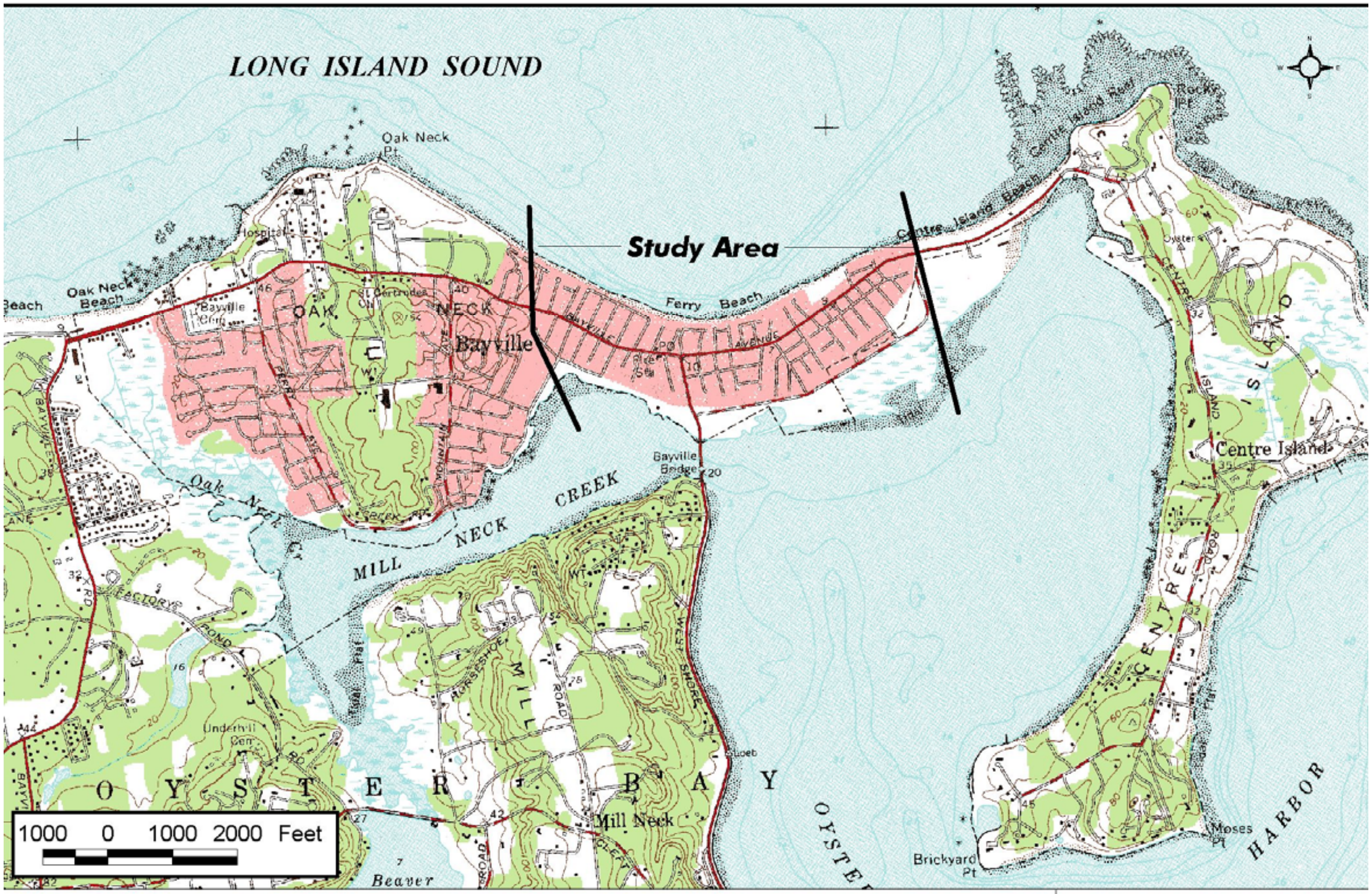
12. Only structural plans survived the initial screening of alternatives. As a result, the nonstructural plans were not updated for the current analysis.

DESCRIPTION OF THE STUDY AREA

Location

13. The area of study described in this report is contained within Bayville, located on the northernmost boundary of the Town of Oyster Bay, Nassau County. It occupies a 1.41 square mile area along the North Shore of Long Island. The Village is bordered to the north by Long Island Sound, to the south by Mill Neck Bay and Oyster Bay Harbor, to the east by Centre Island, and to the west by Lattingtown, NY.

14. The study area in Bayville is the low-lying area between Arlington Lane and West Harbor Drive, with Long Island Sound to the north and Oyster Bay to the south. (See Figure 1). The area is subject to severe tidal inundation. Structures along the Long Island Sound shorefront are also subject to wave runup and wave impact. Wave runup is a term used to describe the dynamic elevation of water above the still water level due to wave action, usually defined as the vertical extent above the still water level reached by waves rushing up the face of a coastal structure such as a beach or seawall. The geology in the study area is characterized by a moderately flat glacial outwash plain. It ranges in elevations from +15 feet (ft) North Atlantic Vertical Datum of 1988 (NAVD88) on the north shore to +6 ft NAVD88 in certain interior sections. Historically, flooding in Bayville is due to inundation from high tides, waves and storm surge throughout Long Island Sound and Oyster Bay/Mill Neck Creek, as well as inadequate local drainage.



Source: Bayville Quad, USGS

Figure 1: Bayville, NY

Figure 1

Accessibility

15. The Village is an automobile-oriented suburban community. The primary local road access to the Village from the south is by West Shore Road to the Bayville Bridge over Oyster Bay, and by Bayville Avenue from the west. Major area roadways include Route 25A/North Hempstead Turnpike and Route 106, which leads to the Jericho Turnpike, the Long Island Expressway (I-495), and the Northern State Parkway. Nearby communities including Locust Valley, Oyster Bay, and Glen Cove are serviced by the Oyster Bay Branch of the Long Island Rail Road (LIRR,) which provides passenger rail access to Penn Station in New York City. At Penn Station, passengers can transfer to New Jersey Transit (NJT) and Amtrak lines for regional and national rail transportation.

Population

16. The population of Nassau County is essentially a stable population level. According to the U.S. Census bureau, Bayville had a 2010 population of 6,669 and an estimated 2014 population of 6,748[1]. The 2014 U.S. Census American Community Survey indicates that Bayville is a predominantly year-round community. The community's population is roughly estimated to be 90.2% white and 0.3% black, 0.4% American Indian, 1.7% Asian, or 6.5% Hispanic or Latino, and 1.4% two or more races. New York State's population is 67.1% white and 31% black, American Indian, Asian, Pacific, or other race. The average household size in Bayville is 2.69, compared to 2.61 for New York State.

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[1] Estimate of the 2014 population in Bayville, NY, provided by the U.S. Census Bureau. http://quickfacts.census.gov/qfd/states/36/3605034.html

Table 1: Population of Project Study Area

Population	*2010*	*2014*	*2010-2014 Estimated % Change*
Bayville	6,669	6,748	***1.2%***
Nassau County	1,349,616	1,358,627	***0.7%***
Suffolk County	1,493,346	1,502,968	***0.6%***
Queens County	2,230,722	2,321,580	***4.1%***

Income

17. The U.S. Census Bureau American Community Survey (U.S. Census, 2014) indicates that Bayville's median household income of $98,362 is significantly above the New York State median of $58,003. The local per capita income of $42,827 is above the New York state level of $32,382. The percentage of families in Bayville below the poverty level (5.2%) is less than that of New York State (15.3%).

Land Use

18. The majority of land in the study area is in residential use. Commercial development is concentrated along Bayville and Ludlam Avenues. The average age of a house within the study area was over 65 years old, based on the data provided by the municipal building department. Therefore, the majority of the housing stock was constructed before the implementation of the National Flood Insurance Program (NFIP) and adoption of associated floodplain management regulations. Many of the residential streets in the community are private and open to residents only. There is a sand beach along the Long Island Sound shore, with the residents-only Sound side Beach Park located at Bayville Avenue and 8th St. West Harbor Beach, another residents-only park, is located along the Oyster Bay shoreline, on the southern side of Bayville. The Bayville Preserve, established in 1998, is municipal parkland beginning at the West Harbor Drive Bridge and extending eastward. The Bayville Preserve is a coastal wetland and salt marsh. The municipal border between Bayville and Centre Island to the east is along West Harbor Drive. Centre Island Beach Village Park is located adjacent to West Harbor Drive, and consists

of a parking area, football field, beach, and marsh. This facility is under the jurisdiction of Centre Island, NY, which lies immediately to the east of Bayville.

Economy

19. Historically, the local economy has been based around water-dependent industries, such as shellfish cultivation and boating. During the 1800s, the Village became a popular summer resort with small cottages, several estates and an entertainment complex called the Bayville Casino. Bayville is also known for the firm of Frank M. Flower & Sons, founded in 1887, located on the western end of the village. The company currently employs approximately 40 people, and is the last remaining oyster harvesting company on Long Island. There is a sizable marina located on the Mill Neck Bay shoreline just west of the Bayville Bridge, and there are a number of restaurants on Bayville Avenue. A small commercial core is located around the intersection of Bayville Avenue and Ludlam Avenue. The mean travel time to work for Bayville residents (workers 16 years of age and older) was estimated to be 36.2 minutes (2009-2013), which indicates a substantial portion of residents work outside the community.

Recreation

20. As discussed, there are two residents-only waterfront parks in Bayville. The Village Woods Park and the Mill Neck Preserve are located in the higher-elevation western portion of the community. Other recreation opportunities in the community include boating and fishing in Mill Neck Bay, Oyster Bay, and Long Island Sound. Numerous county and state parks are located within a 10-mile radius of Bayville, including Caumsett State Historic Park on Lloyd Neck. Recreation opportunities will not be significantly altered through project implementation.

PROBLEM IDENTIFICATION

21. Bayville, situated between Oyster Bay and Long Island Sound, is a low-lying community vulnerable to severe flood inundation damage. Shorefront areas are also subject to damage from wave runup and wave impact. The eastern and western low-lying areas are comprised of two distinctive landforms. The eastern low-lying area is defined between Ludlam Ave, West Harbor Drive to the south, and Long Island Sound to the north. In this area, the ground surface gently slopes away to the south from Bayville Avenue, creating a flat depression at elevations of +5 ft NAVD88 to +7 ft NAVD88. The higher elevation of West Harbor Drive causes the floodwater to be trapped between West Harbor Drive and Bayville Avenue. Flooding in this area tends to persist longer than in the western portion of town.

22. In contrast, the western low-lying area, between West Harbor Drive (at Ludlam Avenue) and Arlington Lane, is characterized by moderately sloped terrain. The slopes in this area decrease gently, allowing surface runoff to drain into surrounding lower areas and to merge with floodwater over Bayville Avenue.

Flood History

23. The community has a history of inundation and storm damage. Tropical storms, northeasters, and hurricanes have impacted the Long Island Sound area, altering the shoreline composition over time and causing extensive flooding to the study area. Storms affecting the community include the Halloween Storm of 1991, the March 1993 “Blizzard of the Century”, the Christmas Eve 1994 storm, and the storms of September and October 1996. In 2012, Hurricane Sandy impacted the community; but the storm’s arrival did not coincide with high tide, which allowed the community to escape the risk of greater flood damages.

24. One of the more severe events, the northeaster of December 10-14, 1992, affected the mid-Atlantic and northeastern coastline of the United States. This storm produced east-to-northeast winds of gale force strength (39 to 54 mph) that gusted to above hurricane strength (greater than 73 mph) and caused heavy rain, and extensive coastal flooding. (Schubert and Busciolano, USGS) The strong northeast winds contributed to sizable storm surges, which allowed water levels to reach a maximum elevation of +9.63

ft NAVD88 as recorded at the Mill Neck Creek gauging station. Three days of deep coastal flooding ensued and certain sections of the study area were flooded up to five days.

25. During this event, the storm surge arrived at the north side of the study area (Long Island Sound) and at the south (Oyster Bay/Mill Creek Neck,) concurrently, resulting in widespread flooding in the low-lying areas of the Village along Bayville Avenue. Storm surge impacts also included the overtopping and destruction of seawalls located around the Village's perimeter, along the interface with Long Island Sound and Oyster Bay/Mill Neck Creek. Additionally, a number of single-family residences were severely damaged by wave impact and wave run-up. Utility services were disrupted and power lines felled, cars damaged or destroyed, and floodwaters were contaminated by discharge from the wastewater collection system.

26. In addition, the storm surge prevented interior flood waters from draining into Oyster Bay and Long Island Sound, resulting in five days of severe flooding in the Village's low-lying areas. Local fire companies used pumps to discharge the interior flood waters over West Harbor Drive into Oyster Bay, and the Bayville Fire Company alone answered 336 alarms in a 36-hour period. Relief efforts lasted for three weeks, during which 26 other fire departments assisted the local fire company in their efforts. Two homes were destroyed by fire, and hundreds of residences and businesses were flooded by high tides and water up to five feet over main floors for up to a week after the onset of the northeaster. During the Oct. 19th, 1996 coastal storm, up to three feet of water covered many streets in town, and more than 100 homes were damaged and dozens of cars destroyed. The worst-affected areas were in and around 1st, 2nd, 5th, 6th, and 7th Streets. The causeway to Centre Island was also inundated and impassable.

WITHOUT-PROJECT FUTURE CONDITIONS

27. The without-project future conditions for Bayville are identified as: (1) flooding and wave impacts from future storm events, and (2) the possibility of an increase in erosion of the exposed perimeter beach/bay front along the interface with Long Island Sound. Tidal inundation is expected to increase gradually, in direct relation to the anticipated rise in the relative sea level. It is expected that current interior drainage issues will persist, due to the inability of the current drainage system to effectively reduce ponding from severe precipitation events. Substantial amounts of additional residential and commercial development appears unlikely, since open space and various HOA zoning regulations do not provide significant space for growth or increased density. In the absence of project implementation, it is anticipated that local landowners and HOAs will maintain and repair existing bulkheads to prevent land loss or extensive erosion.

STORM DAMAGE

General

28. The following basic steps were used to analyze storm damage:

    - Assign evaluation reaches
    - Inventory flood plain development
    - Estimate depreciated replacement cost
    - Assign generalized damage functions
    - Calculate aggregated stage vs. damage relationships
    - Calculate equivalent annual damages

29. These steps have been completed, and the results are presented within this Economics Appendix. The first four steps provide inputs to the estimation of flood damages. The calculation of damages was done using the Hydrologic Engineering Center's Flood Damage Analysis computer program (HEC-FDA).

Reach Selection

30. In order to conduct economic benefit analyses for without-project and with-project alternative plans, and to simplify the stage vs. damage analyses, the study area has been divided into 12 economic reaches; three along the Long Island Sound Shore, three along the Mill Neck Bay shore, and the remainder inland, as shown in Figure 2.

    - <u>Shorefront areas</u>: Structures along the Long Island Sound shorefront are susceptible to wave impact damage in addition to flood damage during major storms. These structures were assigned to separate reaches for the analysis of wave damage.

    - <u>Interior drainage areas</u>: Interior areas, not subject to wave runup or wave impact but to inundation, were assigned reach identification numbers that can be correlated to the adjacent shorefront reach. For example, shorefront reach 2.0 is bordered to the south (inland) by reaches 2.1, 2.2 and 2.3. This delineation simplifies alignment of the reaches for modeling any interior drainage damages.

- Potential limits to risk reduction: Certain areas of the community could potentially lie outside some of the risk reduction measures identified in this study. Plan optimization or implementation may cause the plan to be adjusted or changed to accommodate existing conditions or local preferences. Identifying those areas as separate reaches may facilitate the eventual modeling of the benefit cost ratio (BCR) differences between the alternatives.

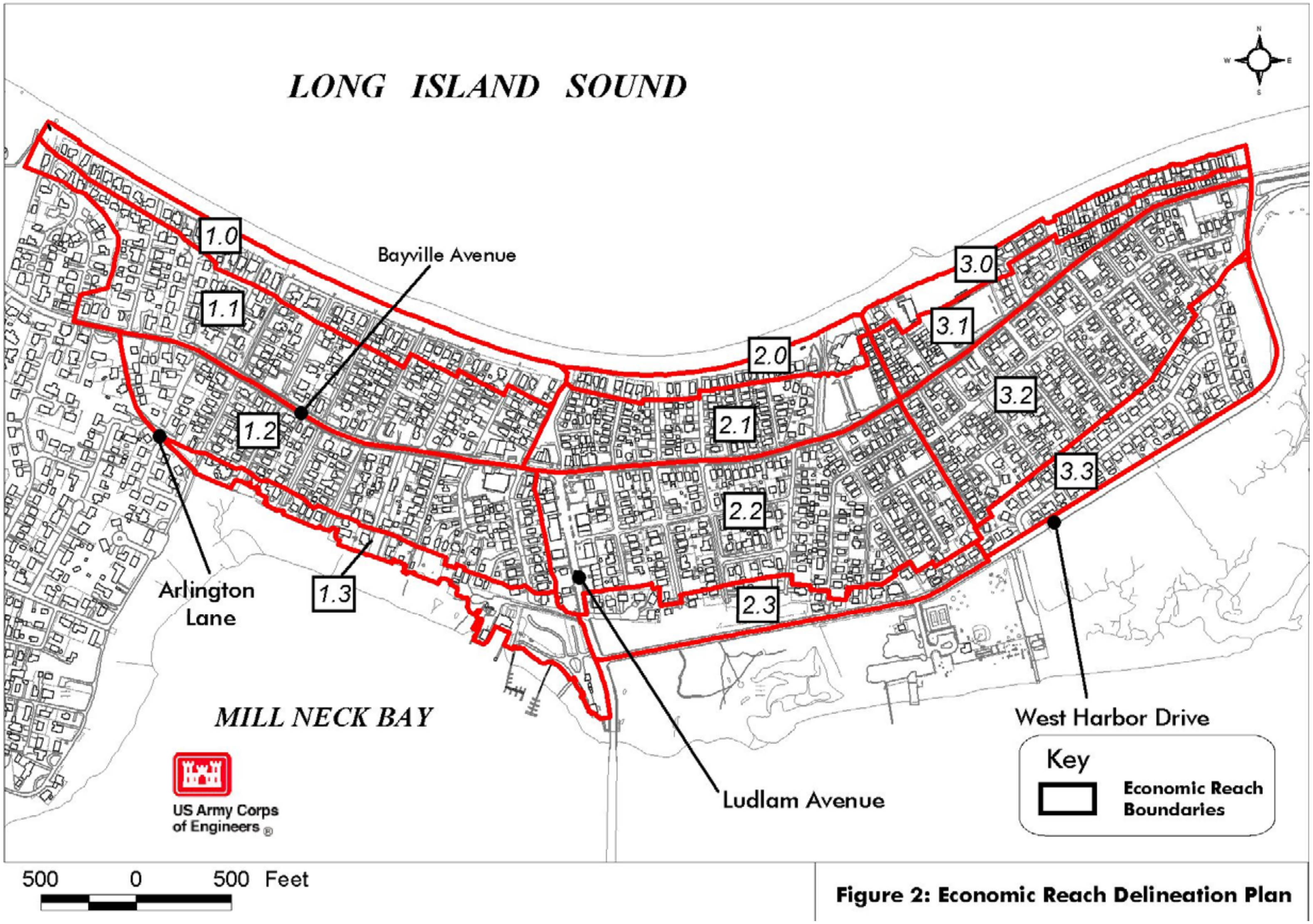

Figure 2: Economic Reach Delineation Plan

Figure 2

Building Damage

Survey Methodology

31. A structure database was originally developed in 2003-2004 to assist in predicting flood damages. Details of the database are provided in the report “Village of Bayville, NY Feasibility Study: Report on Building Inventory” (March 2004). The database was updated to the October 2010 price level, and again updated to the October 2015 price level. The development of the original database is described below, followed by a description of the two price updates. The structural database was generated via a “windshield survey” of the area, using topographic mapping with a 2-foot contour interval. Elevations on the mapping are expressed in feet and tenths of a foot, and refer to the National Geodetic Vertical Datum of 1929 (NGVD29). The elevations referenced to NGVD29 were later converted to NAVD88. Table 2 outlines the data obtained for the structure inventory.

Table 2: Physical Characteristics Surveyed for Structure Inventory

1)	Structure ID	2)	Damage Reach
3)	Station	4)	Structure Type/Damage Category
5)	Usage Code Lookup	6)	Size (Sq. Ft.)
7)	Stories	8)	Basement
9)	Garages	10)	Exterior
11)	Build Quality	12)	Condition
13)	Reference Elevation	14)	First Floor Height
15)	Low Opening	16)	Depreciated Replacement Structure Value

32. The data collected was used to categorize the structure population into groups with 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, condition, and the presence of basements and garages. More than 1,030 structures were identified for surveying, of which 94% were residential. Table 3 provides an overview of the number and type of structures in each reach:

Table 3: Overview of Development Economic Reaches

Reach Number	Reach Description	Number of Structures		
		Residential	Non-Residential	Total
1.0	Long Island Sound (West)	43	0	43
1.1	Inland	119	3	122
1.2	Bayville Avenue (West)	120	7	127
1.3	Mill Neck Bay	19	9	28
2.0	Long Island Sound (Central)	26	1	27
2.1	Inland	94	10	104
2.2	Bayville Avenue (Central)	194	22	216
2.3	Oyster Bay	26	0	26
3.0	Long Island Sound (East)	39	1	40
3.1	Inland	55	3	58
3.2	Bayville Avenue (East)	184	2	186
3.3	Oyster Bay	55	0	55
	Totals	**974**	**58**	**1,032**

Inventory Update and Derivation of Factor for Price Level Update

33. The original Bayville structure inventory (1,032 structures) reflected conditions in the floodplain circa 2003-04 and used an assumed price level of July 2003. The discussion in the following section documents the actions to develop an update factor in order to revise the depreciated structure replacement values of all structures in the inventory to a price level of October 2010. The inventory was then updated for a second time to the price level of October 2015.

Sample Selection for Derivation of Update Factor

34. The 2010 update factor was derived from a survey of randomly selected structures in the community, and then applied to all structures in the original inventory. An MS Excel spreadsheet was used to sort the existing inventory database and assign all those structures a unique identification number from 1 to 1,032. The random number generating function of Excel was then used to select 100 of these structures for inclusion in the update survey. The distribution of the sample set is shown in Table 4:

Table 4: Distribution of Sample Set for Survey Update

Reach	Description	Total	% of Total	Sample	% of Sample
1.0	Shorefront	43	4%	5	5%
1.1	1st Interior	122	12%	10	10%
1.2	2nd Interior	127	12%	9	9%
1.3	Bayfront	28	3%	1	1%
2.0	Shorefront	27	3%	1	1%
2.1	1st Interior	104	10%	19	19%
2.2	2nd Interior	216	21%	16	16%
2.3	Bayfront	26	3%	4	4%
3.0	Shorefront	40	4%	2	2%
3.1	1st Interior	58	6%	3	3%
3.2	2nd Interior	186	18%	20	20%
3.3	Bayfront	55	5%	10	10%
	Total	**1,032**		**100**	

Survey and Calculation of Structure Values

35. Each of the 100 randomly selected structures was visually surveyed from public roads and their physical characteristics recorded in November 2010. The following data was recorded in order to calculate current depreciated structure replacement values, and to facilitate future flood damage calculations:

- Type
- Usage
- Stories (# of)
- Attached Garage
- Basement Type
- Size Adjustment
- Exterior (Construction Material)
- Build Quality
- Current Condition
- Ground Elevation
- Main Floor Height
- Lowest Opening

36. Since the calculation of structure values is principally based on the area of finished living space, the footprint areas of structures were reduced to account for any attached garages, large covered porches,

or decks that were observed in the field. It should be noted that an ancillary garage in reach 1.2 was found to be included in the 100 randomly selected structures; such structures should not be included in the inventory and it was removed from further analyses, resulting in 99 surveyed structures.

37. Depreciated structure replacement values were calculated for all surveyed structures using the RSMeans Square Foot Costs.

38. All structures in the survey were deemed to be of “Low”, “Medium”, or “High” Build Quality and the basic square foot construction costs for a single family residence in each category were derived from RSMeans prices for “Economy”, “Average”, and “Custom” homes, respectively. Within these designations square foot construction costs varied depending on factors such as number of stories, number of garages, and type of exterior.

Results – 2010 Derived Update Factor

39. The depreciated structure replacement values calculated for the 99 random sample structures were compared with those from the original study, with a Price Level of July 2003. Averaging the ratio of 2010 value/July 2003 value for all 99 structures yielded an overall update factor of 1.77.

40. Of the 99 structures surveyed, the October 2010 Price Level value was found to be less than the July 2003 value for one structure (1%), indicating that this structure has experienced very significant wear and tear over the last 7 years.

2015 Inventory Update Factor

41. Values from the October 2010 price level update were then updated to October 2015 using the RSMeans historical cost index, which allowed for the most current data set available for the analysis. This October 2010 to October 2015 RSMeans index escalation resulted in an update factor of 1.117. After the original inventory’s depreciated structure replacement values were updated in 2010 and again in 2015, damage modeling was then conducted using HEC-FDA.

Summary of Structure Value

42. An update factor was developed to estimate the depreciated structure replacement values at the October 2010 price level. The October 2010 price level was then updated with a cost index escalation to the

October 2015 price level. A summary of the approximate total value of structures within each reach, at the October 2015 price level, is presented in Table 5.

Table 5: Summary of Depreciated Structure Replacement Values
Price Level: October 2015.

Reach Number	Reach Description	Structures	Approximate Total Value
1.0	Long Island Sound (West)	43	$19,219,000
1.1	Inland	122	$34,639,000
1.2	Bayville Avenue (West)	127	$44,695,000
1.3	Mill Neck Bay	28	$7,374,000
2.0	Long Island Sound (Central)	27	$15,419,000
2.1	Inland	104	$25,476,000
2.2	Bayville Avenue (Central)	216	$52,406,000
2.3	Oyster Bay	26	$8,715,000
3.0	Long Island Sound (East)	40	$12,180,000
3.1	Inland	58	$10,839,000
3.2	Bayville Avenue (East)	186	$43,578,000
3.3	Oyster Bay	55	$23,465,000
	Totals	**1,032**	**$298,009,000**

Description of Damage Functions

43. Depth-damage functions for structures and contents were applied in the updated inventory to calculate floodwater damage. The primary source of damage functions were generic depth-damage functions. The damage functions for residential structures were developed by the U.S. Army Corps of Engineers, Institute for Water Resources (IWR), following an expert opinion elicitation exercise carried out by FEMA and USACE/IWR. These functions include depth-damage estimates for structures and content. For further information on IWR damage functions, see Economic Guidance Memorandum (EGM) 01-03, and Generic Depth-Damage Relationships for Residential Structures with Basements (EGM) 04-01. The damage functions for non-residential structures were developed during the Passaic River Basin,

NJ study. The Passaic River Basin (PRB) damage functions were originally developed in 1982 as part of the Passaic River Basin Feasibility Study. The Functions were later updated in 1995. These Passaic River damage functions include depth-damage estimates for structure, contents, and other-to-structure damages such as landscaping, out buildings, evacuation, and cleanup costs.

Uncertainty

44. The following areas of uncertainty were incorporated into the damage functions:

- stage frequency (using equivalent record length)
- first floor elevation
- depreciated structure value
- content-to-structure value ratio
- other-to-structure value ratio

45. For this Bayville HEC-FDA model, an equivalent record length of 50 years was assumed. A first floor standard deviation of 0.6 feet was selected based on recommendations in the USACE Engineering Manual, EM 1110-2-1619.

46. The analysis recognizes that estimates of depreciated structure value based on windshield inventories contain inherent uncertainty. The Institute for Water Resources (IWR) depth-damage functions assume a structural value coefficient of variation of 10%, and a 10% coefficient of variation is incorporated into simulations of content values. IWR depth-damage functions do not estimate other-to-structure damages. Within Passaic River Basin (PRB) depth-damage functions, a coefficient of variation of 10% was applied to structure values, and 25% was applied to the content-to-structure value ratio. Because the PRB depth-damage functions present other damage as a percent of structure value, the other-to-structure value ratio contains a coefficient of variation of 10%. The IWR generic functions are certified for residential structures, and the PRB damage functions are suitable for the Bayville non-residential structures due to the similarity of structures, contents, and other-to-structure damage values within the studied areas.

Sea Level Change

47. The rate of sea level change for the study area is anticipated to be 0.008 feet per year, or 0.8 feet per century. Correspondingly, an increase of 0.4 ft for the 50-year period of analysis was used in this study. The potential for sea level rise under medium or high forecast scenarios would be expected to increase the potential for greater storm damages. All alternatives are expected to be impacted equally by changes in sea level.

48. The corresponding water surface profiles applied to this study were calculated in 2010 using the Hydrologic Engineering Center's Interior Flood Hydrograph software. The Hydrology and Hydraulics appendix explains the current Hydrologic Modeling System used to compare and verify peak hydrologic flows from the 2010 water surface profiles. Water surface profiles will be generated using North Atlantic Coast Comprehensive Study (NACCS) data during the optimization phase.

Flood Damage Analysis Modeling

49. Modeling of the benefits was conducted using a standard Flood Damage Analysis model run through the Hydrologic Engineering Center's Flood Damage Analysis software, (HEC-FDA, version 1.4). This software applies Monte Carlo Simulations to calculate equivalent damage values while explicitly accounting for uncertainty in the input data. Expected annual damages were calculated within HEC-FDA using the damage-frequency curves, derived from relating absolute values of damage to various storm events with estimated probabilities of occurrence. The cost of reconstructing or replacing structures after a flood event is the main source of damage in this model. Damage estimates also include assumptions for damage to the contents of buildings. Commercial, municipal, and some residential structures that used Passaic River damage functions contain estimates for other-to-structure damage types such as landscaping, out buildings, evacuation and cleanup costs. These assumptions of content and other damages are included in the HEC-FDA model as a percentage of the structural value, and are based on impacts from previous flood events analyzed by the USACE Passaic River Basin study, and the Institute for Water Resources. Damages were estimated under a 1 percent flood scenario.

Without-Project Annual Damages

50. Using HEC-FDA, the Expected Annual Damages were calculated for the base year and future years, and the Equivalent Annual Damage was calculated for the 50-year period of analysis. Equivalent annual damage amounts by reach are provided in Table 6.

Table 6: Equivalent Annual Damage (EAD), Without-Project Conditions
Price Level: October 2015. FY16 Discount rate: 3.125%

		BUILDING CATEGORIES [1]			
Economic Reach Name	**Reach Description**	**COM**	**MUN**	**RES**	**Total**
1.0	Long Island Sound (West)	$ -	$ -	$ 244,000	**$ 244,000**
1.1	Inland from 1.0	$ 12,000	$ 18,000	$ 470,000	**$ 501,000**
1.2	Bayville Avenue (West)	$ 28,000	$ 114,000	$ 1,201,000	**$ 1,343,000**
1.3	Mill Neck Bay	$ 22,000	$ -	$ 187,000	**$ 210,000**
2.0	Long Island Sound (Central)	$ 65,000	$ -	$ 138,000	**$ 203,000**
2.1	Inland from 2.0	$ 63,000	$ -	$ 419,000	**$ 482,000**
2.2	Bayville Avenue (Central)	$ 91,000	$ 2,000	$ 1,803,000	**$ 1,895,000**
2.3	Oyster Bay (West)	$ -	$ -	$ 130,000	**$ 130,000**
3.0	Long Island Sound (East)	$ 21,000	$ -	$ 191,000	**$ 212,000**
3.1	Inland from 3.0	$ 37,000	$ 3,000	$ 266,000	**$ 306,000**
3.2	Bayville Avenue (East)	$ 13,000	$ -	$ 1,353,000	**$ 1,366,000**
3.3	Oyster Bay (East)	$ -	$ -	$ 156,000	**$ 156,000**
	Totals	**$ 351,000**	**$ 138,000**	**$ 6,559,000**	**$ 7,049,000**

[1] Building Categories: COM = Commercial MUN = Municipal RES = Residential

NONSTRUCTURAL PLAN

51. A plan for coastal storm risk management through nonstructural measures was developed in 2010. The 2010 nonstructural analysis resulted in a benefit cost ratio that was markedly lower than any of the structural alternatives, and this made the nonstructural plan especially unlikely to be selected over other alternatives. As a result of the low benefit cost ratios, nonstructural alternatives were not given further consideration. The 2010 nonstructural analysis is outlined in the following paragraphs.

52. The nonstructural design level of risk management was based on the higher of the base flood elevation from the latest Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Map (DFIRM) plus one foot of freeboard, or the 100-year water surface elevation (as determined by the USACE) plus one foot of freeboard.

53. Three types of nonstructural retrofit were evaluated for the buildings in the study area:
    1. Buyout: Applicable to structures which have 2.5 ft or more flooding during the 2-year (50 percent flood) and 5-year (20 percent flood) events.

    2. Flood Proofing: Applicable to structures without basements that have less than 3.0 ft of standing water above the ground surface during any storm.

    3. Raise: Applicable to structures which have 3.0 ft or more flooding during a 10 percent or greater flood, and structures with basements which have less than 3.0 ft of flooding during any event.

54. Two nonstructural plans were developed: one to retrofit structures in the 10 percent floodplain, and a second plan to retrofit buildings in the 1 percent floodplain.

Cost Estimation for Nonstructural Plan

55. Implementation costs were calculated based on the type of improvement or retrofit, incidental costs associated with the type of improvement, and average footprint area of the structure. These costs were

estimated as part of the planning phase for the purpose of determining project feasibility, providing a means of comparing costs in relation to different storm stages and to approximate costs for the proposed improvements. For the alternative assessment, all alternatives have the same cost assumptions. A contingency cost of 20% was included to account for uncertainties in all alternatives. Costs for Planning, Engineering, and Design (PED) and Construction Management were assumed as 10% and 8%, respectively, of the total direct (construction) costs. Also overhead (15%), profit (10%), bond (.07%) and mobilization/demobilization costs were considered.

56. For flood proofing, $4,000 was added per structure to account for utilities and sewer backflow valves, sump pumps, and other incidental costs. For building elevation, $8,000 was added per structure to account for utilities and sewer backflow valves, sump pumps, and incidental costs. The estimated costs are based on updates to the costs developed for the Passaic River Basin study, shown in the Quantities and Cost Curves for Flood Control Measures report (USACE-NY District, 1980). The estimated costs are based on an average structure footprint area of 1,485 square feet.

57. The implementation of a nonstructural plan would require several additional elements, including a limited building buyout for creation of a drainage basin (1 percent flood plan only), storm water mitigation, and minimum facility interior drainage measures. Costs for nonstructural plans at the 10% and 1% flood levels (including the additional measures) are provided in Table 7.

Table 7: Nonstructural Plan Costs, Bayville, NY
Price Level: October 2010. FY11 Discount Rate: 4.125%. Contingency 20%.

Level of Risk Management	10% Floodplain	1% Floodplain
Flood Proof/Raising/Buyout	$ 5,307,000	$ 67,999,000
Limited Buyout for Drainage Basin	$ -	$ 2,500,000
Storm Water Mitigation	$ 500,000	$ 500,000
Minimum Facility (Interior Drainage)	$ 1,000,000	$ 1,000,000
TOTAL FIRST COST:	**$ 6,807,000**	**$ 71,999,000**
Annualized First Cost:	$ 323,000	$ 3,424,000
Flood Plain Management:	$ 250,000	$ 250,000
TOTAL ANNUAL COST:	**$ 573,000**	**$ 3,674,000**

STRUCTURAL ALTERNATIVES EVALUATED

58. Four structural plan alternatives for Bayville were developed. These four structural plans provide coastal storm risk management on the Long Island Sound and along the Bay side. For each design cross-section, elevations were selected to ensure that overtopping would be minimized and to ensure reliable structural performance. Because the alternatives use different structure types and construction methods, these elevations were established for the individual alternatives and thus will vary. The alternatives all provide the equivalent level of coastal storm risk management. Alternative cost estimates were generated by the Corps of Engineers cost engineering division, based on construction estimates for the management measures. As rough approximations that are subject to later refinement, the Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs were estimated to be constant across alternatives, and the duration of construction was estimated to be 24 months for each alternative. Since beach erosion is not a main cause of damage, none of the alternatives incorporate regular beach renourishment.

Alternative 1

59. Alternative 1 includes the placement of rock to reduce damage to existing seawalls and buried dunes along the Sound. Sheetpile floodwalls provide risk reduction along the bay. Based on preliminary designs, the first costs are estimated to be $70,846,000 including minimum interior drainage facilities. Cost details are provided in Table 8.

Alternative 2

60. Alternative 2 would provide new bulkheads with rock toe revetment, and buried floodwalls along the Sound. Road-raising with sheetpile cutoff walls and buried floodwalls would provide risk reduction along the bay. Based on preliminary designs, the first costs are estimated to be $67,739,000 including minimum interior drainage facilities. Cost details are provided in Table 8.

Alternative 3

61. Alternative 3 includes the reinforcement of the existing seawall and construction of buried floodwalls along the Sound. Road-raising with sheetpile cutoff walls and a buried floodwall would provide risk

reduction along the bay. Based on preliminary designs, the first costs are estimated to be $65,256,000 including minimum interior drainage facilities. Cost details are provided in Table 8.

Alternative 4

62. Alternative 4 includes the reinforcement of the existing seawall and construction of a buried floodwall along the Sound. Road-raising with sheetpile cutoff walls plus raised ground elevations and building elevations provide risk reduction along the bay. Based on preliminary designs, the first costs are estimated to be $64,469,000 including minimum interior drainage facilities. Cost details are provided in Table 8.

Table 8: Annual Cost of Alternatives 1 to 4
Price Level: Oct. 2015. FY16 Discount Rate: 3.125%. Contingency: 37%.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
First Cost	$70,846,000	$67,739,000	$65,256,000	$64,469,000
Interest During Construction	$1,627,000	$1,556,000	$1,499,000	$1,481,000
Annualized Total Investment Cost	$2,889,000	$2,763,000	$2,662,000	$2,630,000
Annual OMRR&R Cost	$166,000	$166,000	$166,000	$166,000
Total Annual Cost:	$3,055,000	$2,929,000	$2,828,000	$2,796,000

RESIDUAL DAMAGES

63. The four structural alternatives all provide equivalent levels of coastal storm risk management. Risk remains that severe storms could cause damages from waves overtopping the risk management structures. The HEC-FDA model was used to estimate the Equivalent Annual Damage (EAD) that would remain with the projects implemented. Residual damages for nonstructural alternatives are provided in Tables 9 and 10. Residual damages from overtopping by reach are provided for structural alternatives in Table 11.

64. For structural alternatives, it was determined that the interior drainage facilities in the with-project condition would effectively eliminate the risk of damage from drainage trapped behind the risk management structures. Under the with-project condition, interior runoff will be drained to the bay using a network of storm sewer pipes and three pumping stations. Sizing and interior drainage facilities are to be refined during the optimization phase. The final interior drainage plan, including damage estimates from potential interior drainage issues, will be provided during optimization.

65. Using the October 2010 price level data, residual damage under the 10 percent and 1 percent flood nonstructural plans are shown in Tables 9 and 10.

Table 9: Residual Equivalent Annual Damage (EAD) with 10 Percent Flood Nonstructural Plan (NS-1)

Price Level: October 2010. FY11 Discount Rate: 4.125%

		BUILDING CATEGORIES(1)			
Economic Reach Name	**Reach Description**	**COM**	**MUN**	**RES**	**Total**
1.0	Long Island Sound (West)	$ -	$ -	$ 308,000	$ 308,000
1.1	Inland from 1.0	$ 10,000	$ 15,000	$ 535,000	$ 559,000
1.2	Bayville Avenue (West)	$ 22,000	$ 90,000	$1,159,000	$ 1,271,000
1.3	Mill Neck Bay	$ 1,000	$ -	$ 193,000	$ 194,000
2.0	Long Island Sound (Central)	$ 43,000	$ -	$ 133,000	$ 176,000
2.1	Inland from 2.0	$ 49,000	$ -	$ 393,000	$ 443,000
2.2	Bayville Avenue (Central)	$ 72,000	$ -	$1,439,000	$ 1,511,000
2.3	Oyster Bay (West)	$ -	$ -	$ 123,000	$ 123,000
3.0	Long Island Sound (East)	$ 19,000	$ -	$ 173,000	$ 192,000
3.1	Inland from 3.0	$ 9,000	$ 2,000	$ 221,000	$ 232,000
3.2	Bayville Avenue (East)	$ 10,000	$ -	$1,005,000	$ 1,015,000
3.3	Oyster Bay (East)	$ -	$ -	$ 164,000	$ 164,000
	Totals	$235,000	$107,000	$5,845,000	$ 6,188,000

(1) Building Categories: COM = Commercial MUN = Municipal RES = Residential

Table 10: Residual Equivalent Annual Damage (EAD) with 1 Percent Flood Nonstructural Plan (NS-2)
Price Level: October 2010. FY11 Discount Rate: 4.125%

		BUILDING CATEGORIES[(1)]			
Economic Reach Name	**Reach Description**	**COM**	**MUN**	**RES**	**Total**
1.0	Long Island Sound (West)	$ -	$ -	$ 50,000	$ 50,000
1.1	Inland from 1.0	$ 2,000	$ 2,000	$ 226,000	$ 230,000
1.2	Bayville Avenue (West)	$ 6,000	$ 9,000	$ 364,000	$ 380,000
1.3	Mill Neck Bay	$ 1,000	$ -	$ 61,000	$ 62,000
2.0	Long Island Sound (Central)	$ 43,000	$ -	$ 89,000	$ 132,000
2.1	Inland from 2.0	$ 10,000	$ -	$ 216,000	$ 226,000
2.2	Bayville Avenue (Central)	$ 17,000	$ -	$ 482,000	$ 500,000
2.3	Oyster Bay (West)	$ -	$ -	$ 65,000	$ 65,000
3.0	Long Island Sound (East)	$ 3,000	$ -	$ 127,000	$ 130,000
3.1	Inland from 3.0	$ 2,000	$ 1,000	$ 101,000	$ 104,000
3.2	Bayville Avenue (East)	$ 2,000	$ -	$ 613,000	$ 615,000
3.3	Oyster Bay (East)	$ -	$ -	$ 101,000	$ 101,000
	Totals	$ 86,000	$13,000	$2,496,000	$2,594,000

(1) Building Categories: COM = Commercial MUN = Municipal RES = Residential

66. Total equivalent annual damages for the structural plans due to overtopping structures is $1,016,000, as shown in Table 11.

Table 11: Equivalent Annual Damage (EAD) from Storms Exceeding Construction Design, With Implementation of Structural Plan Alternatives
Price Level: October 2015. FY16 Discount Rate: 3.125%

		BUILDING CATEGORIES(1)			
Economic Reach Name	**Reach Description**	**COM**	**MUN**	**RES**	**Total**
1.0	Long Island Sound (West)	$ -	$ -	$ 34,000	**$ 34,000**
1.1	Inland from 1.0	$ 5,000	$ 8,000	$ 159,000	**$ 172,000**
1.2	Bayville Avenue (West)	$ 7,000	$34,000	$ 134,000	**$ 176,000**
1.3	Mill Neck Bay	$ 2,000	$ -	$ 22,000	**$ 24,000**
2.0	Long Island Sound (Central)	$ 12,000	$ -	$ 15,000	**$ 27,000**
2.1	Inland from 2.0	$ 16,000	$ -	$ 73,000	**$ 89,000**
2.2	Bayville Avenue (Central)	$ 25,000	$ -	$ 169,000	**$ 194,000**
2.3	Oyster Bay (West)	$ -	$ -	$ 22,000	**$ 22,000**
3.0	Long Island Sound (East)	$ 4,000	$ -	$ 20,000	**$ 24,000**
3.1	Inland from 3.0	$ 4,000	$ 1,000	$ 40,000	**$ 46,000**
3.2	Bayville Avenue (East)	$ 3,000	$ -	$ 137,000	**$ 140,000**
3.3	Oyster Bay (East)	$ -	$ -	$ 69,000	**$ 69,000**
	Totals	**$ 78,000**	**$ 44,000**	**$ 894,000**	**$1,016,000**

(1) Building Categories: COM = Commercial MUN = Municipal RES = Residential

SUMMARY OF EAD, WITHOUT AND WITH-PROJECT CONDITIONS

Table 12: Equivalent Annual Damage (EAD), Without and With-Project Conditions

Economic Reach Name	Reach Description	Equivalent Annual Damage (EAD) Under Conditions			
		Price Level: October 2015. FY16 Discount Rate: 3.125%		Price Level: October 2010. FY11 Discount Rate: 4.125%	
		Without-Project Conditions	**Structural Alternatives**	**10 percent flood Nonstructural Plan**	**1 percent flood Nonstructural Plan**
1.0	Long Island Sound (West)	$ 244,000	$ 34,000	$ 308,000	$ 50,000
1.1	Inland from 1.0	$ 501,000	$ 172,000	$ 559,000	$ 230,000
1.2	Bayville Avenue (West)	$ 1,343,000	$ 176,000	$ 1,271,000	$ 380,000
1.3	Mill Neck Bay	$ 210,000	$ 24,000	$ 194,000	$ 62,000
2.0	Long Island Sound (Central)	$ 203,000	$ 27,000	$ 176,000	$ 132,000
2.1	Inland from 2.0	$ 482,000	$ 89,000	$ 443,000	$ 226,000
2.2	Bayville Avenue (Central)	$ 1,895,000	$ 194,000	$ 1,511,000	$ 500,000
2.3	Oyster Bay (West)	$ 130,000	$ 22,000	$ 123,000	$ 65,000
3.0	Long Island Sound (East)	$ 212,000	$ 24,000	$ 192,000	$ 130,000
3.1	Inland from 3.0	$ 306,000	$ 46,000	$ 232,000	$ 104,000
3.2	Bayville Avenue (East)	$ 1,366,000	$ 140,000	$ 1,015,000	$ 615,000
3.3	Oyster Bay (East)	$ 156,000	$ 69,000	$ 164,000	$ 101,000
	Total Storm Damage	**$ 7,049,000**	**$ 1,016,000**	**$ 6,188,000**	**$ 2,594,000**
	Interior Drainage	**n/a**	**$ n/a**	**n/a**	**n/a**
	Total Damage	**$ 7,049,000**	**$ 1,016,000**	**$ 6,188,000**	**$ 2,594,000**

STORM DAMAGE REDUCTION BENEFITS

67. The nonstructural alternatives, as evaluated in 2010, produced markedly lower net benefits and BCRs. All four structural alternatives produced comparable net benefits and BCRs. The highest performing alternative was Alternative 4, which produced annual net benefits of $3,237,000. Alternative 4 also had the highest BCR, followed very closely by Alternative 3. Table 13 summarizes the storm damage reduction benefits and costs by alternative, as analyzed to date.

Table 13: Summary of Estimated Costs and Benefits	**Alternative**	**Annual Cost**	**Annual Benefits**	**Annual Net Benefits**	**BCR**
Price Level: October 2010. FY11 Discount Rate: 4.125%	NS-1 (10% flood)	$573,000	$554,000	$(19,000)	**1.0**
	NS-2 (1% flood)	$3,674,000	$4,148,000	$474,000	**1.1**
Price Level: October 2015. FY16 Discount Rate: 3.125%.	Alternative 1	$3,055,000	$6,033,000	$2,978,000	**2.0**
	Alternative 2	$2,929,000	$6,033,000	$3,104,000	**2.1**
	Alternative 3	$2,828,000	$6,033,000	$3,205,000	**2.1**
	Alternative 4	$2,796,000	$6,033,000	$3,237,000	**2.2**

Sensitivity

68. Sensitivity tests were applied to the estimation of damages and project benefits. To gauge the sensitivity of the with-project level of risk management, the levee/floodwall/dune heights in the HEC-FDA model were lowered by one foot in a sensitivity test. Under this lower risk management condition, the with-project storm EAD increased about 52%, from roughly $1,016,000 to $1,542,000. This outcome suggests that lowering the level of coastal storm risk management by one foot would create a large increase in the with-project storm damage estimate.

69. The most cost-effective alternative was determined to be the structural measure Alternative 4, which has a benefit cost ratio of 2.2 when calculated with the FY2016 discount rate of 3.125%. As a sensitivity test, a 7% discount rate was applied. This higher rate is typically used to determine priority for project funding. Using a 7% discount rate, the BCR for Alternative 4 was reduced from 2.2 to 1.2. This demonstrates that Alternative 4 remains economically justifiable under conditions with higher discount rates.

SUMMARY

This appendix documents procedures and results of the storm damage economic analysis, and the economic performance of various coastal storm risk management measures within Bayville. The report describes the processes used to conduct the economic base study, compile a structure inventory and value survey, and develop structure damage functions used in the storm damage analysis. The storm damage analysis quantified without-project equivalent annual damages (EAD), and the with-project EAD over a 50-year period of analysis. Benefits are measured as the difference between without-project damages and with-project damages. Structural alternatives 1 through 4 were all determined to be economically justifiable. Alternative 4 was calculated to provide the greatest contribution to National Economic Development. As a result, this analysis identifies alternative 4 as the NED plan for further development.