Suffolk County, New York

Coastal Storm Risk Management Study

Hashamomuck Cove

Draft Economics Appendix

US Army Corps of Engineers
New England District

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Executive Summary

The Hashamomuck Coastal Strom Risk Management Project consists of approximately 1.5 miles of shoreline along the north coast of Long Island's north fork. The entirety of the project is located in the Town of Southold, New York.

The Report is intended to evaluate alternatives that will manage coastal storm risk. Coastal damage for each of these alternatives is evaluated using the Corps' Coastal Risk Management model, Beach-fx. Damage for each alternative is compared to damage without the project and the plan with the largest net annual benefit is identified. This plan is referred to as the National Economic Development (NED) Plan. The Tentatively Selected Plan (TSP) is also identified. Net annual benefit is annual benefit minus annual cost. Benefit and cost are stated in the FY 2016 price level. Damage and cost estimates are discounted using the FY 2016 federal interest rate of 3.125%.

1 Introduction

This report presents and evaluates the economic benefits of options designed to manage coastal storm risk to the area around Hashamomuck Cove, in Southold, Long Island New York. This Coastal Storm Risk Management assessment is conducted at a Feasibility level. This assessment looks at approximately 1.5 miles of shoreline along the north shore of Long Island's North Fork.

1.1 Purpose of Report

The report is intended to investigate the feasibility of alternatives designed to reduce risk to the Hashamomuck Cove area from coastal storm damage. The purpose of this document is to evaluate the future without-project condition and the future with-project conditions described by various alternatives, as simulated by the Corps certified coastal model Beach-fx. It is intended to explain the approach, assumptions, and results of the analyses. The National Economic Development Plan (NED) is identified as the plan that maximizes the difference between annual benefit and annual cost. Annual benefit is the difference in damage between an improvement alternative and the without project condition. A Tentatively Selected Plan (TSP) is also identified. Typically it is also the NED plan but may be a Locally Preferred Plan (LPP).

1.2 Design of Document

This document provides information about the existing and future without-project conditions, as well as the future conditions determined by the proposed alternatives.

1.3 Beach-fx Economic Modeling Approach

Beach-fx was developed by the USACE Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi. The model links the predictive capability of coastal evolution modeling with project area infrastructure information, structure and content damage functions, and economic valuations to estimate the costs and total damages under various shore protection alternatives. Beach-fx fully incorporates risk and uncertainty, and is used to simulate future hurricane and storm damages at existing and future years and to compute accumulated present worth damages and costs. Storm damage is defined as the damage incurred by the temporary loss of a given amount of shoreline as a direct result of waves, erosion, and inundation caused by a storm of a given magnitude and probability. Beach-fx is an event-driven life-cycle model that estimates damages over a 50 year period of analysis based on storm probabilities, tidal cycle, tidal phase, beach morphology and many other factors. Damages or losses to developed shorelines include buildings, pools, patios, parking lots, roads, utilities, seawalls, revetments, and bulkheads.

The Hashamomuck site specific model was developed by US Army Corps Engineers (USACE Wilmington Engineering Division. All coastal morphology inputs were developed by the engineering (see engineering Coastal Appendix). This model has been built in accordance with the Beach-fx User's Manual (August 2009).

1.3.1 Model Reaches

The broadest spatial category of socioeconomic inputs into Beach-fx is the model coastal reach. There are 13 total reaches in the Hashamomuck model and 15 economic reaches. Damage is collected and presented by economic reach.

1.3.2 Lots

Lots are simply an organizational container in the system for Damage Elements. A lot can be the entire size of the Reach or the size of an actual plot of land in the study area. They are built into the model as quadrilaterals encapsulated within model reaches and are used to transfer the effect of coastal morphology changes to the damage element. Lots are also the repositories for coastal armor costs, specifications, and failure threshold information. Within Beach-fx, armor is defined at the lot level. An aerial view of the model reaches and lots is provided in Figure 1.1. Lots are outlined in green. Economic reaches are outlined in purple and labeled E1 to E15.

Figure 1.1a: Aerial view of model reaches, West Cove

Figure 1.1b: Aerial view of model reaches, Central Cove

Figure 1.1c: Aerial view of model reaches, East Cove

1.3.3 Damage Elements

A Damage Element (DE) represents any structure where damages can be incurred. This could be a house, commercial buildings, deck, pool, walkover structure, parking lot, and road. Damage Elements are members of a specified lot and are defined by a single, representative central point (X, Y coordinates).

Beach-fx handles economic considerations at the DE level. These considerations include extent of damage, cost to rebuild, and time to rebuild. Beach-fx uses pre-defined damage functions to calculate the extent of damage. For each damage element, the following information is input into Beach-fx:

- Geographical reference (northing and easting of center point)
- Alongshore length and cross-shore width
- Usage (e.g., single family, multi-family, commercial, walkover, pool, gazebo, tennis court, parking lot)
- Number of floors
- Construction type (e.g., wood frame, concrete, masonry)
- Foundation type (e.g., shallow piles, deep piles, slab)
- Armor type (e.g., seawall, bulkhead)
- Ground and/or first floor elevation
- Value of structure (replacement cost less depreciation)
- Value of contents

The geospatial location and footprint of the damage elements was obtained using aerial photography in Arc Map. Structure market values were used to represent depreciated replacement value. An uncertainty of +/- 105% was assigned to these values. The value of contents was assumed to be 50% of the structure value based on previous Corps studies.

1.4 Existing Condition Coastal Inventory

The Hashamomuck Cove study area has 100 individual damage elements, including 58 residential structures, 4 commercial structures, and one major highway. The total value of the existing inventory is estimated to be $46 million (not including existing coastal armor such as bulkheads). A summary of the damage elements (by type excluding the highway) is provided in Table 1-1.

Table 1-1: Distribution of Depreciated Replacement Value by Structure Type, $

Type	Description	No. of Structures.	Structure Value	Contents Value	Total Value
COM1B	Commercial 1-sty w Base	1	1,658,100	829,050	2,487,150
COM2B	Commercial 2-sty w Base	3	4,196,600	2,098,300	6,294,900
SFR1	Residential 1-sty	34	13,152,800	6,576,400	19,729,200
SFR2	Residential 2-sty	23	10,636,900	5,318,450	15,955,350
SFR3	Residential 3-sty	1	1,047,000	523,500	1,570,500
Total		62	30,691,400	15,345,700	46,037,100

A summary of the damage elements by economic reach is provided in Table 1- 2. The Hashamomuck study area is divided into three coves-West, Central and East. The West Cove is primarily residential and includes a public beach, the Central Cove is all residential, and the East Cove is a mix of residential and commercial including a motel and restaurant. The West Cove consists of economic reaches E1 to E5, the Central Cove E6 to E11, and the West Cove E12 to E15.

Table 1-2: Structure Value Distribution by Economic Reach, $

Reach	No. of Structures	Structure Value	Contents Value	Total Value
E-1	3	533,100	266,550	799,650
E-2	3	1,760,700	880,350	2,641,050
E-3	0	0	0	0
E-4	8	4,730,800	2,365,400	7,096,200
E-5	4	2,521,300	1,260,650	3,781,950
E-6	5	1,641,100	820,550	2,461,650
E-7	2	1,162,400	581,200	1,743,600
E-8	11	3,059,800	1,529,900	4,589,700
E-9	5	2,247,900	1,123,950	3,371,850
E-10	2	1,205,100	602,550	1,807,650
E-11	3	2,269,200	1,134,600	3,403,800
E-12	5	2,021,400	1,010,700	3,032,100
E-13	7	1,683,900	841,950	2,525,850
E-14	2	2,634,600	1,317,300	3,951,900
E-15	**2**	3,220,100	1,610,050	4,830,150
Total	62	30,691,400	15,345,700	46,037,100

1.4.1 Residential

Family residential structures are found throughout the study area. Family homes are 94 percent of the total and represent the largest category of total economic depreciated replacement value (more than $37 million).

1.4.2 Commercial Structures

A motel and restaurant are located in the East Cove. These complexes are of high value and are not elevated. Commercial structures comprise six percent of the total 19 percent of the value (8.8 million).

1.4.3 Roads

All lots in the study have one road damage element, typically located near the landward edge of the lot. The roads are defined a linear damage element in Beach-fx. Depreciated replacement values for roads were based on the estimated cost of repairing the road. The cost is defined on a per liner foot basis.

Data provided by the State of New York Transportation Department indicate that usage of CR 48 as measured by Average Annual Daily Trips (AADT) in Southhold, New York was 5,861 eastbound (EB) and 5,797 westbound (WB) for a daily total of 11,658 trips. The traffic count was taken in August, 2012.The net detour mileage due to road closure in the project area was estimated as 1.68 with the use of Google Earth software. The nearest alternative road is SR 25.

The dollar value of time saved by preventing detour CR 48 in the project area is calculated according to Corps of Engineers guidance contained in ER 1105-2-100, Appendix D, Page D-18, "Opportunity Cost of Time", dated 30 June 2004. Time savings are categorized by purpose as work trips, social/recreation trips, or other trips. For this analysis it was assumed that half the total trips are work trips and half are social/recreation trips. The guidance provides percentages of hourly family income to use to value time savings based on the purpose of the trip and the length of time saved. The guidelines assume that time saved on work trips has a higher value than time spent on social, recreation or other trips, and that larger increments of time savings have higher value than shorter increments of time savings (time savings increments include 0 to 5 minutes, 6 to 15 minutes, and greater than 15 minutes). The 2009-2013 median household income of $87,173 for Suffolk County, New York, from the US Census Bureau of was used for this analysis, converted to an hourly rate of $42.19 based on 2080 work hours per year. It was assumed that the 1.68 miles detour would result in extra time spent driving of about 2.9 minutes, based on an average speed of 35 miles per hour. It was also assumed that an average of 11,658 vehicles per day would be detoured, based on the traffic count data. Applying the value of time savings guidance, the value of time while detoured equals $10,000 daily. These detour costs would be prevented with a coastal risk management project, resulting in a daily benefit of $10,000. The actual benefit depends on the time needed to put the road back in service. If one month is needed to repair the road the value lost would be $485,900. If a section of the road was lost permanently due to long-term erosion the annual loss in value of time would be $1,901,100.

The dollar value of mileage savings due to preventing the 1.7 mile detour is calculated using the 2015 American Automobile Association cost per mile to operate a medium size car of $0.58. Assuming 11,658 vehicles detoured per day and a detour length of 1.7 mile, this yields total mileage costs of $22,700 per day, $340,800 per month and $4,146,200 per year. These transportation costs would be prevented with a coastal risk management project.

1.4.4 Armor

About one-half the lots in the study area have existing coastal armor, which are primarily bulkheads differing in value and construction type. A map of the armor locations is provided in Figure 1-2.

Figure 1-2: Map of Existing Armor in the Study Area

2 Model Assumptions

This section documents modeling assumptions.

2.1 Period of Analysis and Discount rate

This feasibility study evaluates the feasibility of various coastal protection options over a 50-year period of participation. The present value of damages have been calculated using the current (FY16) water resources discount rate 3.125%.

2.2 Content Values

Estimating content values is an important part of developing the structure inventory. Typically, content-to-structure value ratios (CSVRs) are used to define content value as a percentage of the depreciated structure value. Previous Corps studies have shown content value to be between 40 and 60% of depreciated replacement value for residential structures. In this study a content to structure value ratio of 0.50 is used for all residential structures. Corps studies have also shown that for commercial/industrial structures the value of contents can be greater than the depreciated replacement value of the structure. A content to structure value of 1.0 was used for commercial structures in this study.

2.3 Structure Rebuild

The number of rebuilds specifies the maximum number of times a class of damage elements (SFR1, COMM1, etc.) can be rebuilt. This assumption is important, because it effectively creates a cap after which structure and content damages cannot be incurred. In this study, all damage elements other than roads were assumed to be rebuilt once. Road damage elements were allowed a number of rebuilds of 100 in order that the road is repaired after each storm.

All damage elements other than roads are considered. Once a damage element is condemned, it cannot be rebuilt. The condemnation ratio, the ratio of post-storm structure value divided by initial structure value below which will result in the structure being marked as condemned, provided that the damage element type is also marked as condemnable. In this case, the condemnation ratio was 0.5, meaning that if a single storm results in more than the loss of 50 percent of the initial value, it will not be rebuilt.

2.4 Armor Assumptions

Most of the lots in the model are armored in the existing condition. Those lots that are not armored are assumed to not be armorable in the future. Because armor is a major part of the existing coastal inventory, the armor assumptions are important to the analysis. In particular, the failure thresholds and the armor construction distance triggers are very important. In the case of the distance triggers, the Beach-fx lots have been drawn such that the seaward edge of the lot is located where armor would reasonably be constructed. In the case of failure thresholds, the assumed threshold depends on the type of armor and the relevant damage driver (erosion, inundation, or wave attack). According to the Beach-fx User's Guide, the erosion failure threshold is defined as "the magnitude of vertical erosion (feet) at the cross-shore location of the armor unit that will cause the armor to fail." The armor modeling assumptions used in this analysis are summarized in Table 2-1; they were developed by coastal engineering. Photographs and characteristics of the armor were obtained on a site visit and during elevation survey work by USACE New England District engineering staff.

Table 2-1: Armor Failure Thresholds

Economic Reach	Lot id	Armor Length	WOP Armor Erosion Failure Threshold	WP Armor Erosion Failure Threshold	Armor Flooding Failure Threshold	Armor Wave Failure Threshold
E2	2	192	2	7	10	12
E2	4	210	2	7	7.5	9.5
E4	6	850	2	6	9	11

E5	7	400	2	6	9	11
E6	8	215	2	6	9	11
E8	10	445	2	8	6.5	8.5
E8	12	90	2	8	8	10
E8	14	80	2	6	8	10
E9	15	350	2	6	6.5	8.5
E11	18	375	2	6	11	13
E12	19	560	2	6	8.5	10.5
E13	21	165	2	8	7	9
E13	23	55	2	7	10	12
E13	25	185	2	8	7	9

A number of important modeling assumptions are noted below:

- **Storm Suite:** Both tropical and extra tropical storms comprised the storm suite.
- **Back Bay Flooding:** In this study back bay flooding was not simulated. Based on historical experience, it is not expected that back flooding would be significant in this area.
- **Planned Nourishment:** Planned nourishment was part of the with project condition.
- **Emergency Nourishment:** No emergency nourishment was assumed in either the with or without project condition based on historical experience.
- **Armor Construction Length:** Length was measured in feet as the parallel to shore lot length.
- **Seed Value:** The Beach-fx manual recommends using a large prime number as a simulation seed value. In this case, the number 15486586 was used.
- **Number of Iterations.** The number of iterations was 300.

3 Damages by Alternative

3.1 Structure and Content Damages

Structure damages refer to economic losses resulting from the structures situated along the coastline being exposed to wave attack, inundation, and erosion damages. Content damages refer to the material items housed within the aforementioned structures that are potentially subject to damage. Armor damages are not included in this table.

Table 3-1: Damage Existing Condition by Cove and Damage Element Type, Average Discounted Sum, $

Damage Element Type	West Cove		Central Cove		East Cove		Total	
	Structure	Content	Structure	Content	Structure	Content	Structure	Content
SFR3	0	0	153,400	63,300	0	0	153,400	63,300
SFR2	1,608,500	765,200	1,646,900	741,200	611,980	276,780	3,867,380	1,783,180
SFR1	1,658,100	715,100	2,513,800	1,036,800	580,388	249,378	4,752,288	2,001,278
ROAD	852,200	0	530,000	1,295,600	1,106,967	0	2,489,167	1,295,600
ROAD2	399,800	0	0	0	0	0	399,800	0
PARKINGLOT	0	0	0	0	4,800	0	4,800	0
COM2B	0	0	0	0	1,809,300	702,900	1,809,300	702,900
COM1B	0	0	0	0	358,300	178,100	358,300	178,100
Total	4,518,600	1,480,300	4,844,100	3,136,900	4,471,735	1,407,157	13,834,435	6,024,357

3.2 Armor Damages

Beach-*fx* provides the capability to estimate the costs incurred from measures likely to be taken to protect coastal assets and or prevent erosion in the study area. Armor damage includes the cost of reconstructing existing armor as well as the cost associated with erecting new armor.

Table 3-2: Damage by Reach, Alt. 1, Without Project Condition, Ave Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage
E-1	572,800	112,000	0	684,800
E-2	1,064,100	295,200	975,200	2,334,500
E-3	399,800	0	0	399,800
E-4	1,476,500	630,100	3,257,200	5,363,800
E-5	1,005,400	443,000	1,221,000	2,669,400
Total West	4,518,600	1,480,300	5,453,400	11,452,300
E-6	16,500	7,600	135,100	159,200
E-7	540,700	242,400	0	783,100
E-8	2,398,600	2,165,500	1,266,400	5,830,500
E-9	636,900	323,800	42,700	1,003,400
E-10	569,900	159,300	0	729,200
E-11	681,500	238,300	2,527,800	3,447,600
Total Central	4,844,100	3,136,900	3,972,000	11,953,000
E-12	456,700	184,300	2,207,500	2,848,500
E-13	1,289,400	341,800	290,900	1,922,100
E-14	1,040,200	234,500	0	1,274,700
E-15	1,685,400	646,500	0	2,331,900
Total East	4,471,700	1,407,100	2,498,400	8,377,200
Total All Coves	13,834,400	6,024,300	11,923,800	31,782,500

3.3 Land Loss

Land loss is due to the landward march of the shoreline over the 50 year study period. The extent of land loss in each economic reach is show in Table 3-3 below. The square footage in each reach that is lost annually is converted to acres and then multiplied by the value per acre as estimated by the USACE, New York District (NAN) Real Estate office. The value of near shore is used as shorefront property is not lost but transferred landward. The erosion discussed here is not storm induced, but long-term as a result of sand lost to the system over time.

Table 3-3: Hashamomuck Cove Land Loss

Economic Reach	Average Erosion Rate (Ft/Yr)	Predicted Erosion in Total Feet (2069)	Reach length	Average Annual Land Loss (acres)	$ per Acre	Average Annual Land Loss Cost $
E1	-0.35	-19.25	329	0.0026	479,160	1,300
E2	-1.29	-70.95	541	0.0160	479,160	7,700
E3	-1.10	-60.5	972	0.0245	479,160	11,800
E4	-0.64	-35.2	868	0.0128	479,160	6,100
E5	-0.54	-29.7	406	0.0050	479,160	2,400
WEST				0.0610	479,160	29,200
E6	-0.59	-32.45	253	0.0034	479,160	1,600
E7	-1.24	-68.2	236	0.0067	479,160	3,200
E8	-1.3	-71.5	839	0.0250	479,160	12,000
E9	-0.58	-31.9	545	0.0073	479,160	3,500
E10	-0.60	-33	326	0.0045	479,160	2,200
E11	-0.66	-36.3	376	0.0057	479,160	2,700
CENTRAL				0.0526	479,160	25,200
E12	-0.28	-15.4	584	0.0038	479,160	1,800
E13	-0.79	-43.45	681	0.0124	479,160	5,900
E14	-0.11	-6.05	893	0.0023	479,160	1,100
E15	-0.30	-16.5	603	0.0042	479,160	2,000
EAST				0.0225	479,160	10,800

Table 3-3: Damage by Reach, Alternative 2A, 25-ft Berm, Ave. Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Damage	Total Damage
E-1	143,800	36,000	0	179,800
E-2	282,400	136,300	272,800	691,500
E-3	83,300	0	0	83,300
E-4	296,200	126,300	379,600	802,100
E-5	136,900	58,400	147,800	343,100
Total West	942,600	357,000	800,200	2,099,800
E-6	0	0	89,700	89,700
E-7	10,700	4,900	0	15,600
E-8	2,346,500	2,235,100	2,120,800	6,702,400
E-9	378,600	185,200	209,600	773,400
E-10	75,700	16,000	0	91,700
E-11	51,700	21,100	39,000	111,800
Total Central	2,863,200	2,462,300	2,459,100	7,784,600
E-12	108,100	47,900	292,700	448,700
E-13	1,202,600	407,600	487,000	2,097,200
E-14	357,100	154,200	0	511,300
E-15	718,900	276,600	0	995,500
Total East	2,386,700	886,300	779,700	4,052,700
Total All Coves	6,192,500	3,705,600	4,039,000	13,937,100

Table 3-4: Damage by Reach, Alternative 2B, 50-ft Berm, Ave. Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage
E-1	244,700	60,300	0	305,000
E-2	321,600	141,300	388,900	851,800
E-3	96,600	0	0	96,600
E-4	340,700	151,500	398,100	890,300
E-5	138,800	60,100	43,700	242,600
Total West Cove	897,700	352,900	830,700	2,081,300
E-6	0	0	79,400	79,400
E-7	5,800	2,500	0	8,300
E-8	1,406,300	2,701,900	1,712,100	5,820,300
E-9	350,200	169,700	736,700	1,256,600
E-10	48,100	9,100	0	57,200
E-11	35,000	13,600	45,200	93,800
Total Central Cove	1,839,600	2,894,300	2,494,000	7,227,900
E-12	77,500	35,800	146,200	259,500

E-13	1,207,100	411,700	892,100	2,510,900
E-14	415,700	184,200	0	599,900
E-15	750,300	282,800	0	1,033,100
Total East Cove	2,450,600	914,500	1,038,300	4,403,400
Total All Coves	5,187,900	4,161,700	4,363,000	13,712,600

Table 3-5: Damage by Reach, Alternative 2C, Variable 75-ft Berm, Ave. Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage
E-1	116,100	32,500	0	148,600
E-2	157,900	72,700	389,800	620,400
E-3	418,100	0	0	418,100
E-4	340,100	147,500	339,000	826,600
E-5	272,300	121,000	179,300	572,600
Total West Cove	1,304,500	373,700	908,100	2,586,300
E-6	0	0	90,900	90,900
E-7	17,800	8,100	0	25,900
E-8	1,317,000	1,784,400	834,400	3,935,800
E-9	635,000	321,400	36,400	992,800
E-10	551,900	154,100	0	706,000
E-11	77,900	36,200	18,900	133,000
Total Central Cove	2,599,600	2,304,200	980,600	5,884,400
E-12	292,600	121,900	1,983,300	2,397,800
E-13	775,000	272,200	612,300	1,659,500
E-14	412,900	181,700	0	594,600
E-15	842,900	319,600	0	1,162,500
Total East Cove	2,323,400	895,400	2,595,600	5,814,400
Total All Coves	6,227,500	3,573,300	4,484,300	14,285,100

Table 3-6: Damage by Reach, Alternative 3, 50-ft Berm & 5-ft Dune, Ave. Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage
E-1	94,200	23,700	0	117,900
E-2	153,200	78,500	395,300	627,000
E-3	35,600	0	0	35,600
E-4	111,400	47,600	369,100	528,100
E-5	31,400	13,900	19,400	64,700
Total West	425,800	163,700	783,800	1,373,300

E-6	0	0	79,400	79,400
E-7	5,800	2,500	0	8,300
E-8	949,600	1,669,300	825,100	3,444,000
E-9	335,100	164,300	883,200	1,382,600
E-10	64,400	16,900	0	81,300
E-11	35,000	13,600	45,200	93,800
Total Central	1,389,900	1,866,600	1,832,900	5,089,400
E-12	84,000	39,000	95,000	218,000
E-13	678,800	242,500	696,100	1,617,400
E-14	415,700	184,200	0	599,900
E-15	750,300	282,900	0	1,033,200
Total East	1,928,800	748,600	791,100	3,468,500
Total All Coves	3,744,500	2,778,900	3,407,800	9,931,200

Table 3-7: Damage by Reach, Alternative 4A, Bulkhead, Ave. Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage
E-1	94,100	9,200	0	103,300
E-2	510,600	147,700	0	658,300
E-3	84,100	0	0	84,100
E-4	2,800	1,200	0	4,000
E-5	7,700	6,100	0	13,800
Total West	699,300	164,200	0	863,500
E-6	500	300	0	800
E-7	8,000	5,600	0	13,600
E-8	167,200	1,364,300	0	1,531,500
E-9	430,900	250,900	0	681,800
E-10	23,100	3,800	0	26,900
E-11	65,900	34,500	0	100,400
Total Central	695,600	1,659,400	0	2,355,000
E-12	88,100	41,800	0	129,900
E-13	324,700	132,300	0	457,000
E-14	623,400	237,800	0	861,200
E-15	35,100	14,200	0	49,300
Total East	1,071,300	426,100	0	1,497,400
Total All Coves	2,466,200	2,249,700	0	4,715,900

Table 3-8: Damage by Reach, Alternative 4B, Road Bulkhead, Ave. Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage
E-1	572,800	112,000	0	684,800
E-2	1,064,100	295,200	975,200	2,334,500
E-3	0	0	0	0
E-4	1,476,500	630,100	3,257,200	5,363,800
E-5	1,005,400	443,000	1,221,000	2,669,400
Total West	4,118,800	1,480,300	5,453,400	11,052,500
E-6	16,500	7,600	135,100	159,200
E-7	540,700	242,400	0	783,100
E-8	1,919,800	2,165,500	1,266,400	5,351,700
E-9	636,900	323,800	42,700	1,003,400
E-10	569,900	159,300	0	729,200
E-11	681,500	238,300	2,527,800	3,447,600
Total Central	4,365,300	3,136,900	3,972,000	11,474,200
E-12	456,700	184,300	2,207,500	2,848,500
E-13	473,000	341,800	290,900	1,105,700
E-14	451,500	234,500	0	686,000
E-15	1,685,400	646,500	0	2,331,900
Total East	3,066,600	1,407,100	2,498,400	6,972,100
Total All Coves	11,550,700	6,024,300	11,923,800	29,498,800

Table 3-9: Damage by Reach, Alternative 5, Buyout, Ave. Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage
E-1	325,600	0	0	325,600
E-2	521,800	0	975,200	1,497,000
E-3	403,400	103,100	0	506,500
E-4	1,466,500	626,000	3,257,200	5,349,700
E-5	1,005,200	442,700	1,221,000	2,668,900
Total West	3,722,500	1,171,800	5,453,400	10,347,700
E-6	17,300	7,900	135,100	160,300
E-7	539,000	242,100	0	781,100
E-8	610,300	1,361,300	1,266,400	3,238,000
E-9	48,300	0	42,700	91,000
E-10	580,100	162,900	0	743,000
E-11	677,300	236,600	2,527,800	3,441,700
Total Central	2,472,300	2,010,800	3,972,000	8,455,100

E-12	462,300	186,800	2,207,500	2,856,600
E-13	548,900	0	290,900	839,800
E-14	553,500	0	0	553,500
E-15	0	0	0	0
Total East	1,564,700	186,800	2,498,400	4,249,900
Total All Coves	7,759,500	3,369,400	11,923,800	23,052,700

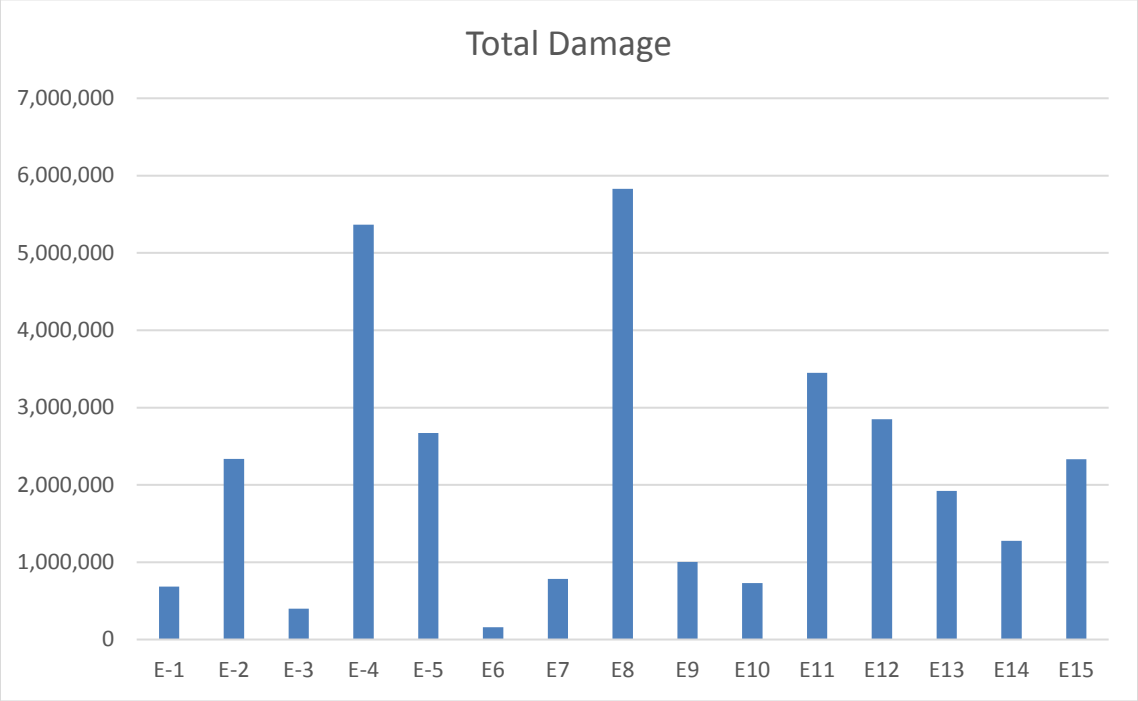

Figure 3-1: Total Discounted Average Damage by Economic Reach

The reaches with the largest proportion of total damage were E-4 ($5.4 M in PV damages), and E-8 ($4.5). The reaches with the smallest damage were E-3 and E-6 (about $0.5 million and $0.2million in present value damages, respectively).

Armor damages include damage to existing armor. In lots with existing armor, erosion damage to structures and contents is prevented throughout the simulation (unless the armor fails). However, even in armored lots, structures are vulnerable to inundation and wave attack from major storms. Storm surge can sometimes inflict damage behind seawalls even if the armor itself does not fail.

3.4 Temporal Distribution of Without Project Damage

The temporal distribution of without project damage shows that damage declined over time due the removal of structures from the inventory when condemned and discounting. Model results showed the road receiving damage on an average of once in year 1 through 10, three times in years 11 through 20, five times in years 21 through 30, five times in years 31 through 40 and 3 times in years 41 through 50. Each of these occurrences resulted in delays and additional travel cost to motorists.

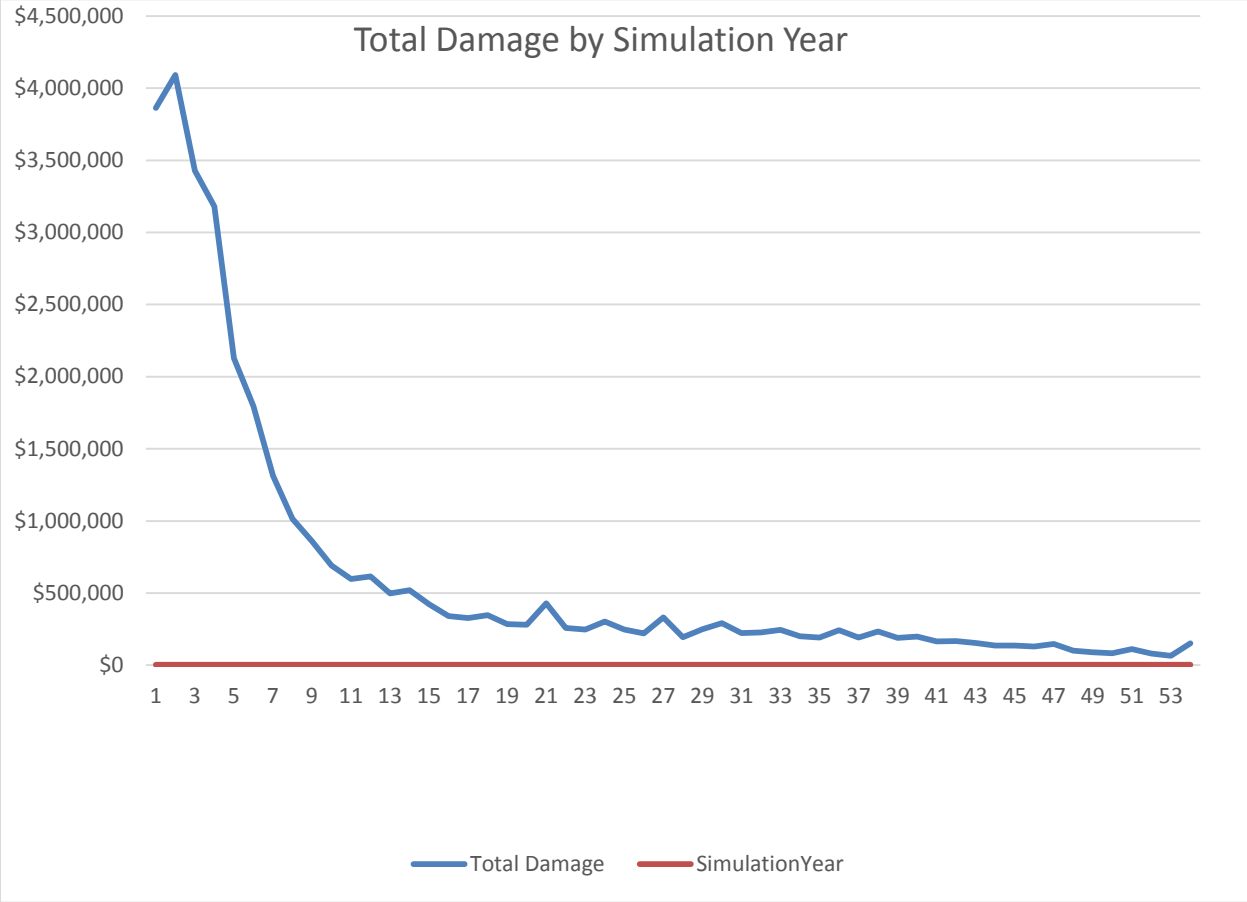

Figure 3-2: Total Discounted Average Damage by Simulation Year

3.5 Model Stability

One issue facing any Beach-fx study concerns the appropriate number of iterations (each representing a life cycle simulation). In order to determine the idea number of iterations, the modeler must find a balance between stability of the results and a reasonable simulation time. Typically, the results become more stable and converge within a more narrow range with more iterations. However, simulation time increases with more iterations, as does the size and

complexity of the output files. As previously stated, 300 iterations were used for the model simulation for this study. The results for 300 iterations were stable.

3.6 Damage in alternative Sea Level Rise (SLR) scenarios

ER 1165-2-211 provides both a methodology and a procedure for determining a range of sea level rise estimates based on the local historic sea level rise rate, the construction (base) year of the project, and the design life of the project. The Beach-*fx* results presented above refer to the baseline scenario, which is based on the historic erosion rate. The results associated with the other two SLR scenarios will be presented in the final report to demonstrate the sensitivity of the results to various sea level rise conditions.

3.7 Beach-fx Simulation Conclusion

The future without and with project conditions simulated here suggests that the study area may be subject to considerable storm damage throughout the period of analysis. In particular, there are five important conclusions:

- Most of the FWOP damage is attributable to direct damage to structures, though content and armor damage are also significant.
- The damages vary considerably over space (different reaches have significantly different types and magnitudes of damage).
- The damages are fairly consistent over time.
- Most of the damage is caused by erosion

4 Project Cost by Alternative

The tables below provide project cost for each alternative.

Table 4-1: Alternative 2A (25' Berm) Investment Cost by Cove, $

Costs	West	Central	East	Total
Sand Placement Cost (48$/cy)	2,293,100	2,381,900	4,025,400	8,700,400
Contingency Beach Fill 18.5%	424,200	440,700	744,700	1,609,600
Mitigation Cost	0	0	0	0
Real Estate Cost ($)	1,032,100	808,900	429,900	2,270,800
Total Project Cost (does not include IDC)	3,749,400	3,631,400	5,200,000	12,580,800
IDC	19,600	19,000	27,200	65,700
TOTAL INVESTMENT COST	3,768,900	3,650,400	5,227,200	12,646,500

Table 4-2: Alternative 2B (50' Berm) Investment Cost by Cove, $

Costs	West	Central	East	Total
Sand Placement Cost (48$/cy)	6,091,100	5,336,800	7,028,000	18,455,900
Contingency Beach Fill 18.5%	1,126,900	987,300	1,300,200	3,414,400
Mitigation Cost	0	0	0	0
Real Estate Cost ($)	703,500	284,900	276,700	1,265,100
Total Project Cost (does not include IDC)	7,921,500	6,609,000	8,604,900	23,135,300
IDC	41,400	34,500	44,900	120,800
TOTAL INVESTMENT COST	7,962,900	6,643,500	8,649,800	**23,256,200**

Table 4-3: Alternative 2C (75/25' Berm) Investment Cost by Cove, $

Costs	West	Central	East	Total
Sand Placement Cost (48$/cy)	3,023,000	3,052,600	6,965,000	13,040,600
Contingency Beach Fill 18.5%	559,300	564,700	1,288,500	2,412,500
Mitigation Cost	0	0	0	0
Real Estate Cost ($)	1,032,100	809,900	429,900	2,271,800
Total Project Cost (does not include IDC)	4,614,300	4,427,200	8,683,400	17,724,900
IDC	54,500	52,200	102,500	209,200
TOTAL INVESTMENT COST	4,668,800	4,479,500	8,785,800	**17,934,100**

Table 4-4: Alternative 3 (dune/Berm) Investment Cost by Cove, $

Costs	West	Central	East	Total
Sand Placement Cost (48$/cy)	6,039,100	4,761,500	6,658,200	17,458,800
Contingency Beach Fill 18.5%	1,117,200	880,900	1,231,800	3,229,900
Mitigation Cost	0	0	0	0
Real Estate Cost ($)	1,032,100	809,900	429,900	2,271,800
Total Project Cost (does not include IDC)	8,188,400	6,452,200	8,319,800	22,960,400
IDC	42,800	33,700	43,400	119,900
TOTAL COST	8,231,100	6,485,900	8,363,300	**23,080,300**

Table 4-5: Alternative 4A (Bulkhead) Investment Cost by Cove, $

Costs	West	Central	East	Total
Bulkhead Cost (includes 8% PED)	11,644,700	10,257,400	10,444,600	32,346,600
Contingency Bulkhead	2,504,000	2,205,500	2,245,300	6,954,800
Mitigation Cost ($50/sq. ft.)	200,000	350,000	650,000	1,200,000
Real Estate Cost ($)	1,032,100	809,900	429,900	2,271,800
Total Project Cost (does not include IDC)	15,380,800	13,622,700	13,769,700	42,773,200
IDC	80,300	71,100	71,900	223,400
TOTAL INVESTMENT COST	15,461,100	13,693,800	13,841,600	**42,996,500**

Table 4-6: Alternative 4B (Road Bulkhead) Investment Cost by Cove, $

Costs	West	Central	East	Total
Bulkhead Cost (includes 8% PED)	3,726,900	1,782,700	5,348,500	10,858,100
Contingency Bulkhead	782,600	374,400	1,123,200	2,280,200
Mitigation Cost ($50/sq. ft.)	0	0	0	0
Real Estate Cost ($)	329,700	54,400	193,800	577,900
Total Project Cost (does not include IDC)	4,839,200	2,211,500	6,665,500	13,716,200
IDC	25,300	11,500	34,800	71,600
TOTAL INVESTMENT COST	4,864,500	2,223,000	6,700,300	**13,787,800**

Table 4-7: Alternative 5 (Buyout) Investment Cost by Cove, $

Costs	West	Central	East	Total
Not Impaired Market Value for Buyouts	9,259,200	32,447,900	17,712,200	59,419,200
Mitigation Cost ($50/sq. ft.)	0	0	0	0
Total Project Cost (does not include IDC)	9,259,200	32,447,900	17,712,200	59,419,200
IDC	48,400	169,400	92,500	310,300
TOTAL COST	9,307,500	32,617,300	17,804,700	**59,729,500**

Note: Row 1 includes Not Impaired Structure and Land Value, Demolition and Incidental Costs

5 Comparison of Alternatives

5.1 Benefit Cost Summary

This section compares the benefit and cost of each alternative and identifies the National Economic Development (NED) Plan and the Tentatively Selected Plan (TSP). In this case the TSP is the NED Plan. Plan 2A which provide a 25-ft berm has the largest net benefit of all alternatives evaluated in the West Cove.

Table 5-1: West Cove Benefit Cost Summary, $

	Sum of PV Damage	Sum of PV Benefit	Annual Benefit	Annual Cost	Annual Net Benefit	Benefit-Cost Ratio
1 (WOP)	11,452,300					
2A	2,099,800	9,352,500	401,400	150,000	251,400	2.68
2B	2,081,300	9,371,000	402,100	330,000	72,100	1.22
2C	2,586,300	8,866,000	382,000	185,800	196,200	2.06
3	1,373,300	10,079,000	430,300	327,500	102,800	1.31
4A	863,500	10,588,800	450,600	615,200	-164,600	0.73
4B	11,052,500	399,800	15,900	193,600	-177,700	0.08
5	10,347,700	1,104,600	44,000	370,400	-326,400	0.12

Note: Annual Benefit includes the prevention of land loss from Table 3-3.

In the Central Cove show in Table 5-2 the alternative with largest net benefit is 2C which provides a 75-berm in the high erosion areas (Reach E-8) tapering to a 25-berm in Reach E-7 and Reach E-9.

Table 5-2: Central Cove Benefit Cost Summary, $

	Sum of PV Damage	Sum of PV Benefit	Annual Benefit	Annual Cost	Annual Net Benefit	Benefit-Cost Ratio
1 (WOP)	11,953,000					
2A	7,784,600	4,168,400	191,100	145,300	45,800	1.32
2B	7,227,900	4,725,100	213,200	285,400	-72,200	0.75
2C	5,884,400	6,068,600	266,700	178,300	88,400	1.50
3	5,089,400	6,863,600	273,100	258,100	15,000	1.06
4A	2,355,000	9,598,000	381,900	544,900	-163,000	0.70
4B	11,474,200	478,800	19,100	88,500	-69,400	0.22
5	8,455,100	3,497,900	139,200	1,297,900	-1,158,700	0.11

Note: Annual Benefit includes the prevention of land loss from Table 3-3.

In the East Cove the alternative with the greatest net benefit is 2A which provides a 25-ft berm.

Table 5-3: East Cove Benefit Cost Summary, $

	Sum of PV Damage	Sum of PV Benefit	Annual Benefit	Annual Cost	Annual Net Benefit	Benefit-Cost Ratio
1 (WOP)	8,377,200					
2A	4,052,700	4,324,500	182,900	208,000	-25,100	0.88
2B	4,403,400	3,973,800	168,900	327,000	-158,100	0.52
2C	5,814,400	2,562,800	112,800	349,600	-236,800	0.32
3	3,468,500	4,908,700	206,100	332,800	-126,700	0.62
4A	1,497,400	6,879,800	284,600	550,800	-266,200	0.52
4B	6,972,100	1,405,100	55,900	266,600	-210,700	0.21
5	4,249,900	4,127,300	164,200	708,500	-544,300	0.23

Note: Annual Benefit includes the prevention of land loss from Table 3-3.

Table 5-4 displays a summary of the three coves. Taken as a group Alternative 2A has the largest net benefit.

Table 5-4: Combined Coves Benefit Cost Summary, $

	Sum of PV Damage	Sum of PV Benefit	Annual Benefit	Annual Cost	Annual Net Benefit	Benefit-Cost Ratio
1 (WOP)	31,782,500					
2A	16,523,900	15,258,600	669,300	503,300	166,000	1.33
2B	13,712,600	18,069,900	784,300	942,400	-158,100	0.83
2C	14,285,100	17,497,400	761,500	713,700	47,800	1.07
3	9,931,200	21,851,300	934,700	918,400	16,300	1.02
4A	4,715,900	27,066,600	1,142,300	1,710,900	-568,600	0.67
4B	29,498,800	2,283,700	90,900	548,700	-457,800	0.17
5	23,052,700	8,729,800	347,400	2,376,800	-2,029,400	0.15

Note: Annual Benefit includes the prevention of land loss from Table 3-3.

5.2 Systems Approach

With the exception of delays and additional vehicle operating cost the three coves may be evaluated separately, or incrementally with respect to structure, content and road damage. However, with post-storm recovery detours due to road re-construction have to be evaluated on a system wide basis. A County Road 48 outage will impact all users irrespective on which cove it appeared in. Benefit cannot be claimed for prevention of road damage in the East Cove if damage also occurs in either the West or Central Coves. In order not to double count benefit delay cost is estimate by one damage element only although the road could be taken out in more than one location. Delay damage is estimated in the Central Cove (Reach E-8) where the highway is closest to the shoreline. Delay cost in the without project condition. is estimated at $1,293,700 for a discounted sum over 50 years or annually, $51,500. With a coastal risk management project the delay cost is estimated at a discounted sum of $161,200, or $6,400 annually. The difference between these two estimates is the delay reduction benefit shown in Table 5-4 below.

Table 5-5a: Benefit Cost Summary, $

	West Cove	Central Cove	East Cove	All Coves
	Alt 2A	Alt 2C	Alt 2A	
Annual Benefit				
Damage Reduction	405,400	266,700	76,800	748,900
Delay Reduction				
Total Annual Benefit	405,400	266,700	76,800	748,900
Annual Cost	150,000	178,300	74,800	403,100
Annual Net Benefit	255,400	88,400	2,000	345,800
Benefit-Cost Ratio	2.70	1.50	1.03	1.86

The benefit cost summary found in Table 5-5a for the East Cove reflects protection in Economic Reaches E-12 and E-13 only. The net annual benefit for the three coves is estimated at $345,800. No benefit is taken for detour delay and cost as it is possible that road is also damaged in the other coves (double counting) or that road damage is prevented in the other coves as well as the protected reaches in the East Cove, but the road is damaged in the unprotected reaches and the benefit cannot be claimed (alternative lacks completeness). Table 5-5b displays the benefit and cost with the three coves taken as a system. In the East Cove the 25-foot berm project is extended to the two most eastern reaches, E-14 and E-15. Extending the length of the project results in less benefit than cost in the two additional reaches, but reduction in travel time and vehicle operating cost may be taken which results in a larger annual net benefit that that shown in Table 5-5a.

Table 5-5b: System Benefit Cost Summary, $

	West Cove	Central Cove	East Cove	All Coves
	Alt 2A	Alt 2C	Alt 2A	
Annual Benefit				
Damage Reduction	405,400	266,700	182,900	855,000
Delay Reduction				45,200
Total Annual Benefit	405,400	266,700	182,900	900,200
Annual Cost	150,000	178,300	208,000	536,300
Annual Net Benefit	255,400	88,400	-25,100	363,900
Benefit-Cost Ratio	2.70	1.50	0.88	1.68

5.3 TSP Plan

The Tentatively Selected Plan, which is also the NED Plan, would provide a 25-foot berm in the West Cove, a combination 75/ 25-foot berm in the Central Cove, and a 25 foot berm in the East Cove. The benefit cost summary of this plan can be found in Table 5-5b.

5.4 Residual Damage

Residual damage is storm damage from erosion, wave and flooding that would be expected to still occur even with the TSP project in place. Table 5-6 shows residual damage by economic reach and cove as an average discounted sum over 300 iterations for the 50 year study period. In the West Cove damage is more or less evenly split between economic reaches E-2, E-3 and E-4. In the Central Cove residual damage in economic reach eight (E-8)is about 86 % of the total for the cove. In the East Cove most of the residual damage occurs in reaches E-13 and E-15. The annualized residual damage for all three coves is $554,600.

Table 5-6: Residual Damage with TSP, Average Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage	% Total
E-1	143,800	36,000	0	179,800	8.6%
E-2	282,400	136,300	272,800	691,500	32.9%
E-3	83,300	0	0	83,300	4.0%
E-4	296,200	126,300	379,600	802,100	38.2%
E-5	136,900	58,400	147,800	343,100	16.3%
Total West	942,600	357,000	800,200	2,099,800	15.1%
E-6	0	0	89,700	89,700	1.2%
E-7	10,700	4,900	0	15,600	0.2%

E-8	2,346,500	2,235,100	2,120,800	6,702,400	86.1%
E-9	378,600	185,200	209,600	773,400	9.9%
E-10	75,700	16,000	0	91,700	1.2%
E-11	51,700	21,100	39,000	111,800	1.4%
Total Central	2,863,200	2,462,300	2,459,100	7,784,600	55.9%
E-12	108,100	47,900	292,700	448,700	11.1%
E-13	1,202,600	407,600	487,000	2,097,200	51.7%
E-14	357,100	154,200	0	511,300	12.6%
E-15	718,900	276,600	0	995,500	24.6%
Total East	2,386,700	886,300	779,700	4,052,700	29.1%
Total All Coves	6,192,500	3,705,600	4,039,000	13,937,100	100%

6 Recreation

With the TSP the beach berm will be extended and maintained providing an enhanced recreation experience to local beach goers. The largest increase in recreation value will be in the West Cove where the town beach is located.

7 Other Accounts

Corps guidance requires that study alternatives be evaluated under all accounts the National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE) and Environmental Quality (EQ). NED effects have been addressed in the appendix. RED effects would be the impact of project spending, either direct or induced, on the local economy. It is expected that with increased Federal spending on beach construction and nourishment spending, income and employment would show some modest increase. With respect to the OSE account the project would maintain the viability of County Route 48 providing access and egress to both the north and south sections of outer Long Island. County Route 48 is main road serving outer Long Island. Maintaining its integrity will increase the efficiency of emergency response teams in the area.

8 Summary

The recommended plan, the TSP, is provide a beach with a 25-ft berm in the West Cove and the East Cove. In the Central Cove, a 75-ft berm would be provided in the higher density more eroded areas where more property value is at risk and a 25-ft berm is recommended for the lower density portions of the Central Cove. This alternative has largest net benefit (NED).