HASHAMOMUCK COVE, SOUTHOLD, NEW YORK, COASTAL STORM RISK MANAGEMENT

FEASIBILITY STUDY

ECONOMIC APPENDIX

September 2019

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Introduction

This Appendix presents and evaluates the economic benefits and costs of alternatives 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 overall Feasibility level report is intended to investigate alternatives designed to reduce risk to the Hashamomuck Cove area from coastal storm damage. The purpose of this Economics Appendix is to determine the likely future without-project condition and compare it with the future with-project conditions described by various alternatives, as simulated by the Corps certified coastal model, *Beach-fx*. The Appendix explains the approach, assumptions, and results of the analyses. Per USACE requirements and guidance, the National Economic Development (NED) Plan is identified as the plan that maximizes the difference between annual benefits and annual costs. Annual benefits are the reduction in annualized damages between an improvement alternative and the without project condition. A Tentatively Selected Plan (TSP) is also identified. Typically, it is the NED plan but may be a Locally Preferred Plan (LPP).

1.2 *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 damages under various shoreline 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 damages and costs discounted to a present value. Storm damage is defined as the damage incurred 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, Monte-Carlo life-cycle model that estimates damages over a given period of analysis based on storm probabilities, tidal cycle, tidal phase, beach morphology and many other factors. Damages or losses to developed shorelines can include buildings, pools, patios, parking lots, roads, utilities, seawalls, revetments, and bulkheads.

Beach-fx Version 1.0 is a USACE-certified program. *Beach-fx* Version 1.1 is not certified, however, Dr. Mark Gravens has received an exemption letter from USACE Headquarters allowing the use of updated versions of *Beach-fx* for coastal hurricane and storm damage reduction projects. *Beach-fx* Version 1.1 compiles SBEACH data in a more realistic way to form the storm response database (SRD). The updated model also considers sea level change (SLC) according to the methodologies described in ETL 1100-2-1 "Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaption".

The Hashamomuck site specific model was developed by USACE Wilmington District's Engineering Division, who provided all coastal morphology inputs (see Coastal Engineering Appendix). This model has been built in accordance with the *Beach-fx* User's Manual (August 2009), and updated accordingly through advice from Dr. Gravens.

1.2.1 Model Reaches

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

1.2.2 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 elements. Lots are also the repositories for coastal armor costs, specifications, and failure threshold information. Within *Beach-fx*, armor is defined at the lot level. Model-defined lots also influence damage elements' ability to be repaired or rebuilt within the model, as once erosion reaches the centroid of a lot, the lot is condemned and rebuilding is restricted. An aerial view of the model reaches and lots is provided in Figure 1-1, Figure 1-2, and Figure 1-3. Lots are outlined in green. Economic reaches are outlined in purple and labeled E1 to E15.

Figure 1-1 Aerial view of model reaches, West Cove

Figure 1-2 Aerial view of model reaches, Central Cove

Figure 1-3 Aerial view of model reaches, East Cove

1.2.3 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, or road. DEs 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 damage functions to calculate the extent of damage. For each DE, the following information is input into *Beach-fx*:

- Geographical reference (northing and easting of center point)
- Alongshore length and cross-shore width
- Usage (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 were obtained using aerial photography in Arc Map. Structure market values were used to represent depreciated replacement values (as determined by for the Hashamomuck analysis by Mr. Edmund O'Leary, Regional Technical Specialist -Economics). An uncertainty of +/- 25% was assigned to these values. The value of contents was assumed to be 50% of the structure value based on previous Corps studies.

1.3 Existing Condition Coastal Inventory

The Hashamomuck Cove study area has 87 individual damage elements, including 58 residential structures, 4 commercial structures, several segments of one major highway, and a parking lot. 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 road) is provided in Table 1-1.

Table 1-1: Distribution of Depreciated Replacement Structure 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 DEs by economic reach is provided in Table 1-2. The Hashamomuck Cove 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 entirely 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: Distribution of Structure Value 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**

1.3.1 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).

1.3.2 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 yet represent 19 percent of the value (8.8 million).

1.3.3 Roads

All lots in the study have a road damage element, typically located near the landward edge of the lot. The roads are defined as 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.

1.3.4 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 1-4.

Figure 1-4: Map of Existing Armor

The Initial Phase of the Alternative Analysis used *Beach-fx* Version 1.1, Kernel 2.0.0.4. The model was used without Planform Rates. Planform rates make adjustments to the average erosion rate over time. With each cycle of planned nourishment, planform rates can adjust erosion to account for the shoreline changes. The most promising alternatives from the Initial Phase were retained for further analysis, which included refinement and utilizing planform rates to explore a systems approach, in the Optimization Phase.

2.1.1 Period of Analysis and Discount rate

This Economic Appendix evaluates the feasibility of various coastal protection options over a 50-year period of analysis. The present value of the damages, for the Initial Phase, was calculated using the (FY16) water resources discount rate 3.125%, which was in effect at that time.

2.1.2 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.

2.1.3 Structure Rebuilds

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 in the Initial Phase.

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.

2.1.4 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

2.1.5 Inputs

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 bay 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.

2.2 Damages

The Initial Phase utilized *Beach-fx* and engineering estimates to prioritize several alternatives (Alt.), which include:

- **Alt. 1:** Without Project (Existing) Condition
- **Alt 2A:** 25-foot Berm Width
- **Alt 2B:** 50-foot Berm Width
- **Alt 2C:** Variable Berm Width (West and Central 75-foot and East Cove 25-foot.)
- **Alt 3:** Berm and Dune
- **Alt 4A:** Bulkhead
- **Alt 4B:** Road Bulkhead
- **Alt 5:** Buyout

The alternatives were evaluated to reduce risk of coastal storm damage, to achieve project objectives. Reduced damages include armor damages, structure damages, and content damages. The damages for each of the alternatives are displayed from Table 2-1 as average discounted sum values.

Table 2-1: Initial Phase Damages: Alt. 1 - Without Project

DAMAGES	Alt 1 - WOP			
	West	Central	East	Total
Structure Damages	$4,518,600	$4,844,100	$4,471,700	**$13,834,400**
Content Damages	$1,480,300	$3,136,900	$1,407,100	**$6,024,300**
Armor Damages	$5,453,400	$3,972,000	$2,498,400	**$11,923,800**
TOTAL DAMAGES	**$11,452,300**	**$11,953,000**	**$8,377,200**	**$31,782,500**

Table 2-2: Initial Phase Damages: Alt 2A - 25-ft Berm

DAMAGES	Alt 2A - 25 foot Berm			
	West	Central	East	Total
Structure Damages	$942,600	$2,863,200	$2,386,700	**$6,192,500**
Content Damages	$357,000	$2,462,300	$886,300	**$3,705,600**
Armor Damages	$800,200	$2,459,100	$779,700	**$4,039,000**
TOTAL DAMAGES	**$2,099,800**	**$7,784,600**	**$4,052,700**	**$13,937,100**

Table 2-3: Initial Phase Damages: Alt 2B - 50-ft Berm

DAMAGES	Alt 2B - 50 Foot Berm			
	West	Central	East	Total
Structure Damages	$897,700	$1,839,600	$2,450,600	**$5,187,900**
Content Damages	$352,900	$2,894,300	$914,500	**$4,161,700**
Armor Damages	$830,700	$2,494,000	$1,038,300	**$4,363,000**
TOTAL DAMAGES	**$2,081,300**	**$7,227,900**	**$4,403,400**	**$13,712,600**

Table 2-4: Initial Phase Damages: Alt 2C - Variable Berm Width

DAMAGES	Alt. 2C - Variable Berm Width			
	West	Central	East	Total
Structure Damages	$1,304,500	$2,599,600	$2,323,400	**$6,227,500**
Content Damages	$373,700	$2,304,200	$895,400	**$3,573,300**
Armor Damages	$908,100	$980,600	$2,595,600	**$4,484,300**
TOTAL DAMAGES	**$2,586,300**	**$5,884,400**	**$5,814,400**	**$14,285,100**

Table 2-5: Initial Phase Damages: Alt. 3 - Berm + Dune

DAMAGES	Alt 3 - 50 Foot Berm + 5 Foot Dune			
	West	Central	East	Total
Structure Damages	$425,800	$1,389,900	$1,928,800	**$3,744,500**
Content Damages	$163,700	$1,866,600	$748,600	**$2,778,900**
Armor Damages	$783,800	$1,832,900	$791,100	**$3,407,800**
TOTAL DAMAGES	**$1,373,300**	**$5,089,400**	**$3,468,500**	**$9,931,200**

Table 2-6: Initial Phase Damages: Alt. 4A - Bulkhead

DAMAGES	Alt 4A - Bulkhead			
	West	Central	East	Total
Structure Damages	$699,300	$695,600	$1,071,300	**$2,466,200**
Content Damages	$164,200	$1,659,400	$426,100	**$2,249,700**
Armor Damages	$0	$0	$0	**$0**
TOTAL DAMAGES	**$863,500**	**$2,355,000**	**$1,497,400**	**$4,715,900**

Table 2-7: Initial Phase Damages: Alt. 4B - Road Bulkhead

DAMAGES	Alt 4B - Road Bulkhead			
	West	Central	East	Total
Structure Damages	$4,118,800	$4,365,300	$3,066,600	**$11,550,700**
Content Damages	$1,480,300	$3,136,900	$1,407,100	**$6,024,300**
Armor Damages	$5,453,400	$3,972,000	$2,498,400	**$11,923,800**
TOTAL DAMAGES	**$11,052,500**	**$11,474,200**	**$6,972,100**	**$29,498,800**

Table 2-8: Initial Phase Damages: Alt. 5 - Buyout

DAMAGES	Alt 5 - Buyout			
	West	Central	East	Total
Structure Damages	$3,722,500	$2,472,300	$1,564,700	**$7,759,500**
Content Damages	$1,171,800	$2,010,800	$186,800	**$3,369,400**
Armor Damages	$5,453,400	$3,972,000	$2,498,400	**$11,923,800**
TOTAL DAMAGES	**$10,347,700**	**$8,455,100**	**$4,249,900**	**$23,052,700**

2.2.1 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 ideal 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.

2.3 Estimated Project Cost by Alternative

Beach-fx provides a sand placement quantity as an output file for each planned nourishment alternative. These quantities were used to determine costs for the beach nourishment alternatives, in conjunction with other considerations. Cost estimates were also created for the other alternatives. Table 2-9 to Table 2-16 provide project cost for each alternative. Interest during Construction (IDC) included in the Tables is the opportunity cost of money and was calculated based on an assumed 5 month construction period per cove and FY16 interest rate of 3.125 %.

2.4 Comparison of Alternatives

2.4.1 Benefit Cost Summary

This section compares the benefit and cost of each alternative.

Table 2-9: Initial Phase Costs: Alt. 1 - Without Project

COSTS	Alt 1 - WOP			
	West	Central	East	Total
Sand Placement	$0	$0	$0	**$0**
Contingency (18.5%)	$0	$0	$0	**$0**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$0	$0	$0	**$0**
IDC	$0	$0	$0	**$0**
TOTAL COSTS	**$0**	**$0**	**$0**	**$0**

Table 2-10: Initial Phase Costs Alt 2A - 25-ft Berm

COSTS	Alt 2A - 25 foot Berm			
	West	Central	East	Total
Sand Placement	$2,293,100	$2,381,900	$4,025,400	**$8,700,400**
Contingency (18.5%)	$424,200	$440,700	$744,700	**$1,609,600**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,100	$808,900	$429,900	**$2,270,900**
IDC	$19,600	$19,000	$27,200	**$65,800**
TOTAL COSTS	**$3,769,000**	**$3,650,500**	**$5,227,200**	**$12,646,700**

Table 2-11: Initial Phase Costs: Alt 2B - 50-ft Berm

COSTS	Alt 2B - 50 Foot Berm			
	West	Central	East	Total
Sand Placement	$6,091,100	$5,336,800	$7,028,000	**$18,455,900**
Contingency (18.5%)	$1,126,900	$987,300	$1,300,200	**$3,414,400**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,100	$808,900	$429,900	**$2,270,900**
IDC	$41,400	$34,500	$44,900	**$120,800**
TOTAL COSTS	**$8,291,500**	**$7,167,500**	**$8,803,000**	**$24,262,000**

Table 2-12: Initial Phase Costs: Alt 2C – Variable Berm Width

COSTS	Alt. 2C - 75 Foot Berm			
	West	Central	East	Total
Sand Placement	$3,023,000	$3,052,600	$6,965,000	**$13,040,600**
Contingency (18.5%)	$559,300	$564,700	$1,288,500	**$2,412,500**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,100	$809,900	$429,900	**$2,271,900**
IDC	$54,500	$52,200	$102,500	**$209,200**
TOTAL COSTS	**$4,668,900**	**$4,479,400**	**$8,785,900**	**$17,934,200**

Table 2-13: Initial Phase Costs: Alt. 3 - Berm + Dune

COSTS	Alt 3 - 50 Foot Berm + 5 Foot Dune			
	West	Central	East	Total
Sand Placement	$6,039,100	$4,761,500	$6,658,200	**$17,458,800**
Contingency (18.5%)	$1,117,200	$880,900	$1,231,800	**$3,229,900**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,100	$809,900	$429,900	**$2,271,900**
IDC	$42,800	$33,700	$43,400	**$119,900**
TOTAL COSTS	**$8,231,200**	**$6,486,000**	**$8,363,300**	**$23,080,500**

Table 2-14: Initial Phase Costs: Alt. 4A - Bulkhead

COSTS	Alt 4A - Bulkhead			
	West	Central	East	Total
Cost	$11,644,700	$10,257,400	$10,444,600	**$32,346,700**
Contingency (18.5%)	$2,504,000	$2,205,500	$2,245,300	**$6,954,800**
Mitigation	$200,000	$350,000	$650,000	**$1,200,000**
Real Estate Cost	$1,032,100	$809,900	$429,900	**$2,271,900**
IDC	$80,300	$71,100	$71,900	**$223,300**
TOTAL COSTS	**$15,461,100**	**$13,693,900**	**$13,841,700**	**$42,996,700**

Table 2-15: Initial Phase Costs: Alt. 4B - Road Bulkhead

COSTS	Alt 4B - Road Bulkhead			
	West	Central	East	Total
Cost	$3,726,900	$1,782,700	$5,348,500	**$10,858,100**
Contingency (18.5%)	$782,600	$374,400	$1,123,200	**$2,280,200**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$329,700	$54,400	$193,800	**$577,900**
IDC	$25,300	$11,500	$34,800	**$71,600**
TOTAL COSTS	**$4,864,500**	**$2,223,000**	**$6,700,300**	**$13,787,800**

Table 2-16: Initial Phase Costs: Alt. 5 - Buyout

COSTS	Alt 5 - Buyout			
	West	Central	East	Total
Market Value	$9,259,200	$32,447,900	$17,712,200	**$59,419,300**
Contingency (18.5%)	$0	$0	$0	**$0**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$0	$0	$0	**$0**
IDC	$48,400	$169,400	$92,500	**$310,300**
TOTAL COSTS	**$9,307,600**	**$32,617,300**	**$17,804,700**	**$59,729,600**
Note: Row 1 includes Not Impaired Structure and Land Value, Demolition and Incidental Costs				

Table 2-17: Initial Phase Benefit Cost Summary (FY16 3.125%)

ANALYSIS	Alt. 1 WOP	Alt. 2A 25-ft Berm	Alt. 2B 50-ft Berm	Alt. 2C Variable Berm	Alt. 3 Berm and Dune	Alt. 4A Bulkhead	Alt. 4B Road Bulkhead	Alt. 5 Buyouts
Total Damages	$31,782,500	$13,937,100	$13,712,600	$14,285,100	$9,931,200	$4,715,900	$29,498,800	$23,052,700
Total Benefits[1]	$0	$17,845,400	$18,069,900	$17,497,400	$21,851,300	$27,066,600	$2,283,700	$8,729,800
Total Costs[2]	$0	$12,646,700	$24,262,000	$17,934,200	$23,080,500	$42,996,700	$13,787,800	$59,729,600
Total Net Benefits	$0	$5,198,700	-$6,192,100	-$436,800	-$1,229,200	-15,930,100	-11,504,100	-50,999,800
Average Annual Damages	$1,264,700	$554,600	$545,700	$568,400	$395,200	$187,700	$1,173,800	$917,300
Average Annual Benefits	$0	$710,100	$719,100	$696,300	$869,500	$1,077,100	$90,900	$347,400
Average Annual Costs	$0	$503,200	$965,500	$713,700	$918,400	$1,711,000	$548,700	$2,376,800
Average Annual Net Benefits	**$0**	**$206,900**	**-$246,400**	**-$17,400**	**-$48,900**	**-$633,900**	**-$457,800**	**-$2,029,400**
Benefit Cost Ratio	**-**	**1.41**	**0.78**	**0.98**	**0.95**	**0.63**	**0.17**	**0.15**

[1] Includes damage reduction benefits only. Recreation, traffic delay, reduction in vehicle operation costs, and other benefits are only included in the Optimization Phase.
[2] The Initial Phase cost estimates were derived using a $48 per cubic yard cost for sand placement, and the *Beach-fx* output for placement quantity, and include contingency, mobilization, real estate, IDC, and other costs.

2.4.2 Systems Approach

With the exception of delays and additional vehicle operating cost, the three coves may be evaluated separately, or incrementally, with respect to armor, structure, and content damage, including road damage in the Initial Phase. When evaluating the coves incrementally in the Initial Phase, Alt. 2A (25-ft Berm) appeared to be the most efficient alternative for the West Cove and the East Cove, while Alt. 2C (75-ft Berm) appeared to be the most efficient alternative for the Central Cove. This combination of alternatives was carried forward to the Optimization Phase to further examine the systems approach by utilizing planform rates. Within the Optimization Phase, updated results will be presented, in which planform rates were included to evaluate this new alternatives' systemic relationship to determine if these benefits would hold true under a more refined analysis..

2.4.2.1 Traffic Delays & Vehicle Operating Costs

With post-storm recovery, detours due to road re-construction were evaluated on a system-wide basis in the Initial Phase. 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 an effort to avoid double counting, benefit delay cost is estimated by one damage element only, although the road could be taken out in more than one location. In this Initial Phase, 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 2-18.

Table 2-18: Initial Phase – Systems Approach Benefit Cost Summary, $

Benefit Cost Summary	West Cove	Central Cove	East Cove	All Coves
	Alt 2A	Alt 2C	Alt 2A	
Annual Damage Reduction	405,400	266,700	76,800	748,900
Annual Delay Reduction	-	-	-	45,100
Total Annual Benefit	405,400	266,700	76,800	794,000
Annual Cost	150,000	178,300	74,800	403,100
Annual Net Benefit	255,400	88,400	2,000	390,900
Benefit-Cost Ratio	**2.70**	**1.50**	**1.03**	**1.97**

2.4.3 TSP Plan

The Tentatively Selected Plan from the Initial Phase was the beach nourishment project that 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 2-18.

2.4.3.1 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 2-19 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 2-19: 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%**

2.4.3.2 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 2-20 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 2-20: Initial Phase 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	1,200
E2	-1.29	70.95	541	0.0160	479,160	7,700
E3	-1.10	60.5	972	0.0245	479,160	11,700
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	29,300
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	-6.3	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

2.4.3.3 Recreation Benefits

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. Recreation benefits are analyzed and presented in more detail in the Optimization Phase.

2.4.3.4 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 this 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 the main road serving outer Long Island. Maintaining its integrity will increase the efficiency of emergency response teams in the area. Other Accounts were analyzed and will be presented in more detail within the Optimization Phase.

2.4.3.5 Sea Level Rise (SLR) scenarios

ER-1100-2-8162 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 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 Optimization Phase to demonstrate the sensitivity of the results to various sea level rise conditions.

2.5 Initial Phase Summary

The tentatively selected plan (TSP) from the Initial Phase was a hybrid beach nourishment alternative. This alternative included a 25-ft berm (Alt. 2A) in the West Cove and East Cove, and a 75-ft berm (Alt. 2C) in the Central Cove. This alternative had the largest net benefit and was the identified TSP and the National Economic Development (NED) plan..

The Initial Phase modeling determined that a beach nourishment alternative was the most promising alternative. The Optimization Phase includes engineering analysis of the beach nourishment alternatives, required to refine the NED plan.

3 Alternative Analysis – Optimization Phase

This section summarizes the results of the modelling and corresponding analysis during the Optimization Phase. The initial phase narrowed down alternatives such that those most promising alternatives could be analyzed further; those alternatives were then carried forward to the Optimization Phase for further refinement and analysis. The alternatives considered in the Optimization Phase included:

- Alt. 1: Without Project Conditions
- Alt. 2A: 25-ft Berm
- Alt. 2B: 50-ft Berm
- Alt 2C: 75-ft Berm (all coves)
- Alt 2D: 25/75-ft Berm Hybrid Plan

3.1 Model Assumptions

This section documents changes to the model utilized in the Optimization Phase.

3.1.1 Versions

The Initial phase utilized *Beach-fx* Version 1.1 Kernel 2.0.0.4 to consider the hurricane and storm damage reduction of beach fill alternatives. Since the conclusion of the Initial Phase, ERDC has made several updates to the *Beach-fx* model. As a result, the Optimization Phase utilized an updated version.

The project team coordinated with Dr. Mark Gravens to obtain the most up-to-date version of *Beach-fx*. At the time of Optimization Phase, the most accurate update of *Beach-fx* was Version 1.1 Kernel 2.0.0.9.4. Many of the updates occurring between the two Kernel versions, that of the Initial Phase and that of the Optimization Phase, were the result of improvements made for subsequent *Beach-fx* projects. The updates included updating the back bay flooding and sea level change (SLC) features, including shoreline erosion computations.

3.1.1 Inputs

In addition to a model update, there were also several input changes to refine the model output, as shown in Table 3-1.

The Use Planform configuration setting was updated from 0 (no planform rates) to 1 (use stored planform rates). Planform rates are triggered after the initial planned nourishment, and adjust the average erosion rates over time. Planform rates, also known as the project inducted erosion rates, were not utilized in the Initial Phase. Using planform rates allows *Beach-fx* to calculate benefits and costs considering a system-wide approach. In the prior, Initial Phase, planform rates were not used and as a result, the system-wide approach was less accurate.

The Critical Erosion Amount, an input which is measured as the vertical erosion distance that will compromise the foundation, for various foundation types was updated to be a more realistic model. Prior to updating the critical erosion amounts, many damage elements experienced excessive erosion damages that did not seem realistic. This was experienced primarily in the commercial buildings in the East Cove, but also in some residential homes in the Central and West Coves. After updating the critical erosion amounts, the structures accrued more realistic damages, and no longer experienced the premature condemnation seen within the Initial Phase modeling results.

The interest rate was updated appropriately. The interest rate is input within *Beach-fx* as 0.0%, and then the FY18 interest rate of 2.75%, as of the time of the Optimization Phase, was applied in post-processing in Microsoft Access due to a minor calculation error within *Beach-fx*[3]. The FY19 interest rate of 2.875 represents a very minor change, so there is only a negligible change from the analysis performed at the FY18 rate.

Table 3-1 *Beach-fx* Input Changes

	Input	Original File	Updated Files
Configuration Settings	DataCheckMinimumLotSize	0.1	0
	DataCheckMaximumLotSize	0.1	20
	UsePlanform	0	1
Foundation Types	Cement, Critical Erosion Amount	0.6	*2
	Concrete, Critical Erosion Amount	0.8	*3
	Pilings, Critical Erosion Amount	10	*8
	Concblocks, critical erosion amount	2	*2
	Conc Piers, critical erosion amount	2	*8
	RD-FND, critical erosion amount	0.8	*0.8
Scenario	Interest Rate	0.03125	0.0275

Source: Beach-fx files, Microsoft Access, Microsoft Excel
**Updated only for the East Cove*

3.1.1 Lot Condemnation and Road Condemnation

The Initial Phase included lots that spanned from approximately the bulkhead line to the landward side of County Road 48. The project team noticed that there was excessive lot condemnation in several lots, and suggested altering the lots accordingly. It was determined that it would be appropriate to adjust the lot dimensions to realistically simulate lot condemnation from erosion. The Coastal Erosion Hazard Area (CEHA) map was utilized to determine which lots would be appropriate to experience lot condemnation. A secondary modeling run was used with alternative landward points for each lot to determine reduced lot condemnation. The lot alterations included moving the landward points of the lot further landward, in turn moving the centroid further from the shore. *Beach-fx* considers a lot to be condemned once the erosion passes the centroid of the lot. The modeling results for these secondary, reduced lot condemnation runs were utilized for the lots and reaches where appropriate according to the CEHA.

In the model, as originally compiled, the road damage elements were located within the same lots as private property. It was agreed that the road should always, or almost always, be rebuilt, despite lot condemnation. However, the simulations using the Initial Phase inputs resulted in several areas of the road being condemned when they resided in a condemned residential lot. This resulted in decreasing road

[3]Output indicates that the model uses the following formula to calculate present value, where i is the annual interest rate and n is the number of days from the base year: $PV = 1 / (1+i/365)^n$ To be economically correct, the term i/365 should be replaced with I, where: $I= ((1+i)(1/365)) – 1$ A solution to this is to input a 0% discount rate within *Beach-fx* and use an external program to properly discount damages, nourishment costs, and other values using the correct present value formula.

damages over time, as when the road was damaged, it was not rebuilt. As a result, the secondary, reduced lot condemnation results were utilized for all road damages in every lot.

3.1.2 Optimization Phase 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 during the Optimization Phase were calculated using the FY18 water resources discount rate of 2.75%.

3.1.1 Structure Rebuilds

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. However, in *Beach-fx,* the term “rebuild” does not mean that the structure was destroyed and then rebuilt in entirety. In *Beach-fx*, the term simply means that the structure was damaged, even at 1% of the structures’ value, and then repaired to the structures full value. If structures are taken out of the inventory, by damage element condemnation or lot condemnation, too early in the 50-year project life, the benefits of each alternative could be biased. As a result, insuring the proper number of rebuilds is crucial to determining the proper alternative.

In the Optimization Phase, all DEs other than roads were allowed to be rebuilt, or repaired, 55 times. 55 rebuilds was chosen to allow for 1 repair per year from start year to the simulation completion. To ensure that the structures were not being completely destroyed and majority rebuilt multiple times in a 50-year span, the *Beach-fx* results were post-processed to confirm that this did not happen more than twice in the average iteration. Road damage elements were allowed a number of rebuilds of 1,000 to ensure that the road is always repaired after each storm. All damage elements other than roads are considered.

3.1.2 Calibration – Applied Erosion Rates

Due to utilizing an updated version of the model, the project team updated the calibration of the model accordingly using the same Target Erosion Rates as the Initial Phase.

Figure 3-1 *Beach-fx* Calibration

Feet per Year

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

Reach	Structure Damage	Content Damage	Armor Damages	Total Damage
E-1	5,113,000	116,000	$0	5,229,000
E-2	4,263,000	897,000	$1,080,000	6,240,000
E-3	5,334,000	0	$0	5,334,000
E-4	1,920,000	810,000	$3,408,000	6,138,000
E-5	1,628,000	734,000	$1,322,000	3,683,000
WEST	**18,258,000**	**2,557,000**	**5,810,000**	**26,624,000**
E-6	0	0	0	0
E-7	1,497,000	685,000	0	2,183,000
E-8	4,781,000	143,000	60,000	4,984,000
E-9	774,000	456,000	130,000	1,360,000
E-10	2,142,000	843,000	632,000	3,617,000
E-11	183,000	71,000	848,000	1,103,000
CENTRAL	**9,377,000**	**2,199,000**	**1,671,000**	**13,247,000**
E-12	974,000	407,000	2,559,000	3,941,000
E-13	12,599,000	85,000	382,000	13,066,000
E-14	7,419,000	64,000	8,289,000	15,771,000
E-15	16,510,000	5,000	6,515,000	23,030,000
EAST	**37,502,000**	**561,000**	**17,745,000**	**55,808,000**
Total All Coves	**65,137,000**	**5,316,000**	**25,225,000**	**95,678,000**

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

Reach	Structure Damage	Content Damage	Armor Damage	Total Damage
E-1	3,722,000	116,000	$0	3,837,000
E-2	895,000	540,000	$2,317,000	3,753,000
E-3	85,000	0	$0	85,000
E-4	151,000	67,000	$3,408,000	3,626,000
E-5	0	0	$1,322,000	1,322,000
WEST	**4,853,000**	**723,000**	**7,047,000**	**12,622,000**
E-6	0	0	56,000	56,000
E-7	14,000	7,000	0	21,000
E-8	4,593,000	125,000	30,000	4,748,000
E-9	254,000	139,000	170,000	563,000
E-10	21,000	3,000	441,000	466,000
E-11	30,000	15,000	7,000	51,000
CENTRAL	**4,912,000**	**288,000**	**705,000**	**5,905,000**
E-12	239,000	106,000	296,000	641,000
E-13	12,234,000	227,000	3,000	12,464,000
E-14	8,950,000	234,000	0	9,184,000
E-15	10,681,000	4,495,000	5,403,000	20,580,000
EAST	**32,105,000**	**5,062,000**	**5,701,000**	**42,868,000**
Total All Coves	**41,869,000**	**6,074,000**	**13,453,000**	**61,396,000**

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

Reach	Structure Damage	Content Damage	Armor Damages	Total Damage
E-1	4,305,000	155,000	$0	4,460,000
E-2	314,000	200,000	$1,583,000	2,098,000
E-3	88,000	0	$0	88,000
E-4	185,000	77,000	$1,015,000	1,277,000
E-5	79,000	34,000	$87,000	200,000
WEST	**4,971,000**	**467,000**	**2,685,000**	**8,123,000**
E-6	0	0	45,000	45,000
E-7	3,000	1,000	0	4,000
E-8	2,179,000	141,000	61,000	2,381,000
E-9	244,000	131,000	740,000	1,115,000
E-10	22,000	3,000	471,000	495,000
E-11	29,000	13,000	18,000	60,000
CENTRAL	**2,477,000**	**288,000**	**1,335,000**	**4,100,000**
E-12	138,000	62,000	357,000	556,000
E-13	7,789,000	270,000	88,000	8,146,000
E-14	1,753,000	223,000	0	1,976,000
E-15	2,115,000	860,000	7,628,000	10,603,000
EAST	**11,794,000**	**1,414,000**	**8,073,000**	**21,281,000**
Total All Coves	**19,242,000**	**2,169,000**	**12,093,000**	**33,504,000**

Table 3-5: Damage by Reach, Alt. 2D, Hybrid 25/75-ft Berm, Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Damages	Total Damage
E-1	3,774,000	109,000	$0	3,883,000
E-2	988,000	602,000	$2,200,000	3,790,000
E-3	85,000	0	$0	85,000
E-4	345,000	148,000	$0	494,000
E-5	362,000	163,000	$0	525,000
WEST	**5,555,000**	**1,023,000**	**2,200,000**	**8,777,000**
E-6	0	0	52,000	52,000
E-7	83,000	38,000	0	121,000
E-8	436,000	165,000	146,000	747,000
E-9	263,000	140,000	372,000	775,000
E-10	21,000	3,000	443,000	467,000
E-11	42,000	21,000	6,000	68,000
CENTRAL	**844,000**	**367,000**	**1,019,000**	**2,231,000**
E-12	242,000	107,000	307,000	656,000
E-13	12,075,000	219,000	2,000	12,296,000
E-14	9,477,000	231,000	0	9,708,000
E-15	10,689,000	4,512,000	5,266,000	20,467,000
EAST	**32,483,000**	**5,068,000**	**5,575,000**	**43,126,000**
Total All Coves	**38,883,000**	**6,458,000**	**8,793,000**	**54,134,000**

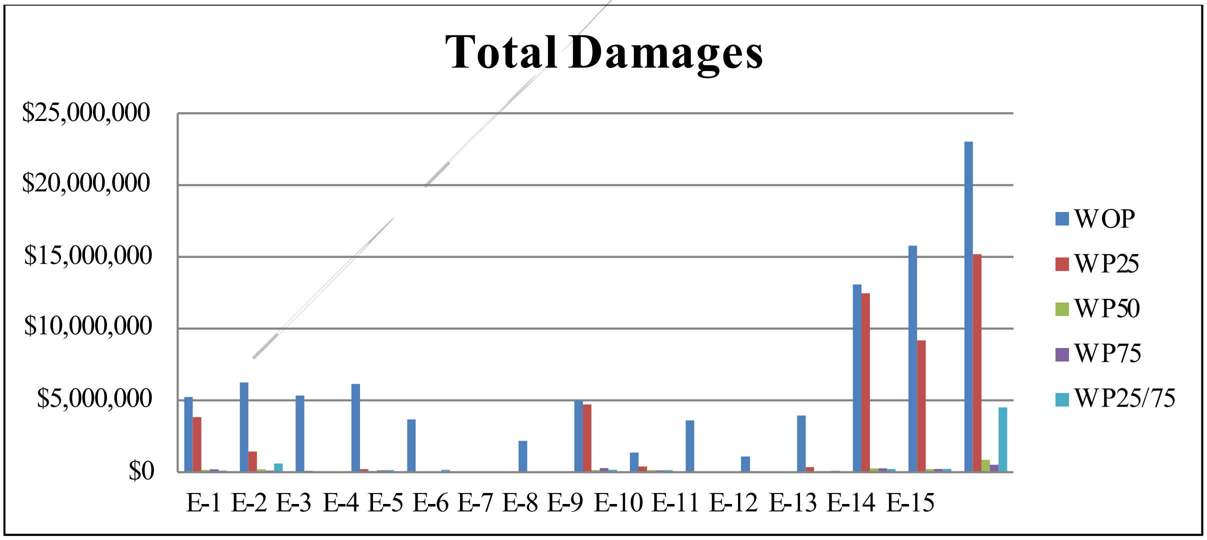
Table 3-6: Damage by Reach, Alt. 2C, 75 Berm, Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Damages	Total Damage
E-1	4,321,000	189,000	$0	4,509,000
E-2	214,000	106,000	$746,000	1,066,000
E-3	89,000	0	$0	89,000
E-4	289,000	120,000	$311,000	719,000
E-5	77,000	33,000	$19,000	129,000
WEST	**4,990,000**	**447,000**	**1,076,000**	**6,513,000**
E-6	0	0	89,000	89,000
E-7	3,000	1,000	0	4,000
E-8	1,196,000	278,000	146,000	1,621,000
E-9	244,000	129,000	1,962,000	2,335,000
E-10	22,000	3,000	173,000	197,000
E-11	30,000	13,000	22,000	65,000
CENTRAL	**1,495,000**	**424,000**	**2,392,000**	**4,311,000**
E-12	125,000	55,000	257,000	437,000
E-13	2,404,000	256,000	625,000	3,286,000
E-14	1,123,000	209,000	0	1,332,000
E-15	1,362,000	510,000	7,132,000	9,004,000
EAST	**5,014,000**	**1,031,000**	**8,014,000**	**14,059,000**
Total All Coves	**11,498,000**	**1,903,000**	**11,482,000**	**24,883,000**

3.2.2 Summary of Damages

Figure 3-2 displays a summary a comparison of total damages by economic reach for the various plans.

Figure 3-2: Total Discounted Average Damage by Economic Reach



The reaches with the largest proportion of total damages, in the without project condition, were E-15 and E-14. The reaches with the smallest damage were E-11 and E-9. Without project damages have increased significantly in the Optimization Phase due to a reduction in lot condemnation. As a result, damage elements remain in the inventory longer, and are repaired to their full value, which in turn, increases damages over time. The damages for each of the alternatives are displayed from Table 3-7 to Table 3-11.

Table 3-7: Optimization Phase Damages: Alt. 1 - Without Project

DAMAGES	Alt 1 - WOP			
	West	Central	East	Total
Structure Damages	$4,898,000	$4,867,000	$18,523,000	**$28,289,000**
Content Damages	$2,557,000	$2,199,000	$561,000	**$5,316,000**
Parking Lot Damages	$0	$0	$21,000	**$21,000**
Road Damages	$13,359,000	$4,510,000	$18,958,000	**$36,827,000**
Armor Damages	$5,810,000	$1,671,000	$17,745,000	**$25,225,000**
TOTAL DAMAGES	**$26,624,000**	**$13,247,000**	**$55,808,000**	**$95,678,000**

Table 3-8: Optimization Phase Damages: Alt 2A - 25-ft Berm

DAMAGES	Alt 2A - 25 foot Berm			
	West	Central	East	Total
Structure Damages	$938,000	$557,000	$11,974,000	**$13,469,000**
Content Damages	$723,000	$288,000	$5,062,000	**$6,074,000**
Parking Lot Damages	$0	$0	$23,000	**$23,000**
Road Damages	$3,915,000	$4,354,000	$20,108,000	**$28,377,000**
Armor Damages	$7,047,000	$705,000	$5,701,000	**$13,453,000**
TOTAL DAMAGES	**$12,622,000**	**$5,905,000**	**$42,868,000**	**$61,396,000**

Table 3-9: Optimization Phase Damages: Alt 2B - 50-ft Berm

DAMAGES	Alt 2B - 50 Foot Berm			
	West	Central	East	Total
Structure Damages	$794,000	$569,000	$3,356,000	**$4,719,000**
Content Damages	$467,000	$288,000	$1,414,000	**$2,169,000**
Parking Lot Damages	$0	$0	$33,000	**$33,000**
Road Damages	$4,178,000	$1,907,000	$8,405,000	**$14,490,000**
Armor Damages	$2,685,000	$1,335,000	$8,073,000	**$12,093,000**
TOTAL DAMAGES	**$8,123,000**	**$4,100,000**	**$21,281,000**	**$33,504,000**

Table 3-10: Optimization Phase Damages: Alt 2C - 75-ft Berm

DAMAGES	Alt. 2C - 75 Foot Berm			
	West	Central	East	Total
Structure Damages	$823,000	$917,000	$2,567,000	**$4,307,000**
Content Damages	$447,000	$424,000	$1,031,000	**$1,903,000**
Parking Lot Damages	$0	$0	$59,000	**$59,000**
Road Damages	$4,167,000	$577,000	$2,388,000	**$7,132,000**
Armor Damages	$1,076,000	$2,392,000	$8,014,000	**$11,482,000**
TOTAL DAMAGES	**$6,513,000**	**$4,311,000**	**$14,059,000**	**$24,883,000**

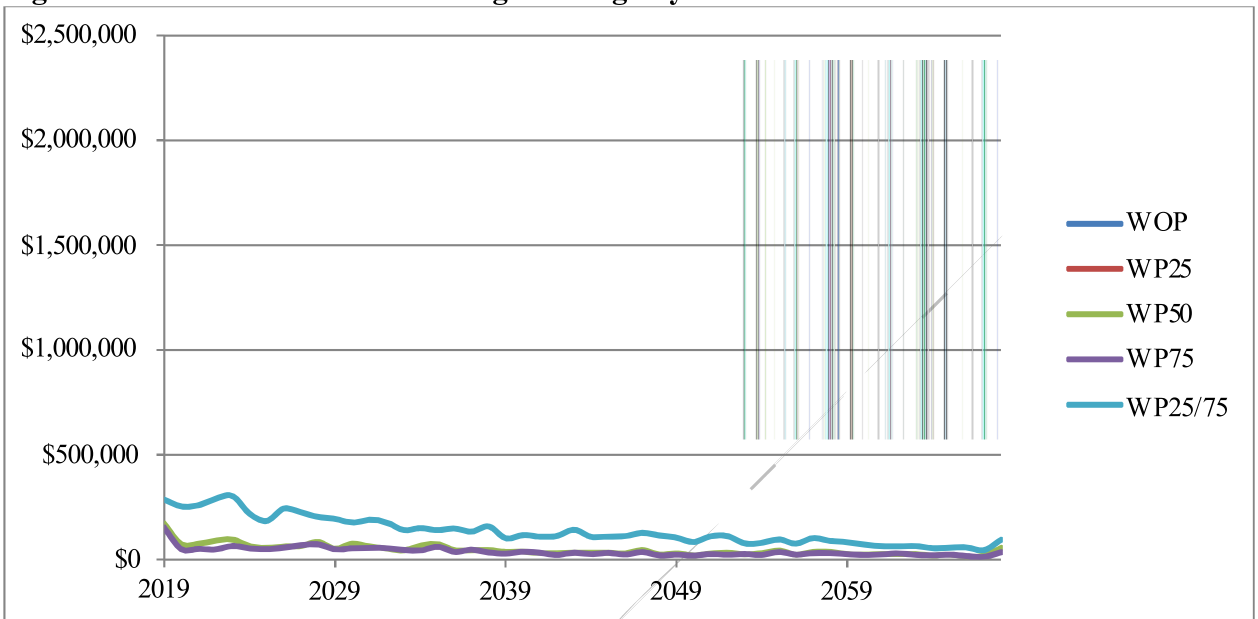
Table 3-11: Optimization Phase Damages: Alt. 2D – 25/75-ft Berm

DAMAGES	Alt. 2D – 25/75 Berm			
	West	Central	East	Total
Structure Damages	$1,500,000	$745,000	$11,969,000	**$14,214,000**
Content Damages	$1,023,000	$367,000	$5,068,000	**$6,458,000**
Parking Lot Damages	$0	$0	$22,000	**$22,000**
Road Damages	$4,055,000	$100,000	$20,492,000	**$24,647,000**
Armor Damages	$2,200,000	$1,019,000	$5,575,000	**$8,793,000**
TOTAL DAMAGES	**$8,777,000**	**$2,231,000**	**$43,126,000**	**$54,134,000**

3.2.3 Temporal Distribution of Damage

The temporal distribution of without project damage shows that damage declined over time due to the removal of structures from the inventory when condemned and discounting.

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



3.2.4 Model Stability

300 iterations were used for the model simulation in the Optimization Phase. The results for 300 iterations were stable, which is consistent with the Initial Phase findings.

3.3 Project Costs by Alternative

Beach-fx provides a sand placement quantity as an output file for each planned nourishment alternative. These quantities were used to determine costs for the beach nourishment alternatives, in conjunction with other considerations. Cost estimates were also created for the other alternatives. Table 3-12 to Table 3-16 provide project cost for each alternative.

Table 3-12: Optimization Phase Costs: Alt. 1 - Without Project

COSTS	Alt 1 - WOP			
	West	Central	East	Total
Initial Nourishment	$0	$0	$0	$0
Nourishment	$0	$0	$0	$0
Total PN	$0	$0	$0	$0
Contingency (18.5%)	$0	$0	$0	**$0**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$0	$0	$0	**$0**
IDC	$0	$0	$0	**$0**
TOTAL COSTS	**$0**	**$0**	**$0**	**$0**

Table 3-13: Optimization Phase Costs Alt 2A - 25-ft Berm

COSTS	Alt 2A - 25 foot Berm			
	West	Central	East	Total
Initial Nourishment	$4,491,000	$3,956,000	$1,822,000	**$10,269,000**
Nourishment	$6,997,000	$3,000,000	$4,665,000	**$14,662,000**
Total PN	$11,488,000	$6,955,000	$6,487,000	**$24,930,000**
Contingency (18.5%)	$2,125,000	$1,287,000	$1,200,000	**$4,612,000**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,000	$809,000	$430,000	**$2,271,000**
IDC	$20,000	$19,000	$27,000	**$66,000**
TOTAL COSTS	**$14,666,000**	**$9,070,000**	**$8,144,000**	**$31,879,000**

Table 3-14: Optimization Phase Costs: Alt 2B - 50-ft Berm

COSTS	Alt 2B - 50 Foot Berm			
	West	Central	East	Total
Initial Nourishment	$8,128,000	$7,084,000	$6,468,000	**$21,679,000**
Nourishment	$9,288,000	$4,283,000	$10,379,000	**$23,950,000**
Total PN	$17,416,000	$11,367,000	$16,847,000	**$45,630,000**
Contingency (18.5%)	$3,222,000	$2,103,000	$3,117,000	**$8,441,000**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,000	$809,000	$430,000	**$2,271,000**
IDC	$41,000	$35,000	$45,000	**$121,000**
TOTAL COSTS	**$21,711,000**	**$14,313,000**	**$20,439,000**	**$56,463,000**

Table 3-15: Optimization Phase Costs: Alt 2C - 75-ft Berm

COSTS	Alt. 2C - 75 Foot Berm			
	West	Central	East	Total
Initial Nourishment	$11,553,000	$10,104,000	$10,734,000	**$32,391,000**
Nourishment	$11,195,000	$5,453,000	$13,350,000	**$29,998,000**
Total PN	$22,748,000	$15,556,000	$24,084,000	**$62,388,000**
Contingency (18.5%)	$4,208,000	$2,878,000	$4,456,000	**$11,542,000**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,000	$810,000	$430,000	**$2,272,000**
IDC	$41,000	$35,000	$45,000	**$121,000**
TOTAL COSTS	**$28,030,000**	**$19,279,000**	**$29,014,000**	**$76,323,000**

Table 3-16: Optimization Phase Costs: Alt.2D – 25/75-ft Berm

COSTS	Alt. 2D – 25/75 Berm			
	West	Central	East	Total
Initial Nourishment	$4,606,000	$6,014,000	$1,822,000	**$12,443,000**
Nourishment	$4,113,000	$12,592,000	$3,195,000	**$19,900,000**
Total PN	$8,719,000	$18,606,000	$5,018,000	**$32,342,000**
Contingency (18.5%)	$1,613,000	$3,442,000	$928,000	**$5,983,000**
Mitigation	$0	$0	$0	**$0**
Real Estate Cost	$1,032,000	$810,000	$430,000	**$2,272,000**
IDC	$55,000	$52,000	$103,000	**$209,000**
TOTAL COSTS	**$11,419,000**	**$22,910,000**	**$6,478,000**	**$40,807,000**

3.4 Comparison of Alternatives

3.4.1 Benefit Cost Summary

This section compares the benefit and cost of each alternative. Plan 2B, which would provide a 50-ft berm, has the largest net benefit of all alternatives evaluated. Plan 2A, which would provide a 25-ft berm, has the next highest net benefits. The plan with the largest net benefit is typically selected as the NED plan. However, due to the large increase in nourishment quantities in the Optimization Phase, it was unclear if the $48 per cubic yard cost estimate would still apply for the 50 or 75 foot berms. As a result, Alt. 2A (25-ft berm) and Alt. 2B (50-ft berm) went through a more detailed cost engineering process prior to identifying the NED plan. .

Table 3-17: Optimization Phase Benefit Cost Summary Based on Beach-fx.

ANALYSIS	Alt. 1	Alt. 2A	Alt. 2B	Alt. 2C	Alt. 2D
Total Damages	$95,678,000	$61,396,000	$33,504,000	$24,883,000	$54,134,000
Total Benefits	$0	$41,594,000	$69,728,000	$78,636,000	$48,788,000
Damage Reduction Benefits	$0	$34,282,000	$62,174,000	$70,795,000	$41,544,000
Total Costs	$0	$31,879,000	$56,463,000	$76,323,000	$40,807,000
Total Net Benefits	$0	$9,715,000	$13,265,000	$2,314,000	$7,981,000
Average Annual Damages	$3,544,000	$2,274,000	$1,241,000	$922,000	$2,005,000
Average Annual Benefits	$0	$1,541,000	$2,583,000	$2,913,000	$1,807,000
Average Annual Costs	$0	$1,181,000	$2,091,000	$2,827,000	$1,512,000
Average Annual Net Benefits	**$0**	**$360,000**	**$491,000**	**$86,000**	**$296,000**
Benefit Cost Ratio		**1.30**	**1.23**	**1.03**	**1.20**

Total net and annual benefits provided in Table 3-17 above include benefits for traffic delay reduction (Section 3.4.2.1), reduction of land loss (Section 3.6.2), and recreation benefits (Section 3.6.3). Recreation benefits included represent a relatively small percentage of the overall benefit ($3.7 Million) and do not exceed 50 percent of the storm damage reduction benefit.

3.4.2 Systems Approach

The Optimization Phase incorporated the systems approach on a more dynamic level through the use of planform rates. Planform rates are used in the *Beach-fx* model after the first planned nourishment event. The planform rates adjust the average erosion rate to account for movement between each cove. The traffic delay and vehicle operating costs benefits were calculated and attributed to each cove in the Optimization Phase. As a result, the results displayed above in Table 3-17 is reflective of all benefits.

3.4.2.1 Trafic Delays & Vehicle Operating Costs

In the Initial Phase, it was stated that 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. Initial Phase noted that with post-storm recovery detours due to road re-construction, thebenefits have to be evaluated on a system-wide basis as a County Road 48 outage will impact all users irrespective of which cove it appeared in. Benefits 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 to avoid double counting, the benefit for reduction of costs due to traffic delays is estimated with one damage element only although the road could be taken out in more than one location at any given time.

These statements are true. However, by utilizing post-processing of the *Beach-fx* output in Microsoft Access and Excel, the project team was able to assign benefits to each cove, without risk of double counting the benefits. To do this, the annual probability of road closure was calculated by summing the number of the road closures in each cove by storm, by year for all 300 iterations. Then, the project team divided these closures by the 300 iterations to determine an annual probability per cove per storm. Next, a query paired each storm and each year to determine if a single storm affected more than one cove. If so, the furthest east cove closure was used to determine benefits for those traveling eastbound, and the furthest west cove closure was used to determine benefits for those traveling westbound.

The minutes saved per trip was used from direction measurements from Google Maps. The travel time was calculated based on travel from the Peconic Bay Medical Center in Riverhead, NY to the Orient Ferry, or from individual coves to either destination. Without detour, the route is directly on CR 48. With detour, the route is on County Road 48 when possible, and diverts to SR 25 at the cross road nearest the road damage. The detour may take place on Boisseau Avenue, Albertson Lane, Chapel Lane, or Main Road. The net detour mileage due to road closure for each of these origins was estimated with the use of Google Earth software. The nearest alternative road is SR 25.

Table 3-18: Net Detour Mileage by Origin

Origin	Net Detour Mileage	
	East Bound	West Bound
East of Project	0	1.8
East Cove	1.9	2.2
Central Cove	4.8	2.7
West Cove	3.9	3.5
West of Project	1.9	0

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 6,320 eastbound (EB) and 6,040 westbound (WB) for a daily total of 11,658 trips. The traffic count was taken in August, 2015, and was post-processed to account for the seasonal fluctuations. Using Census Tract populations, and

AADT counts north and south of the project, trips originating east of the project, west of the project, and within each cove were calculated.

The dollar value of time saved by preventing a detour away from 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 88% of the total trips are work trips and 12% are social/recreation trips, based on an analysis of the population and the AADT.

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 2011-2015 median household income of $77,688, a combination of the median household incomes for the three Census Tracts within the project area, from the US Census Bureau was used for this analysis, converted to an hourly rate of $37.35 based on 2080 work hours per year. The hourly rate was updated to 2017 dollars, using CPI, for 2017 hourly rate of $38.60.

Note that a level of service analysis was not conducted to determine if the State Route 25 can accommodate this additional temporary traffic. There is a possibility that travel time savings are even greater as a result of congestion on State Route 25 if the detour does occur. Quantifying this induced delay would require more extensive traffic modeling, but would be unlikely to change the result of the optimized plan. As such, the traffic delay benefits provided are based on existing travel times for each route and are based on only those who are being diverted, not those that may potentially experience induced congestion.

In addition to travel time savings from the detour, there are also benefits associated with reduced vehicle miles traveled (VMT), such as less vehicle operations, and less roadway maintenance. Page E-194 of Engineer Regulation ER 1105-2-100 states that round-trip distance from origin can be converted to monetary values by summing the most recent U.S. Department of Transportation average variable costs in cents per mile to operate an automobile. The latest data released by US DOT, Table 3-17 Average Cost of Owning and Operating an Automobile, is for 2015. CPI-U was used to adjust the published cost.

Table 3-19 Road Closure Benefits by Cove, Average Discounted Sum, $

Scenario	Opportunity Cost of Time Benefits			Vehicle Operating Cost Benefits			Total Road Closure Benefits			
	West	Central	East	West	Central	East	West	Central	East	Total
Alt 2A	$2,000	$3,000	$132,000	$1,000	$2,000	$76,000	$3,000	$5,000	$208,000	$216,000
Alt 2B	$180,000	$4,000	$289,000	$104,000	$4,000	$165,000	$284,000	$8,000	$454,000	$746,000
Alt 2C	-$68,000	$37,000	$123,000	-$42,000	$23,000	$74,000	-$110,000	$60,000	$197,000	$148,000
Alt 2D	$308,000	$20,000	$145,000	$176,000	$12,000	$84,000	$484,000	$32,000	$229,000	$745,000

3.5 Constructability and Schedule Considerations

As previously stated, the nourishment quantities increased after refining inputs for the model software and other values in the Optimization Phase. As a result, there was a concern that the initial cost estimate of $48 per cubic yard, which assumes trucking in sand, would no longer be technically feasible, or the correct cost estimate. As a result, two alternatives with the highest net benefits underwent a more rigorous cost engineering process, Alt. 2A (25-ft berm) and Alt. 2B (50-ft berm), to identify the NED plan.

3.5.1 NED Plan - Cost Engineering Results

The costs previously presented the Optimization Phase are preliminary based on nourishment quantities provided by *Beach-fx*, based on a unit cost of $48/ per cubic yard of sand. The project team raised concerns that the new, much larger quantities produced by the *Beach-fx* modeling may require alternative solutions beyond trucking. As a result, more detailed costs for Alternatives 2A and 2B were calculated by Cost Engineering outside the Beach-fx model for identification of the NED plan. The updated benefit cost summary is provided below and the 25-foot berm is the plan with the highest net benefits and is the NED plan. It was determined that Alternative 2A is also more technically feasible due to the lower quantity of sand required to be trucked to the project site. The initial 25-foot berm placement is anticipated to take about 1 year and one construction period. The 50-foot berm placement would be spread over 3 construction periods due to the larger quality of sand required and the potential triggering of environmental windows during placement. The updated benefit cost summary is shown below. Annual benefits shown include damage reduction, traffic delay reduction, reduction of land loss, and recreation benefits. The NED Plan –Cost Engineering analysis was completed using the FY19 interest rate of 2.875% and includes price level updates for benefits, as well as costs. Damages were updated using the price level update from 2015 to 2018 using a means-based update factor of 1.102. Other benefits were updated appropriately using CPI and FY19 Recreation Unit Day Values.

Table 3-20: Optimization Phase: Cost Engineering Results, Benefit Cost Summary, $

Alt.	Sum of PV Damage	Sum of PV Benefit*	Annual Benefit	Annual Cost	Annual Net	Benefit-Cost Ratio
1 (WOP)	99,449,000					
2A*	59,452,000	45,494,000	1,726,000	$1,450,000	276,000	1.2
2B	35,970,000	68,978,000	2,618,000	$3,002,000	-$384,000	0.87
*The sum of PV Benefits includes $3.7 million in recreation benefits.						

3.6 Selected Plan

The Optimization Phase selected plan was Alt. 2A, which is the beach nourishment 25-ft berm plan.

3.6.1 Residual Damage

Residual damage is storm damage from erosion, wave and flooding that would be expected to still occur even with the proposed project in place. Table 3-21 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-1, E-2 and E-4. In the Central Cove residual damage in economic reach eight (E-8) is about 80 % 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 $2.3 million.

Table 3-21: Selected Plan Residual Damage, Average Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Cost	Total Damage	% Total
E-1	3,964,000	125,000	$0	4,089,000	6.9%
E-2	957,000	579,000	$132,000	1,668,000	2.8%
E-3	91,000	0	$0	91,000	0.2%
E-4	277,000	118,000	$0	395,000	0.7%
E-5	161,000	72,000	$0	233,000	0.4%
WEST	5,451,000	893,000	132,000	6,476,000	10.9%
E-6	0	0	61,000	61,000	0.1%
E-7	2,000	1,000	0	2,000	0.0%
E-8	4,863,000	135,000	33,000	5,031,000	8.5%
E-9	269,000	146,000	191,000	606,000	1.0%
E-10	23,000	3,000	476,000	502,000	0.8%
E-11	20,000	9,000	9,000	38,000	0.1%
CENTRAL	5,176,000	294,000	771,000	6,241,000	10.5%
E-12	265,000	117,000	318,000	701,000	1.2%
E-13	13,473,000	246,000	3,000	13,722,000	23.1%
E-14	9,858,000	256,000	0	10,114,000	17.0%
E-15	11,528,000	4,849,000	5,822,000	22,199,000	37.3%
EAST	35,124,000	5,468,000	6,143,000	46,735,000	78.6%
Total All Coves	45,751,000	6,655,000	7,046,000	59,452,000	100.0%

3.6.2 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 3-22 below.

Table 3-22: Hashamomuck Cove Land Loss

Economic Reach	Historic Average Erosion Rate (Ft/Yr)	Cumulative Predicted Erosion (Low SLR, 2069)	Reach Length	Average Annual Land Loss (acres)	Cost per Acre	Average Annual Land Loss Cost (rounded)
E1	-0.35	17.5	329	0.003	$511,264	$1,300
E2	-1.29	64.5	541	0.010	$511,264	$4,800
E3	-1.1	55	972	0.008	$511,264	$4,100
E4	-0.64	32	868	0.005	$511,264	$2,400
E5	-0.54	27	406	0.004	$511,264	$2,000
WEST				**0.030**	**$511,264**	$14,700
E6	-0.59	29.5	253	0.004	$511,264	$2,200

E7	-1.24	62	236	0.009	$511,264	$4,700
E8	-1.3	65	839	0.010	$511,264	$4,900
E9	-0.58	29	545	0.004	$511,264	$2,200
E10	-0.6	30	326	0.005	$511,264	$2,300
E11	-0.66	33	376	0.005	$511,264	$2,500
CENTRAL				**0.038**	**$511,264**	$18,700
E12	-0.28	14	584	0.002	$511,264	$1,100
E13	-0.79	39.5	681	0.006	$511,264	$3,000
E14	-0.11	5.5	893	0.001	$511,264	$400
E15	-0.3	15	603	0.002	$511,264	$1,100
EAST				**0.011**	**$511,264**	**$5,600**
TOTAL				**0.078**	**$511,264**	**$38,900**

3.6.3 Recreation

Under all with-project scenarios, 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. Facilities here include restrooms, a playground, a picnic area, and a beach wheelchair ramp for disabled patrons. Parking at the Southold Town Beach is by Southold Town permit only. The beach has lifeguards on duty from 11:00 am to 5:00 pm during the summer, as well as beach attendants on duty from Friday to Sunday to issue daily parking permits. Other parking permits, for both residents and non-residents, may be purchased at the Town Clerk's office.

To determine the appropriate unit day values for recreation, the project team reviewed the amenities of the Southold Town Beach, other local beaches, and the with-project public access plan. The Town of Southold maintains several other public beaches near the Southold Town Beach, including Kenney's Beach, McCabe's Beach, and New Suffolk Beach. Additionally, the New York State Parks operates one beach state park with bathrooms and other amenities within 30 minutes of Hashamomuck Cove, Orient Beach State Park. The beaches managed by the Town of Southold are all of similar quality as, and with similar amenities to, the Southold Town Beach. The Orient Beach State Park has improved amenities, and has attracted an average of 400,000 visitors per year over the last 5 years.

Given the existing and projected amenities at the Southold Town Beach, as well as the surrounding beaches, the project team estimated the unit day values and number of visitors with and without the project. Under the without project conditions the beach will continue to erode into the existing structures, resulting in a degraded recreation experience. The unit day values are estimated to be $6.08 in the without project condition and $9.37 in the with-project condition. The biggest difference in the unit day values is associated with improved environmental condition with the project.

Continued erosion in the without project condition will also reduce the available parking over time. Overall the beach usage under the without project condition is expected to decline from an estimate of about 26,200 visits per year to about 14,200 visits per year as the number of available parking is reduced from 184 spaces to 85 spaces. The change in usage was assumed to occur linearly over the 50 year period of analysis. The with-project usage is forecast to increase from an estimate of about 26,200 visits per year to about 37,000 visits per year. The parking in the with-project condition, including the total of 4 new spaces at the Central Cove and East Cove public access points, is sufficient to realize these benefits; these benefits are based upon predominately an increase in the usage of the parking lot from 1 car per space per day to 1.5 cars per space per day on peak days. There is also in increase of 4 spaces.

Subtracting the total without project value per year from the total with project value per year results in the recreation benefit in that year. Annual recreation benefits were adjusted to their present value, and summed to calculate that the total benefits over the 50-year period of analysis. The total present value of recreation benefits is calculated to be $3.7 million.

3.6.4 Other Accounts

3.6.4.1 Evacuation

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 one of the main roads serving outer Long Island. Maintaining its integrity will increase the efficiency of emergency response teams in the area. FEMA flood maps indicate that the low-lying area east of Hashamomuck Pond on State Route 25 is just as, or more, likely to flood than County Route 48.

As such, if County Road 48 is closed due to flooding, it is likely that several thousand residents residing from Southold to Orient, NY will not be able to evacuate or require more expensive evacuations (such as air lifts).

In the event that County Road 48 is damaged by wave or erosion, it is likely that State Road 25 is still passable, and thus there are no evacuation benefits. There are simply traffic delay benefits. However, in the event that County Road 48 is damaged by flooding, approximately 5,300 residents in and northeast of the project will not be able to safety evacuate their homes. State Road 25 is the north fork's official hurricane evacuation route. However, County Road 48 has a much higher volume of traffic, and is the preferred route of local residents. Closure of both of these roads due to flooding would be detrimental to the evacuation of the north fork.

3.6.4.2 Community Resiliency Considerations

The Suffolk County Water Authority has indicated that there are main water lines running under or near both State Road 25 and County Road 48. The main lines are 24" and 12" respectively. In addition to impeding evacuation, in the event that the road is both damaged by erosion (which may cause damage to the water lines), and flooded, the stranded residents would have limited access to clean water. According to the National Grid, there are approximately 1,000 customers east of the project area that rely on gas lines below County Road 48. Repairing a break within the gas line, and relighting the homes could take approximately 1-2 weeks. The project contributes to local storm resiliency by reducing the damage to the local roadway. By increasing the probability that County Road 48 remains intact following a storm event, the project is also increasing the probability of a faster recovery, as it would allow utility repair teams, debris removal, and home repair services to safely and efficiently access areas east of the project.

3.6.4.2.1 Life Safety Considerations

3.6.4.2.1.1 Risk of Injury or Drowning during the storm

As described in the Evacuation section, the official Hurricane Evacuation Route is State Road 25. According to FEMA maps, this route is just as likely, or more likely to flood as County Road 48. In the event that County Road 48 is flooded, it is also likely that State Road 25 is also flooded. When both of these roads are impassable, approximately 5,300 residents in and northeast of the project could be prevented from safely evacuating. There would be a risk of drowning during the storm, and further risk of drowning if residents attempted to evacuate on flooded roadways following the storm. In the with-project condition, the berm extends further from the roadway, preventing the likelihood of roadway flooding on County Road 48. This reduces the risk of injury or drowning in the with-project scenario. Although there would likely still be flooding on the official hurricane evacuation route, State Road 25, the prevention of flooding on County Road 48 provides an alternate route for evacuation to reduce the risks of injury and drowning.

3.6.4.2.1.2 Loss of Critical Facilities

There are no critical facilities within the immediate project area. There are three fire departments northeast of the project; the Greenport Fire Department, the East Marion Department, and the Orient Fire Department. There is an additional fire department south of the project; the Southold Fire Department. The nearest fire department to the Southold Town Beach, which one of the furthest west areas of the project, is the Southold Fire Department, at approximately 2 miles away. However, the closest fire department to the Soundview Inn, which is one of the furthest east areas of the project, is the Greenport Fire Department, at approximately 2.5 miles. There is one hospital northeast of the project, the Eastern Long Island Hospital. There are additional hospitals south of the project, such as the Peconic Bay Medical Center, in Riverhead, NY; however, they are nearly 20 miles away from the project. In the event that both County Road 48 and State Road 25 are impassable due to flooding restrictions in only one location within the project area, it would be likely that fire department and hospital services from either north or south could service the residences within the project area. However, in the event that County Road 48 and State Road 25 are impassable in multiple locations, there is a possibility that some residences within the project area would not be able to receive fire department or hospital services for the period of time that the roadways are impassable. There are no police departments or Sheriff's offices in or north of the project area. The nearest police department is the Southold Police Department, approximately 4.5 miles south of the project. In the event that County Road 48 and State Road 25 are impassable at even one location, there is a possibility that residences within and north of the project would not be able to receive police services for the period of time that the roadways are impassable.

3.6.4.2.1.3 Detours and Emergency Response delay

When a life-threatening situation occurs, timely emergency care is a key factor that affects the chances of survival. When critical facilities such as fire departments, hospitals, and other emergency medical services providers are delayed such as due to a flood event, there may be a cost in lives. Flooding may increase the response time of critical services or cause a critical facility to temporarily shut down.

In the event that County Road 48 is impassable due to erosion or wave damages, traffic can likely be diverted to State Road 25. Depending on the location of the road damage, and the origin of the emergency response service, the detour can delay response by 4 to 13 minutes. The shorter the response time for emergency service professionals, the better chance of a successful outcome. Response time is related to the distance between the EMS facility and the location of the emergency.

When a critical facility in the Project Area that provides EMS is temporarily closed, the nearest available EMS facility would serve a larger geographical area and the average response time would increase. When flooding causes a fire station or an EMS provider to temporarily shut down, increased response time can cost lives. Although fire stations offer many services to communities, this approach is focused on the EMS provided by fire stations.

3.6.5 Sea Level Change Sensitivity

ER 110-2-8162 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 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 are presented below to demonstrate the sensitivity of the results to various sea level rise conditions. The results, presented for the selected plan, Alt. 2A, which includes a 25-ft Berm, show that the damages are not highly sensitive to higher rates of sea level rise. This is because the Beach-fx model assumes that the increase in shoreline erosion associated with accelerated sea level change will result in condemnation of the lot and a reduction in future damage.

Table 3-23: Int. SLR Damage by Reach, Alt. 2A, 25-ft Berm, Average Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Damage	Total Damage
E-1	3,953,000	122,000	$0	4,075,000
E-2	623,000	299,000	$2,505,000	3,427,000
E-3	97,000	0	$0	97,000
E-4	254,000	108,000	$4,233,000	4,595,000
E-5	132,000	58,000	$363,000	553,000
Total West	5,058,000	586,000	7,102,000	12,747,000
E-6	0	0	62,000	62,000
E-7	35,000	15,000	0	50,000
E-8	3,483,000	815,000	32,000	4,330,000
E-9	360,000	184,000	181,000	725,000
E-10	38,000	7,000	466,000	510,000
E-11	30,000	14,000	11,000	55,000
Total Central	3,946,000	1,036,000	750,000	5,732,000
E-12	5,000	0	304,000	309,000
E-13	13,560,000	250,000	2,000	13,812,000
E-14	9,596,000	262,000	0	9,858,000
E-15	11,162,000	4,691,000	5,773,000	21,626,000
Total East	34,323,000	5,203,000	6,078,000	45,605,000
Total All Coves	43,327,000	6,825,000	13,930,000	64,083,000

Table 3-24: High SLR Damage by Reach, Alt. 2A, 25-ft Berm, Average Discounted Sum, $

Reach	Structure Damage	Content Damage	Armor Damage	Total Damage
E-1	3,730,000	158,000	$0	3,888,000
E-2	772,000	398,000	$2,527,000	3,697,000
E-3	108,000	0	$0	108,000
E-4	229,000	96,000	$4,288,000	4,613,000
E-5	96,000	43,000	$346,000	484,000
Total West	4,934,000	695,000	7,161,000	12,790,000
E-6	0	0	54,000	54,000
E-7	28,000	12,000	0	40,000
E-8	3,590,000	815,000	40,000	4,445,000
E-9	458,000	244,000	0	702,000
E-10	56,000	15,000	446,000	517,000
E-11	33,000	16,000	11,000	60,000
Total Central	4,165,000	1,103,000	551,000	5,819,000
E-12	230,000	110,000	305,000	646,000
E-13	13,778,000	260,000	3,000	14,041,000
E-14	8,630,000	266,000	0	8,896,000
E-15	10,568,000	4,418,000	5,918,000	20,904,000
Total East	33,206,000	5,054,000	6,227,000	44,487,000
Total All Coves	42,305,000	6,852,000	13,938,000	63,095,000

4 Summary

The recommended plan is a 25-foot berm in all coves. The plan had the highest net benefits of all alternatives on a system-wide basis in both the Initial and Optimization Phases. The plan is technically feasible based on cost engineering results and addresses project objectives.