CAPE MAY SEAWALL FEASIBILITY STUDY

CAPE MAY, NEW JERSEY

CONTINUING AUTHORITIES PROGRAM, SECTION 103

ECONOMIC APPENDIX

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EXECUTIVE SUMMARY

The economic modeling for the Cape May Seawall CAP 103 Feasibility Study consists of three reaches in Cape May, NJ. In total, these reaches contain 1,392 potentially damageable structures with over $605,000,000 in total value.

This study is undertaken to assess the feasibility of providing Federal coastal storm risk management measures to any or all sections of the study area. Coastal storm impacts are evaluated using the certified Hydrologic Engineering Center – Flood Damage Reduction Analysis (HEC-FDA) model version 1.4.2. HEC-FDA provides integrated hydrologic engineering and economic risk analysis during the formulation and evaluation of flood damage reduction plans. The model employs a Monte Carlo simulation analysis to calculate Expected Annual Damage (EAD), also referred to as Average Annual Damages (AAD), while explicitly accounting for uncertainty in the basic hydrologic and economic parameters.

Following preliminary screening and detailed study evaluation, the Project Delivery Team (PDT) has determined the National Economic Development (NED) Plan for reducing flood risk and reasonably maximizing net national economic development benefits. The NED Plan consists of modifying the existing seawall from 9.5ft NAVD88 to an increased height of 17ft NAVD88. Benefits are captured by reducing damage from high frequency storm events in all three reaches.

Plan formulation and economic results are presented using the Low (Historic) Relative Sea Level Change (RSLC) curve.

The evaluation covers a 50-year period of analysis with final NED benefits stated at the FY21 Project Evaluation and Formulation Rate (Federal Discount Rate) of 2.5%. The NED Plan stands at $96,000 (rounded) in Average Annual Net Benefits (AANB) with a 1.6 Benefit-Cost Ratio (BCR).

Table 1: NED Plan Average Annual Net Benefits Summary

Item	NED Plan
Total Estimated Construction	$3,563,000
Average Annual Cost	$162,000
Without Project EAD	$725,000
With Project EAD	$467,000
Average Annual Benefits	$258,000
Average Annual Net Benefits	**$96,000**
Benefit-Cost Ratio	**1.6**

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INTRODUCTION

This appendix provides the results of the economic analysis of existing conditions storm damages and coastal storm risk management benefits for Cape May City, Cape May County, New Jersey. The analysis described within this document was conducted as an element of the Cape May Seawall CAP 103 Feasibility Study. The economic analysis described in this appendix is consistent with Federal water resources policies and practice, including *Risk-Based Analysis for Flood Damage Reduction Studies* (EM 1110-2-1619), and the *Planning Guidance Notebook* (ER 1105-2-100).

The purpose of this appendix is to evaluate plan alternatives against economic constraints for the U.S. Army Corps of Engineers' (USACE) participation in coastal storm risk management projects. The economic constraints are:

- The need for coastal storm risk management features to be efficient (i.e., Average Annual National Economic Development (NED) Benefits exceed Average Annual Costs)
- The requirement to select the coastal storm risk management plan that reasonably maximizes net NED benefits (i.e., the NED Plan)

Contributions to NED include increases in the net value of the national output of goods and services expressed in monetary units. Direct benefits (e.g., prevented damages, reduction of emergency services costs) that accrue in the planning area from implementation of a coastal storm risk management project are contributions to NED. A positive difference of project benefits minus project costs becomes a net contribution to NED. Similarly, if the result of project benefits divided by project costs exceeds 1.0, the project is said to have a positive benefit-to-cost ratio (BCR).

The Federal objective of water resources development is to identify a plan that maximizes net contributions to NED consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. This plan is referred to as the NED Plan, and becomes the basis for Federal cost-sharing in any project for flood damage reduction.

Opportunity Identification

Coastal storm risk management opportunities include the potential to reduce property damages, injuries, and loss of life. Due to certain study limitations, non-physical losses, including transportation delay costs and non-transferable income losses, were not evaluated nor quantified in this study.

Initial structure inventory quantification, economic damage analysis, and estimated construction costs were completed using FY2018 price levels and the FY2018 Federal Discount Rate of 2.75%. These results are presented in the Appendix with final results escalated to FY2021 price levels and the FY2021 Federal Discount Rate of 2.5%. Final results are presented in the section titled "FY2021 Price Level and Discount Rate" near the end of the Appendix.

Methodology Overview

Coastal storm damages are expressed in terms of expected annual damages (EAD), which are defined as the monetary value of physical damages and non-physical losses that can occur in any given year based on the magnitude and probability of losses from all possible events. The basis for determining existing damages is an examination of losses sustained in historical floods, supplemented by appraisals, application of depth-percent damages functions, and an inventory of capital investment within the floodplain.

Expected annual damages are estimated using the HEC-FDA 1.4.2 model.

Major Damage Categories

Flood damages throughout the study area are classified as either physical or non-physical damages. As non-physical damages are not quantified in this study, physical damages account for all the evaluated total flood damages and including the following categories:

- Structural damages to buildings
- Loss of content value of buildings

Potential additional non-physical damages are not expected to comprise a significant proportion of total flood damages nor are additional physical damage categories such as vehicles or infrastructure.

Selected Planning Reaches

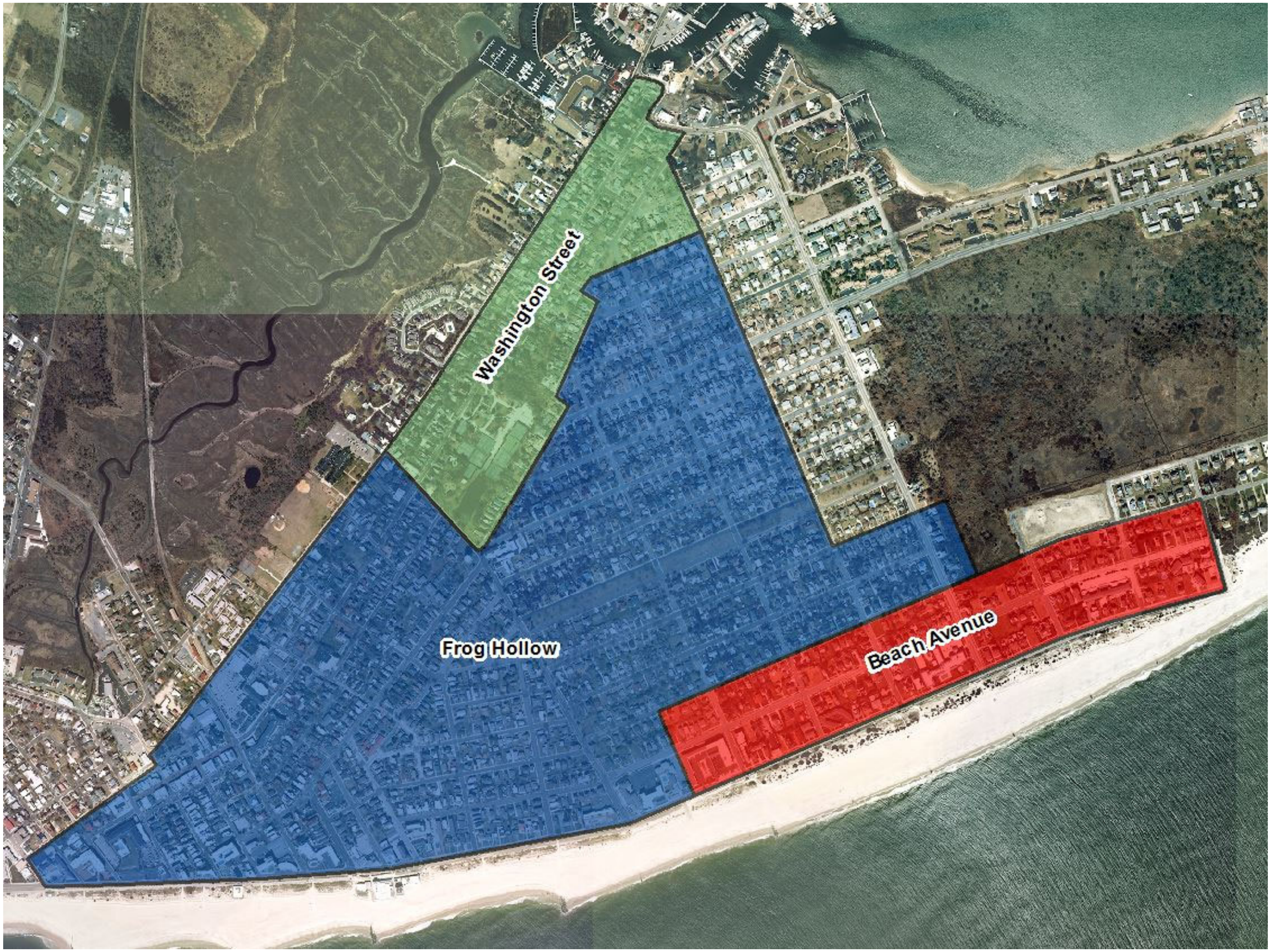
The study area is located entirely within the City of Cape May along the southern coastline of New Jersey. Three separate, distinct reaches were delineated for the study: Beach Avenue, Frog Hollow, and Washington Street (Figure 1). Reaches were delineated based on hydraulic criteria including the source of inundation and the manner in which coastal flooding moves through the area. More information on the hydraulic analysis can be found in the Coastal Engineering Appendix. See Table 2 below for a brief overview of the study area asset inventory.

Table 2: Study Area Reaches

Reach	Name	Structures	Value*
1	Beach Avenue	335	$142,244,300
2	Frog Hollow	880	$214,117,600
3	Washington Street	177	$34,128,900
	TOTAL	1,392	$390,490,800

*does not include other potential value sources (e.g., content value)

Figure 1: Study Area Reach Boundaries



STRUCTURE INVENTORY DEVELOPMENT

Development of the structure inventory involves surveying existing floodplain structures to collect the data necessary to determine expected coastal storm damages. The purpose for collecting this information is to determine what structures are located in the 1% Annual Exceedance Probability (AEP) event floodplain, the depreciated replacement value of those structures and their associated contents, and the zero-damage elevation at which they are initially susceptible to flooding. This information is then used in the computation of the with- and without-project condition flood damages.

Structure inventory development began by establishing the geographic limits of the study area as defined by the study area reaches shown in Geographic Information System (GIS) shapefiles. The reach shapefiles are shown projected on aerial photography in Figure 1 and correspond to the reaches listed in Table 2 shown previously.

Study Area Tax Assessment Data and Tax Parcels

Tax Assessment data was acquired through the New Jersey Geographic Information Network (NJGIN), managed by the NJ Office of Information Technology, Office of GIS. Tax Parcels and Tax Assessment Records assist in compiling characteristics and values for each of the structures within the study area.

Specifically, tax records can provide information on structure location (Northing & Easting Coordinates), street address, building type, number of stories, parcel ID number, and county tax assessment value. Figure 2 shows the tax parcel overlay for the entire City of Cape May.

For the actual study inventory, only the structures within the 1% AEP event floodplain (as defined by the North Atlantic Coast Comprehensive Study (NACCS)) were evaluated as these structures are most greatly impacted by storm events. Figure 3 shows the boundary of the 1% AEP floodplain in blue with the extent of the 0.2% AEP floodplain in red added for reference.

Figure 4 shows the inventory after the tax parcel polygons are converted to a singular data point, or centroid, and then clipped to the 1% AEP event floodplain. This figure shows the final 1,392 structures that were eventually imported into the HEC-FDA 1.4.2 economic analysis model. Figure 5 shows the same distribution of structures delineated by their Reach designations.

Figure 2: Cape May Tax Parcel Overlay

Figure 3: Cape May 1% Annual Exceedance Probability (AEP) Event Floodplain

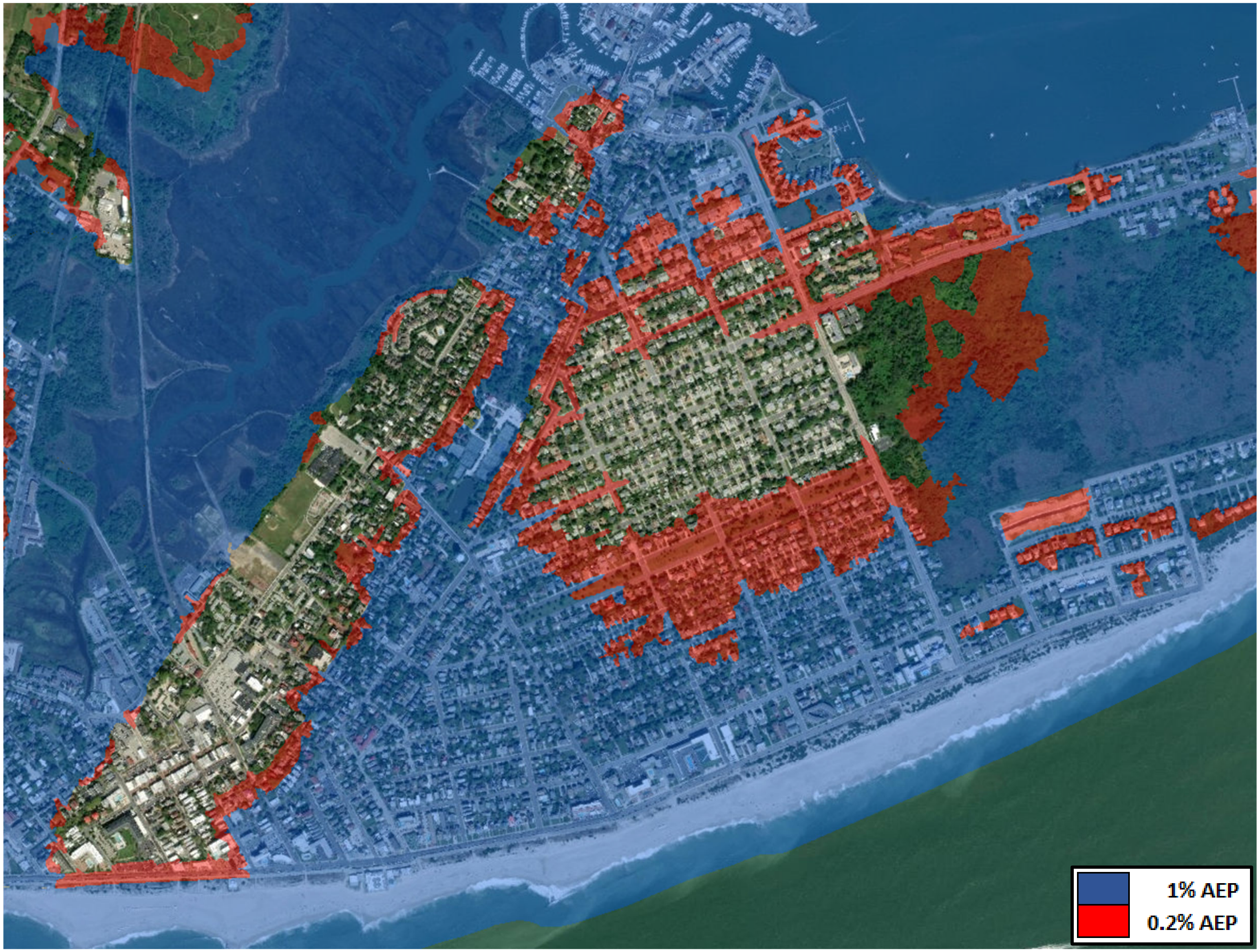
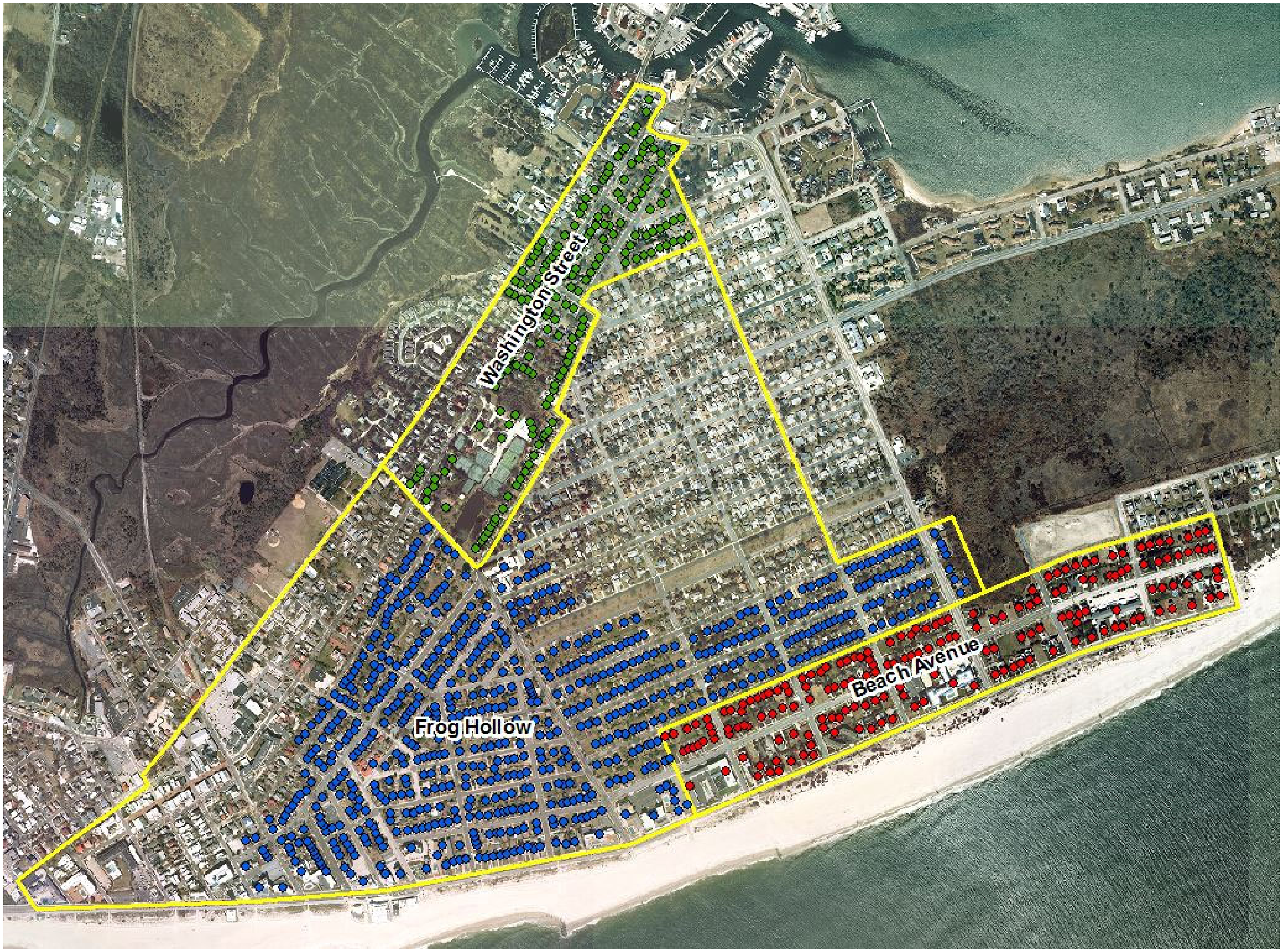


Figure 4: Cape May Structure Inventory

Figure 5: Cape May Structure Inventory by Reach



Structure Characteristics and Valuation Data

Tax assessment records provided the basis for Depreciated Replacement Value (DRV) in compliance with EM 1110-2-1619 *Risk Based Analysis for Flood Damage Reduction Studies* (August 1996). Tax assessment values were identified for each structure and entered into the inventory. A representative sample of 70 structures (5.01% of total inventory) were also analyzed using Marshall & Swift Residential Estimator 7 and Marshall & Swift Commercial / Agricultural Estimator to independently estimate their DRV and compare it to the county tax assessment records. For this particular study, the tax assessment values for the City of Cape May were similar enough to the results of the Marshall & Swift independent test to allow the tax assessment values to be used as direct values for DRV without the need for any weighting adjustments.

To account for uncertainty in the assigned Depreciated Replacement Values, each structure value and content value was transformed to a normal distribution in HEC-FDA 1.4.2.

Structure and content values derived from the Cape May County Tax Assessor records are assigned a normal distribution of values to account for any uncertainty in assigned Depreciated Replacement Value.

Tax records for the City of Cape May also provided information on structure category and occupancy type as well as the number of floors. This data is added to the structure inventory to inform the proper selection of Depth-Percent Damage Functions and Content-to-Structure Value Ratios (CSVR). Table 3 below shows the inventory breakdown by Reach and occupancy type.

Table 3: Structure Count Distribution by Type and Reach

Struc. by Reach	Beach Avenue	Frog Hollow	Washington Avenue	Total
Residential	327	797	163	**1,287**
Commercial	4	30	7	**41**
Apartment	4	47	3	**54**
Public	0	2	3	**5**
Church	0	3	0	**3**
Other Exempt	0	1	1	**2**
Total	**335**	**880**	**177**	**1,392**

Residential structure types constitute a significant majority of the inventory in each of the three reaches and represent over 92% of the total structure database. It is important to note that while Commercial buildings have a low overall structure count, these structure types have a higher median value and, in this study area, are constructed in high risk areas in Beach Avenue and Frog Hollow reaches. Table 4 shows structure value distribution for Cape May.

Table 4: Structure Value Distribution by Type and Reach

Value by Reach	Beach Avenue	Frog Hollow	Washington Avenue	Total
Residential	$119,756,200	$164,870,600	$30,211,600	$314,838,400
Commercial	$17,344,300	$23,689,300	$1,095,000	$42,128,600
Apartment	$5,143,800	$22,880,000	$1,119,700	$29,143,500
Public	$0	$896,800	$1,624,700	$2,521,500

Church	$0	$1,583,600	$0	$1,583,600
Other Exempt	$0	$197,300	$77,900	$275,200
Total	**$142,244,300**	**$214,117,600**	**$34,128,900**	**$390,490,800**

Residential structure types still maintain a majority of DRV at 80.6% of total value, but Commercial structures constitute over 10.8% of value despite representing only 2.9% of the inventory by count.

Table 5 shows the Residential structure value distribution statistics by reach while Table 6 shows the Commercial structure value distribution by reach.

Table 5: Residential Structure Depreciated Replacement Value Statistics by Reach

Item	Beach Avenue	Frog Hollow	Washington Avenue	Total
Minimum	$20,000	$7,500	$6,600	$6,600
Maximum	$4,769,300	$1,361,900	$657,000	$4,769,300
Median	$242,700	$170,800	$150,00	$165,100
Std. Deviation	$407,300	$155,500	$114,700	$253,631
Total Res. Value	$119,756,200	$164,870,600	$30,211,600	$314,838,400

Beach Avenue, with the highest percentage of larger, newer oceanfront residential property, has the overall highest individual residential structure value as well as the highest residential median value. Frog Hollow also has some oceanfront property, but a majority of structures are smaller inland structures. This results in a lower residential median value and reduced variability.

Washington Avenue is situated closer to the back bay and has the lowest minimum and maximum individual residential structures. Washington Avenue also has the lowest median residential value.

Table 6: Commercial Structure Depreciated Replacement Value Statistics by Reach

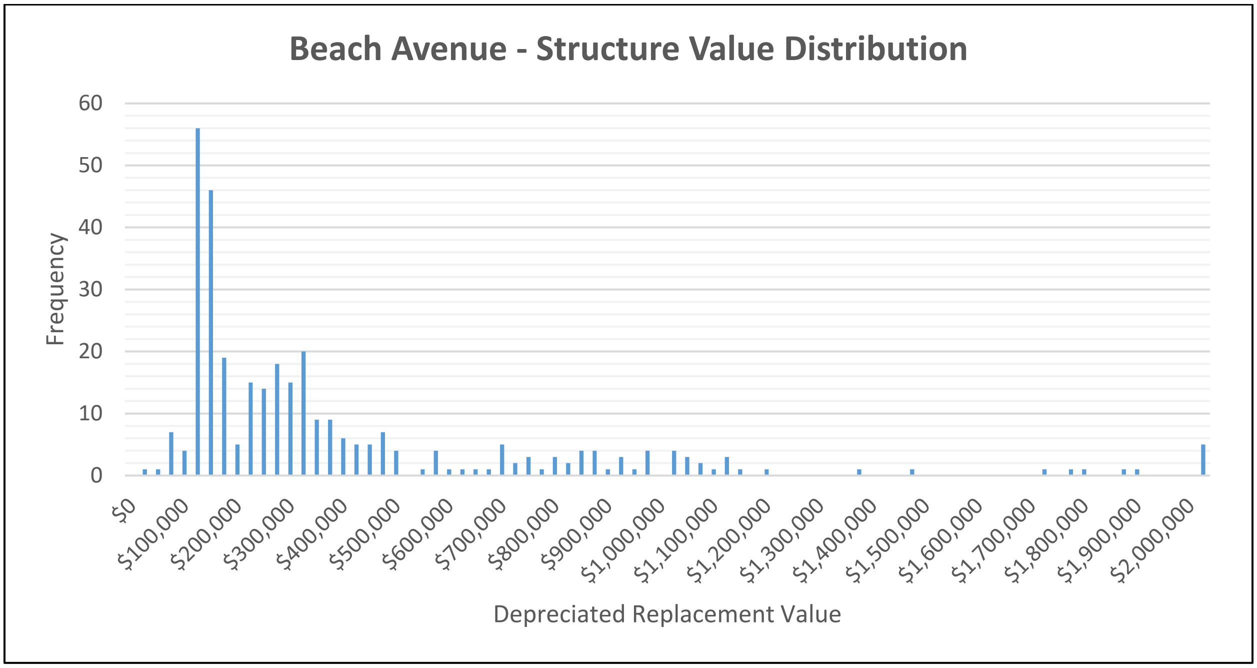
Item	Beach Avenue	Frog Hollow	Washington Avenue	Total
Minimum	$265,800	$51,900	$8,400	$8,400
Maximum	$8,504,200	$2,542,500	$346,900	$8,504,200
Median	$4,287,150	$527,250	$170,200	$351,700
Std. Deviation	$3,199,340	$720,986	$106,910	$1,618,589
Total Com Value	$17,344,300	$23,689,300	$1,095,000	$42,128,600

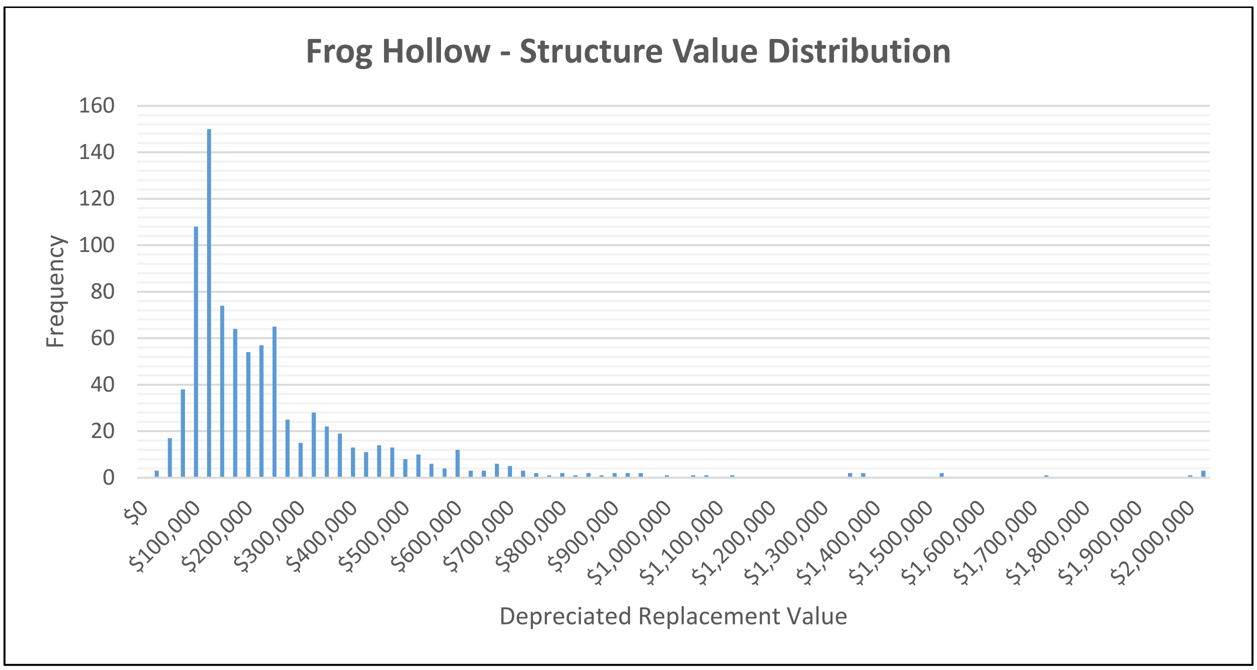
Beach Avenue only has four Commercial structures, but 75% of these structures have a value greater than $2,000,000. This pushes the median Commercial value approximately $4,000,000 higher than the median Residential value. Frog Hollow has a greater volume of Commercial structures compared to Beach Avenue, but the median value is roughly only $350,000 higher than the median residential value.

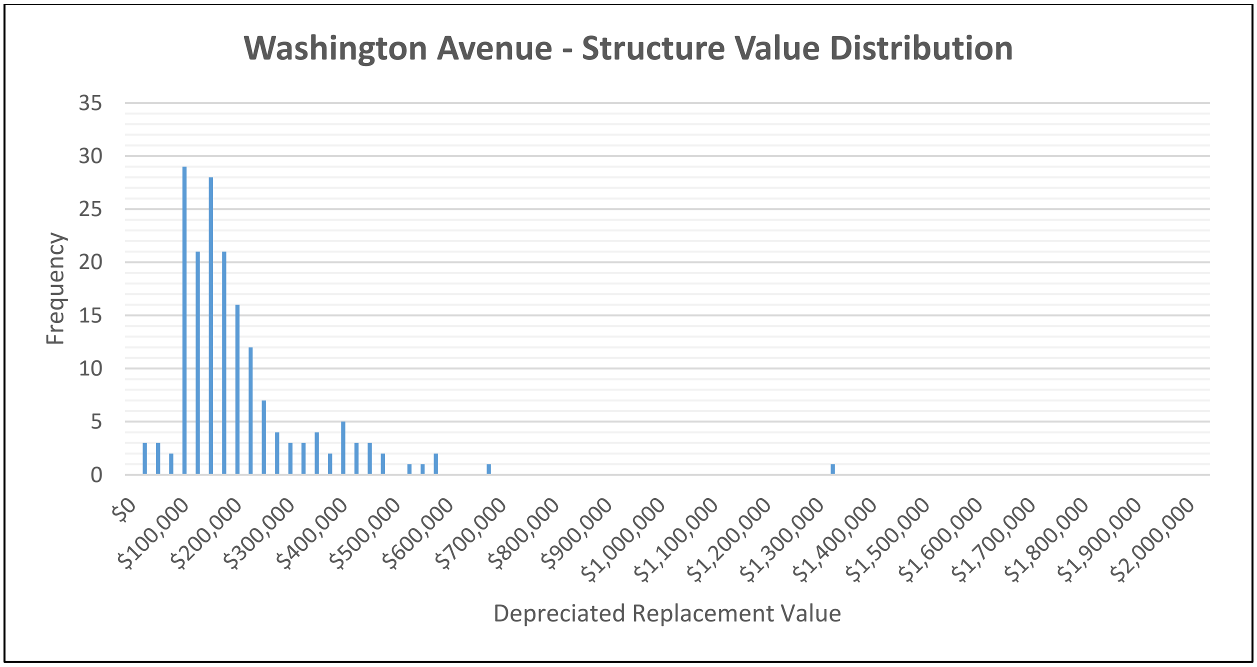
Washington Avenue only has seven Commercial structures and these structures are mostly comparable to Residential buildings in the same reach. Median and standard deviation are similar suggesting analogous levels of value and variability.

Figure 6 shows the distribution of depreciated replacement value for all structure types for each reach.

Figure 6: Depreciated Replacement Value Distribution by Reach







Beach Avenue has a slight bimodal distribution with clusters around $150,000 depreciated replacement value for inland structures and $350,000 depreciated replacement value for larger, oceanfront structures. Beach Avenue also has the largest skew of the three reaches with a sizeable number of very high value residential properties and a few exceptionally high value commercial properties.

Frog Hollow is closer to a normal distribution of value though the presence of high value commercial and residential oceanfront structures provides a slight right-tailed skew. The overall variability is significantly less than Beach Avenue

Washington Avenue has almost no skew and has the closest approximation of a normal distribution.

Structure Category and Occupancy Codes

As mentioned earlier, HEC-FDA 1.4.2 utilizes category and occupancy codes to inform the Depth-Percent Damage Function and CSVR. Structures with varying uses or floors have varying damage risks and content values. These codes create the correct matrix to properly address those differences. The structure inventory has 4 categories and 5 occupancy types.

- Residential – Single Family Residential 1 Story (SFR1) / Single Family Residential Multi-Story (SFRM)
- Commercial
- Apartment
- Other – Includes Public, Churches, and Other Exempt Property

For the purposes of this study, Public, Religious, and Other Exempt properties are grouped together into a single OTHER category and use the same Depth-Percent Damage Function / CSVR due to their assumed similar structure composition. As these structures constitute only 0.7% of the total inventory by count, any errors associated with this simplifying assumption should have no bearing on the overall analysis results.

Depth-Percent Damage Functions

Depth-Percent Damage Functions were compiled from the North Atlantic Coast Comprehensive Study (NACCS) Physical Depth Damage Function Summary Report (January 2015). Damage functions are designed to be predictive of the damages that would be incurred in future coastal events for both the with- and without-project condition for a given structure type at a given First Floor Elevation (FFE). Damage functions are provided for inundation damages and for both structure and content damages categories.

The NACCS does not provide a damage function for the OTHER category of structures and Commercial structures were deemed to have the closest alternative depth-percent damage function.

Depth-Percent Damage Functions are provided in a triangle distribution of values to capture some of the knowledge uncertainty and natural variability found in predicting future damage events. Functions are outlined as Minimum, Most Likely, or Maximum for a variety of stage heights relative to FFE. Combined with the uncertainty bands in the Water Surface Profiles (see Engineering Appendix), this allows for HEC-FDA 1.4.2 to employ a Monte Carlo analysis on a variety of return frequencies, stage heights, and damage percentages. This offers a much more comprehensive and descriptive analysis of predicted damage results compared to only using the mean value for every input variable.

With 5 category types, 2 damageable assets (structure and content), and only 1 damage driver, this study employed 8 unique Depth-Percent Damage Functions. These functions are shown in Table 7.

Table 7: Depth-Percent Damage Functions

Single Family Residential One Story (SFR1)

Stage	Structure			Content		
	Most Likely	Min	Max	Most Likely	Min	Max
-1.0	0	0	0	0	0	0
-0.5	0	0	5	0	0	0
+0.0	1	0	10	0	0	5
+0.5	10	6	20	20	5	30
+1.0	18	10	30	40	18	60
+2.0	28	16	40	60	34	84
+3.0	33	20	45	80	60	100
+5.0	42	30	60	90	80	100
+7.0	55	42	94	100	100	100
+10.0	65	55	100	100	100	100

Single Family Residential Multi-Story (SFRM)

Stage	Structure			Content		
	Most Likely	Min	Max	Most Likely	Min	Max
-2.0	0	0	0	0	0	0
-1.0	0	0	2	0	0	0
-0.5	1	0	3	0	0	3
+0.0	5	0	8	5	0	8
+0.5	10	5	10	12	5	20
+1.0	15	9	20	25	15	30
+2.0	20	15	25	35	25	40
+3.0	25	20	30	45	32	60
+5.0	30	25	40	55	40	80
+7.0	50	40	55	70	50	100
+10.0	60	50	70	80	60	100

Apartment (APT)

Stage	Structure			Content		
	Most Likely	Min	Max	Most Likely	Min	Max
-1.0	0	0	0	0	0	0
-0.5	0	0	0	0	0	0
+0.0	5	0	8	2	1	8
+0.5	8	5	12	10	5	15
+1.0	20	7	25	15	8	20
+2.0	28	10	29	20	15	25
+3.0	28	18	30	25	20	30
+5.0	38	20	44	30	25	32
+7.0	46	35	50	35	30	40
+10.0	50	35	60	45	37	50

Commercial (COM) / Other (OTHER)

Stage	Structure			Content		
	Most Likely	Min	Max	Most Likely	Min	Max
-1.0	0	0	0	0	0	0
-0.5	0	0	0	0	0	0
+0.0	5	0	9	5	0	8
+0.5	10	5	17	18	5	28
+1.0	20	12	27	35	17	50
+2.0	30	18	36	39	28	58
+3.0	35	28	43	43	37	65
+5.0	40	33	48	47	43	65
+7.0	53	43	60	70	50	90
+10.0	58	48	69	75	50	90

Content-to-Structure Value Ratio (CSVR)

The content-to-structure value ratio (CSVR) is a common approach to estimating the content value of residential, commercial, and other category types. Content value is estimated as a fraction of the structure value based on certain determining characteristics of that structure including number of floors and usage.

The content-to-structure value ratios for this study are pulled from EM 1110-2-1619 *Risk-Based Analysis for Flood Damage Reduction Studies* (August 1996) and IWR Report 96-R-12 *Analysis of Nonresidential Content Value and Depth-Damage Data for Flood Damage Reduction Studies* (May 1996). Table 8 shows the total inventory DRV with structure and content values accounted for:

Table 8: Structure and Content Depreciated Replacement Values by Reach

Reach	Count	Structure	Content	Total	Median
Beach Av	335	$142,244,300	$57,300,000	$199,544,300	$348,257
Frog Hollow	880	$214,117,600	$87,100,000	$301,217,600	$240,653
Washington St	177	$34,128,900	$14,200,000	$48,328,900	$213,809
Total	**1,392**	**$390,490,800**	**$158,600,000**	**$549,090,800**	**$247,339**

Content depreciated replacement value constitutes approximately 40% of the total inventory value and raises total damageable assets to just under $550,000,000 across all structure types and reaches.

First Floor Elevation (FFE)

The final input variable of the inventory is first floor elevation (FFE). This is the elevation of the main floor of the structure and calculated by adding ground elevation and foundation height.

Ground elevation for this study is measured using a NOAA Digital Coast LiDAR-derived Bare Earth Digital Elevation Model (DEM). This DEM provides a topographical survey of Cape May and allows for the quantification of ground elevation at every structure location with a high degree of certainty. Figure 7 shows the DEM for Cape May and Figure 8 shows the DEM with the structure inventory point data overlay.

The lowest elevations in the study area are shown in red (approximately 3ft NAVD88) with the highest elevations shown in blue (approximately 16ft NAVD88). The DEM provides insight into identifying the more at-risk locations of the study areas as well as providing the ground elevation measurement. A more detailed topographic map is shown in the Main Report.

Foundation height estimates are based on field evaluations as well as detailed foundation height surveys from other comparable inventory databases. A mean value was estimated for each category type and added to the individually measured ground elevation at that structure's location. A mean value methodology was selected as the best available estimation technique to avoid over- or underestimating predicted damages. SFR1 structure foundations are estimated at 2.5ft above ground elevation, SFRM structure foundations are estimated at 3.5ft above ground elevation, and all other occupancy types are estimated at 1.5ft above ground elevation. Each structure occupancy type is also assigned a normal distribution of values to account for knowledge uncertainty in FFE identification.

Figure 7: Cape May Digital Elevation Map

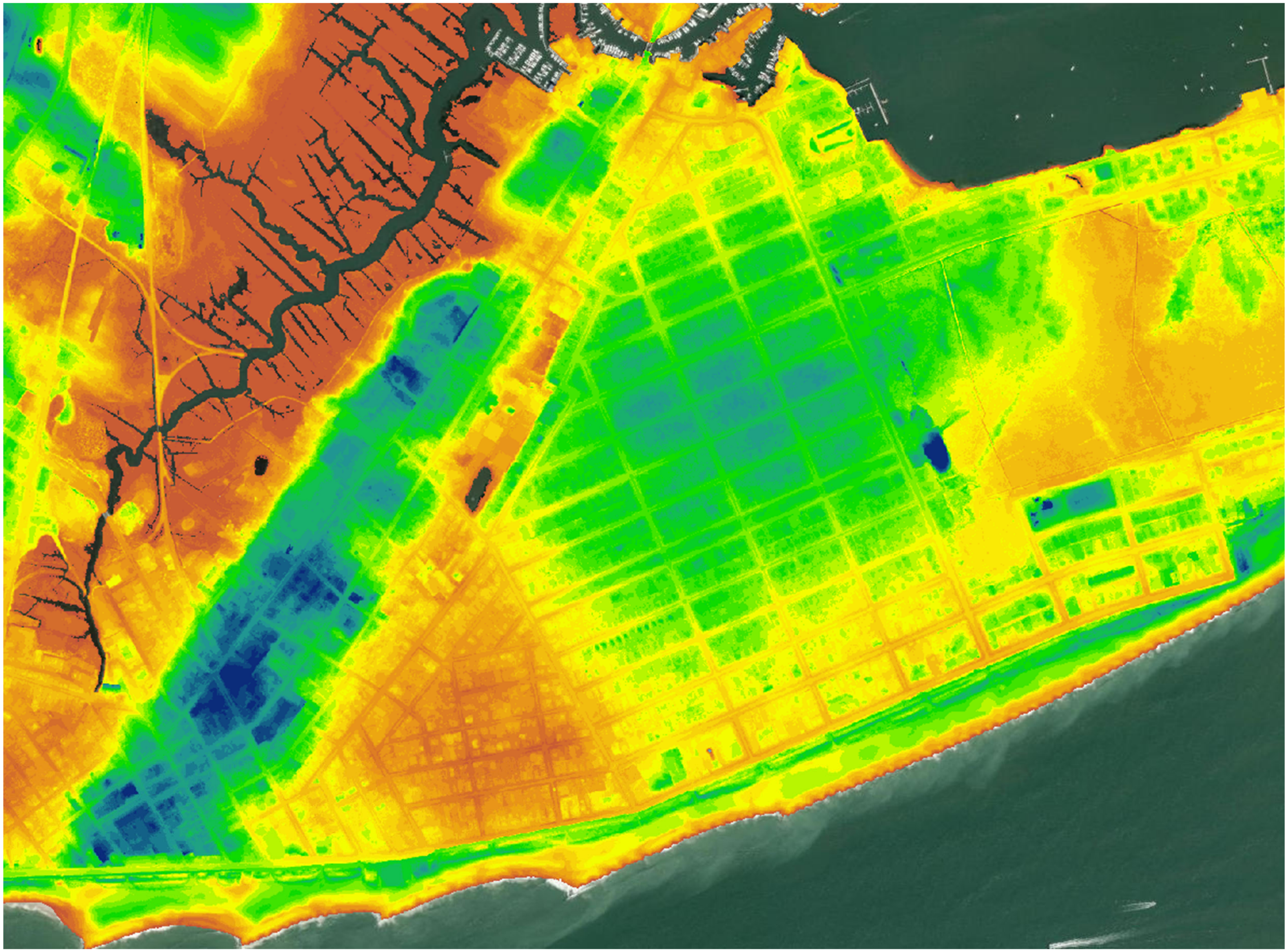
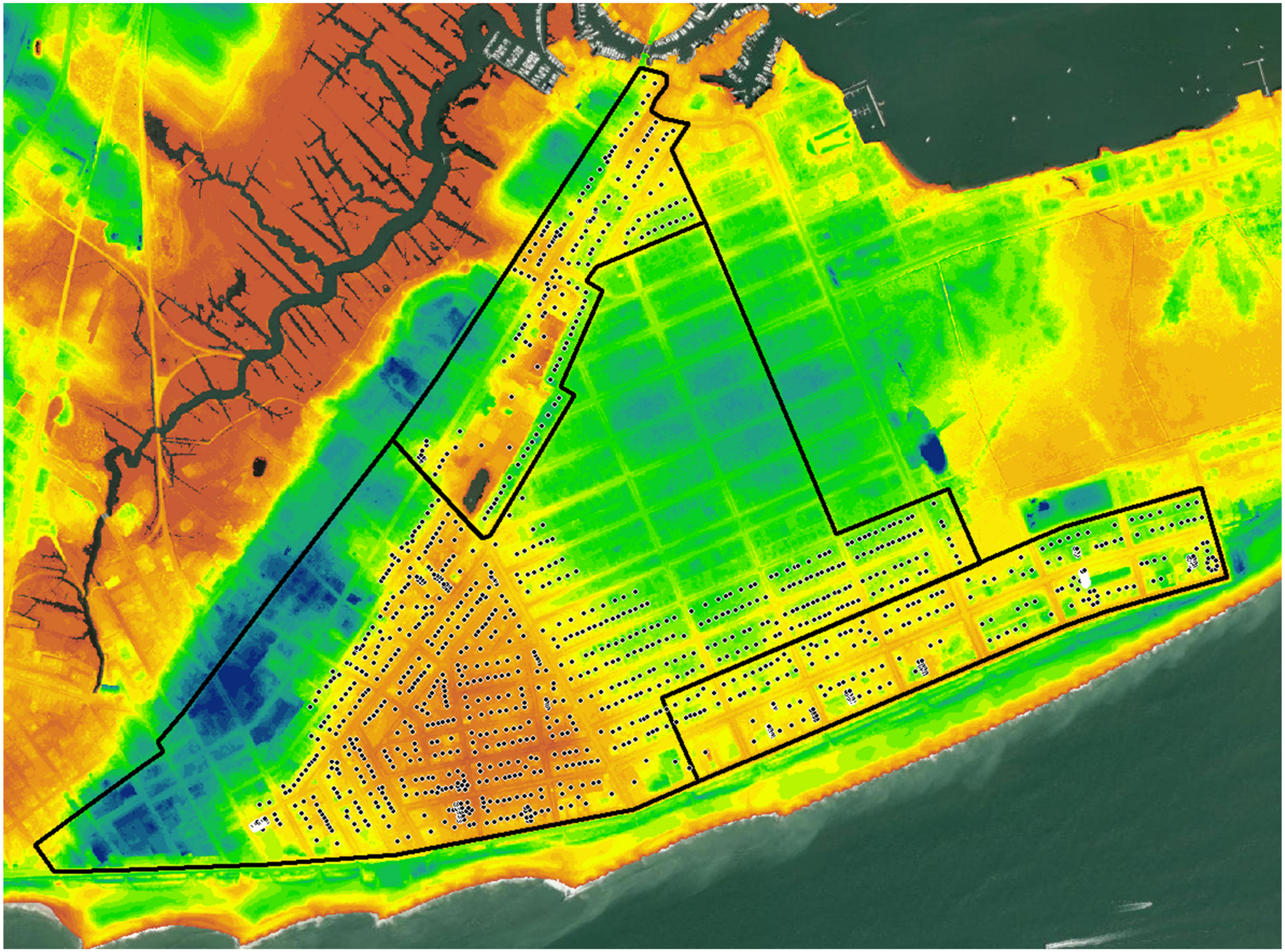


Figure 8: Cape May Digital Elevation Map with Inventory



HEC-FDA 1.4.2 MODEL RESULTS

HEC-FDA Methodology Overview

Expected Annual Damages (EAD) are presented in the then current FY18 price level, FY18 discount rate of 2.75%, and a 50-year period of analysis. For the purposes of this analysis, it is assumed that the existing level of development will remain the same for the 50-year period of analysis under future without-project conditions.

HEC-FDA 1.4.2 employs a Monte Carlo model evaluation to satisfy the risk analysis requirements in ER 1105-2-100 *Planning Guidance Notebook* and ER 1105-2-101 *Risk Analysis for Flood Damage Reduction Studies*. HEC-FDA 1.4.2 creates a stage-damage curve based on the intersections of structure and content value, first floor elevation, and depth-percent damage curves. A stage-damage curve provides information on the expected actual dollar amount damage a given structure endures for a given flood stage height.

This stage-damage curve is then interfaced with a stage-frequency curve (see Engineering Appendix) to compute the damage-frequency curve across a range of eight potential storm frequencies (50% ACE to .5% ACE). This damage-frequency curve procedure is repeated for every structure in the inventory for both the base year (2020) and future year (2070) to estimate the expected annual damage for each reach.

HEC-FDA will repeat this process over thousands of iterations during the Monte Carlo analysis to incorporate the uncertainty embedded in the stage-frequency curves, structure and content values, first floor elevations, and depth-percent damage curves. The result of a Monte Carlo simulation is a range of possible EAD outcomes that provides more detailed results for evaluating project risk and uncertainty.

More detailed information on HEC-FDA can be found in the *HEC-FDA Flood Damage Reduction Analysis User's Manual* (April 2016).

Without-Project Equivalent Annual Damages

The City of Cape May experiences a mean of $653,550 in Expected Annual Damages from a variety of sources including ocean water flowing over the eastern most section of the seawall on Beach Avenue, ocean water flowing directly over the coastal beach project, and inundation from Cape May Harbor.

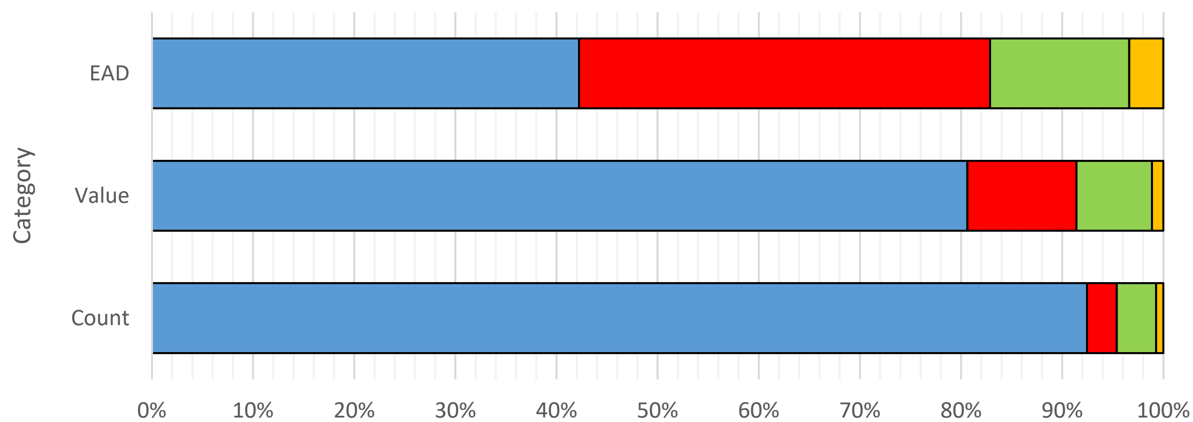
Table 9: Without-Project EAD by Reach and Category

Category	Beach Avenue	Frog Hollow	Washington St	TOTAL
RES	$720	$264,060	$11,140	$275,920
COM	$158,780	$103,510	$3,370	$265,660
APT	$2,020	$87,880	$20	$89,920
OTHER	$0	$4,790	$17,260	$22,050
TOTAL	**$161,520**	**$460,240**	**$31,790**	**$653,550**

Frog Hollow, with 54.8% of total inventory by structure value and 63.2% of total inventory by structure volume, accounts for 70.4% of total inventory EAD. Residential structures account for 77.0% of Frog Hollow inventory value, but account for only 57.4% of EAD. Commercial and Apartment structures comprise the majority of the remaining EAD.

Beach Avenue comprises the majority of Commercial structure EAD with 59.8% of total damages despite containing only 41.2% of total Commercial inventory value. Commercial structure damages represent almost all EAD in Beach Avenue due to their significant inundation risk. Figure 9 shows the relative relationship between Residential, Commercial, Apartment, and Other structures in regard to inventory volume, value, and contribution to EAD.

Figure 9: Relationship of Structure Types across Count, Value, and EAD



	Count	Value	EAD
Residential	1287	$314,838,400	$275,920
Commercial	41	$42,128,600	$265,660
Apartment	54	$29,143,500	$89,920
Other	10	$4,380,300	$22,050

Percent of Total Value

Residential structures constitute an overwhelming majority of total inventory count and value, but only a plurality of equivalent annual damages at 42.2%. Commercial structures have lower volume, but higher depreciated replacement values and risk levels, contributing a 40.6% share of without-project expected annual damages.

With-Project Condition Equivalent Annual Damages

Proposed structural alternatives for the study area include modification of the existing seawall from 9.5ft NAVD88 to an increased height by adding a reinforced concrete cap. The addition of the concrete cap helps to prevent ocean water from overtopping the structure and inundating the study area during storm events. Additionally, a nonstructural alternative was considered, but qualitatively screened due to lower probability of economic viability and high residual damages.

Nonstructural Alternatives

The nonstructural alternative was developed by identifying vulnerable structures that may be eligible for elevation, floodproofing, or acquisition. Vulnerable structures were identified according to their First Floor Elevation (FFE) in comparison with the expected stage level at that comparable event frequency. FFE is a combination of Foundation Height and Ground Elevation. Foundation Height was identified by the PDT using a virtual inspection of each structure and Ground Elevation was estimated using LiDAR-derived Digital Elevation Models.

During the initial formulation process, nonstructural measures were qualitatively screened due to estimated high costs and low probability of economic viability. Residential structures were considered for either elevation or acquisition while non-residential structures were considered for wet- or dry-floodproofing.

Elevating or floodproofing the structures within the 1% AEP event floodplain (398 structures) was approximately $89,550,000 in initial construction. Reducing the scope of the nonstructural floodplain to the 2.875% AEP event floodplain (82 structures) was approximately $18,450,000 in initial construction. Reducing the scope even further dramatically elevated the residual damages compared to the structural alternatives.

As the nonstructural alternatives were either more expensive and/or less effective than comparable structural alternatives, they were screened from further consideration.

Structural Alternatives

HEC-FDA 1.4.2 was used to model the estimated average annual damage reduction from construction of a 13ft NAVD88 seawall (9.5ft existing seawall with 3.5ft concrete cap) up to an 18ft NAVD88 seawall (9.5ft existing seawall with 8.5ft concrete cap) in one foot increments. With each one-foot increase in height, the concrete cap was increased one foot in width to improve stability and limit the risk from sliding or other failure mechanisms.

Expected Annual Damages (EAD) are presented in the then current FY18 price level, an FY18 discount rate of 2.75%, and a 50-year period of analysis. As with the Without-Project Condition scenario, it is assumed that the existing level of development will remain the same for the 50-year period of analysis.

Table 10: With-Project Condition Average Annual Damages by Category ($1,000s)

Alternative	Description	APT	COM	OTHER	RES	TOTAL	RESID
No Action	Without Project	89.92	265.66	22.05	275.92	653.55	100.0%
13ft	Concrete Cap at 13ft NAVD88	64.60	191.71	14.14	205.28	475.73	72.8%
14ft	Concrete Cap at 14ft NAVD88	62.98	170.12	14.03	201.27	448.40	68.6%
15ft	Concrete Cap at 15ft NAVD88	61.86	160.60	13.95	198.58	434.99	66.6%
16ft	Concrete Cap at 16ft NAVD88	61.06	155.41	13.84	195.86	426.17	65.2%
17ft	Concrete Cap at 17ft NAVD88	60.31	153.88	13.74	193.47	421.40	64.5%
18ft	Concrete Cap at 18ft NAVD88	60.31	153.88	13.74	193.47	421.40	64.5%

As discussed in the previous section and presented in Table 9, Cape May receives an estimated $653,500 in Average Annual Damages. Those damages originate from a variety of sources including ocean water flowing over the easternmost section of the existing seawall, ocean water flowing directly over the beach project, and inundation from Cape May Harbor.

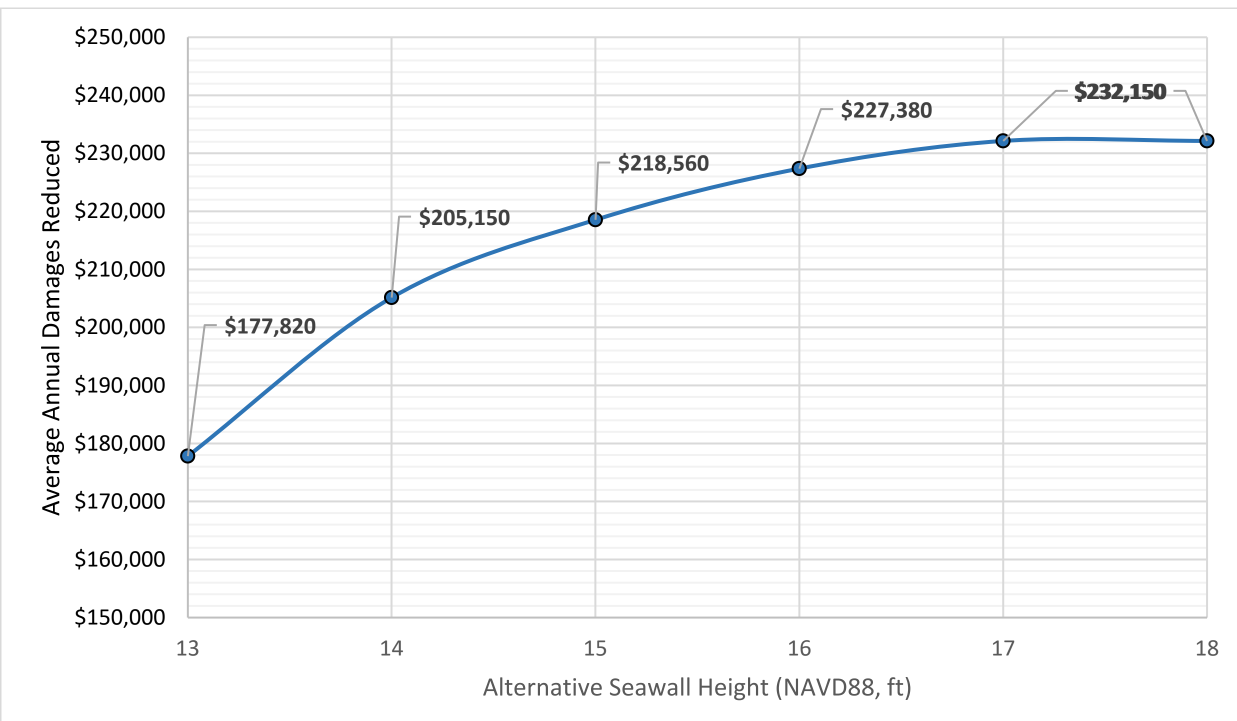
From all these sources, approximately 35.5% ($232,150) of Average Annual Damages originate from water flowing over the easternmost portion of the seawall. Even with a project constructed that prevents 100% of ocean water from flowing over this section of the seawall, eventually ocean water elevations and back bay elevations would increase high enough that inundation would occur from other sources. At a certain point, raising the easternmost section of the wall would no longer add benefits as dune/seawall overtopping occurs elsewhere along the beach and inundation occurs from the harbor.

It is important to note that this CAP Feasibility Study focused on readily implementable solutions to high frequency, low impact inundation events in Cape May. As high frequency events can only cause inundation from overtopping the easternmost section of the existing seawall, this became the focus of the economic analysis.

Residual damages from low frequency, high impact events, especially from inundation originating from Cape May Harbor, may be higher than stated in this report. While residual damages do not affect the Average Annual Net Benefits calculation nor impact the economic justification of the project, it does show the limits of the proposed solution and provide expectations on the With-Project Condition scenario.

Figure 10 shows the Average Annual Damages Reduced across the six modeled alternatives:

Figure 10: Average Annual Damages Reduced by Alternative



As the alternatives increase in height, the rate at which each successive foot added to the seawall improves Average Annual Benefits diminishes until the seawall at 17ft NAVD88 maximizes damages reduced. To optimize the seawall height, the percentage increase in benefits from each successive foot will need to outpace the percentage increase in cost from each successive foot. Cost estimates are shown in the following section and Average Annual Net Benefits shown in Table 12.

At this point, constructing the easternmost portion of the seawall any higher than 17ft NAVD88 no longer provides any tangible reduction in damages as inundation now occurs from other sources.

CONSTRUCTION COST ESTIMATES

Initial Construction cost, Interest During Construction, and projected Operations & Maintenance costs were estimated for each proposed alternative. Initial construction costs were completed using Micro-Computer Aided Cost Estimating System (MCACES) Second Generation (MII). MCACES involves risk analysis via Oracle Crystal Ball and the Recommended Plan final cost estimates are certified through Agency Technical Review and the USACE Cost Engineering Directory of Expertise (Cost DX) at Walla Walla District.

Interest during Construction is estimated using a six-month construction timeline with the then-current FY2018 2.75% Federal Discount Rate. Operations and Maintenance is based on historic O&M costs for similar constructed projects.

Figure 11 shows the MCACES initial construction cost results for Alternatives 13ft NAVD88 through 18ft NAVD88:

Figure 11: Initial Construction Cost Estimates for Alternatives 13ft NAVD88 through 18ft NAVD88

13FT NAVD88 SEAWALL

Number					Product Description	Quantity	UOM	Unit Price	Estimated	Escalation	Contingency	TOTAL
10					**BREAKWATERS AND SEAWALLS**				**$1,710,849**	**$66,723**	**$355,514**	**$2,133,086**
10	00	01			Mobilization, Demobilization, and Prepatory Work	1	JOB	LS	$452,954	$17,665	$94,124	$564,743
10	00	47	02		Site Work				$310,869	$12,124	$64,599	$387,591
		47	02	01	Foundation Work	1	JOB	LS	$292,109	$11,392	$60,700	$364,201
				05	Backfill	1	JOB	LS	$18,760	$732	$3,898	$23,390
10	00	99			Associated General Items							
		99	01		Traffic Control				$947,026	$36,934	$196,792	$1,180,752
		99	01	01	Temporary Detour Roads	1	JOB	LS	$546,684	$21,321	$113,601	$681,606
		99	01	04	Flagging	1	JOB	LS	$378,767	$14,772	$78,708	$472,246
		99	01	05	Barriers and Marking	1	JOB	LS	$21,575	$841	$4,483	$26,900
30					**PLANNING, ENGINEERING, AND DESIGN**	**1**	**JOB**	**LS**	**$256,627**	**$10,008**	**$53,327**	**$319,963**
31					**CONSTRUCTION MANAGEMENT (S&A)**	**1**	**JOB**	**LS**	**$133,788**	**$5,218**	**$27,801**	**$166,807**
					TOTAL ESTIMATED AMOUNT							**$2,619,857**
					ROUNDED							**$2,620,000**

14FT NAVD88 SEAWALL

Number					Product Description	Quantity	UOM	Unit Price	Estimated	Escalation	Contingency	TOTAL
10					**BREAKWATERS AND SEAWALLS**				**$1,745,212**	**$68,063**	**$362,655**	**$2,175,930**
10	00	01			Mobilization, Demobilization, and Prepatory Work	1	JOB	LS	$441,489	$17,218	$91,742	$550,449
10	00	47	02		Site Work				$380,666	$14,846	$79,102	$474,614
		47	02	01	Foundation Work	1	JOB	LS	$361,727	$14,107	$75,167	$451,002
				05	Backfill	1	JOB	LS	$18,938	$739	$3,935	$23,612
10	00	99			Associated General Items							
		99	01		Traffic Control				$923,057	$35,999	$191,811	$1,150,867
		99	01	01	Temporary Detour Roads	1	JOB	LS	$532,848	$20,781	$110,726	$664,354
		99	01	04	Flagging	1	JOB	LS	$369,180	$14,398	$76,716	$460,294
		99	01	05	Barriers and Marking	1	JOB	LS	$21,029	$820	$4,370	$26,219
30					**PLANNING, ENGINEERING, AND DESIGN**	**1**	**JOB**	**LS**	**$261,782**	**$10,209**	**$54,398**	**$326,389**
31					**CONSTRUCTION MANAGEMENT (S&A)**	**1**	**JOB**	**LS**	**$136,476**	**$5,323**	**$28,360**	**$170,158**
					TOTAL ESTIMATED AMOUNT							**$2,672,477**
					ROUNDED							**$2,672,000**

15FT NAVD88 SEAWALL

Number					Product Description	Quantity	UOM	Unit Price	Estimated	Escalation	Contingency	TOTAL
10					**BREAKWATERS AND SEAWALLS**				**$1,788,734**	**$69,761**	**$371,699**	**$2,230,193**
10	00	01			Mobilization, Demobilization, and Prepatory Work	1	JOB	LS	$428,345	$16,705	$89,010	$534,060
10	00	47	02		Site Work				$464,815	$18,128	$96,589	$579,532
		47	02	01	Foundation Work	1	JOB	LS	$445,737	$17,384	$92,624	$555,745
				05	Backfill	1	JOB	LS	$19,078	$744	$3,964	$23,787
10	00	99			Associated General Items							
		99	01		Traffic Control				$895,574	$34,927	$186,100	$1,116,602
		99	01	01	Temporary Detour Roads	1	JOB	LS	$516,983	$20,162	$107,429	$644,574
		99	01	04	Flagging	1	JOB	LS	$358,188	$13,969	$74,431	$446,589
		99	01	05	Barriers and Marking	1	JOB	LS	$20,403	$796	$4,240	$25,439
30					**PLANNING, ENGINEERING, AND DESIGN**	**1**	**JOB**	**LS**	**$268,310**	**$10,464**	**$55,755**	**$334,529**
31					**CONSTRUCTION MANAGEMENT (S&A)**	**1**	**JOB**	**LS**	**$139,879**	**$5,455**	**$29,067**	**$174,401**
					TOTAL ESTIMATED AMOUNT							**$2,739,124**
					ROUNDED							**$2,739,000**

16FT NAVD88 SEAWALL

Number					Product Description	Quantity	UOM	Unit Price	Estimated	Escalation	Contingency	TOTAL
10					**BREAKWATERS AND SEAWALLS**				**$1,833,963**	**$71,525**	**$381,098**	**$2,286,586**
10	00	01			Mobilization, Demobilization, and Prepatory Work	1	JOB	LS	$416,092	$16,228	$86,464	$518,784
10	00	47	02		Site Work				$547,914	$21,369	$113,856	$683,139
		47	02	01	Foundation Work	1	JOB	LS	$528,766	$20,622	$109,878	$659,266
				05	Backfill	1	JOB	LS	$19,148	$747	$3,979	$23,873
10	00	99			Associated General Items							
		99	01		Traffic Control				$869,957	$33,928	$180,777	$1,084,663
		99	01	01	Temporary Detour Roads	1	JOB	LS	$502,195	$19,586	$104,356	$626,137
		99	01	04	Flagging	1	JOB	LS	$347,943	$13,570	$72,302	$433,815
		99	01	05	Barriers and Marking	1	JOB	LS	$19,819	$773	$4,118	$24,711
30					**PLANNING, ENGINEERING, AND DESIGN**	**1**	**JOB**	**LS**	**$275,095**	**$10,729**	**$57,165**	**$342,988**
31					**CONSTRUCTION MANAGEMENT (S&A)**	**1**	**JOB**	**LS**	**$143,416**	**$5,593**	**$29,802**	**$178,811**
					TOTAL ESTIMATED AMOUNT							**$2,808,385**
					ROUNDED							**$2,808,000**

17FT NAVD88 SEAWALL

Number					Product Description	Quantity	UOM	Unit Price	Estimated	Escalation	Contingency	TOTAL
10					**BREAKWATERS AND SEAWALLS**				**$1,882,844**	**$73,431**	**$391,255**	**$2,347,530**
10	00	01			Mobilization, Demobilization, and Prepatory Work	1	JOB	LS	$404,221	$15,765	$83,997	$503,983
10	00	47	02		Site Work				$633,486	$24,706	$131,638	$789,830
		47	02	01	Foundation Work	1	JOB	LS	$614,220	$23,955	$127,635	$765,810
				05	Backfill	1	JOB	LS	$19,266	$751	$4,003	$24,020
10	00	99			Associated General Items							
		99	01		Traffic Control				$845,137	$32,960	$175,619	$1,053,717
		99	01	01	Temporary Detour Roads	1	JOB	LS	$487,867	$19,027	$101,379	$608,273
		99	01	04	Flagging	1	JOB	LS	$338,016	$13,183	$70,240	$421,438
		99	01	05	Barriers and Marking	1	JOB	LS	$19,254	$751	$4,001	$24,006
30					**PLANNING, ENGINEERING, AND DESIGN**	**1**	**JOB**	**LS**	**$282,427**	**$11,015**	**$58,688**	**$352,130**
31					**CONSTRUCTION MANAGEMENT (S&A)**	**1**	**JOB**	**LS**	**$147,238**	**$5,742**	**$30,596**	**$183,577**
					TOTAL ESTIMATED AMOUNT							**$2,883,237**
					ROUNDED							**$2,883,000**

18FT NAVD88 SEAWALL

Number					Product Description	Quantity	UOM	Unit Price	Estimated	Escalation	Contingency	TOTAL
10					**BREAKWATERS AND SEAWALLS**				**$1,934,811**	**$75,458**	**$402,054**	**$2,412,322**
10	00	01			Mobilization, Demobilization, and Prepatory Work	1	JOB	LS	$415,378	$16,200	$86,315	$517,893
10	00	47	02		Site Work				$650,970	$25,388	$135,272	$811,630
		47	02	01	Foundation Work	1	JOB	LS	$631,173	$24,616	$131,158	$786,946
				05	Backfill	1	JOB	LS	$19,797	$772	$4,114	$24,683
10	00	99			Associated General Items							
		99	01		Traffic Control				$868,463	$33,870	$180,467	$1,082,799
		99	01	01	Temporary Detour Roads	1	JOB	LS	$501,333	$19,552	$104,177	$625,061
		99	01	04	Flagging	1	JOB	LS	$347,345	$13,546	$72,178	$433,070
		99	01	05	Barriers and Marking	1	JOB	LS	$19,785	$772	$4,111	$24,668
30					**PLANNING, ENGINEERING, AND DESIGN**	**1**	**JOB**	**LS**	**$290,222**	**$11,319**	**$60,308**	**$361,848**
31					**CONSTRUCTION MANAGEMENT (S&A)**	**1**	**JOB**	**LS**	**$151,302**	**$5,901**	**$31,441**	**$188,644**
					TOTAL ESTIMATED AMOUNT							**$2,962,814**
					ROUNDED							**$2,963,000**

In addition to the initial construction cost posted in Figure 11, final costs include Interest during Construction over the estimated six-month construction duration and annual Operations and Maintenance costs. Average Annual Costs (FY18 Discount Rate of 2.75%) are shown in Table 11. Costs are developed with a 20% contingency.

Table 11: Average Annual Cost Summary by Alternative

Item	13ft	14ft	15ft	16ft	17ft	18ft
Project Life	50	50	50	50	50	50
FY18 Discount Rate	2.75%	2.75%	2.75%	2.75%	2.75%	2.75%
Capital Recovery Factor	.0370409	.0370409	.0370409	.0370409	.0370409	.0370409
Initial Construction Cost	$2,620,000	$2,672,000	$2,739,000	$2,808,000	$2,883,000	$2,963,000
Interest During Construction	$36,000	$37,000	$38,000	$39,000	$40,000	$41,000
Total Estimated Construction	**$2,657,000**	**$2,709,000**	**$2,777,000**	**$2,847,000**	**$2,923,000**	**$3,004,000**
Initial Average Annual Cost	$98,000	$100,000	$103,000	$105,000	$108,000	$111,000
Average Annual O&M	$13,000	$14,000	$14,000	$14,000	$15,000	$15,000
Average Annual Cost (AAC)	**$112,000**	**$114,000**	**$117,000**	**$120,000**	**$123,000**	**$127,000**

Table 11 shows that adding further elevation to the seawall alternative only marginally increases projected Average Annual Cost. Each additional foot in height only increases costs by 2% to 3%. Fixed costs (e.g. Mobilization/Demobilization, Traffic Control, PE&D, S&A) represent the majority of items in the cost projections and far outweigh the variable costs associated with higher elevations.

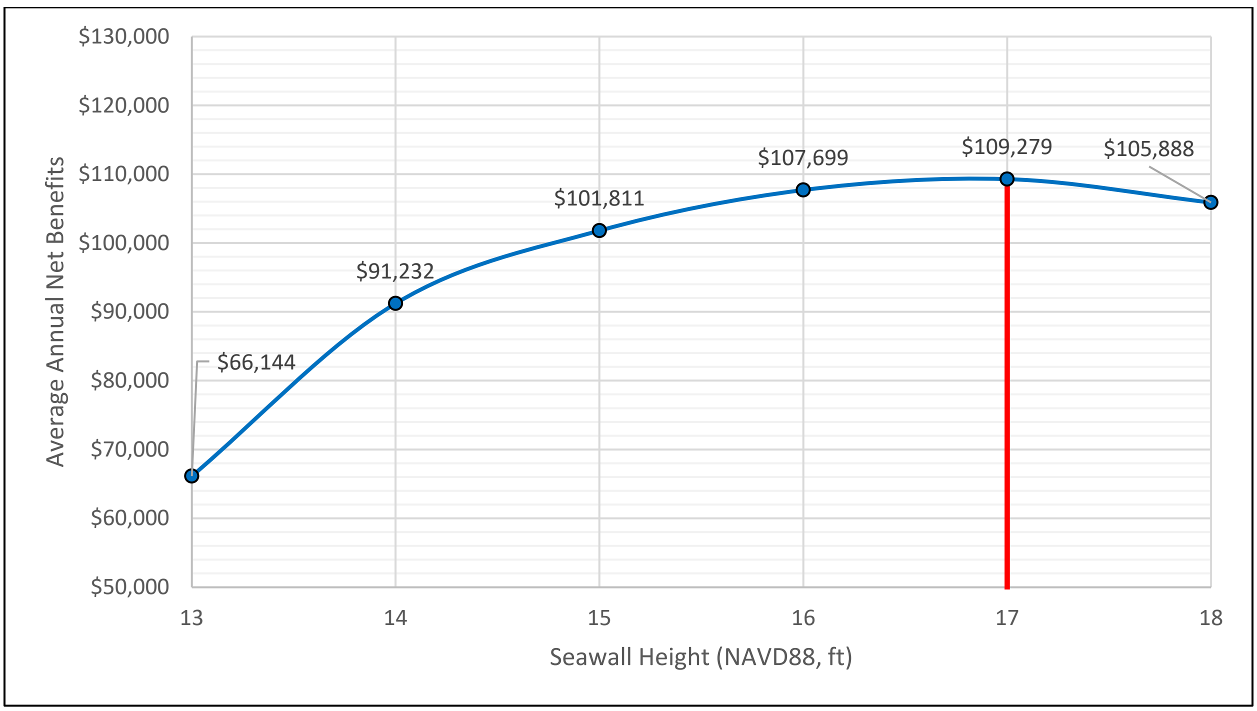
AVERAGE ANNUAL NET BENEFITS

Combining the results shown in Table 10 and Table 11 allows for calculating the Average Annual Net Benefits and Benefit-Cost Ratio for each proposed alternative.

Table 12: Average Annual Net Benefits by Alternative

ITEM	13ft	14ft	15ft	16ft	17ft	18ft
Total Estimated Construction	$2,657,000	$2,709,000	$2,777,000	$2,847,000	$2,923,000	$3,004,000
Average Annual Cost	**$112,000**	**$114,000**	**$117,000**	**$120,000**	**$123,000**	**$127,000**
Without Project EAD	$654,000	$654,000	$654,000	$654,000	$654,000	$654,000
With Project EAD	$476,000	$448,000	$435,000	$426,000	$421,000	$421,000
Average Annual Benefits	**$178,000**	**$205,000**	**$219,000**	**$227,000**	**$232,000**	**$232,000**
Benefit-Cost Ratio	**1.6**	**1.8**	**1.9**	**1.9**	**1.9**	**1.8**
Average Annual Net Benefits	**$66,000**	**$91,000**	**$102,000**	**$108,000**	**$109,000**	**$106,000**

Figure 12: Average Annual Net Benefits by Alternative



National Economic Development (NED) Benefits are maximized for this study area with the construction of a concrete cap atop the existing seawall to bring the final seawall elevation to 17ft NAVD88. Figure 12 shows the optimization at 17ft NAVD88 with $109,000 in AANB.

SENSITIVITY AND RISK ANALYSIS

Sea Level Change Sensitivity

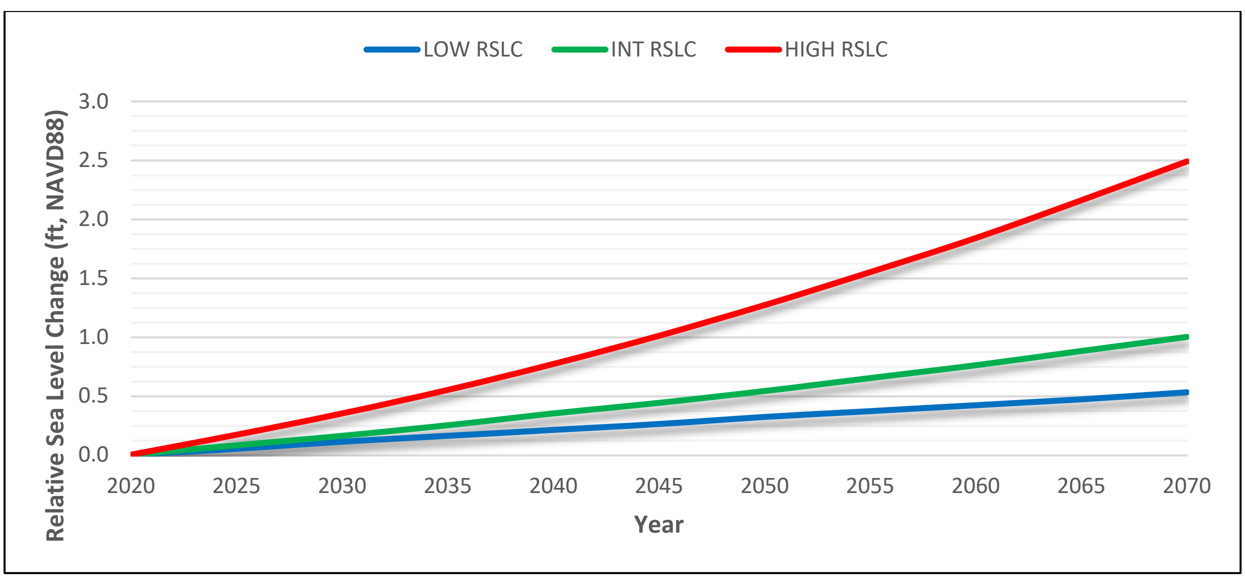
Plan formulation and NED optimization of the selected alternative relied on the Low (Historic) Relative Sea Level Change (RSLC) curve for the 50-year period of analysis. This decision was made based on two considerations: (1) the selected alternative is designed to combat high frequency, repetitive inundation from ocean water cresting the existing seawall and (2) the assumption that the structure inventory remains static becomes slightly less reliable with Intermediate RSLC and completely unreliable with High RSLC.

Relative Sea Level Change (RSLC) sensitivity analysis is intended to provide insight on project performance and economic justifiability with varying future sea level change scenarios. RSLC curves are developed from the USACE Sea-Level Change Curve Calculator (version 2017.55) in accordance with EC 1165-2-212 *Sea-Level Change Considerations for Civil Works Programs* and ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*.

Table 13: Relative Sea Level Change Scenarios (ft, NAVD88)

YEAR	LOW	INT	HIGH
2020	0.00	0.00	0.00
2025	0.05	0.08	0.17
2030	0.11	0.16	0.35
2035	0.16	0.25	0.55
2040	0.21	0.35	0.77
2045	0.26	0.44	1.01
2050	0.32	0.54	1.27
2055	0.37	0.65	1.55
2060	0.42	0.76	1.84
2065	0.47	0.88	2.16
2070	0.53	1.00	2.49

Figure 13: Relative Sea Level Change Scenarios (ft, NAVD88)



As shown in Table 13 and Figure 13, the Low (Historic) and Intermediate RSLC curves for this study area are fairly linear across the 50-year period of analysis. Sea level height increases at a roughly uniform annual rate. In total, from Project Year 0 (2020) until Project Year 50 (2070), sea level height increases 0.53ft in the Low RSLC scenario and 1.00ft in the Intermediate RSLC. However, the High RSLC curve follows a more exponential path, increasing by 2.49ft over the 50-year period of analysis.

The High RSLC scenario for this study creates issues with two key project assumptions for the Future Without-Project Condition (FWOP) baseline. The FWOP scenario typically assumes the most-likely future condition will include a static inventory (maintains current volume, value, and characteristics) and no new coastal measures constructed by the Federal government, State government, Municipal government, or other entity. These assumptions are reasonable when considering the Low and Intermediate RSLC scenarios as future sea level conditions are not dramatically different than current sea level conditions. These assumptions, however, are not reasonable when considering High RSLC scenario.

Under the High RSLC curve, 10% ACE events (10 year flood response) and 2% ACE events (50 year flood response) in the Year 2020 would be equivalent to 50% ACE events (2 year flood response) and 20% ACE events (5 year flood response) in the Year 2070, respectively. This means that flood events expected to occur, on average, every 50 years would instead be expected to occur, on average, every 5 years. It is reasonable to assume that the future most-likely condition in this aggressive scenario would involve significant changes to the inventory in the form of building elevations / acquisitions and also in the form of modifications to the existing seawall to provide greater coastal storm risk management.

Predicting the exact nature and quantity of changes in the inventory for the High RSLC scenario is beyond the scope of this study and does not impact the selected alternative. Realistically, under the High RSLC scenario, the selected alternative would still be economically justified, but would need to be combined with measures to prevent ocean water from cresting the other parts of the seawall and measures to limit inundation from back bay flooding in order to provide realistic CSRM benefits.

The RSLC sensitivity results presented in Table 14 and Figure 14 are meant to show the economic viability of the selected plan in comparison to other modeled alternatives and the project performance of the selected plan in terms of residual damages.

Table 14: Relative Sea Level Change Sensitivity Results

LOW RSLC	Beach Ave	Frog Hollow	Wash. Ave	Total AAD	Reduced AAD	Residual AAD	Total AAC	Total AANB
No Act.	$162,000	$460,000	$32,000	$654,000	$0	100.0%	$0	$0
13ft	$115,000	$340,000	$21,000	$476,000	$178,000	72.8%	$112,000	$66,000
14ft	$95,000	$333,000	$21,000	$448,000	$205,000	68.6%	$114,000	$91,000
15ft	$87,000	$328,000	$21,000	$435,000	$219,000	66.6%	$117,000	$102,000
16ft	$82,000	$323,000	$20,000	$426,000	$227,000	65.2%	$120,000	$108,000
17ft	$82,000	$319,000	$20,000	$421,000	$232,000	64.5%	$123,000	$109,000
18ft	$82,000	$319,000	$20,000	$421,000	$232,000	64.5%	$126,000	$106,000

INT RSLC	Beach Ave	Frog Hollow	Wash. Ave	Total AAD	Reduced AAD	Residual AAD	Total AAC	Total AANB
No Act.	$203,000	$658,000	$47,000	$908,000	$0	100.0%	$0	$0
13ft	$147,000	$467,000	$29,000	$643,000	$265,000	70.8%	$112,000	$153,000
14ft	$131,000	$454,000	$28,000	$614,000	$294,000	67.6%	$114,000	$180,000
15ft	$115,000	$444,000	$28,000	$588,000	$320,000	64.7%	$117,000	$203,000
16ft	$112,000	$435,000	$28,000	$575,000	$333,000	63.4%	$120,000	$213,000
17ft	$112,000	$433,000	$28,000	$573,000	$335,000	63.1%	$123,000	$212,000
18ft	$112,000	$433,000	$28,000	$573,000	$335,000	63.1%	$126,000	$209,000

HIGH RSLC	Beach Ave	Frog Hollow	Wash. Ave	Total AAD	Reduced AAD	Residual AAD	Total AAC	Total AANB
No Act.	$727,000	$3,094,000	$217,000	$4,038,000	$0	100.0%	$0	$0
13ft	$702,000	$2,683,000	$165,000	$3,550,000	$488,000	87.9%	$112,000	$376,000
14ft	$680,000	$2,492,000	$161,000	$3,333,000	$705,000	82.5%	$114,000	$591,000
15ft	$490,000	$2,339,000	$161,000	$2,991,000	$1,047,000	74.1%	$117,000	$931,000
16ft	$480,000	$2,284,000	$157,000	$2,921,000	$1,117,000	72.3%	$120,000	$997,000
17ft	$480,000	$2,283,000	$157,000	$2,920,000	$1,118,000	72.3%	$123,000	$995,000
18ft	$480,000	$2,283,000	$157,000	$2,920,000	$1,118,000	72.3%	$126,000	$991,000

As shown previously in this Appendix, the NED optimizing alternative in the Low (Historic) RSLC scenario is the 17ft NAVD88 seawall with the 16ft NAVD88 seawall alternative only 1.4% lower in terms in Average Annual Net Benefits.

For the Intermediate RSLC, estimated FWOP damages increase 38.9% to $908,000 Total AAD. With this RSLC curve, inundation from elsewhere on the seawall and from back bay flooding occurs slightly more frequently, dropping the NED optimizing alternative to 16ft NAVD88 though the 17ft NAVD88 alternative has only 0.5% fewer AANB.

The High RSLC scenario also supports the construction of either the 16ft NAVD88 or 17ft NAVD88 alternative, but previously discussed limitations on this scenario prevent any reliable insights or inferences from the data results.

In summary, the 17ft NAVD88 alternative is still the reasonably NED maximizing alternative when considering all three RSLC curve scenarios as this alterative maintains similar AANB and AAC in comparison to the 16ft NAVD88 alternative with slightly reduced residual damages.

FY2021 PRICE LEVEL AND DISCOUNT RATE

Following the completion of the economic analysis optimization and RSLC sensitivity testing, all HEC-FDA inputs, including structure inventory values and estimated construction costs, were updated to the FY2021 price level and all economic calculations re-computed using the FY2021 Federal Discount Rate of 2.5%. This action does not impact plan selection nor alter any associated study risk, but does provide the most current economic results and allows for the most accurate investigation of Average Annual Net Benefits and Benefit-Cost Ratio.

In addition to updating the Price Level and Federal Discount Rate, the economic analysis was revised by recalculating Interest During Construction for a shorter 3-month duration schedule, implementing the updated FY2021 construction cost estimates, and increasing the estimated average annual OMRR&R estimates.

The updated FY2021 economic results for the 17ft NAVD88 Alternative are presented in Table 15 below:

Table 15: Average Annual Net Benefits (FY2021)

ITEM	**17ft Alternative**	
	FY18	**FY21**
Project Life	50	50
Discount Rate	2.75%	2.5%
Capital Recovery Factor	0.0370409	0.0352581
Subtotal Estimated Construction	$2,883,000	$3,563,000
Interest During Construction	$40,000	$11,000
Total Estimated Construction	**$2,923,000**	**$3,574,000**
Subtotal Average Annual Cost	$108,000	$126,000
Operations & Maintenance	$15,000	$36,000
Total Average Annual Cost	**$123,000**	**$162,000**
Without Project EAD	$654,000	$725,000
With Project EAD	$421,000	$467,000
Total Average Annual Benefits	**$232,000**	**$258,000**
Average Annual Net Benefits	**$109,000**	**$96,000**
Benefit-Cost Ratio	**1.9**	**1.6**

With FY2021 price levels and the FY2021 Federal Discount Rate of 2.5%, the NED maximizing alternative for the study area is the 17ft NAVD88 measure with $96,000 AANB and a 1.6 BCR.

SUMMARY

The City of Cape May, NJ is highly susceptible to storm-induced flood damages with a particular vulnerability to storm surge cresting the easternmost portion of the existing seawall. Residential homes are the most strongly affected damageable asset category in this area, with some commercial properties also experiencing significant impact. The HEC-FDA economic analysis results have demonstrated that, in the absence of a federal project, significant economic damage from coastal forces can be expected over the next 50 years.

The NED Plan has been determined using technical expertise, professional judgment, and rigorous certified modeling to reasonably maximize net benefits in the reduction of coastal storm damage. With reduced damages from coastal high-frequency storm events, the present value Average Annual Net Benefits for the NED Plan is $96,000 with a Benefit-Cost Ratio of 1.6.